ANALYSIS OF THE INFLUENCE OF OVERLOADING VEHICLES ON DECREASING THE LIFE OF ROAD PLANS ON RIGID PAVEMENT ON PANTURA ROAD KM 11 TO KM 21, BATANG DISTRICT

by Farida Yudaningrum

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Abstract. The north coast road is the main route that connects several provinces, cities, and regencies on the north coast of Java. The road is traversed by many heavy vehicles loaded with goods, so there is the potential for frequent violations caused by excessive loads. Given these problems, this study aims to determine the effect of excessive load on heavy vehicles on decreasing road life.

The data used are primary and secondary data, primary data in the form of photos of observations at the Subah Weighbridge and interviews with the head of the Subah Weighbridge, secondary data in the form of actual vehicle weight data from the Subah Weighbridge, LHR, and road age from the National Road Planning Center. Central Java – DI Yogyakarta, then calculate the percentage value of VDF due to overload and decrease in the design life of the road using the vehicle damage factor value using the Bina Marga method (1987).

The results of this study indicate that excessive load on heavy vehicles can affect the decrease in road design life. With the actual overload that occurred on Jalan Pantura KM 11 to KM 21, Batang Regency, the cumulative VDF increase based on the Bina Marga method (1987) was 2.63%. The decrease in design life due to actual overload based on the Bina Marga method (1987) was 0.04 years.

Keywords: Overload, Design Life, Bina Marga (1987)

1. Introduction

The development of development in Indonesia is currently very advanced, one of the important factors in this regard is the means of road transportation. Highways can expedite economic activities in a place because they can help people go or send goods more quickly to their destination. With the existence of roads, commodities can flow to the local market and economic results from the local area can be sold smoothly to other regions.

Rigid pavement is one type of pavement used in Indonesia, rigid pavement (Rigid Pavement) consists of Portland cement concrete plates that are located directly above the subgrade, or above the granular layer (Subbase) which is above the subgrade. FHWA (2006) defines a rigid pavement as a pavement consisting of Portland cement concrete slabs built on a foundation layer (Base) whose position is above the subgrade [1]. The northern coastal route, which is located in Batang district, Central Java, precisely at KM 11 to KM 12, is part of the National Route 1 Road, so this road is one of the connecting roads between provinces that carry commercial goods.

Heavy traffic causes the traffic load to increase, thus affecting road conditions, especially on the pavement structure. Traffic load is one of the parameters in the calculation of road pavement planning, namely as the number of standard axle load paths that occur during the life of the road plan. Overloading is a type of violation that usually occurs in heavy goods transport vehicles [2]. This violation can actually be minimized by a weighbridge that operates 24 hours non-stop to take action against violators of excess loading that do not comply with the permit. The overloading load has the potential to affect the traffic load that occurs, so that it can affect the condition of the planned road pavement [3]. Therefore it is necessary to do research on the effect of vehicle overload on the design life of rigid pavements on the Pantura road KM 11 to 21 located in Batang Regency.

2. THEORY

Road Pavement

Portland cement concrete pavement, more commonly known as rigid pavement, consists of components of Portland cement concrete slabs and a foundation layer (or the absence of it) on the subgrade. Concrete pavement that is rigid and has a high modulus of elasticity, will be able to distribute the load over a fairly large area of land, so that the largest part of the capacity of the pavement structure is obtained from the concrete slab itself [4]. This is different from a flexible pavement in which the strength of the pavement is obtained from thick layers of subbase, foundation and surface layers. Because the most important thing is to know the load-bearing capacity of the structure, so the most important factor to consider in designing a portland cement concrete road is the strength of the concrete itself, the various strengths of the subgrade and/or foundation have only a relatively small effect on the structural capacity of the pavement (slab thickness). concrete), but for the design of the road body (subgrade) a separate geotechnical study is needed if a soil classification is found that is not good as subgrade soil.

