JICE Journal Innovation of Civil Engineering
Vol. 4, No. 1, pp. 98-108, March 2023
e-ISSN: 2775-5592

THE EFFECT OF OVERLOAD ON THE DESIGN OF LIFE OF ROAD PAVEMENT (CASE STUDY: KOTI ROAD, JAYAPURA CITY)

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ABSTRACT
The roads hold a vital role in the transportation system in the Province of Papua, especially in the Jayapura area. However, real road conditions often experience a decrease in performance (damage) due to construction failures or deviant utilization. On Koti Road in Jayapura, sometimes vehicles passing it do not match the maximum permissible load. Consequently, excessive loading on the pavement can directly affect the design life of a road section. Therefore, this study aims to analyze the percentages of actual overload on each vehicle class, the increase in the cumulative VDF value, and the decrease in the design life on Koti Road, Jayapura. The research results indicated that the actual overload on Koti Road, Jayapura, obtained 81.06% for group 6a, 43.13% for group 6b, and 40.42% for group 7a. According to the Bina Marga method (1987), the cumulative VDF value increased by 133.8% due to actual excessive load in the field, while based on the NAASRA method (2004), it was 121.2%. In terms of the actual overload effects, the design life decreased by 9,273 years, or 46,365%, from the 20-year design life using the Bina Marga (1987) method, while based on the NAASRA (2004) method, the decrease in design life was 8.7898 years, or 43.949%, from the 20-year life plan.

***Keywords:** Importance Performance Analysis, Facility Feasibility, Field Show Terminal*

1. Introduction

Roads are land transportation infrastructure covering all parts of the road, including buildings and equipment intended for modes of transportation, which are on the ground, below the ground, and above the water, except for railroads, lorry roads, and cable roads. Road highway moments often have damage in a relatively very short time (early damage)[1][2] for both newly constructed roads and newly repaired roads (overlays) [3][4][5][6]. Some research results have done the main cause of road damage are execution quality, drainage, and from a vehicle load that exceeds the provisions (overloading) [7][8][9][10]. The ability of a road pavement structure will experience a decrease in the function of the structure and this decrease will be proportional to the increasing age of the pavement and the increasing traffic load that passes on the road.

At the location under review, the traffic load is quite heavy and allows vehicles to experience overloading [11][12][13] which can result in road damage and reduce the design life of the road. Through this research, it is hoped that the authors will find out the value of the reduced design life [14][15][16] so that they can provide solutions for road damage that occurs. The area under review is Koti Road with a 2/2 UD road type and the function of a Secondary Artery Road which is an important road section in the business and industrial area. This resulted in heavy/large vehicles crossing the road so that the road conditions suffered road damage [17]. Vehicles that pass through Koti Road and are stuck in traffic jams will certainly burden the road.

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2. Methods

Steps in analyzing the Effect of Overload on the Planned Life of Road Paving on Jl. Koti Kota Jayapura is as follows:

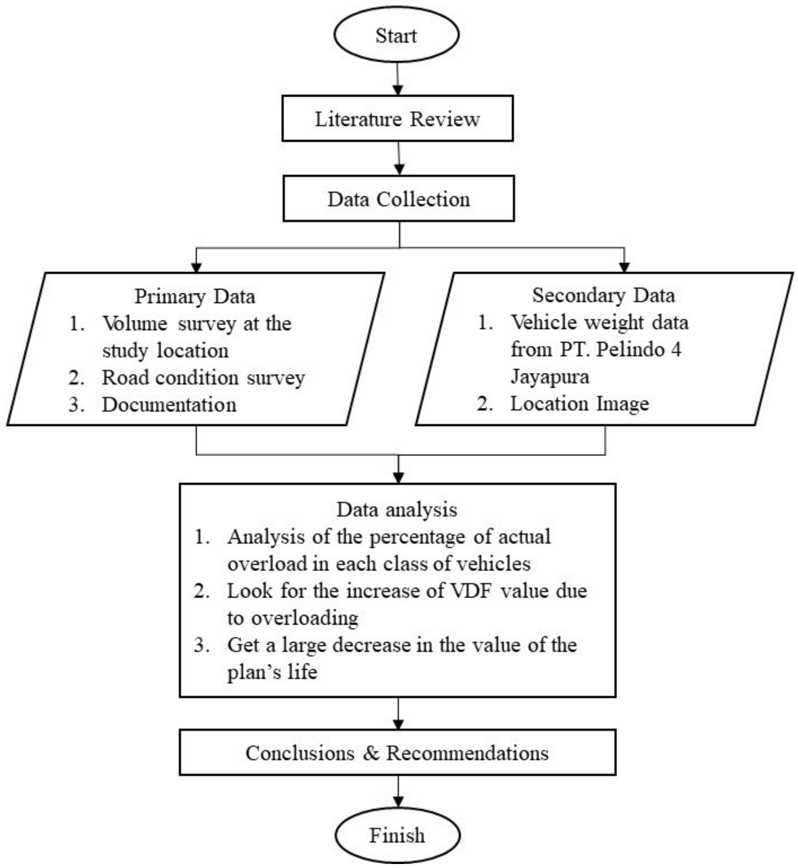

Figure 1. Step of Research

2.1. Research sites

The location of the study area is needed to collect some information about the area and environment where or the location of the research. For this reason, data collection is made directly or indirectly. What is meant by direct data collection is observation and direct measurement carried out in the field. And what is meant indirect data collection is data collection from agencies or officials related to the procurement of data to help fulfill and complete the data. Data collection at the location on Jalan Koti, Jayapura City.

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Figure 2. Research Location Map

2.2. Data collection technique

A study requires several sources of data to be used as material for analysis in completing a study. In this study, there were 2 sources of data, namely primary data and secondary data. For the primary data itself in the form of:

- Road width and length data. The results of observations in the field obtained a road length of 1400 m and a width of 8 m (2/2 UD).
- LHR survey at the study site with an interval of 15 minutes for 24 hours.
- Damaged Road Condition Survey.
- Documentation of the area that is reviewed when large vehicles pass and when there is a traffic jam caused by an anchored ship.

As for secondary data in the form of:

- Vehicle weight data obtained from PT. Pelindo 4 Jayapura.
- Location images obtained via the internet or more details via Google maps.

2.3. Data analysis technique

Data processing for this research is the analytical method using the 1987 Bina Marga method. Data analysis is one of the factors that influence the success of research. Correct data analysis, using a method of calculating the correct data, will produce results that can be accounted for. The stages of data analysis for this study are as follows:

- Calculating the percentage of actual overload on each vehicle using the equation:

$$\text{Persentase } Overload = \frac{\text{Hasil Penimbangan} - \text{JBI}}{\text{JBI}} \text{ x } 100\% \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

- Calculating the increase in the value of VDF due to overloading uses the equation from Highways:

$$\text{Single Axis} = \left(\frac{\text{L}}{8160}\right)^4 \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\text{Double Axis} = 0{,}086 \left(\frac{\text{L}}{8160}\right)^4 \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\text{Triple Axis} = 0{,}031 \left(\frac{\text{L}}{8160}\right)^4 \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Calculating the magnitude of the increase in the VDF value due to overloading using the equation from NAASRA[5]:

$$\text{Single Axis, Single Wheel} = \left(\frac{\text{L}}{5400}\right)^4 \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$\text{Single Axis, Double Wheel} = \left(\frac{\text{L}}{8200}\right)^4 \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

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$$\text{Double Axis, Double Wheel} = (\frac{L}{13600})^4 \quad (7)$$

After the normal VDF and VDF values due to overload are obtained, proceed with finding the cumulative VDF value using the following equation.

$$VDF \text{ Cumulative} = \text{Total } n \text{ per Year} \times VDF \text{ n} \quad (8)$$

- Calculating the value of the decline in the design life using the equation:

$$Rl = 100[1 - \left[\frac{Np}{N1,5}\right]] \quad (9)$$

3. Result and Discussion

3.1 Daily Traffic Volume and Traffic Growth Factor

Daily traffic volume uses data in 2022 obtained from survey results and for daily traffic volume in 2022 as follows.

