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Analysis of Effect Overloading on the Remaining Life Pavement Plan on the Bungah Highway - Ngawen Highway Section

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ABSTRACT

Bungah -Ngawen highway section is one of the accesses to the industrial area in Gresik City. This affects the vehicles that cross this road, which are dominated by heavy vehicles that distribute goods and services. These conditions can cause faster damage to the pavement which can hinder smooth transportation. This research aims to analyze the impact of vehicle loads on the remaining life of the plan on the Jalan Raya Bungah-Jalan Raya Ngawen section (STA 0+000-STA 5+500). The reason for this research is the amount of damage to the pavement. Based on a direct survey, this road has a road width of 6 m with a length of road damage of 2,15 km from the road section under review. The data used are primary data in the form of average daily traffic and secondary data, namely LHR data and vehicle load data. The calculation method used is the AASHTO 1993 Method. From the primary and secondary data obtained, traffic growth, percentage of overload, ESAL value, W_{18} value, and the remaining value of the road plan life can be calculated. From the calculation results, the standard $\sum W_{18}$ value during the plan life is 338422516.86 to 4796885453.64, while for the overload $\sum W_{18}$ value is 531674277.94 to 6849455940.63. The main trigger for pavement damage on the Jalan Raya Bungah-Jalan Raya Ngawen section is class VIb vehicles because they have the largest overload of 27,90%. The remaining life value of standard load conditions in 2024 of 57,46% decreased under overloading conditions to 33,29%, with a difference of -24,17% and the road service life will end in March 2026 or a reduction from the planned life of 10 years.

Keywords: *Vehicle Load; Daily Traffic (LHR); Remaining Life of Road Plan*.

INTRODUCTION

Roads are a means of land transportation that connects one region to another. A good road considers comfort and safety factors, one of which is the quality of road pavement [1]. Road pavement construction consists of a pavement layer between the subgrade and vehicle tires that serves to provide a means of transportation that is expected not to experience significant damage during the service period. However, each road section must be able to accommodate the capacity of most vehicles [2]. Roads generally become less robust as they age. Early deterioration often occurs on newly constructed or closed highways [3].

Overloading, also known as overloading, is when the axle load of a vehicle exceeds the standard load used in the pavement design assumptions or the number of operational passes before the plan life [4]. Meanwhile, the pavement plan life is the number of traffic load repetitions in Equivalent Standard Axle Load (ESAL) units that the road can serve before the pavement layer experiences structural damage [5].

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In general, road damage can be caused by several factors, such as improper planning, the use of inappropriate materials, stagnant water entering the pavement construction, and inappropriate pavement layer thickness, which causes the road life to be shorter than planned [6]. The condition of the planned pavement life will change because vehicles carrying overloading affect the traffic load [7].

Bungah -Ngawen highway is a national road that connects Gresik City with several other cities both within the province and outside the province. The road that crosses the Java coast certainly connects several logistics ports such as the international Teluk Lamong Terminal. This has an influence on vehicles that cross this road more dominated by heavy vehicles that distribute goods and services that can affect the increasing needs and economic growth of a city. These conditions can cause an increase in traffic volume growth, which can result in congestion and traffic density of private vehicles, public transportation, freight transportation and also heavy vehicles that exceed capacity [8].

Based on a direct survey, this road has a road width of 6 m with a length of road damage of 2,15 km from the road section under review. Road damage is characterized by the presence of fine cracks, alligator cracks, holes, grooves, wavy, grain release, and surface layer peeling. This causes losses for road users, which will take longer travel time, and it is also feared that traffic accidents will occur due to this damage [9].

Based on these problems, this research needs to be done to determine the level of influence of excess vehicle loads on reducing the planned life of the pavement. The calculation method used in this research is the AASHTO 1993 Method [10].

Traffic Growth

Traffic growth is the increase in traffic from year to year during the life of the pavement plan [11]. The calculation of traffic growth (i) uses the AASHTO 1993 method with the following formula:

$$i = \left(\frac{LHR_n}{LHR_0}\right)^{\frac{1}{n}} - 1 \quad (1)$$

$$LHR_n = LHR_0\,(1+ i)^n \quad (2)$$

Description:

LHR_n = Average daily traffic of year n
LHR_0 = Average daily traffic at the beginning of the plan year
i = Growth factors (%)
n = Year

Overload Percentage

Overload is a condition where the axle load (axles) of the vehicle exceeds the maximum allowable load limit [12]. The calculation used to calculate the percentage value of the overload on the vehicle, is as follows:

$$\text{Overload percentage} = \frac{(\text{Average load}) - (\text{JBI Average})}{\text{Standard load}}\, x\ 100\% \quad (3)$$

