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Analyzing Toll Road as a Solution to The Existing Highway Problem

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Abstract

Pantura national highway or Route 1 in Indonesia is one of the important routes which drive the most economic movement in Indonesia. For years this route suffering over dimensions and overloading phenomena causing serious early failure to it's pavement. Republic Indonesia government recently built the Trans Java Toll Road connecting Java island with a toll road from west to east, the initial route is Cipali (Cikampek to Palimanan) Toll Road Section as long 116 km which officially opened on 13th of June 2015. One of Cipali Toll Road Section aims is to move the most traffic from Pantura highway to Cipali Toll Road to reduce the Pantura highway burden. This research aimed to find out the impact of the Trans Java Toll especially Cipali Section to Pantura National Highway Pavement Service Life. The Liddle's formula used with k–factor = 1 for single axles, 0.086 and 0.031 for tandem and tridem axles to get the CESA between before the toll existence and after the toll existence. The findings are that Trans Java toll road reduce Pantura national road (route 1) traffic as much 180.818 PCU, and the Trans Java toll presence road help Pantura national road (route 1) back to it's designed CESA.

Keywords – overloading truck, pavement service life, vdf, ESAL

1. Introduction

Indonesia's transportation system is being massively improved, in recent years the mass transportation system has been improved; becoming cashless, unclear departure and arrival schedules are also being improved, as is the headway, comfort and cleanliness in modes is a priority, the need for the elderly and women is also given attention, on the Jabodetabek commuter line (train-based mode) it even provides two wagons specifically for women; one at the front and one wagon at the back with a very disciplined officer maintaining ensures the use of those wagons, as well as in the busway there is available space for women and even women-only buses, priority seats for the elderly and pregnant women are provided, and rooms for disbality passengers who use wheel chair.

Infrastructure development is a priority program of the government, since 2015 to 2018 as long 2018 3,432 km of national roads and 941 km of toll roads have been built and the government has also built bridges with a total length of 39.8 km to support connectivity (Afriyadi, 2018). The government finally realized to connect Java Island by toll road, Java Island with an area of 128,297 km^2 is the fifth largest island of thousands of islands in Indonesia, but 60% of Indonesia's population settle in this island.

Java island, where Jakarta the capital city is located has an important nation highway named Java North Beach Highway (Pantura), Route 1, which plays a strategic role to Indonesian economy (Kinasih, Putri, & Nabila, 2020). Unfortunately, as the busiest highway connecting some big industry cities and the capital city, Pantura highway suffering over dimension and overloading phenomenon leading early failure to the pavement. More over Indonesia has two seasons; wet and dry season. In the wet season, flooding will worsen the pavement which experience overloading phenomenon (Hatmoko et al, 2017). Meantime, Widyaningsih (2018) mention that rapid traffic growth gives impact to the structure of the pavement and to the use of its material.

As mentioned by Rakhmani (2015) based on Article 28 of Republic Indonesia Constitution No. 22 of year 2009 concerning Traffic and Road Transportation states that the safety of road transport is the responsibility of the government. As the responsibility it is a must for the government to provide a safe road infrastructure for the people. More over a good transportation connecting regions effectively and affecting economic raising significantly.

Contrary to Republic Indonesia Constitution No. 22/2009 concerning Traffic and Road Transportation, record of road accident caused by overloading truck increased. No wonder, holes in the road at high speed are prone to serious accidents. Besides, overloading makes the tire quickly damaged, as well as the suspension and steering system. Indonesian vehicle owners usually overcome this by applying stronger tires rather than the standard tire that it should be, and modifying the suspension by adding several leaf springs, but these tricks proved failed to reduce the risk of safety, because the axles will be broken and raises greater possibility the brakes function failure due to heat caused by overloading, moreover if the vehicle crossing contoured road like in the hills or mountains, the risk of brake failure is higher.

Republic Indonesia government recently built the Trans Java Toll Road, it is a toll road network that connecting two largest cities in Indonesia; Jakarta in the west and Surabaya in the east via the toll road. The Trans Java Toll Road is a part of The Asian Highway 2 (AH2) or the Asian Road Network that connects Asia from Denpasar, Bali, Indonesia to Khosravi in Iran. One of the initial route of Trans-Java Toll Road is Cikopo – Palimanan (Cipali Route) as long 116 kilometers connecting Cikopo, Purwakarta to Palimanan in Cirebon, East Java. This route main aim is not only to reduce the travel time to Cirebon city, but to reduce the burden of Pantura national highway which was the only main road connecting west to east Java island. This research goal is to find out how much reduction of the traffic in Pantura national highway and the impact to Pantura pavement caused by the Trans-Java Toll Road. Pantura highway burden must be reduced to prevent early damaging which is proved causing accidents, longer travel time and financial loss for the country due to expensive and undue pavement repair costs.

