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Economic Feasibility Analysis of Local Road Maintenance in West Bandung Regency: A Case Study of Cangkorah Street STA 0+000 – 1+300

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ABSTRACT

This study aims to determine the economic feasibility of the local road maintenance scenario in West Bandung Regency with a case study of Cangkorah Street. As a strategic road to pass through the route to the city of Bandung and have a heavy traffic with a lot of heavy vehicles pass the road, roads must be maintained in order to create a safe and comfortable road for passengers. There are several ways to maintain the road, one of them is direct survey using IKP guidelines. The result from IKP value by using IKP guidelines will produce in an International Roughness Index (IRI) values the economic feasibility analysis is carried out based on a road maintenance scenario, while the maintenance scenario being tested is a do-something scenario, by doing road maintenance in the form of overlay once every 5 years in 10 year time compared by a do-nothing scenario that is not doing any maintenance for the next 10 years. The research instruments used were prediction of the performance of the Cangkorah Street Pavement for the next 10 years, determine road maintenance scenarios, maintenance budget plans, calculate Vehicle Operational Costs (VOC) for each scenario, and time value. The conclusion of the study is comparing to the scenarios, do-nothing and do-something, the feasibility of do-something scenario from an economic point of view shows that the scenario is feasible with NPV is Rp. 36,674,480,627>0 and a BCR of 11.39>1.

Keywords: Pavement Prediction, Budget Plan, Vehicle Operating Cost (VOC), Time Value, NPV, BCR.

INTRODUCTION

One of the routine activities in road management is the implementation of road investigations by measuring the performance of road pavements. One way to determine the performance of road pavements is identify road damage by looking at the cracks that occur on the pavement surface. Cracks usually start at the bottom layer of the pavement structure which receives the greatest stress due to the load received, then the crack will continue to the surface (Dauzats & Rampal, 1987).

West Bandung Regency has 113 roads with a total length of 536 kilometers (Badan Pusat Statistik, 2021). According to the Department of Public Works and Spatial Planning of West Bandung Regency, 20% of the total road length still needs to be improved. This means that more than 100 kilometers of roads are damaged and others need maintenance (Verawati, 2021).

One of the roads in West Bandung Regency with a damaged condition is Cangkorah street located in Giriasih Village, Batujajar District. It is an access road connecting the city of Cimahi with a 1.3 km length and is categorized as a regency road. The damage was caused by heavy vehicles of industrial activities located around the Batujajar District so that affecting the strength of the pavement structure. Therefore, the traffic volume increases by 6% every year (Badan Pusat Statistik, 2021). Damage to one or more components of the structure makes it no longer bear the traffic load and disrupts the safety and comfort of road users. This also makes the Vehicle Operating Costs (VOC) increase. This call for corrective maintenance activities by predicting the pavement performance to determine the right treatment for the pavement performance maintenance for several years.

The pavement condition in Cangkorah Street must be evaluated in order to know the right treatment to maintain the pavement performance. Pavement Condition Index (PCI) is a method to evaluate the performance of the road pavement using the index value according to the guidelines Pd 01-2016 B. The PCI can be the basis for providing recommendations for road pavement maintenance, either preventively or repressively. The PCI value can be converted to an IRI (International Roughness Index) value which can be used to predict road pavement conditions as a basis for determining road maintenance in the future. Road maintenance are activities to maintain, repair, add or replace existing buildings so their functions can be maintained for a longer time (Peraturan Menteri Pekerjaan Umum No. 13/PRT/M/2011, 2011).

In recent years, there has several research about evaluating pavement performance at different location. Sihombing, Sirait, Prayogo, and Ambat (2021) did a research about road pavement evaluation using the Pavement Condition Index (PCI) Pd 01-2016 B for determine road management recommendations. In contrast to Sihombing, Sirait, Prayogo, and Ambat (2021) research, Fiata (2013) designed a road management and maintenance strategy with 4 alteratives for the next ten years by surveying pavement condition using Pavement Condition Index (PCI). The present study focusses from combining those topics because not only evaluate the pavement performance but also design the scenario for road maintenance. To determine the benefit of the road maintenance scenario, this study will use the NPV and BCR formula.

Road maintenance for Cangkorah Street will be made for the next ten years with two scenarios, do nothing and do something scenarios based on predictions of road conditions and Vehicle Operating Costs (VOC). The do-nothing scenario is a scenario where nothing is done in the next 10 years. Meanwhile, the do something scenario is carrying out a road maintenance in the next 10 years according to the recommendations from the Pavement Condition Index (PCI). The result of the scenarios can be used as a

reference in maintaining optimum road conditions, which are used in preparation for future handling.