Axle Load Equivalent Number

The vehicle axle load equivalent number is a number that expresses the ratio of the level of damage caused by a single/double axis load path of the vehicle to the level of damage caused

by a single axis standard load path weighing 8,16 tons [13].
The equivalent number of each axle load class for each vehicle axis is determined by the formula, as follows:

1. Single wheelbase equivalent number
   ESTRT $= \left(\frac{axis\ load(t)}{5{,}40}\right)^4$ (4)
2. Double wheelbase equivalent number
   ESTRG $= \left(\frac{axis\ load\ (t)}{8{,}16}\right)^4$ (5)
3. Double wheel two-axis equivalent number
   EsdRG $= \left(\frac{axis\ load\ (t)}{13{,}76}\right)^4$ (6)
4. Equivalent number of dual three-wheel axes
   ESTrRG $= \left(\frac{axis\ load\ (t)}{18{,}45}\right)^4$ (7)

Equivalent Single Axle Load (ESAL)

The W_{18} value is obtained by calculating the ESAL value first. The Equivalent Single Axle Load (ESAL) calculation is shown in the following equation:

ESAL = Average daily traffic per class × VDF (8)

After the Equivalent Single Axle Load (ESAL) calculation results are obtained, the next step is to find the W_{18} value. The calculation of the W_{18} value is shown in the following equation:

$W_{18} = \sum ESAL \times D_D \times D_L \times i \times 365$ (9)

Description:
VDF = Vehicle Damage Factor
W_{18} = Cumulative equivalent standard axle load over the plan life
D_D = Direction distribution
D_L = Lane distribution
i = Traffic growth

Truck Factor

To determine if a pavement is experiencing an overload condition, the truck factor value can be calculated. The truck factor is the total Equivalent Single Axle Load (ESAL) value used to determine road damage due to overload. If the truck factor value obtained is greater than 1 (TF>1), it means that overload damage has occurred [14].
The equation used to calculate the truck factor value according to AASHTO (1993) as in the equation below:

$$TF = \frac{\sum ESAL}{\sum Average\ Daily\ Traffic} \quad (10)$$

Remaining Life

To determine the remaining life of the pavement can be calculated by determining the amount of traffic that has crossed the road during the year period with the total traffic at the end of the pavement plan life [15]. To determine the remaining life of the pavement, the Remaining Life (RL) formula according to AASHTO (1993) can be used as in the following equation:

$$RL = 100\left(1 - \frac{Np}{N_{1,5}}\right) \quad (11)$$

Description:
RL = Percentage of remaining plan life/Remaining Life
Np = Cumulative ESAL at the end of the year

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$N_{1,5}$ = Cumulative ESAL at the end of the plan life

METHOD

Data Collection

The initial stage in this research is the collection of primary and secondary data information. Primary data was used in the form of vehicle traffic volume data at the research location obtained by direct survey in the field for a total of 54 hours in 6 days. The survey was conducted at strategic locations where vehicles often pass through the point. The survey was conducted to classify vehicles based on axis and load conditions. Meanwhile, secondary data used in this study was obtained through the search for previous data information in related institutions or agencies. Secondary data collection was obtained from the East Java-Bali National Road Implementation Center for average daily traffic (LHR) data for 2019-2022, plan age, and the last year of road overlay and the East Java Class II Land Transportation Management Center for vehicle load data.

Data Analysis

The data analysis stage for the remaining life of the road plan uses the 1993 AASHTO method. The initial stage in the analysis of this research data is to analyze the average daily traffic data that has been obtained to obtain the percentage of vehicle traffic growth which will then be used to obtain the average daily traffic value over the life of the plan. The next stage is to find the growth and percentage of vehicle overloads from vehicle load data. The average daily traffic value and the percentage of vehicle overloads will be used to calculate the standard and overload ESAL values, the standard and overload $\sum W_{18}$ values over the life of the plan, calculate the truck factor value, and analyze the remaining life of the pavement plan due to vehicle loads.

Conclusion

The conclusions drawn based on the results of this study are expected to provide an evaluation of the condition of the pavement that has decreased the planned life so that further road condition rehabilitation measures can be taken.

RESULTS AND DISCUSSION

Secondary Average Daily Traffic

According to the results of the average daily traffic (LHR) survey conducted by the East Java-Bali National Road Implementation Center from 2019 to 2022, it is shown in Table 1 below.