Researches about overloading phenomenon is quiet much carried out both in Indonesia and in other countries. Most researches about overloading phenomenon in Indonesia is mostly to calculate the impact of overload with case studies on certain road sections and calculate how it impacts on reducing pavement service life.

Titi et al (2018) vehicles with excess weight were only 1.8% of the total ADT on STH 140 Road, Wisconsin, predicted causing 18.5% cracking. Overloaded trucks are estimated to contribute more than 1000% of cracks.

Jihanny et al (2018) analized overloaded trucks in Indonesia based on weigh in motion data (East Sumatera national road case study), one of the conclusions is that pavement designed with a 10-year service life ended only in 3 years and 8 months. Shahul (2018) concludes that needed more 5 centimeters thickness to overcome the overload phenomenon in Aryankavu, India. Ojha (2018) state that the ESAL standard on Narayanghat-Muglingin Road, Nepal for 10 years is 34.20 million ESAL, but due to overloading trucks the ESAL number was reached in only 4.10 years. There is a reduction in pavement service life of 5.99 years. While Raheel (2018) using the modified French Pavement Design Guide equation ESAL formula, the factor truck numbers increase for Class B2 and lower for S123 classes. It is also necessary to increase the thickness of the asphalt layer from 10 cm to 20 cm for Class BH3 and S123 in Punjab.

Hatmoko et al (2017) shows a significant impact of flood empirically on the damage to pavement that have been worsened by indication of overloading through the road. For this reason, strategic efforts and coordination of relevant ministries are needed to overcome the problem of road damage. Karli, Vaidhya and Jayswal (2017) concluded that trucks with overloads of 10% had a pavement damage greater than 40% compared to the same trucks carrying normal loads in Ahmedabad Ring Road.

Palmaputri (2016) overloading in Yogyakarta city reduce pavement service life from 5 years degined to 4,795 years. Nkem (2014) Axle load measurements in Nigeria shows that most heavy vehicles carried overload cause damage factors up to 11.12 and 9.39 for the North and South Regions, respectively. Atiya (2014) wrote same conclusion that Poor Jembatang Weighing Performance Salam affects the service life of road pavement. Simanjuntak (2014) the existing pavement structure can only withstand overload loads for 5.6 years from the planned service life which is 10 years. While Karim's (2013) research in Malaysia revealed the level of overload is still high, especially for 2 axles and 3 axles trucks. Half of the 3 axles trucks were found to carry excess loads up to 101% of the allowable load limit.

Those researchers concluded the same things that overloading must be reduced or eliminated to overcome losses due to early damage. In Indonesia, Trans Java Toll Road, mainly Cipali Toll Road section aims to not only as a shortcut to east Java areas but to reduce Pantura National highway burden, because Pantura highway burden is greater than expected. Is the goal to reduce the burden of the Pantura lane success or not must be assessed, the high cost of Trans Java toll prices from West Java to East Java could have made expedition trucks continue to choose through the Pantura line rather than to use Trans Java Toll Road, especially Cipali Toll Road.

2. Methods

2.1. Data Collection Method

This research needs past traffic data in the years where there was no Toll Trans Java, mainly Cipali Toll Road section. Before toll presence will be used Average Daily Traffic (ADT) from Kinasih (2013), while to collect ADT after toll presence a traffic survey conducted with 8 traffic counting surveyors was hired, divided in 2 groups to get precision result. The survey done next to Cikampek exit toll in the left side to make sure only vehicles heading to Pantura counted. Survey conducted in 2 shifts; day and night shifts. Author responsibility here to provide direction and supervision so that survey conducted according to the needs of this study. Collected ADT data was tabulated.

2.2. Data Procession Method

Indonesia regulate maximum permitted load that can legally carried by vehicles which is written on circular letter of Republic Indonesia Directorate General of Land Transportation No.SE.02/AJ.108/DRJD/2008 concerning the Maximum Limitation Guide Maximum Permitted Load and Permitted Combination Load. In that circular letter and in Road Pavement Manual with Benkelman Beam No. 01/MN/BM/83 which is distributed by Republic Indonesia Public Work Ministry also stated axle load distributions. Those two standards are used in ESAL calculation in this study. In this study Equivalency Single Axle Load (ESAL), Cumulative Equivalent Standard Axle Load (CESA) and Axle Load Efficiency (ALE) was calculated to find out the traffic impact to pavement service life.