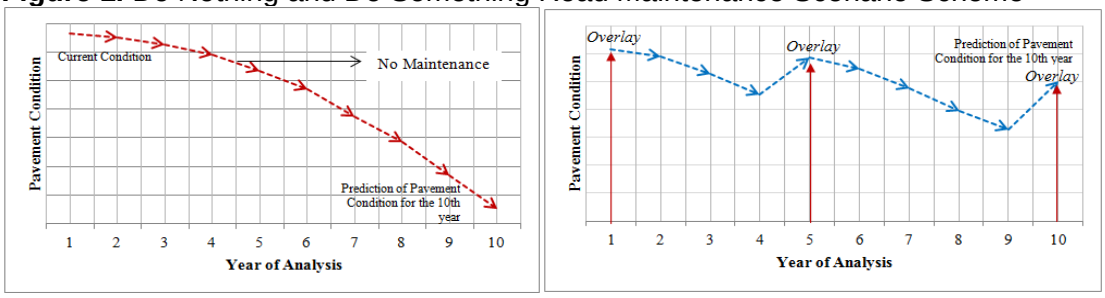
LITERATURE REVIEW

Pavement is part of a highway that is hardened with a certain layer of construction that has a certain thickness, strength, stiffness and stability in order to be able to transfer traffic loads on it to the subgrade soil. According to Sukirman (1999) based on the binding material, road pavement construction can be divided into flexible pavement, rigid pavement, and composite pavement.

Wibowo (2001) in Efendy (2021) stated that basically every road pavement structure will experience a process of progressive deterioration since the road was first opened to traffic. This is in line with research conducted by Putri, Zamheri, Ridho, Paisal, and Africano (2022) stated that public facilities were not good and had not been paved, thus damaging visitors and taking longer to reach their destination. To overcome this, determine the road conditions so that road maintenance program can be developed. Evaluation of road pavement conditions is one of the stages to determine the type of maintenance. There are several parameters that can be used to assess road pavement conditions. Parameters for evaluating pavement conditions include the Pavement Condition Index (PCI), International Roughness Index (IRI), Road Condition Index (RCI), and Surface Distress Index (SDI).

Road conditions tend to decrease, as indicated by the damage to the road pavement. To slow down deterioration and maintain them at a reasonable level, the road network needs proper management to ensure the road's functionality at all times. Figure 1 illustrates that the value of road construction will increase when periodic maintenance is implemented.

Figure 1. Do Nothing and Do Something Road Maintenance Scenario Scheme



a b

From the Figure 1, there are two scheme that shows about the scenarios. The first one is scenario do nothing where the road pavement not maintained for the next 10 years. But the second one is scenario do something where the road maintenance is carried out every 5 years in the form of overlays and handling according to the recommended Pavement Condition Index (PCI) value in the first year.

The Pavement Condition Index (PCI) from Pd 01-2016 B is one of the indicators for evaluating road pavement conditions. As a numerical indicator of pavement conditions, PCI shows the level of pavement surface conditions. The PCI shows a measure of the condition of the pavement at the time it was surveyed, based on observed damage to the pavement surface, which also indicates the structural integrity and functional condition of the pavement (unevenness and roughness).

Pavement Performance Prediction

Many models have been developed to predict future pavement performance to estimate pavement strength, pavement material, stiffness, pavement thickness, subgrade strength, and pavement surface conditions. The performance of the pavement can be seen from the IRI (International Roughness Index) value that converted from PCI (Pavement Condition Index) value as a parameter of the flatness of a road pavement.

Budget Plan

The unit cost analysis of road works is regulated in Peraturan Menteri No. 1 Tahun 2022 about Guidelines for the Preparation of Estimated Costs of Construction Works in the Public Works. It states that calculating the cost of construction work needs a cost estimation process that combines the analysis of the unit price of the work and the cost analysis of implementing a construction safety management system to get the designer's estimated price, cost budget plan, or estimated price.