Overloading

Effect of overloading is the cause of damage to road structure pavement, as evidenced by the existence of a channel width area greater than 60% of the total structural damage per km, due to the presence of vehicles with a maximum axle load (Max Axle Load) greater than the standard allowable axle load for each class of road. Overloading will increase road damage and shorten the service life of the road, so it is necessary to control overloading in the form of controlling the Axis Load.

Reduction of Design Life

Traffic volume and load capacity have a very direct effect on reducing the road's design life, especially for vehicles that have loads exceeding the permitted payload capacity of 8.16 tons.

Rigid Pavement

Rigid pavement as a pavement consisting of Portland cement concrete slabs built on a foundation layer (Base) which is above the subgrade. So, there are differences in the type of layer (Base or Subbase) that is under the concrete slab. The similarity is that under the concrete slab there is only one layer of material, namely one of the subbase or base layers.

3. Methods

Based on AASTHO 1993 herewith the method for the analysis [4]:

i. Count the number of overloaded vehicles for each group.
ii. Calculating the value of percentage of excess charge for each group by using this equation.

$$\text{Overload Percentage} = \frac{Weighing\ Result - JBI}{JBI} \times 100\%$$

iii. Calculate the distribution of each axel load for each group.
iv. Calculating the vehicle damage factor and the percentage due to overloading for each class of heavy freight vehicle using Bina Marga method (1987). At this stage the steps taken include the following
v. Calculating the increase in the VDF of each class of vehicles using the following equation.

VDF increase = Total ESAL overload – Total ESAL normal

vi. Calculate the remaining design life due to overloading.

4. Result and Discussion

Calculation of Daily Traffic Volume and Traffic Growth Factor

Table 1 Traffic Volume

	Vehicle Class	LHR 2020 (Vehicle/Day)	LHR 2021 (Vehicle /Day)	Number of Vehicles/year (2020)	Number of Vehicles/year (2021)
(1)	Class 1	22065	88194	8053725	32190810
(2)	Class 2	1324	9259	483260	3379535
(3)	Class 3	21	655	7665	239075
(4)	Class 4	1270	5028	463550	1835220
(5)	Class 5a	14	253	5110	92345
(6)	Class 5b	14	36	5110	13140
(7)	Class 6	94	89	34310	32485
(8)	Class 6b	505	870	184325	317550
(9)	Class 7a	8	267	2920	97455
(10)	Class 7b	0	0	0	0
(11)	Class 7c	0	0	0	0
(12)	Class 8	9	529	3285	193085
	Total	25324	105180	9243260	38390700

$$\text{Traffic Growth Factor} = \frac{LHR2021 - LHR\,2020}{LHR2020} \text{ x } 100\ \%$$

$$= \frac{105180 - 25324}{25530} \text{ x } 100\ \%$$

$$= 315{,}33\%$$

Calculation of Vehicle Overload Percentage for Each Vehicle Class

Table 2 Number of Overload Vehicle

No.	Vehicle	Number of Overload Vehicle/Day (2022) (Vehicle)	Number of Overload Vehicle/Day (2022) (Vehicle)
(1)	Gol 3	9	3285
(2)	Gol 4	87	31755
(3)	Gol 6	4	1460
(4)	Gol 7a	9	3285
(5)	Gol 7b	1	365

Table 3 Average Percentage of Actual Overloading of Each Group

No	Vehicle Class	Percentage (%)
(1)	Class 3	19,53
(2)	Class 4	15,07
(3)	Class 6	35,63
(4)	Class 7a	15,6
(5)	Class 7b	6,67

From the table above it is known that the largest average actual percentage of overload occurs in class 6 vehicles with 35.63%.