Journal of Civil Engineering and Vocational Education

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Table 1. Average Daily Traffic in 2019-2022

Vehicle Class	**Average Daily Traffic /day**			
	2019	**2020**	**2021**	**2022**
2	7189	4054	15196	14536
3	471	398	826	1560
4	1803	1599	3847	4700
5a	45	36	62	125
5b	52	27	69	210
6a	1009	939	492	275
6b	4233	3715	4040	5324
7a	4250	4215	4348	4653
7b	92	307	29	42
7c	1484	1517	1289	2035
Total	**20628**	**16807**	**30198**	**33460**

Based on table 1, the classification of vehicles used is taken from class 2 to 7c, the data will be used to calculate the value of the traffic growth factor.

Primary Average Daily Traffic

The survey was conducted for a total of 54 hours over 6 days, resulting in an average daily traffic /12 hours which was then multiplied by a factor of the next 12 hours to determine the average daily traffic /day. The multiplication value of the next 12-hour factor is obtained from the comparison between the calculated average daily traffic /hour. Then the product of the next 12-hour factor will be summed with the previously obtained 12-hour average daily traffic. The sum of the two data will be multiplied by the number of days in a year, namely 365 days, and obtained data in the form of annual average daily traffic. The results of the average daily traffic calculation are presented in the form of table 2 below.

Table 2. Average Daily Traffic in 2024

Vehicle Class	**Axis Configuration**	**Condition**	**2024 /Day**	**2024 /Year**
2	1.1	Standard	7663	2797024
3	1.1	Standard	592	215942
4	1.1	Standard	1065	388726
5a	1.1	Standard	247	90322
5b	1.2	Standard	396	144365
6a	1.1	Loaded	136	49734
		Empty	140	51246
6b	1.2L	Loaded	774	282607
		Empty	492	179738
	1.2H	Loaded	69	25018
		Empty	99	35978
7a	1.22	Loaded	649	236728
		Empty	500	182459
	1.2-2	Loaded	127	46408
		Empty	74	27135
7b	1.2+22	Loaded	31	11489
		Empty	19	7105
7c	1.2-22	Loaded	123	45048
		Empty	37	13605
	1.2-222	Loaded	60	22070
		Empty	36	13152

	1.22-222	Loaded	52	19123
		Empty	57	20861
Total			**13441**	**4905881**

Based on table 2, the average daily traffic data of each vehicle class is obtained with a total of 4905881 vehicles in 2024 which will be used as a reference for calculating vehicle traffic growth over the life of the plan.

Traffic Growth

Based on the data obtained in table 1, there is a difference in the increase and decrease in the number of vehicles. So that it can be estimated the value of traffic growth for the next year. Traffic growth calculations are calculated using equation 1 using traffic data for each vehicle class from 2019 to 2022. The results of the calculation of traffic growth factors from 2019 to 2022 are shown in table 3 below.

Table 3. Traffic Growth Percentage

Vehicle Class	Axis Configuration	Traffic growth (i)			
		2019-2020	2020-2021	2021-2022	Average
2	1.1	-43.61%	274.84%	-4.34%	75.63%
3	1.1	-15.50%	107.54%	88.86%	60.30%
4	1.1	-11.31%	140.59%	22.17%	50.48%
5a	1.1	-20.00%	72.22%	101.61%	51.28%
5b	1.2	-48.08%	155.56%	204.35%	103.94%
6a	1.1	-6.94%	-47.60%	-44.11%	-32.88%
6b	1.2	-12.24%	8.75%	31.78%	9.43%
7a	1.22	-0.82%	3.16%	7.01%	3.12%
7b	1.2+22	233.70%	-90.55%	44.83%	62.66%
7c	1.22-222	2.22%	-15.03%	57.87%	15.02%
Total		**7.74%**	**60.95%**	**51.00%**	**39.90%**

Based on table 3, all classes of vehicles have increased, but there is 1 class with negative value results, the negative value is considered with a value of 0 or no traffic growth. From table 3, it can be predicted to calculate the forward average daily traffic during the life of the plan using the reference average daily traffic data in 2024 in table 2 and calculated using equation 2. The calculation is carried out for each class of vehicles and then the results of the total value of vehicles in each year during the life of the plan are obtained. The results of the growth prediction calculation over the life of the plan are shown in Table 4 below.