Table 1. Traffic Volumes

No	Vehicle Class	LHR 2022 (Vehicle/day)	Number of Vehicles Per Year (2022)
1	Type 1	17979	6562335
2	Type 2	5314	1939610
3	Type 3	1509	550785
4	Type 4	334	121910
5	Type 5a	12	4380
6	Type 5b	10	3650
7	Type 6a	429	156585
8	Type 6b	205	74825
9	Type 7a	240	87600
10	Type 7b	0	0
11	Type 7c	0	0
Total		26032	9953010

The traffic growth factor for Jalan Koti, Jayapura is taken from the 2017 Pavement Design Manual, which is equal to 4.75%.

3.2 Data on Number of Overloaded Vehicles

Vehicle weight data were obtained from PT. Pelindo 4, Jayapura City, Papua Province. The number of overloaded vehicles can be seen as follows.

Table 2. Number of Overloaded Vehicles

No.	Vehicle	Number of Overloaded Vehicles per day (2022)	Number of Overloaded Vehicles per year (2022)
1	Type 6a	351	128115
2	Type 6b	91	33215
3	Type 7a	97	35405

3.3 *Vehicle Damage Factor (VDF)*

3.3.1 Bina Marga Method 1987

The cumulative VDF calculation recapitulation under normal conditions based on Bina Marga (1987) can be seen in Table 3 as follows.

Table 3. Analysis VDF Cumulative Normal Conditions Based on Bina Marga (1987)

No.	Vehicle	Number of Vehicles per Year	Normal VDF	Normal Cumulative VDF
1	Type 2	1939610	0.0005	969,805
2	Type 3	550785	0.2177	119905,8945
3	Type 4	121910	0.2177	26539,807
4	Type 5a	4380	0.2177	953,526
5	Type 5b	3650	0.3006	1097,19
6	Type 6a	156585	0.2177	34088,5545
7	Type 6b	74825	24.141	1.806.350.325
8	Type 7a	87600	27.416	240164,16
9	Type 7b	0	39.088	0
10	Type 7c	0	41.479	0
Total				**604353,9695**

The recapitulation of the cumulative VDF calculation results due to actual overloading based on Highways (1987) can be seen in Table 5 as follows.

Table 5*VDF*Cumulative Due to Actual Overload Based on Bina Marga (1987)

No.	Vehicle	Number of Vehicles per Year	VDF overload	VDF Cumulative overload
1	Type 2	1939610	0.0005	969,805
2	Type 3	550785	0.2177	119905,8945
3	Type 4	121910	0.2177	26539,807
4	Type 5a	4380	0.2177	953,526
5	Type 5b	3650	0.3006	1097,19
6	Type 6a	156585	2.3379	305717,9775
7	Type 6b	74825	10.1233	436696,1105
8	Type 7a	87600	10.6772	521124,078
9	Type 7b	0	3.9088	0
10	Type 7c	0	4.1479	0
Total				1413004,389

From the previous calculations Table 4 and Table 5 the following results are obtained.

Cumulative VDF under normal conditions = 604353,9695
VDF cumulative condition due to overload = 1413004,389

Based on the analysis, the increase in VDF is obtained as follows.

VDF upgrade = Total VDF cumulative overload – Total VDF normal cumulative
= 1413004,389 - 604353,9695
= 808650,4195

The percentage of cumulative VDF due to actual overload is as follows.

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$$\text{Cumulative VDF percentage increase} = \frac{\text{Increasing in VDF}}{\text{Total VDF normal cumulative}} \text{x100\%}$$

$$= \frac{808650{,}4195}{604353{,}9695} x100\% = 133{,}8\%$$

Based on the calculation above, the percentage increase is obtained *VDF* cumulative due to actual overloading of 133.8%, meaning that overloading on heavy vehicles can affect the cumulative VDF. This is because the more the load increases, the total weight of the vehicle increases which causes an increase in the VDF value.