Axel Load Distribution Each Vehicle Class with Standart Condition
Table 4 Axel Load Distribution

No	Axel Load Distribution MST 10 ton			Weight (ton)	Axel Load Configuration (ton)					
						Rear				
	Vehicle Tipe	Class	Axel Configuration		Front SR,RT	1	2	3	4	5
(1)	sedan,jeep, st.wagon	2	1.1	2,00	1,00	1,00				
(2)	pick up, combi	3	1.2	9,92	3,37	6,55				
(3)	Truck 2 as (L),micro truck, mobil hantaran	4	1.2L	9,55	3,24	6,31				
(4)	bus kecil	5a	1.2	8,3	2,82	5,48				
(5)	bus besar	5b	1.2	9,00	3,06	5,94				
(6)	Truck 2 as (H)	6	1.2H	20,55	6,98	13,6				
(7)	Truck 3 as	7a	1.2.2	28,91	7,23	10,8	10,84			
(8)	Truck 4 as , truck gandengan	7b	1.2+2.2	33,49	6,03	9,38	9,05	9,1		
(9)	Truck S. Trailer	7c	1.2.2+2.2	40,13	5,88	10,00	10,00	7,00	7,25	

Axel Load Distribution Each Vehicle Class with Actual Overload

Table 5 Actual Overload Axel Load Distribution

No	Vehicle Class			Weight (ton)	Axel Load Configuration (ton)					
					Front	Rear				
					SR,RT	1	2	3	4	5
(1)	sedan,jeep, st.wagon	2	1.1	2,00	1,00	1,00				
(2)	pick up, combi	3	1.2	9,92	3,37	6,55				
(3)	Truck 2 as (L),micro truck, mobil hantaran	4	1.2L	9,55	3,24	6,31				
(4)	bus kecil	5a	1.2	8,3	2,82	5,48				
(5)	bus besar	5b	1.2	9,00	3,06	5,94				
(6)	Truck 2 as (H)	6	1.2H	20,55	6,98	13,6				
(7)	Truck 3 as	7a	1.2.2	28,91	7,23	10,8	10,84			
(8)	Truck 4 as , truck gandengan	7b	1.2+2.2	33,49	6,03	9,38	9,05	9,05		
(9)	Truck S. Trailer	7c	1.2.2+2.2	40,13	5,88	10,00	10,00	7,00	7,25	

Vehicle Damage Factor Each Vehicle Class with Normal Condition

Table 6 Vehicle Damage Factor Value from Each Vehicle Class Based on Bina Marga (1987)

No	Vehicle Class			Weight (ton)	Axel Load Configuration (ton)						VDF
					Front	Rear					
					SR,RT	1	2	3	4	5	
(1)	sedan,jeep, st.wagon	2	1.1	2,00	1,00	1,00					0,0005
(2)	pick up, combi	3	1.2	8,30	2,82	5,48					0,2177
(3)	Truck 2 as (L),micro truck, mobil hantaran	4	1.2L	8,30	3,24	6,31					0,2177
(4)	bus kecil	5a	1.2	8,30	2,82	5,48					0,2177
(5)	bus besar	5b	1.2	9,00	3,06	5,94					0,3006
(6)	Truck 2 as (H)	6	1.2H	15,15	5,15	10,00					2,4141
(7)	Truck 3 as	7a	1.2.2	25,00	6,25	9,38	9,38				2,7416
(8)	Truck 4 as , truck gandengan	7b	1.2+2.2	31,4	5,65	8,79	8,48	8,48			1,7769
(9)	Truck S. Trailer	7c	1.2.2+2.2	40,13	5,88	10,00	10,00	7,00	7,3		4,17

Table 7 Vehicle Damage Factor Each Vehicle Class with Overload Condition Based on Bina Marga (1987)

NO	Vehicle Class			Weight (ton)	Axel Load Configuration (ton)						VDF
					Front	Rear					
					SR,RT	1	2	3	4	5	
(1)	sedan,jeep, st.wagon	2	1.1	2,00	1,00	1,00					0,0005
(2)	pick up, combi	3	1.2	9,92	3,37	6,55					0,4442
(3)	Truck 2 as (L),micro truck, mobil hantaran	4	1.2L	9,55	3,24	6,31					0,3824
(4)	bus kecil	5a	1.2	8,3	2,82	5,48					0,2177
(5)	bus besar	5b	1.2	9,00	3,06	5,94					0,3006
(6)	Truck 2 as (H)	6	1.2H	20,6	6,98	13,56					8,1610
(7)	Truck 3 as	7a	1.2.2	28,9	7,23	10,84	10,84				4,9015
(8)	Truck 4 as , truck gandingan	7b	1.2+2.2	33,5	6,03	9,38	9,05	9,050			2,3045
(9)	Truck S. Trailer	7c	1.2.2+2.2	40,1	5,88	10,00	10,00	7,00	7,3		4,1730