Vehicle Operating Cost (VOC)

Base Vehicle Operating Costs

According to the Departemen Pekerjaan Umum (2005), Vehicle Operating Costs (VOC) is a costs for owning, operating, and maintaining a vehicle for certain traffic and road conditions type per kilometer (Rupiah/km). It consists of two components: fixed costs and running costs, the formula of which is:

$$\mathrm{VOC_{Base}} = \mathrm{Running\ Costs} + \mathrm{Fixed\ Costs} \qquad \textbf{[1]}$$

Running costs is one of Vehicle Operating Cost component. Running cost needs the fuel costs, oil costs, parts of vehicle costs, maintenance fee, and tire consumption costs in rupiah per kilometer (Apsari, 2017).

Fixed costs is a cost that must to be incurred on a regular basis for a certain period of time and not affected by vehicle operations. The components of fixed costs are vehicle depreciation costs, vehicle crew costs, interest costs, and overhead costs (Apsari, 2017).

Actual Vehicle Operating Costs

The formula to calculate the Actual Vehicle Costs is:

$$\mathrm{VOC_{Actual\ t}} = \mathrm{VOC_{Base}} \times \mathrm{VOC_{Indeks\ t}} \times \mathrm{AADT_t} \qquad \textbf{[2]}$$

Where:

t = observation time period

AADT = Annual Average Daily Traffic

The calculation of these VOC index can be used with the $\mathrm{VOC_{index}}$ equation in the RUCM-IRMS (Hoff & Overgaard, 1992) in Nuryati (2017) the formula is :

$$\mathrm{VOC_{Index\ t}} = \mathrm{k_1} + \frac{\mathrm{k_2}}{\mathrm{V}} + \frac{\mathrm{k_3}}{\mathrm{V^2}} + \mathrm{k_4}.\mathrm{V}.\mathrm{IRI_t} + \mathrm{k_5}.\mathrm{V}.\mathrm{IRI_t^2} \qquad \textbf{[3]}$$

Where :

$\mathrm{VOC_{Index\ t}}$ = The value of the vehicle operating index (in RUCM this $\mathrm{VOC_{index}}$ is calculated for each flowband and then averaged)

$k_1,...k_5$ = Regression coefficient values

V = Vehicle Average Speed

$\mathrm{IRI_t}$ = Effective Roughness Value

Actual Vehicle Operating Costs

The calculation of the VOC quantities can be done by using the $\mathrm{VOC_{Actual}}$ equation contained in RUCM-IRMS (Hoff & Overgaard, 1992) in Nuryati (2017) the formula is :

$$\mathrm{VOC_{Actual\ t}} = \mathrm{VOC_{Base}} \times \mathrm{VOC_{Index\ t}} \times \mathrm{AADT_t} \qquad \textbf{[4]}$$

Where :

$VOC_{Actual\ t}$ = Monetary value of the actual amount of VOC in year t
VOC_{Base} = Value of VOC in the base year
$VOC_{Index\ t}$ = The value of the vehicle operating index
$AADT_t$ = Annual Average Daily Traffic in year t
t = Observation time period

Time Value
The calculation of the time value is influenced by the Gross Regional Domestic Product (GRDP) per capita of the population, the average working hours per month, and travel time. The travel time used to the road maintenance scenario. If no maintenance (do nothing) then the travel time will be higher than doing road maintenance (do something). So that the resulting time value will be different and the cost savings will be obtained from the time value.

Net Present Value (NPV)
This method is known as the present worth method and is used to determine whether a plan has benefits in the period of analysis. It is calculated from the difference between Present Value of Benefit (PVB) and Present Value of Cost (PVC). NPV can be calculated using the following formula :

$$\text{NPV} = \text{Benefit} - \text{Costs} \quad \textbf{[5]}$$

The value of the NPV should be positive because it indicates that the benefits obtained exceed the costs incurred.