2.2.1. Equivalency Single Axle Load (ESAL)

To establish a damage for comparing effect of axles carrying loads, ESAL concept which developed by American Association of State Highway Officials (AASHO) Road Test in the early 1960’s, has been widely used.

ESAL concept is an approach to convert loads of various magnitudes and repetitions (mixed traffic) to "standard" or "equivalent" loads based on the amount of damage caused to pavement. The standard commonly used is 18,000 lb. Equivalent single axle load. (Pavement Interactive).

To determine ESAL, a formula derived by Liddle which is calculated based on an empirical approach has been used in this study, the formula is:

$$ESAL = k\left[\frac{P}{8{,}16}\right]^4 \text{.................................(1)}$$

Where ‘P’ represent load on each group of axle, and k-factor is a correction factor for tandem and triple axles which the value is varied based on the method selected i.e. Asphalt Institute, AASHTO, Bina Marga, etc. Asphalt Institute assign the k-factor value 0.0773 for tandem axle and 0.017 for triple, AASHTO assign 0.133 and 0.044 for tandem and triple, respectively, while Directorate General of Highways, Ministry of Public Work Republic Indonesia define 0.086 for the tandem axle but not listed the value for triple axle, however some researcher proposed, based on their study, 0.053 and 0.031 for triple axle (Hadiwardoyo et al, 2012). For this research, author set 0.086 for tandem axle and 0.031 for triple axle.

ESAL of each group of axle in a vehicle calculated, afterwards total ESAL of the vehicle obtained. This calculation shows the level of damage (vehicle damaging factor) caused by the vehicle, moreover it shows which axle group or axle configuration generates biggest damaging to pavement (Kinasih, 2014).

2.2.2. Cumulative Equivalent Standard Axle Load (CESA)

Designed CESA is defined to determine the thickness of a pavement, it is the accumulation ESAL prediction throughout the pavement's service life. Unfortunately, overloading phenomenon which is surely raising ESAL number makes the designed CESA reached earlier, clearly visible with the appearance of damage to the pavement at the time where it should not have occurred, called as early failure or early damaging. Earlier designed CESA reached also can be happened as if the traffic growth exceed the designed prediction. Total CESA suffered by the pavement along its service life determined by formula (2)

$$Total\ CESA = \frac{n}{20}\left\{\left(\sum_{j=1}^{n} AADT_J \times C_J \times E_J\right) + \left(\sum_{j=1}^{n} AADT_J \times (1+i)^n \times C_J \times E_J\right)\right\}..(2)$$

Where: n = the designed pavement service life, AADT = annual average daily traffic at the opening and at the end of pavement service life, C = lane distribution factor, E = ESAL, i = rate of traffic growth.

Terms CESA in this study is the ESAL accumulation of the traffic in a lane of the road, so the formula is:

$CESA = AADT \times C_J \times E_J$…………… (3)

3. Results and Discussion

Figure 1 is a map of Java island, the red line is Pantura road (Route 1), while the orange line is North coast toll highway which is called as Trans Java Toll road. The initial route of the Trans Java Toll road is Cipali route which was operated in June 2015, ranging from Cikopo to Palimanan. So, when this study began in 2010, there was no toll road, so the Pantura road (Route 1) was the only effective choice to reach west to east Java island and vice versa. This research was conducted in seven interconnected Pantura line segments in West Java area, from Tangerang to Losari as long 274,8 kilometers, the traffic was examined in two directions separately. The seven segments are:

1. Tangerang – Serang
2. Bekasi – Karawang
3. Karawang - Cikampek
4. BTS. Subang - Karawang
5. Pamanukan - Sewo
6. Jatibarang - Lohbener
7. Cirebon – Losari

Figure 1. *Java Northcoast Road*
Source*: (Jalan Nasional Rute 1, 2020)*

3.1. Traffic in Pantura Road

In the table 1 and 2 are the type of vehicles that cross the Pantura road, the AADT is a traffic survey conducted in 2010 (Kinasih, 2013).