Comulative Vehicle Damage Factor

Table 8 Comulative VDF with Normal Condition

No	Vehicle	Number of Vehicle (Year)	VDF Normal	VDF Cumulative Normal
(1)	Class 2	3379535	0,0005	1689,8
(2)	Class 3	239075	0,2177	52047
(3)	Class 4	1835220	0,2177	399527
(4)	Class 5a	92345	0,2177	20104
(5)	Class 5b	13140	0,3006	3949,9
(6)	Class 6	32485	2,4141	78422
(7)	Class 7a	97455	2,7416	267183
(8)	Class 7b	75920	1,7769	0
(9)	Class 7c	75920	4,17	0
		Total		822922,7

Table 9 Overload Cumulative Vehicle Factor Based on Bina Marga (1987)

No	Vehicle	VDF Overload	VDF Cumulative Overload
(1)	Class 2	0,0005	1689,9
(2)	Class 3	0,4442	52790,68
(3)	Class 4	0,3824	404757,44
(4)	Class 5a	0,2177	20104
(5)	Class 5b	0,3006	3949,9
(6)	Class 6	8,1610	86812,513
(7)	Class 7a	4,9015	274277,9
(8)	Class 7b	2,3045	192,574
(9)	Class 7c	4,1730	0
	TOTAL		844574,9

Percentage of Actual Increase in Cumulative VDF due to Overload Based on Bina Marga (1987)

From the previous calculations, the following results were obtained.

Cumulative VDF under normal conditions = 822922,7

Cumulative VDF of actual overload condition = 844574,9

VDF increase = cumulative VDF of actual overload condition – cumulative VDF under normal condition

= 844574,9 – 822922,7

=21652,21

Percentage of cumulative VDF increase $= \frac{VDF\ increase}{Normal\ Cumulative\ VDF\ Total}\ x\ 100\ \%$

$= \frac{21652,21}{822922,7}\ x\ 100\ \%$

= 2,63%

Calculation of Design Life

The design life used is 20 years, before calculating the percentage of plan age in years 1 to 20, the cumulative ESAL is calculated first at the end of the plan age.

$W_{18} = N1.5 = \sum_{Ni}^{Nn} LHR_j \times VDF_j \times D_D \times D_L \times 365$

$= VDF$ komulatif x D_D x D_L x $\left[\frac{(1+g)^{20}}{g} - 1\right]$

$= 822922{,}7$x $0{,}5$ x $0{,}8$ x $\left[\frac{(1+3{,}1533)^{20}}{3{,}1533} - 1\right]$

= 243511673011147000 *ESAL*

1. Percentage of Design Life Year 1

Np $= 822922{,}7 \times 0{,}5 \times 0{,}8 \times \left[\frac{(1+3{,}1533)^1}{3{,}1533} - 1\right]$

$= 329169{,}08$

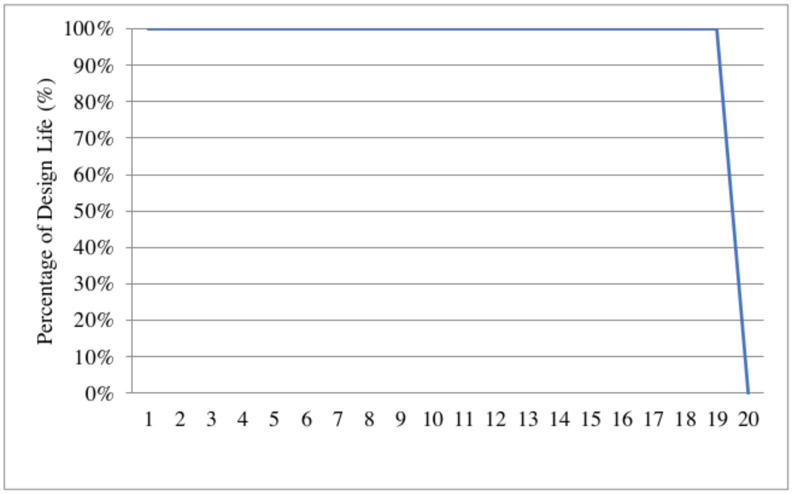
R/ $= 100 \left[1 - \left[\frac{Np}{N1.5}\right]\right]$