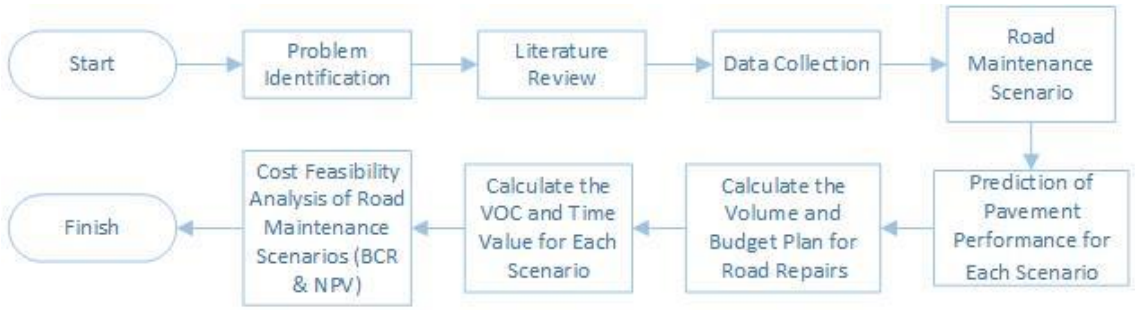
Benefit Cost Ratio (BCR)
Benefit Cost Ratio is a comparison between Present Value Benefit divided by Present Value Cost. The BCR result of a project is said to be economically feasible if its value is more than 1. This method is used to evaluate the feasibility of a project by comparing the total benefits to the total costs that have been discounted to the base year using the discount rate during the plan year. BCR can be calculated using the following formula.

$$\text{BCR} = \frac{\text{B}}{\text{C}} = \frac{\text{Benefit}}{\text{Cost}} \geq 1 \quad \textbf{[6]}$$

RESEARCH METHOD

This research is conducted into four steps: preparation, data collection, analysis step, and results (see Figure 2**).**

Figure 2. Research Flowchart



The do nothing and do something scenarios will be compared using the value of Vehicle Operating Cost (VOC) and the time cost. The do something scenario will be analyzed for its cost feasibility by using BCR Ratio and NPV obtained from VOC, time value, and road maintenance costs.

RESULTS

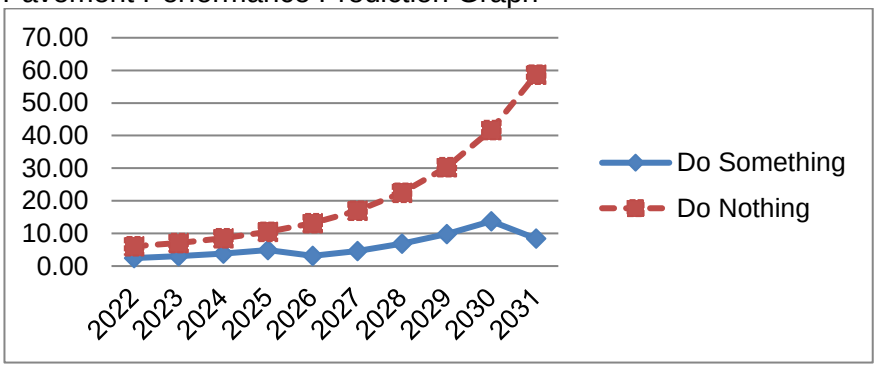
The prediction calculation of Cangkorah Street pavement performance is shown in Table 1 and Figure 3. In Table 1, the IRI value for do nothing scenario and do something scenario has a difference. The difference can be clearly seen in Figure 3 where the do nothing scenario has a bigger IRI value for the next ten years. The do something scenario has a lower IRI value because of the road maintenance that planned for the next ten years.

Table 1. IRI Value Prediction Do Nothing and Do Something

No	Year	IRI Value Prediction Do Nothing	IRI Value Prediction Do Something
1	2022	5.31	5.31
2	2023	6.08	2.45
3	2024	7.11	3.03
4	2025	8.53	3.80
5	2026	10.48	4.89
6	2027	13.20	3.13
7	2028	17.03	4.65
8	2029	22.48	6.84
9	2030	30.32	9.78
10	2031	41.75	13.75
11	2032	58.68	8.42

The result from the Table 1 drawn in Figure 3 as a graph. Based on the graph in Figure 3, the prediction of the IRI value for the next ten years in the do nothing scenario seems to increase significantly with the IRI value in 2032 of 58.68 m/km, while the IRI value for the do something scenario in 2032 by overlaying the pavement once in five years is 8.42 m/km. So that the difference in the predicted IRI value of the do nothing and do something scenarios is 50.26 m/km.

Figure 3. Pavement Performance Prediction Graph



Road maintenance on Cangkorah street in the do something scenario is carried out every five years with an overlay. The overlay is planned to be 6 cm thick in 2023, 2027, and 2032. The budget plan is calculated by multiplying the volume of work with the previously calculated work unit price analysis. In the 2nd year overlay, the asphalt pavement added with the previous maintenance was excavated. Table 2 shows the calculation results of the budget plan for the maintenance of Cangkorah street.