Table 1 *AADT 2010 And 2019 Of Heavy Vehicles*

Heavy Vehicle	**AADT 2010***		**AADT 2019**(forecast without Toll)**		**AADT 2019**(with Toll)**	
	Losari Lane	Tangerang Lane	Losari Lane	Tangerang Lane	Losari Lane	Tangerang Lane
Small Bus 12 ton (5A)	11.515	11.145	23.020	22.280	13.812	13.368
Bus (5B)	10.585	10.244	21.159	20.478	12.695	12.287
3-axle-truck (6)	7.738	7.486	15.469	14.965	9.281	8.979
4-axle-truck (7)	989	956	1.978	1.912	1.187	1.147
4-axle-truck (8)	3.073	2.976	6.145	5.951	3.687	3.571
3-axle-truck (9)	1.282	1.241	2.564	2.482	1.538	1.489
4-axle-truck (10)	1.146	1.108	2.592	2.216	1.555	1.330
5-axle-truck (11A)	629	608	1.258	1.206	755	724
5-axle-truck (11B)	342	331	684	662	410	397
6-axle-truck (11C)	782	756	1.564	1.512	938	907
1 Lane Total	38.081	36.851	76.433	73.664	45.858	44.199
2 Lanes Total	74.932		150.097		90.057	

Source: *(Kinasih, 2013), **calculation

Table 2 *AADT 2010 and 2019 of Light Vehicles*

Light Vehicle	**AADT 2010***		**AADT 2019** (forecast without Toll)**		**AADT 2019** (with Toll)**	
	Losari Lane	Tangerang Lane	Losari Lane	Tangerang Lane	Losari Lane	Tangerang Lane
Passenger Cars 2 ton (2A)	4.796	4.640	9.590	9.278	2.877	2.783
Small truck 2 ton (2B)	20.670	19.998	41.317	39.973	12.395	11.992
Passenger Cars 1 ton (2C)	9.213	8.913	18.417	17.817	5.525	5.345
Small bus 5 tons (3)	3.201	3.097	6.402	6.194	1.921	1.858
Bus 9 tons (4A)	2.233	2.163	4.465	4.326	1.339	1.298
Bus 16 tons (4B)	6.984	6.761	12.061	13.515	3.618	4.055
1 Lane Total	47.097	45.572	92.252	91.103	27.675	27.331
2 Lane Total	92.669		183.354		55.006	

Source: *(Kinasih, 2013), **calculation

AADT 2019 (forecast without toll) obtained from forecasting with vehicle growth in the Pantura road is 8%, forecast method is selected because in 2015 a few parts of the Trans Java toll road was already operating, which is the Cipali route. AADT 2019 (with Toll) data is obtained from a traffic survey conducted in 2019. While the other years which are 2011 – 2018, and 2020 – 2030 were obtained from forecast with 2010 and 2019 as the basic years.

In 2010 traffic survey, Pantura road was dominated by light vehicles as much 55% while heavy vehicles was only 45%, but in 2019 traffic survey the percentage of light vehicles is only 38%, and commercial (heavy) vehicles is 62%.

Even for ESAL calculation AADT is needed, but to compare traffic between toll presence and without toll presence, it is easier if the AADT changed into passenger car unit (PCU). To change AADT into PCU, the AADT must be multiplied by passenger car equivalent (PCE). In this study the PCE is reffered to Indonesia Manual Highway Capacity (1997).

Figure 2 shows that Trans Java toll road reduces Pantura road traffic as much 180.818 PCU, this reduction made Pantura road quieter, affecting local business along the road as stated by the owners. Need further study to ensure the level of services in those seven segments, but in rough sighting it is about in B level.

Table 3 *PCU 2019*

Vehicle Type	PCE	PCU 2019 without Toll		PCU 2019 with Toll	
		Losari Lane	Tangerang Lane	Losari Lane	Tangerang Lane
Small Bus 12 ton (5A)	1,3	29.924	28.963	8.977	8.689
Bus (5B)	1,5	31.739	30.717	9.522	9.215
3-axle-truck (6)	2,5	38.671	37.411	11.601	11.223
4-axle-truck (7)	2,5	4.943	4.778	1.483	1.433
4-axle-truck (8)	2,5	15.357	14.873	4.607	4.462
3-axle-truck (9)	2,5	6.407	6.202	1.922	1.861
4-axle-truck (10)	2,5	5.727	5.537	1.718	1.661
5-axle-truck (11A)	2,5	3.143	3.038	943	912
5-axle-truck (11B)	2,5	1.709	1.654	513	496
6-axle-truck (11C)	2,5	3.908	3.778	1.172	1.133
Passenger Cars 2 ton (2A)	1	9.587	9.275	2.876	2.783
Small truck 2 ton (2B)	1,3	53.715	51.969	16.115	15.591
Passenger Cars 1 ton (2C)	1	18.417	17.817	5.525	5.345
Small bus 5 tons (3)	1,3	8.318	8.048	2.496	2.414
Bus 9 tons (4A)	1,3	5.803	5.621	1.741	1.686
Bus 16 tons (4B)	1,5	20.942	20.273	6.282	6.082
Total		258.311	249.954	77.493	74.986