Table 4. Predicted Daily Traffic Growth Over the Plan Life

Config.	Cond.	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
1.1	Standard	2693613	2713985	2734511	2755192	2776029	2797024	4912396	8627610	15152617	26612446
1.1	Standard	209548	210811	212083	213361	214648	215942	346156	554889	889488	1425852
1.1	Standard	379061	380975	382898	384831	386774	388726	584964	880266	1324644	1993353
1.1	Standard	88042	88493	88947	89403	89862	90322	136638	206704	312699	473045
1.2	Standard	137090	138515	139955	141410	142880	144365	294420	600447	1224565	2497404
1.1	Loaded	50560	50394	50228	50063	49898	49734	49734	49734	49734	49734
	Empty	52097	51925	51755	51584	51415	51246	51246	51246	51246	51246
1.2L	Loaded	281278	281543	281809	282075	282341	282607	309260	338427	370344	405271
	Empty	178893	179061	179230	179399	179568	179738	196689	215239	235538	257752
1.2H	Loaded	24901	24924	24948	24971	24995	25018	27378	29960	32785	35877
	Empty	35809	35842	35876	35910	35944	35978	39371	43084	47147	51594
1.22	Loaded	236359	236433	236507	236580	236654	236728	244103	251708	259550	267637
	Empty	182175	182232	182288	182345	182402	182459	188143	194005	200049	206282
1.2-2	Loaded	46336	46351	46365	46379	46394	46408	47854	49345	50882	52468
	Empty	27092	27101	27109	27118	27126	27135	27980	28852	29750	30677
1.2+22	Loaded	11135	11205	11275	11346	11417	11489	18687	30396	49441	80419
	Empty	6886	6930	6973	7017	7061	7105	11557	18797	30575	49733

1.2-22	Loaded	44711	44778	44845	44913	44980	45048	51815	59599	68553	78851
	Empty	13503	13524	13544	13564	13585	13605	15649	18000	20704	23814
1.2-222	Loaded	21905	21938	21971	22004	22037	22070	25386	29200	33586	38632
	Empty	13053	13073	13092	13112	13132	13152	15127	17400	20014	23020
1.22-222	Loaded	18980	19008	19037	19065	19094	19123	21995	25300	29100	33472
	Empty	20705	20736	20767	20799	20830	20861	23995	27600	31746	36515
Total		**4773733**	**4799777**	**4826013**	**4852441**	**4879064**	**4905881**	**7640543**	**12347806**	**20514759**	**34775095**

Based on table 4, the average daily traffic data of each vehicle class from 2019 to 2028 will be used for further calculations.

Percentage of Overload

Overload vehicle load data used in this study are vehicles included in groups 6a, 6b, 7a, 7b, and 7c. From the vehicle load data obtained then processed to find the percentage of vehicle overload. Calculation of the percentage of overload using equation 3 by using load data from the weighbridge. The results of the calculation of the percentage of overload that has been obtained are shown in the following summary table 5.

Table 5. Vehicle Overload Percentage

Year	Class 6a	Class 6b	Class 7a	Class 7b	Class 7c
2019	21.24%	19.56%	16.76%	11.93%	11.93%
2020	14.83%	22.44%	2.08%	10.21%	10.21%
2021	19.17%	25.61%	14.19%	14.04%	14.04%
2022	32.44%	44.00%	23.08%	16.29%	16.29%
Average	**21.92%**	**27.90%**	**14.03%**	**13.12%**	**13.12%**

Based on Table 5, the average percentage of excess charge from groups 6a, 6b, 7a, 7b, and 7c will be used for the calculation of W_{18}.

Average Daily Traffic of Overloaded Vehicles

Based on the vehicle load data obtained from the weighbridge, it can also be used to obtain the average daily traffic value of overloaded vehicles shown in table 6 below.

Table 6. Average Daily Traffic of Overloaded Vehicles

Vehicle Class	Average Daily Traffic of Overloaded Vehicles			
	2019	2020	2021	2022
VIa	31	25	33	54
VIb	47	24	56	65
VIIa	30	28	51	56
VIIb	14	14	28	30
VIIc	14	14	28	30

From the data obtained in Table 6, it can be obtained the percentage value of overload vehicle traffic growth in some of these years. The calculation of the percentage of overload vehicle traffic growth is the same as calculating normal traffic growth using equation 1. The results of the calculation of the percentage of overload vehicle growth are shown in table 7 below.

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Table 7. Percentage Growth of Overloaded Vehicles

Vehicle Class	Overload Traffic Growth (i)			
	2019-2020	**2020-2021**	**2020-2022**	**Average**
VIa	-18.93%	28.95%	66.14%	25.39%
VIb	-48.22%	130.09%	15.60%	32.49%
VIIa	-4.63%	79.97%	10.93%	28.76%
VIIb	-0.68%	97.03%	6.22%	34.19%
VIIc	-0.68%	97.03%	6.22%	34.19%
Total				**38.75%**

Based on the results of the percentage of overload vehicle growth in table 7 will be used to separate the standard average daily traffic and overload average daily traffic in groups 6a, 6b, 7a, 7b, and 7c found in table 4. The average daily traffic of overloaded vehicles can be used for the calculation of W_{18} overload.