Table 2. Budget Plan for Do-Something Scenario

Job Description			Unit	Volume	Unit Price (Rp.)	Total Price (Rp.)		
						BOQ	Budget Plan	Budget Plan + PPN 10%
CANGKORAH STREET IMPROVEMENT								
A	PREPARATORY WORK							
	A.1	Mobilisasi	Ls	1,000				
B	1st Overlay (2023)						1,210,489,643	1,332,975,230
	B.1	Tack Coat	litre	2,340	32,318	75,623,421		
	B.2	Laston Layer (AC-WC) thick 6 cm	ton	1,076.4	1,054,316	1,134,866,221		
C	2nd Overlay (2027)						1,287,189,332	1,417,522,376
	C.1	Excavation of the Asphalt Pavement with Cold Milling Machine	m3	468	163,888	76,699,689.92		
	C.2	Tack Coat	litre	2,340	32,318	75,623,421		
	C.3	Laston Layer (AC-WC) thick 6 cm	ton	1,076.4	1,054,316	1,134,866,221		
D	3rd Overlay (2032)						1,287,189,332	1,417,522,376
	D.1	Excavation of the Asphalt Pavement with Cold Milling Machine	m3	468	163,888	76,699,689.92		
	D.2	Tack Coat	litre	2,340	32,318	75,623,421		
	D.3	Laston Layer (AC-WC) thick 6 cm	ton	1,076.4	1,054,316	1,134,866,221		

Table 2 shows the budget plan for the maintenance for Cangkorah Street where the maintenance are overlaying the pavement three times for the next ten years. The total price for the first overlay at 2023 is Rp. 1,332,975,230, for the second overlay at 2027 is Rp. 1,417,522,376, and the last overlay at 2032 is Rp. 1,417,522,376. From that data, the total price for all the pavement maintenance plan for Cangkorah Street is Rp. 4,168,019,982.

The calculation of the Vehicle Operating Cost (VOC) begins with determining the price of the VOC component per vehicle type used to calculate the VOC base, including the price of new vehicles, the price of a depreciating vehicle, the price of fuel oil, the price of tires, and the price of mechanic wages. Table 3 shows the price of vehicle components based on vehicle type in 2022. There are six types of vehicle that used for calculate the Vehicle Operating Cost (VOC): light vehicle, light truck, heavy truck 2as, heavy truck 3as, heavy truck 4as, and bus. The unit price of each types of vehicle are different because it depends from the brand. The selected brand that used in Table 3 are the brand that mostly used in Indonesia.

Table 3. The Price of Vehicle Components Based on the Type of Vehicle in 2022

No	VOC Components		Unit	Unit Price
1	Vehicle Price			
	Light Vehicle (2t)	Toyota Avanza 1,3 E MT	Unit	135,300,000
	Light Truck (8,3t)	Hino Dutro Cargo 110 SDL	Unit	227,900,000
	Heavy Truck 2as (15t)	Hino Ranger Cargo FG 235 JK Box Body	Unit	563,500,000
	Heavy Truck 3as (25t)	Mercedes Benz Axor 2528 RMC	Unit	888,200,000
	Heavy Truck 4as (32t)	Hino Ranger FLX 250 JW	Unit	955,000,000
	Bus (9t)	Mercedes Benz OH 1526	Unit	931,000,000
2	**Tire Price**			
	Light Vehicle (2t)	Bridgestone Ecopia EP150 185/70 R14	Piece	610,000
	Light Truck (8,3t)	GT Radial Savero Komodo Extreme 245/75 r16	Piece	2,709,000
	Heavy Truck 2as (15t)	Bridgestone V-LUG 10,00-20-16PR	Piece	3,850,000
	Heavy Truck 3as (25t)		Piece	
	Heavy Truck 4as (32t)		Piece	
	Bus (9t)	Truk Michelin 11 R 22,5 X MULTI Z 2	Piece	4,036,000
3	**Fuel Price**			
	Pertalite	Light Vehicle	Litre	7,650
	Dexlite	Truck and Bus	Litre	12,950
4	**Oil Price**			
	Light Vehicle (2t)	TMO 10W-40 SN	Litre	75,000
	Truck and Bus	Oli Pertamina Meditran S Sae 40 Diesel	Litre	35,000
5	**Maintenance**			
	Light Vehicle (2t)		Hour	18,595
	Truck and Bus		Hour	18,595

After collected the VOC Components, VOC Base can be calculated by totalized the VOC component prices, road length, and vehicle speed. Based on the calculation results of fixed costs for each vehicle type, the total VOC base is presented in Table 4. From the Table 4, it can be known that Vehicle Operating Cost (VOC) Base for do nothing scenario is higher than the do something scenarios.