Source: calculation

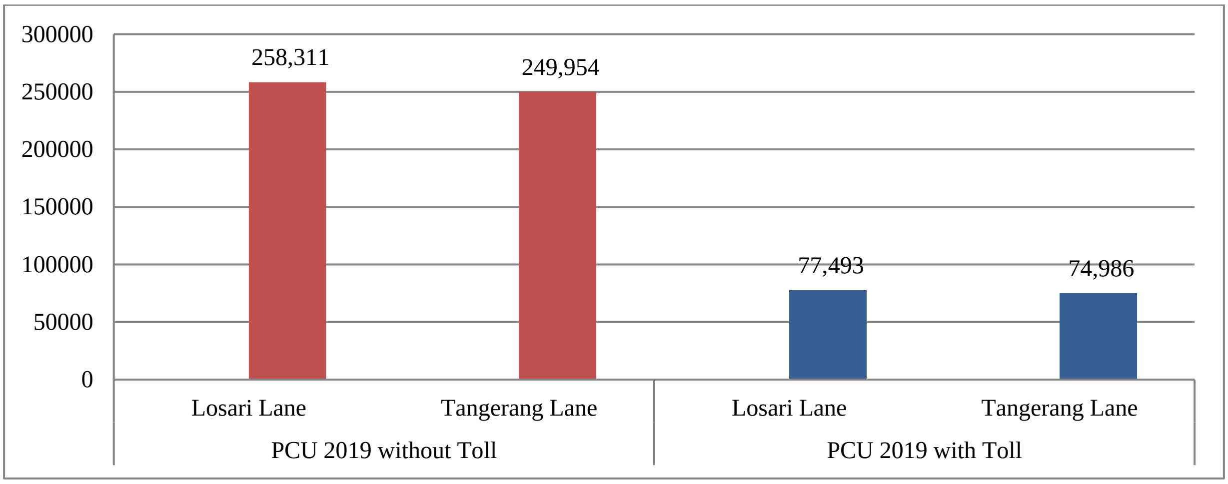

Figure 2. *PCU 2019*
Source: *calculation*

3.2. ESAL Calculation

Each load from the vehicle is distributed to the pavement through the axle. Each type of vehicle has a different number of axles, and different configurations as well. Table 4 shows that the more axles in a vehicle, the smaller the total ESAL contributes from the vehicle to pavement.

Table 4 *ESAL of Heavy Vehicle*

Heavy Vehicle / Axle Configuration	Permitted load (ton)	ESAL Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6	∑ ESAL	ALE (M/Σ ESAL)
Small Bus 12 ton / 1.1	12	0,29231	0,29231					0,58462	20,52612
Bus / 1.2	16	0,29231	2,25548					2,54779	6,27995
3-axle-truck/ 1.22	24	0,29231	2,03623					2,32855	10,30686
4-axle-truck/ 1.1.22	30	0,29231	0,29231	2,03623				2,62086	11,44664
4-axle-trailer /1.2 + 2.2	31,4	0,23017	1,34769	1,16523	1,16523			3,90833	8,03413
3-axle-trailer /1.2-2	26,2	0,11157	3,00317	3,00317				6,11791	4,28251
4-axle-trailer /1.2-22	34	0,29231	2,25548	2,03623				4,58403	7,41706
5-axle-trailer /1.2-222	37	0,27703	2,24647	1,38327				3,90677	9,47073
5-axle-trailer /1.22-22	42	0,29231	2,03623		2,03623			4,36478	9,62248
6-axle-trailer /1.22-222	45	0,29231	2,03623		1,35981			3,68836	12,20056

Source: calculation

Noticed how a 4-axle-truck / 1.2-22 with a permitted load of 34 tons creates total ESAL 4.58403 while a 5-axle-trailer / 1.2-222 with a permitted load of 37 tons creates total ESAL 3.90677. 5-axle-trailer / 1.22-22 with permitted load of 42 tons generates total ESAL of 4.36478, however 6-axle-trailer / 1.22-222 with permitted load of 45 tons actually only generates total ESAL of 3,68836. There, shows that the amount of load that can be transported is not linear with the total ESAL number.

To make the selection of vehicles to be used it is necessary to pay attention to the value of axle load efficiency (ALE), because it is not enough only by look at the total ESAL generated by each vehicle. ALE is the efficiency value between total load and ESAL number generates by the vehicle (Hadiwardoyo, Jachrizal, & Berawi, 2012). For 4-axle-vehicles in the AADT there are 4-axle-trucks / 1.1.22; 4-axle-trailer / 1.2 + 2.2 and 4-axle-trailer / 1.2-22 the biggest efficiency among them is generated by 4 axle-vehicles there are 4-axle-truck / 1.1.22 with ALE number 11,44664.