An example of the calculation of average daily traffic in table 4 if divided into standard and overload average daily traffic based on the percentage that has been obtained from table 7 is shown as follows.

Standard traffic_{2019} class 6a = Class 6a total loaded traffic_{2019} - (Class 6a total loaded traffic_{2019} x traffic growth of overloaded vehicles)
= 50560 - (50560 x 25,39%)
= 37724

Overload traffic_{2019} class 6a = Class 6a total loaded traffic_{2019} - Standard traffic_{2019} class 6a
= 50560 - 37724
= 12836

The same calculation is used for vehicle classes 6b, 7a, 7b, and 7c for the following years. The results of the recapitulation of standard average daily traffic and overload average daily traffic which have been divided based on the percentage of overload average daily traffic that has been obtained,

Calculation of W_{18}

The calculation of remaining life of the road plan can be calculated by calculating the W_{18} value as an initial stage. This research will get the W_{18} value in 2 conditions, namely standard and overload conditions, so that the comparison of the two conditions can be known. The cumulative W_{18} value is obtained from the vehicle damage factor (VDF) value, average daily traffic, D_L value (lane distribution), and D_D value (direction distribution). Jalan Raya Bungah-Jalan Raya Ngawen is a national road with 1 lane in each direction, so it uses a D_L value of 1 and a D_D value of 0,8 by the provisions of AASHTO 1993.

Standard W_{18} Calculation

The standard W_{18} calculation will use average daily vehicle traffic data under standard conditions and normal VDF values taken from AASHTO 1993. The W_{18} calculation starts in 2019, when the last road is overlaid. Before calculating W_{18}, the ESAL value of each vehicle class is calculated using equation 8. After obtaining the ESAL value, the W_{18} value is calculated using equation 9 with normal vehicle traffic growth in table 3. A recapitulation of the calculation of standard ESAL and standard W_{18} values in 2019-2028 is shown in table 8 below.

Table 8. Recapitulation of Standard ESAL and W_{18} Values

Year	ESAL	W_{18}	$\sum W_{18}$
2019	2441061.97	284386056.02	284386056.02
2020	2446323.87	284999072.29	569385128.30
2021	2451621.85	285616291.46	855001419.77
2022	2456956.23	286237752.03	1141239171.79
2023	2462327.35	286863492.85	1428102664.65
2024	2467735.55	287493553.19	1715596217.83
2025	3015202.43	351273968.21	2066870186.04
2026	3939322.78	458934874.46	2525805060.50
2027	5587398.23	650937241.05	3176742301.55
2028	8648987.53	1007615324.49	4184357626.03

Overload W_{18} Calculation

The calculation of W_{18} overload will use the average daily traffic data of vehicles entering and violating the weighbridge. The initial stage of calculating W_{18} overload is to find the value of VDF overload using equations 4 to 7 in the violating groups, namely groups 6a, 6b, 7a, 7b, and 7c. An example of calculating VDF overload for vehicle class 6a is as follows.
Previously it was known that class 6a vehicles had an overload percentage of 21.92%, so the division of the axis became as follows.

It is known:

Front-wheel = 5,15 + (5,15 x 21,92%)
= 6,28 tons

Rear wheel 1 = 10 + (10 x 21,92%)
= 12,19 tons

VDF value of class 6a $= \left(\frac{6.28}{5,40}\right)^4 + \left(\frac{12,19}{5,40}\right)^4$
= 27,81

The same calculation is used for groups 6b, 7a, 7b, and 7c. Then the VDF value for each group was obtained. A comparison of the standard VDF value with the overload VDF value is shown in Table 9 below.

Table 9. Comparison of Standard VDF Value with Overload VDF Value

Vehicle Class	Axis Configuration	VDF Standard	VDF Overload
2	1.1	0.0008	0.0008
3	1.1	0.193	0.193
4	1.1	0.193	0.193
5a	1.1	0.193	0.193
5b	1.2	1.9	1.9
6a	1.1	0.1	27.81
6b	1.2	1.3	8.25
7a	1.22	2.4	8.93
7b	1.2+2.2	4.2	7.99
7c	1.2-22	3.6	10.57
	1.2-222	4.8	11.59
	1.22-222	4.8	11.59

The calculation of the W_{18} overload value is the same as the standard W_{18} calculation, the difference lies in the VDF value using the overload VDF value according to table 11. Before calculating the W_{18} overload value, the ESAL value is calculated first using equation 8.
The calculation of ESAL values is carried out for each vehicle class using data, namely the number of standard and overload average daily traffic (LHR) and standard and overload VDF values in table 11 with the growth of overload vehicle traffic in table 7. Recapitulation of Comparison of ESAL, $\sum W_{18}$ standard and ESAL, $\sum W_{18}$ overload values over the life of the plan is shown in table 10 as follows.