Table 4. VOC Base for Each Type of Vehicle

Vehicle Types	VOC Base	
	Do Nothing	Do Something
Passenger Cas (2t)	5,464	3,913
Bus (9t)	24,147	12,881
Light Truck (8,3t)	17,683	8,820
Heavy Truck 2as (15t)	26,574	12,165
Heavy Truck 3as (25t)	34,162	15,306
Heavy Truck 4as (32t)	36,308	15,970

The calculation of the VOC index uses the VOC prediction model (VOCM in RUCM) in IRMS. The equation [3] $\mathrm{VOC_{Index\,t}} = \mathrm{k_1} + \frac{\mathrm{k_2}}{\mathrm{V}} + \frac{\mathrm{k_3}}{\mathrm{V^2}} + \mathrm{k_4}.\mathrm{V}.\mathrm{IRI_t} + \mathrm{k_5}.\mathrm{V}.\mathrm{IRI_t^2}$ is used to calculate the VOC index that contained in literature review using the IRI value, vehicle

speed and regression coefficient. The results of the VOC index calculation for each scenario for the next ten years are shown in Table 5 and Table 6.

Table 5. VOC Index Do-Nothing Scenario in 10 Years

Year	Vehicle Types					
	Car	Bus	Light Truck	Heavy Truck 2 as	Heavy Truck 3as	Heavy Truck 4 as
2022	3.26	3.16	2.07	2.23	1.83	1.83
2023	3.86	3.78	2.34	2.60	2.08	2.08
2024	4.79	4.73	2.76	3.16	2.46	2.46
2025	6.29	6.27	3.44	4.06	3.08	3.08
2026	8.80	8.84	4.57	5.57	4.11	4.11
2027	13.17	13.32	6.52	8.18	5.89	5.89
2028	21.01	21.37	10.01	12.87	9.08	9.08
2029	35.58	36.31	16.48	21.55	14.97	14.97
2030	63.60	65.04	28.88	38.20	26.25	26.25
2031	119.36	122.23	53.53	71.30	48.65	48.65
2032	234.35	240.20	104.28	139.47	94.76	94.76

Table 5 and table 6 shows that VOC index for each scenarios every year on different types of vehicle are increase. The result of VOC index will used to count the actual VOC which mean to know the VOC savings on each scenarios.

Table 6. VOC Index Do-Something Scenario in 10 Years

Year	Vehicle Types					
	Car	Bus	Light Truck	Heavy Truck 2 as	Heavy Truck 3as	Heavy Truck 4 as
2023	1.75	1.63	1.38	1.31	1.19	1.19
2024	1.97	1.85	1.48	1.45	1.28	1.28
2025	2.33	2.21	1.64	1.67	1.43	1.43
2026	2.97	2.87	1.94	2.06	1.71	1.71
2027	2.01	1.89	1.50	1.47	1.30	1.30
2028	2.82	2.71	1.87	1.96	1.64	1.64
2029	4.53	4.47	2.65	3.00	2.36	2.36
2030	7.85	7.87	4.14	5.00	3.72	3.72
2031	14.18	14.36	6.97	8.79	6.30	6.30
2032	6.16	6.14	3.38	3.99	3.03	3.03

Actual VOC is calculated using equation [2] $VOC_{Actual\ t} = VOC_{Base} \times VOC_{Indeks\ t} \times AADT_t$ in literature review with the base VOC, VOC index and AADTt data. Table 7 presents the AADT for the next ten years by vehicle type. There are ten vehicle class based on the weight of vehicle where the data in 2022 are obtained from the result of field survey. Annual Average Daily Traffic (AADT) for the next ten years is calculated over the plan period of ten years with traffic growth of 6% (Badan Pusat Statistik, 2021).