3.3.2 NAASRA (2004) Method

Analysis of the cumulative VDF calculation under normal conditions based on NAASRA (2004) can be seen in Table 6 as follows.

Table 6. *VDF* Cumulative Normal Conditions Based on NAASRA (2004)

No.	Vehicle	Number of Vehicles per Year	Normal VDF	Normal Cumulative VDF
1	Type 2	1939610	0.0024	4655,064
2	Type 3	550785	0.2738	150804,933
3	Type 4	121910	0.2738	26539,807
4	Type 5a	4380	0.2738	1199,244
5	Type 5b	3650	0.3785	1381,525
6	Type 6a	156585	0.2738	42872,973
7	Type 6b	74825	3.0391	227400,657
8	Type 7a	87600	5.4073	473679.48
9	Type 7b	0	4.8062	0
10	Type 7c	0	8.8394	0
Total				928533,683

Analysis of the cumulative VDF calculation results due to actual overloading based on NAASRA (2004) can be seen in Table 7 on the following page.

Table 7. *VDF* Cumulative Due to Actual Overload Based on NAASRA (2004)

No.	Vehicle	Number of Vehicles per Year	Normal VDF	Normal Cumulative VDF
1	Type 2	1939610	0.0024	4655,064
2	Type 3	550785	0.2738	150804,933
3	Type 4	121910	0.2738	26539,807
4	Type 5a	4380	0.2738	1199,244
5	Type 5b	3650	0.3785	1381,525
6	Type 6a	156585	2.2163	291736,3605
7	Type 6b	74825	12.7444	549762.197
8	Type 7a	87600	21.0592	1027835
9	Type 7b	0	4.8062	0
10	Type 7c	0	8.8394	0
Total				2053914,131

From the previous calculations, the following results were obtained.
Cumulative VDF under normal conditions = 928533,683

VDF cumulative condition due to overload = 2053914,131
The analysis obtained an increase in VDF as follows
VDF upgrade = Total VDF cumulative overload – Total VDF normal cumulative
= 2053914,131 – 928533,683 = 1125380,448

So the percentage of cumulative VDF due to actual overload is as follows.

$$\text{Cumulative VDF percentage increase} = \frac{\text{Increasing in VDF}}{\text{Total VDF normal cumulative}} \text{x}100\%$$

$$= \frac{1125380{,}448}{928533{,}683} \text{x}100\% = 121{,}2\%$$

Based on the calculation above, the percentage increase is obtained VDF cumulative due to actual overloading of 121.2%, meaning that overloading on heavy vehicles can affect the cumulative VDF. This is because the more the load increases, the total weight of the vehicle increases which causes an increase in the VDF value.

4. Decreasing Plan Age

4.1 Bina Marga 1987 Method

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

Table 8. Percentage of Planned Age in Normal Condition Based on Bina Marga (1987)

YEAR UR	N1.5 (ESAL)	NP (ESAL)	RL (%)
1	9479721,941	302176,9848	96,812
2	9479721,941	617951,9338	93,481
3	9479721,941	947936,7556	90
4	9479721,941	1292770,894	86,363
5	9479721,941	1653122,569	82,561
6	9479721,941	2029690.07	78,589
7	9479721,941	2423203,108	74,438
8	9479721,941	2834424,232	70,1
9	9479721,941	3264150,307	65,567
10	9479721,941	3713214,056	60,83
11	9479721,941	4182485,673	55,88
12	9479721,941	4672874,513	50,707
13	9479721,941	5185330,851	45.301
14	9479721,941	5720847,724	39,652
15	9479721,941	6280462,857	33,748
16	9479721,941	6865260.67	27.58
17	9479721,941	7476374,385	21.133
18	9479721,941	8114988,217	14,396
19	9479721,941	8782339,671	7.3566
20	9479721,941	9479721,941	0

Table 9. Percentage of Planned Lifetime of Overload Based on Bina Marga (1987)