Table 10. Comparison of ESAL, $\sum W_{18}$ Standard and ESAL, $\sum W_{18}$ Overload Values

Year	**ESAL Standard**	**ESAL Overload**	**$\sum W_{18}$ Standard**	**$\sum W_{18}$ Overload**
2019	2441061.97	4698484.31	284386056.02	531674277.94
2020	2446323.87	4704249.23	569385128.30	1064000906.44
2021	2451621.85	4710056.80	855001419.77	1596984712.92
2022	2456956.23	4715907.37	1141239171.79	2130630561.81
2023	2462327.35	4721801.26	1428102664.65	2664943354.88
2024	2467735.55	4727738.79	1715596217.83	3199928031.71
2025	3015202.43	5444266.82	2066870186.04	3815994074.18
2026	3939322.78	6565162.61	2525805060.50	4558899203.72
2027	5587398.23	8447262.56	3176742301.55	5514780277.29
2028	8648987.53	11794726.43	4184357626.03	6849455940.63

From table 12 about the comparison of the standard $\sum W_{18}$ and $\sum W_{18}$ overload values in 2019-2028 and can be presented in the form of a graph of the sum of the standard $\sum W_{18}$ and $\sum W_{18}$ overload values in 2019-2028 shown in figure 1 below.

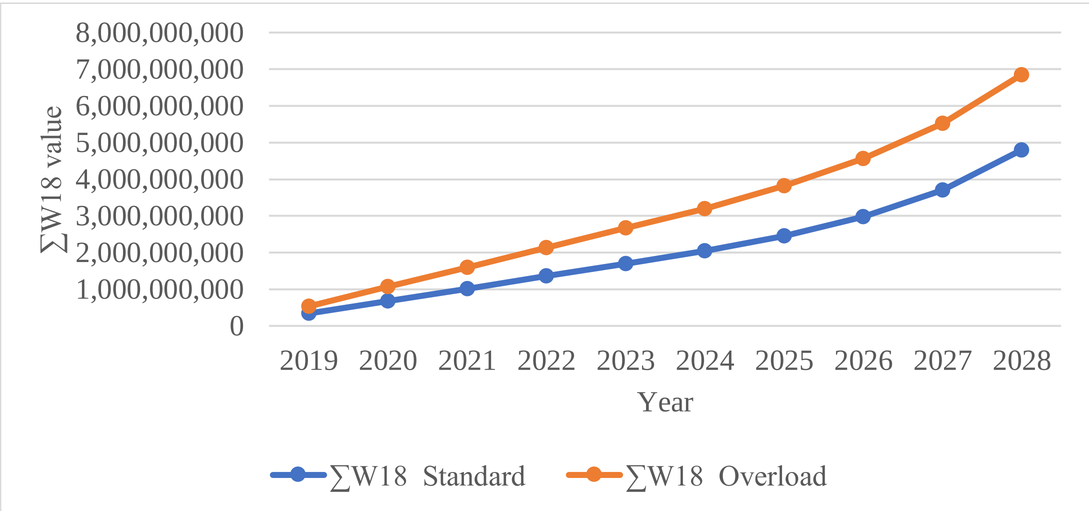

Figure 1. Comparison graph of standard $\sum W_{18}$ and overload $\sum W_{18}$ values

From figure 1 it can be shown that the value of $\sum W_{18}$ has always increased every year and the comparison of the standard $\sum W_{18}$ and $\sum W_{18}$ overload values in 2019-2028 has a significant difference. The $\sum W_{18}$ value will be used for the calculation of Remaining Life (RL).

Truck Factor (TF)

The truck factor (TF) calculation is carried out in 2 conditions, namely normal conditions and overloading conditions so that the value of vehicle overloading can be known. The calculation of standard and overload truck factor (TF) values is based on the ESAL value for 10 years divided by the total LHR value for 10 years. The calculation of standard and overload TF values uses equation 10. The results of the calculation of standard and overload truck factor values are shown in table 11.