Table 5 *ESAL of Light Vehicle*

Light Vehicle /Axle Configuration	Permitted load (ton)	ESAL		∑ ESAL	Axle Load Efficiency
		Axle 1	Axle 2		(M/Σ ESAL)
Passenger Cars 2 ton / 1.1	2	0,000226	0,000226	0,000451	4433,642127
Small truck 2 ton / 1.1	2	0,000226	0,000451	0,000677	2955,761418
Passenger Cars 1 ton / 1.1	1	0,000014	0,000028	0,000042	23646,091346
Small bus 5 tons / 1.1	5	0,008810	0,017621	0,026431	189,168731
Bus 9 tons / 1.1	9	0,011987	0,367292	0,379278	23,729277
Bus 16 tons / 1.2	16	0,378407	2,294093	2,672500	5,986904

Source: calculation

3.3. CESA Calculation

There are four states to compare, which are

If there is Trans Java toll road

A. Ideal state; without overloading and there is the Trans Java toll that was opened in 2015

B. There is the Trans Java toll road starting from 2015 but overloading exists as usual

If there is no Trans Java toll road

C. All vehicles do not carry excessive loads

D. 70% of heavy vehicles carry overload 50% of its permitted load

The difference in CESA from the four states above is shown in the table 6.

Table 6 *CESA year to year*

Year	A		B		C		D	
	Losari Lane	Tangerang Lane	Losari Lane	Tangerang Lane	Losari Lane	Tangerang Lane	Losari Lane	Tangerang Lane
2010	103.163	99.835	348.442	337.184	103.163	99.835	348.442	337.184
2011	111.416	107.822	376.317	364.159	111.416	107.822	376.317	364.159
2012	120.330	116.448	406.422	393.291	120.330	116.448	406.422	393.291
2013	129.956	67.046	438.936	424.755	129.956	67.046	438.936	424.755
2014	140.352	135.825	474.051	458.735	140.352	135.825	474.051	458.735
2015	45.474	44.007	153.593	148.630	151.581	146.691	494.581	478.595
2016	49.112	47.528	165.880	160.521	163.707	158.426	493.086	477.149
2017	53.041	51.330	179.150	173.362	176.804	171.100	532.533	515.321
2018	57.284	55.436	193.482	187.231	190.948	184.788	575.136	556.546
2019	61.867	59.871	208.961	202.210	206.224	199.571	672.872	651.123
2020	66.817	64.661	225.678	218.386	222.722	215.537	670.839	649.155
2021	72.162	69.834	243.732	235.857	240.539	232.780	724.506	701.088
2022	77.935	75.421	263.231	254.726	259.783	251.402	782.466	757.175
2023	84.170	81.454	284.289	275.104	280.565	271.514	845.064	817.749
2024	90.903	87.971	307.032	297.112	303.010	293.235	912.669	883.169
2025	98.175	95.008	331.595	320.881	327.251	316.694	985.682	953.822
2026	106.029	102.609	358.122	346.552	353.431	342.030	1.064.537	1.030.128
2027	114.512	110.818	386.772	374.276	381.706	369.392	1.149.700	1.112.538
2028	123.673	119.683	417.714	404.218	412.242	398.944	1.241.676	1.201.541
2029	133.567	129.258	451.131	436.556	445.222	430.859	1.341.010	1.297.665
2030	144.252	139.598	487.222	471.480	480.840	465.328	1.448.290	1.401.478
Total	1.984.190	1.861.463	6.701.752	6.485.226	5.201.793	4.975.266	15.978.814	15.462.365

Source: calculation

In table 6 state A is an ideal condition, which is, there is a Trans Java toll starting in 2015 and all vehicles do not carry overload. None of the other 3 states that have CESA at the end of the pavement age are nearly the same as A state. Actually, Pantura is well known as a route which it's pavement never in a good condition, it is because of heavy vehicles carrying overloading cargo, so the closest to recent reality is the state B where there is a toll road since 2015 but on the Pantura (non-toll) heavy vehicles are carrying overloading. The total CESA in state b is 3.37 times that of state A.

The observation in the field found the fact that 70% of heavy vehicles carrying overload 30% - 80% of the Indonesian permitted axle load limit (JBI/JBKI) (Kinasih, Putri, & Nabila, 2020). Whereas the calculation results in this study shown in the table above found that when 70% of heavy vehicles carried an average overload of 50%, then the CESA 2019, for example, became 208,961 ESALs for the Losari direction and 202,210 ESALs for the Tangerang direction, increasing 3.38 times the ideal conditions of the CESA 2019 which should only be 61,867 and 59,871 respectively. This means that the actual Pantura highway (route 1), compared to ideal state A, suffering more CESA as much 147,094 ESALs and 142,338 ESALs respectively for the Losari and Tangerang directions in 2019.