$= 100 \left[1 - \left[\frac{329169{,}08}{243511673011147000}\right]\right]$

$= 100\ \%$

Table 10 Percentage of Design Life with Normal Condition Based on Bina Marga (1987)

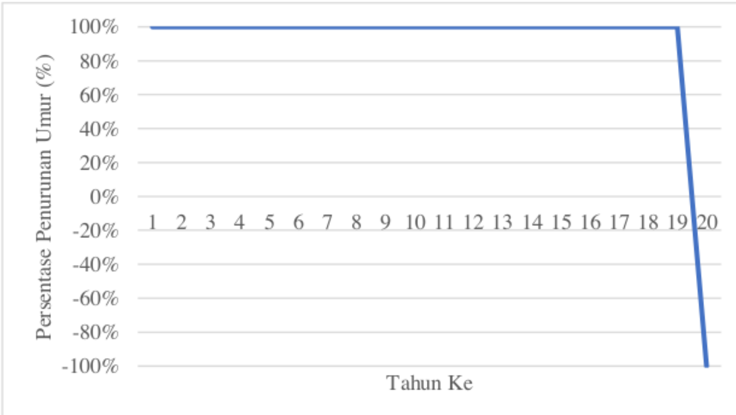
No	Year	Np (*ESAL*)	N1.5 (*ESAL*)	R*l* (%)
(1)	1	329169,08	243511673011147000	100
(2)	2	1696307,02	243511673011147000	100
(3)	3	7374441,026	243511673011147000	100
(4)	4	30957434,99	243511673011147000	99,99999999
(5)	5	128904683,8	243511673011147000	99,99999995
(6)	6	535708992,5	243511673011147000	99,99999978
(7)	7	2225289327	243511673011147000	99,99999909
(8)	8	9242623333	243511673011147000	99,9999962
(9)	9	38387716658	243511673011147000	99,99998424
(10)	10	159436032763	243511673011147000	99,99993453
(11)	11	662186004045	243511673011147000	99,99972807
(12)	12	11422644636821	243511673011147000	99,99887058
(13)	13	11422644636821	243511673011147000	99,9953092
(14)	14	47441670299280	243511673011147000	99,9805177
(15)	15	197039489583167	243511673011147000	99,91908417
(16)	16	818364112414935	243511673011147000	99,66393229
(17)	17	3398911668422120	243511673011147000	98,60420996
(18)	18	14116699832786700	243511673011147000	94,20286524
(19)	19	58630889415842400	243511673011147000	75,92276021
(20)	20	243511673011147000	243511673011147000	0



Images 1 Graph of Declining Design Life in Normal Conditions Based on Bina Marga (1987)