Table 11. Comparison of Standard and Overload Truck Factor Values

Year	Daily Traffic Counts	ESAL Standard	ESAL Overload
2019	4773733	2904890.44	4698484.31
2020	4799777	2910614.52	4704249.23
2021	4826013	2916375.73	4710056.80
2022	4852441	2922174.40	4715907.37
2023	4879064	2928010.87	4721801.26
2024	4905881	2933885.48	4727738.79
2025	7640543	3528515.56	5444266.82
2026	12347806	4510397.65	6565162.61
2027	20514759	6231423.18	8447262.56
2028	34775095	9388356.36	11794726.43
Total	**104315112**	**41174644.19**	**60529656.19**
Truck Factor (TF)		**0.39**	**0.58**

From the results of the truck factor calculation in table 13, the overload truck factor (TF) value is higher than the standard truck factor (TF) value, namely 0.58> 0.39, it can be stated that the Bungah Highway-Ngawen Highway section is overloaded with vehicles.

Analysis of Remaining Life of Pavement

Based on data from the East Java-Bali National Road Implementation Center (BBPJN), the age plan used on the pavement on the Jalan Raya Bungah-Jalan Raya Ngawen section is 10 years. Supposedly the road service life will run out by the planned age, but it cannot be denied that passing vehicles sometimes carry loads that exceed the load requirements.

The calculation of the remaining life (RL) value uses equation 11, using the first year's cumulative W_{18} value data divided by the last year's cumulative W_{18} value of the planned life shown in table 12. The remaining life (RL) value is calculated annually over the planned life. The calculation is done with 2 conditions, namely standard and overload. A recapitulation of the standard remaining life (RL) value for 2019-2028 is shown in table 12.

Table 12. Recapitulation of Standard Remaining Life Value 2019-2028

Year	Np	$N_{1,5}$	RL (%)
2019	338422516.86	4796885453.64	92.94%
2020	677511894.41	4796885453.64	85.88%
2021	1017272458.01	4796885453.64	78.79%
2022	1357708572.03	4796885453.64	71.70%
2023	1698824640.23	4796885453.64	64.58%
2024	2040625106.12	4796885453.64	57.46%
2025	2451700546.07	4796885453.64	48.89%
2026	2977166188.49	4796885453.64	37.94%
2027	3703132952.34	4796885453.64	22.80%
2028	4796885453.64	4796885453.64	0.00%

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http://cived.ppj.unp.ac.id/index.php/CIVED

Based on table 14 on the recapitulation of the standard remaining life (RL) value in 2019-2029, it can be seen that the age of the pavement will run out in 2028 with a remaining life (RL) value of 0%. The recapitulation of the remaining life (RL) value of overload in 2019-2028 is shown in 13.

Table 13. Recapitulation of Remaining Life Overload Value 2019-2028

Year	Np	$N_{1,5}$	RL (%)
2019	531674277.94	4796885453.64	88.92%
2020	1064000906.44	4796885453.64	77.82%
2021	1596984712.92	4796885453.64	66.71%
2022	2130630561.81	4796885453.64	55.58%
2023	2664943354.88	4796885453.64	44.44%
2024	3199928031.71	4796885453.64	33.29%
2025	3815994074.18	4796885453.64	20.45%
2026	4558899203.72	4796885453.64	4.96%
2027	5514780277.29	4796885453.64	-14.97%
2028	6849455940.63	4796885453.64	-42.79%

Based on table 15 regarding the recapitulation of the remaining life (RL) overload value in 2019-2028, it can be seen that the remaining life (RL) overload in 2027 to 2028 is negative, indicating that it has exceeded the planned life of the road.

Decrease in Remaining Plan Life

Based on the analysis of the calculation of the remaining life of the pavement plan, it can be compared between normal pavement and pavement affected by overload. Tables 14 and 15 show that in 2024 there is a decrease in the remaining life of the road plan. The remaining life of the road plan under standard conditions is 57.46%, but under overload conditions, the remaining life of the plan decreases to 33.29%. This shows that during the year 2024, there is a decrease in the planned life of 24%. From tables 14 and 15, a comparison of standard and overload remaining life (RL) values can be presented in the form of a graph shown in figure 2 below.