State C, where all vehicles do not carry overloading but is assumed that there is no Trans Java Toll Road is the condition chosen to be the assumption and initial year in this study, with total CESA in the Losari direction lane is 5,201,793 ESALs and in Tangerang direction lane amounted is 4,975,266 ESALs. The closest state to this CESA number is state B with difference of 1,499,959 ESALs between B and C.

Table 6 shows the accumulation of CESA from year to year until the end of the pavement service life, it has been determined if the designed CESA is 5,201,793 for the Losari direction, then in state B this figure is reached in the 18th year, it means that there is a waste about 3 years. Meanwhile in state D the designed CESA achieved in the 11th year, meaning that it means a waste of around 10 years.

Figure 3 shows CESA numbers from year to year of each states, state B after 5th year and state C having almost same CESA numbers. State C is difficult to gain, where we don't provide toll road but must be assured that heavy vehicles carry load as its permitted load, state B easier to be realized where the toll road provided and in route 1 overloading exist up to 50% of permitted load.

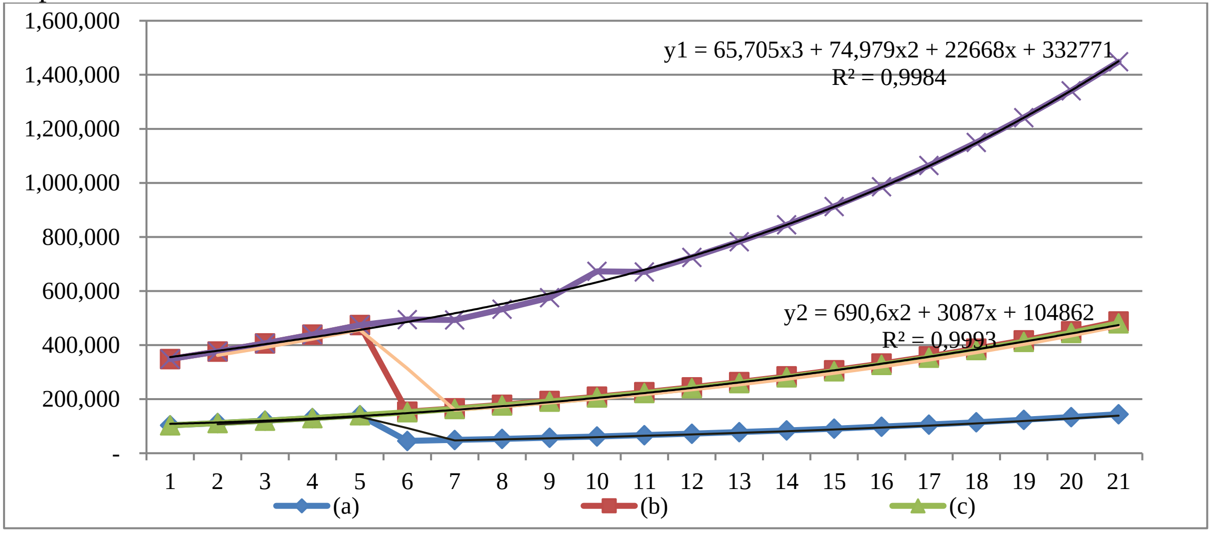

Figure 3 *CESA from year to year*
Source: *calculation*

4.Conclusion and Sugestion

4.1 Conclusion

1. From the result and discussion, the Trans Java toll road reduce Pantura national road (route 1) traffic as much 180.818 PCU
2. The Trans Java toll presence road help Pantura national road (route 1) back to it's designed CESA, if 70% heavy vehicles carry maximum 50% of it's permitted load, as recently happened in that route.
3. In the terms of CESA numbers, state B if there is the Trans Java toll road starting from 2015 but overloading exists as usual and state C where if there is no the Trans Java toll road starting from 2015 and all vehicles do not carry excessive loads, are resulting the same numbers. But in the term AADT or number of traffic that passes Pantura road, the AADT is falling, it is affecting business along the Pantura road.

4.2. Sugestion

1. ALE must be considered in vehicle selection, to minimize its impact to pavement service life, especially to carry excessive loads.
2. Need a regulation to prevent overloading increased, or the existence of the Trans Java toll road will not help Pantura pavement.
3. Trans Java toll road should try to be more attractive to heavy vehicles, so they will choose to use toll road rather than Pantura road.