Table 11 Percentage of Design Life with Overload Condition

No	Year	Np (*ESAL*)	N1.5 (*ESAL*)	R*l* (%)
(1)	1	337829,96	243511673011147000	100
(2)	2	1740939,133	243511673011147000	100
(3)	3	7568472,461	243511673011147000	100
(4)	4	31771966,63	243511673011147000	99,99999999
(5)	5	132296339	243511673011147000	99,99999995
(6)	6	549804214,6	243511673011147000	99,99999977
(7)	7	2283839674	243511673011147000	99,99999906
(8)	8	9242623333	243511673011147000	99,9999962
(9)	9	39397748971	243511673011147000	99,99998382
(10)	10	163631008632	243511673011147000	99,9999328
(11)	11	679609005982	243511673011147000	99,99972091
(12)	12	2822620422377	243511673011147000	99,99884087
(13)	13	11723189738087	243511673011147000	99,99518578
(14)	14	48689924277027	243511673011147000	99,9800051
(15)	15	202223862837608	243511673011147000	99,91695517
(16)	16	839896369861267	243511673011147000	99,65508989
(17)	17	3488341593282630	243511673011147000	98,56748486
(18)	18	14488129139718600	243511673011147000	94,05033485
(19)	19	60173546756331000	243511673011147000	75,28925574
(20)	20	249918791743407000	243511673011147000	-2,631134127



Images 2 Graphic of Age Reduction Due to Actual Overloading Based on Bina Marga (1987)

From the graphic, it can also be obtained the value of the planned life when the percentage of the planned life is 0% and it is known from the graph that the percentage occurs between the 19th and 20th years, so the calculation is as follows.

$$\frac{75{,}2892\,\% + 2{,}6311\,\%}{20-19} = \frac{75{,}2892\,\%}{X}$$

$$X = \frac{75{,}2892\,\%}{75{,}2892\,\% + 2{,}6311\,\%} \times (20 - 19)$$

$$X = 0{,}96$$

Design Life Value = 19 + X

= 19 + 0,96

= 19,96 Tahun

Design Life Decrease = 20 – 19,96

= 0,04 Tahun

= 0,02 %

5. Conclusion and Suggestion

Conclusion:

1. The percentage of actual overload on the Pantura road KM 11 to KM 21, Batang Regency is obtained for group 3 of 19.53%, group 4 of 15.07%, group 6 of 35.63%, group 7a of 15.6% , group 7b of 6.67%.
2. Actual overload in the field can result in an increase in the cumulative VDF value, based on the Highways method (1987) an increase in cumulative VDF of 2.63 % is obtained. This value is relatively small and does not really affect the decrease in the design life of the road, but the increase in the cumulative VDF value proves that the overload load has an effect on the increase in the cumulative VDF.
3. The decrease in the design life due to actual overloading in the field, based on the Bina Marga method (1987) obtained a decrease in the design life of 0.04 years or a decrease of 0.02%. This value is relatively small, but this decrease proves that overload loads can affect a decrease in the road's design life.

Suggestion

1. Supervision at the Subah weighbridge is more stringent so that there are no violations of overloading and also for all vehicles to weigh their loads
2. Officers from related agencies must be more active in educating vehicle drivers to increase self-awareness so that they are more obedient to regulations.
3. Even though the reduction in the design life of the road due to overload on the north coast road KM 11 to KM 21 is very small, road evaluation must still be carried out.
4. Adding a weighbridge at the toll gate to weigh loads and also to sort out overloaded trucks before entering the toll road

REFERENCES

[1] FHWA. 2006. Geotechnical Aspect of Pavement. Washington DC.

[2] Afrizal, E. 2014 Analisa Pengaruh Muatan Berlebih Terhadap Umur Rencana Perkerasan Jalan. Artikel. Universitas Bung Hatta. Padang.

[3] Mulyono, A.T. 2011. Kepatuhan Penerapan Standar Mutu Untuk Mewujudkan Minded Berat yang diizinkan) dan JBKI (Jumlah Berat Kombinasi yang diizinkan) Untuk Mobil Barang, Kendaraan Khusus, Kereta Penarik berikut Kereta Tempelan/Gandengan. Direktorat Jenderal Perhubungan Darat. Jakarta. Penyelenggara Jalan Daerah. Pidato Pengukuhan Jabatan Guru Besar pada Fakultas Teknik Universitas Gadjah Mada. Yogyakarta

[4] Suryawan, A. 2009. Perkerasan Jalan Beton Semen Portland (Rigid Pavement). Beta Offset. Yogyakarta.

[5] AASHTO. 1993. Guide for Design of Pavement Structures. Washington DC.

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GRADEMARK REPORT

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