YEAR UR	N1.5 (ESAL)	NP (ESAL)	RL (%)
1	9479721,941	706502,1945	92,547
2	9479721,941	1444796,988	84,759
3	9479721,941	2216315,047	76,62
4	9479721,941	3022551,418	68,116
5	9479721,941	3865068,427	59,228
6	9479721,941	4745498,7	49,941
7	9479721,941	5665548,336	40,235
8	9479721,941	6627000,206	30,093
9	9479721,941	7631717,41	19,494
10	9479721,941	8681646,888	8.4188
11	9479721,941	9778823,192	-3.1552
12	9479721,941	10925372,43	-15.25
13	9479721,941	12123516,38	-27,889
14	9479721,941	13375576,82	-41,097
15	9479721,941	14683979.97	-54,899
16	9479721,941	16051261,26	-69,322
17	9479721,941	17480070,21	-84,394
18	9479721,941	18973175,57	-100.14
19	9479721,941	20533470,66	-116.6
20	9479721,941	22163979.03	-133.8

The following is a comparison of the percentage of settlement under normal conditions with conditions due to actual overloading based on Highways (1987), can be seen in Figure 2 as follows.

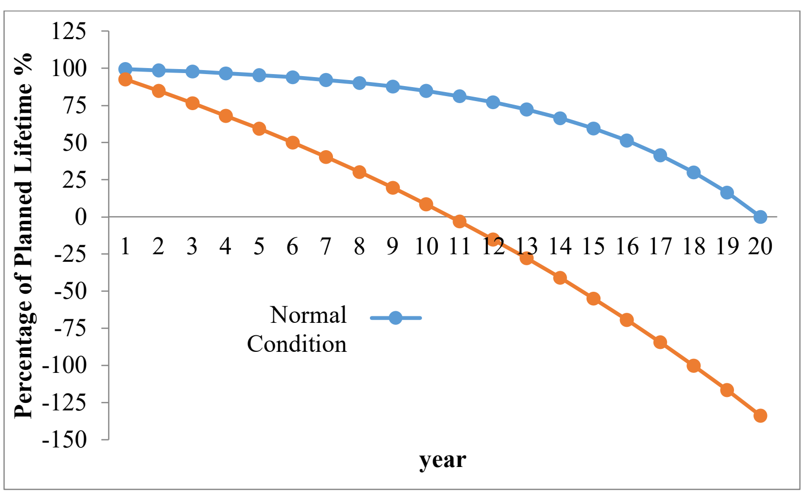

Figure 2. Comparison of Depreciation of Planned Age Based on Bina Marga (1987)

4.2 NAASRA (2004) Method

The design life used is 20 years, before calculating the percentage of the design life in years 1 to 20, the cumulative ESAL at the end of the design life is calculated with a DD value of 0.5 as suggested by AASHTO (1993), which is between 0.3 -0.7 and the DL value is used 1 according to the number of lanes for each lane so the calculation is as follows.

Table 10. Percentage of Planned Age Normal Condition Based on NAASRA (2004)

YEAR UR	N1.5 (ESAL)	NP (ESAL)	RL (%)
1	14564711.36	464266,8415	96.81239
2	14564711.36	949425,6909	93.48133
3	14564711.36	1456416,688	90.00037
4	14564711.36	1986222,281	86.36278
5	14564711.36	2539869,125	82.56149
6	14564711.36	3118430,077	78.58914
7	14564711.36	3723026,272	74.43804
8	14564711.36	4354829,296	70.10013
9	14564711.36	5015063,456	65.56702
10	14564711.36	5705008,153	60.82993
11	14564711.36	6426000,361	55.87966
12	14564711.36	7179437,219	50.70663
13	14564711.36	7966778,735	45.30081
14	14564711.36	8789550,62	39.65173
15	14564711.36	9649347,239	33.74845
16	14564711.36	10547834,71	27.57951
17	14564711.36	11486754,11	21.13298
18	14564711.36	12467924.89	14.39635
19	14564711.36	13493248,35	7.356569
20	14564711.36	14564711.36	0