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References

1. (n.d.). Retrieved 7 3, 2019, from Pavement Interactive: https://www.pavementinteractive.org/reference-desk/design/design-parameters/equivalent-single-axle-load/
2. *Road Pavement Manual with the Benkelman Beam Tool.* (1983). Jakarta: Directorat General Bina Marga, Public Work Ministry Republic of Indonesia.
3. Circular Letter of Directorate General of Land Transportation No. SE.02/AJ.108/DRJD/2008 Concerning the Maximum Permitted Load and Permitted Combination Load. (2008). Indonesia: Directorate General of Land Transportation.
4. Republic of Indonesia Constitution No. 22 Tahun 2009 Concerning to Road Traffic and Transport. (2009).
5. Atiya, A. F., Sari, O. D., Purwanto, D., & Setiadji, B. H. (2014). Analysis of the Effect of Weighbridge Performance on Pavement and Designed Pavement Age (Case Study Salam Weigh Bridge, Magelang). *Jurnal Karya Teknik Sipil*, 662-673.
6. Hadiwardoyo, S. P., Jachrizal, R. S., & Berawi, M. (2012). Tolerance limit for trucks with excess load in transport regulation in Indonesia. *Makara Journal of Technology*.
7. Hatmoko, J. U. (2017). Evaluation of the Effects of Floods, Overload, and Construction Quality to Road Conditions. *Jurnal Transportasi*, 89-98.
8. *Jalan Nasional Rute 1*. (2020, June 10). Retrieved June 18, 2020, from Wikipedia: https://id.wikipedia.org/wiki/Jalan_Nasional_Rute_1

9. Jayswal, H., Karli, S., & Vaidhya, V. (2017). Truck Overloading Study on Ahmedabad Ring Road and Strategy to Minimize its Impact. *International Journal of Advance Research in Engineering, Science & Technology (IJAREST)*.
10. Karim, M. R., Abdullah, A. S., Yamanaka, H., Abdullah, A. S., & Ramli, R. (2013). Degree of Vehicle Overloading and its Implication on Road Safety in Developing Countries. *IISTE*.
11. Kinasih, R. K. (2013). *Thesis: Impact of Truck Axle Number Due to Overloading to Pavement Service Life*. Depok: Universitas Indonesia.
12. Kinasih, R. K. (2014). Impact Simulation Axle Truck with Excess of Achievements Age Content Services. *SCIRJ*.
13. Kinasih, R. K., Putri, M. D., & Nabila. (Vol.2 No.2 May 2020). Modified Zero Overloading Policy Impact to Pavement's Service Life. *EMACS*, 1-6.
14. Ojha, K. N. (2018). Overloading and Pavement Service Life —A Case Study on Narayanghat-Mugling Road, Nepal. *Journal of Transportation Technologies*, 343-356.
15. Palmaputri. (2016). *Analysis of Overloading Vehicle to Pavement and It's Service Life (Case Study Weigh Bridge Kulwaru).* Yogyakarta: Universitas Atmajaya Yogyakarta.
16. PK., S. H., & Prathap, R. C. (2018). Study on Impact of Vehicle Overloading on National Highways in Varying Terrains. *International Journal of Engineering Research and Technology (IJERT)* .
17. Raheel, M., Khan, R., Khan, A., Khan, M. T., Ali, I., Alam, B., et al. (2018). Impact of Axle Overload, Asphalt Pavement Thickness and Subgrade Modulus on Load Equivalency Factor Using Modified ESALs Equation. *Cogent Engineering*.
18. Rakhmani, F. (2015). Government Responsibilities Due to Road Damage to Motor Vehicle Accidents Based on Article 28 of Act No.22 of 2009 concerning Road Traffic and Transportation. *Jurnal Nestor*.
19. Simanjuntak, G. I., Pramusetyo, A., Riyanto, B., & Supriyono. (2014). Analysis of Overloading to Pvement Performance and Designed Service Life of Flexible Pavement (Case Study Pringsurat Highway, Ambarawa – Magelang). *Jurnal Karya Teknik Sipil*, 539-551.
20. Titi, H. H., Coley, N. J., & Latifi, V. (2018). Evaluation of Pavement Performance due to Overload Single-Trip Permit Truck Traffic in Wisconsin. *Hindawi Journal Advances in Civil Engineering*, 11.
21. Widyaningsih, N., & Sutanto, B. (2018). Influence of hyacinth plant as filler on mixed ac-wc (asphalt concrete - wearing course) with marshall test. *IOP Conference Series: Materials Science and Engineering*.