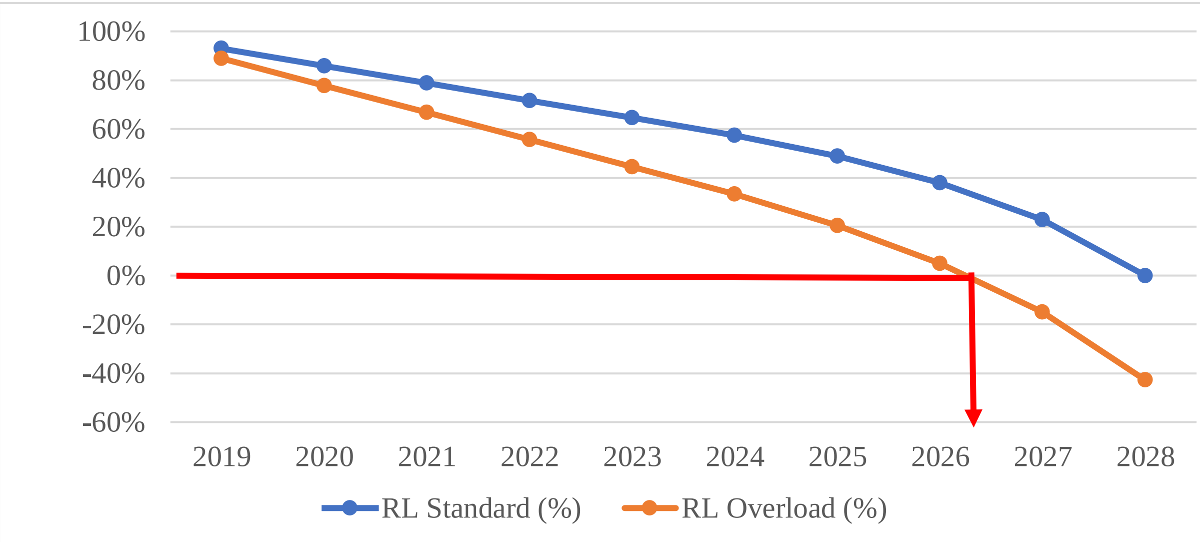

Figure 2. Comparison Chart of Standard Remaining Life Value and Overload Remaining Life Value

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http://cived.ppj.unp.ac.id/index.php/CIVED

From Figure 2, it can be seen that the remaining service life of the Bungah Highway - Ngawen Highway for overload conditions will run out in early 2026. Then the next calculation will be done to find out the month in 2026 which is close to the 0% overload RL value. The calculation is done by interpolating the standard RL and overload RL in 2026. A recapitulation of the interpolation comparison of standard RL values and RL overload values in 2026 is shown in table 14.

Table 14: Comparison of Standard Remaining Life Value and Overload Remaining Life Value in 2026

Year	**RL Standard (%)**	**RL Overload (%)**
January	37.94%	4.96%
February	36.67%	3.30%
March	35.41%	1.64%
April	34.15%	-0.02%
May	32.89%	-1.68%
June	31.63%	-3.34%
July	30.37%	-5.00%
August	29.11%	-6.66%
September	27.85%	-8.32%
October	26.58%	-9.98%
November	25.32%	-11.64%
December	24.06%	-13.31%

Based on Table 16 regarding the comparison of the standard remaining life value and the remaining life overload value, it can be seen that the service life on the Jalan Raya Bungah-Jalan Raya Ngawen section in April shows negative results, which means that the road service life has passed. So, it can be concluded that the planned life of the road runs out in March 2026 or there is a reduction from the planned life of 10 years.

CONCLUSION

Based on the results of the research and data analysis that has been carried out, it can be concluded as follows.

1. The percentage value of traffic growth across the Jalan Raya Bungah-Jalan Raya Ngawen section for normal vehicles is 39.90%, while for overload vehicles it is 38.75%.
2. The percentage value of overload in the Jalan Raya Bungah-Jalan Raya Ngawen section is 21.92% for group 6a, 27.90% for group 6b, 14.03% for group 7a, and 13.12% for groups 7b and 7c.
3. The standard ∑W18 value on the Jalan Raya Bungah-Jalan Raya Ngawen section is 284386056.02 to 4184357626.03, while for the overload ∑W18 value is 531674277.94 to 6849455940.63.
4. The standard truck factor value on the Jalan Raya Bungah-Jalan Raya Ngawen section is 0.39, while the overload truck factor value is 0.58, so it can be stated that the Jalan Raya Bungah-Jalan Raya Ngawen section is overloaded.
5. The percentage value of the reduction in the planned life of Jalan Raya Bungah-Jalan Raya Ngawen under standard conditions is 57.46% in 2024, while the percentage of the planned life under overload conditions is 33.29%. So it can be concluded that there is a reduction in service life of 24.17% in 2024 and it can be ascertained that the planned life of the road will not meet the initial planned life planning for 10 years.

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