Table 11. Percentage of Design Life Due to Actual Overload NAASRA (2004)

YEAR UR	N1.5 (ESAL)	NP (ESAL)	RL (%)
1	14564711.36	1026957,066	92,949
2	14564711.36	2100127,199	855.807
3	14564711.36	3221589,988	778.809
4	14564711.36	4393518,603	698.345
5	14564711.36	5618184,006	614.261
6	14564711.36	6897959,352	526.392
7	14564711.36	8235324,588	43,457
8	14564711.36	9632871.26	338.616
9	14564711.36	11093307,53	238.343
10	14564711.36	12619463,44	133.559
11	14564711.36	14214296,36	240.592
12	14564711.36	15880896,76	-903.681
13	14564711.36	17622494,18	-209.945
14	14564711.36	19442463,48	-334.902
15	14564711.36	21344331,4	-465.483
16	14564711.36	23331783,38	-60,1939
17	14564711.36	25408670,7	-744.537

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YEAR UR	N1.5 (ESAL)	NP (ESAL)	RL (%)
18	14564711.36	27579017,95	-893.551
19	14564711.36	29847030,82	-104,927
20	14564711.36	32217104,27	-121.2

The following is a comparison of the percentage of settlement under normal conditions with conditions due to actual overloading based on NAASRA (2004), can be seen in Figure 3 as follows.

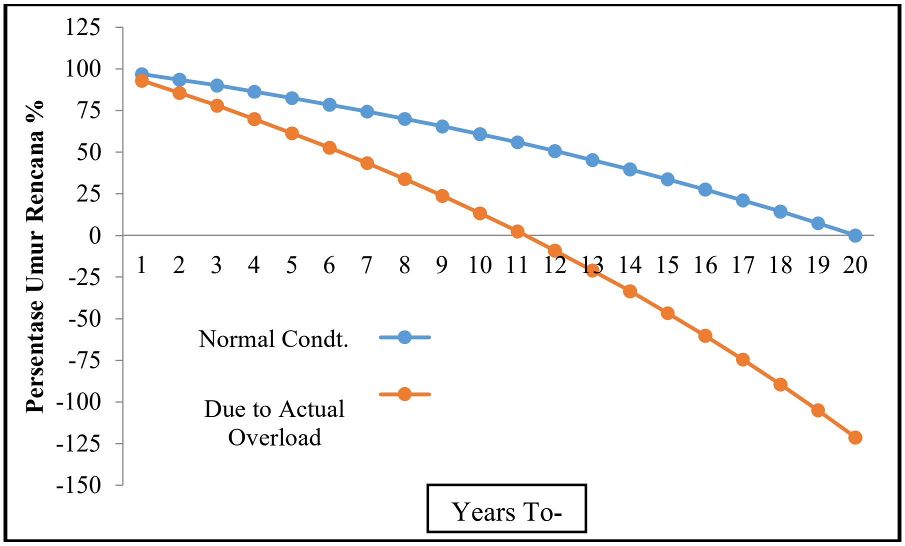

Figure 3. Comparison of Decrease in Planned Age Based on NAASRA (2004)

5. Conclusions

The actual percentage of overload on the Koti road, Jayapura was obtained for class 6a of 81.06%, class 6b of 43.13%, and class 7a of 40.42%. Actual overload in the field can result in an increase in the cumulative VDF value, based on the Bina Marga (1987) method, an increase in cumulative VDF due to actual overload in the field is 133.8%, while based on the NAASRA method (2004) it is 121.2%. Decreasing of the design life due to actual overload in the field, based on the method of Highways (1987) obtained a decrease in the design life of 9.273 years or a decrease of 46.365% from the design life of 20 years, while based on the NAASRA method (2004) a decrease in the design life of 8.7898 years was obtained. decreased by 43.949% from the planned age of 20 years.

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Vol. 4, No. 1, pp. 98-108, March 2023
e-ISSN: 2775-5592