Table 7. AADT Prediction on Cangkorah Street

Vehicle Class	Vehicle/Day/2ways										
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
1	32963	34940	37037	39259	41614	44111	46758	49563	52537	55689	59031
2	3900	4134	4382	4645	4924	5219	5532	5864	6216	6589	6984
3	838	888	941	997	1057	1121	1188	1259	1335	1415	1500
4	1488	1577	1671	1772	1878	1991	2110	2237	2371	2513	2664
5a	13	13	14	15	16	17	18	19	20	21	22

5b	375	398	421	447	473	502	532	564	598	634	672
6a	600	636	674	715	757	803	851	902	956	1014	1075
6b	1000	1060	1124	1191	1262	1338	1419	1504	1594	1689	1791
7a	175	186	197	208	221	234	248	263	279	296	313
7b	25	27	28	30	32	33	35	38	40	42	45

Table 8 and Table 9 show the results of the actual VOC calculation for each scenario for the next ten years for each type of vehicle by multiplying the Annual Average Daily Traffic (AADT) and the results of the base VOC and VOC index calculations calculated previously 2022 to 2032.

Table 8. Actual VOC Do-Nothing Scenario for Each Vehicle Type

Year	Passenger Car	Bus	Light Truck	Heavy Truck 2as	Heavy Truck 3as	Heavy Truck 4as
2022	79,318,191	16,029,635	10,112,876	27,160,366	4,892,926	729,280
2023	139,201,278	44,263,671	29,149,707	73,210,065	13,172,688	2,000,037
2024	182,947,869	59,900,215	37,342,240	94,315,170	16,543,426	2,511,823
2025	254,679,801	85,781,356	50,594,668	128,562,915	21,938,644	3,330,991
2026	377,944,735	130,550,163	73,120,105	186,922,513	31,034,790	4,712,078
2027	599,348,499	211,316,840	113,235,659	291,060,770	47,137,900	7,157,047
2028	1,014,022,710	363,012,167	187,882,704	485,132,032	76,976,569	11,687,515
2029	1,820,096,573	658,394,431	332,284,866	860,974,525	134,531,227	13,584,563
2030	3,447,930,175	1,255,516,063	622,856,307	1,617,877,806	250,116,222	37,975,673
2031	6,859,566,250	2,507,714,726	1,230,247,139	3,200,998,818	491,404,367	74,610,962
2032	14,276,245,879	5,230,840,689	2,548,174,317	6,637,556,410	1,014,482,577	54,031,029

From the Table 8, it shows that the actual VOC are increase every year in each type of vehicle. The actual VOC for passenger car is Rp. 79,318,191 in 2022. Ten years from 2022, the actual VOC for passenger car increase with the value is Rp. 14,276,245,879. Actual VOC for do something scenario that shows in Table 9 has a smaller value than the do nothing scenario that shows in Table 8.

Table 9 Actual VOC Do-Something Scenario for Each Vehicle Type

Year	Passenger Car	Bus	Light Truck	Heavy Truck 2as	Heavy Truck 3as	Heavy Truck 4as
2022	79,318,191	16,029,635	0,112,876	27,160,366	4,892,926	729,280
2023	45,295,353	7,698,399	6,437,372	16,903,067	3,369,663	502,241
2024	53,909,607	9,571,663	7,487,204	19,751,802	3,855,296	574,623
2025	67,524,851	12,632,490	9,089,883	24,134,380	4,577,091	682,205
2026	91,461,671	18,156,800	1,819,982	31,653,426	5,776,934	861,039
2027	65,617,450	11,737,694	9,074,966	23,961,029	4,658,864	694,393
2028	97,311,968	19,093,329	2,683,919	33,905,436	6,238,472	929,831
2029	165,903,747	35,289,247	0,269,018	54,945,092	9,491,941	940,891
2030	304,708,691	68,326,932	5,358,233	96,963,154	15,893,125	2,368,835
2031	583,429,617	34,947,342	5,335,925	80,643,984	28,527,333	4,251,936
2032	268,676,926	59,085,892	1,809,442	86,835,337	14,531,078	2,165,825

Table 10 shows the total VOC actual for each scenario and the VOC savings obtained for ten years. Actual VOC for do-something scenario expending more few costs than the Actual VOC do nothing, which means saving more costs on 2032 of Rp. 27,629,550,571.

Table 10. Actual VOC Do-Something Scenario for Each Vehicle Type

Year	Actual VOC Do Nothing	Actual VOC Do Something	VOC Savings
2022	138,841,450	138,841,450	0
2023	291,454,390	82,396,328	209,058,062
2024	378,988,626	97,234,282	281,754,344
2025	521,801,964	120,432,944	401,369,020
2026	766,250,099	160,832,341	605,417,757
2027	1,204,008,103	118,169,846	1,085,838,257
2028	2,022,083,348	171,620,171	1,850,463,177
2029	3,602,910,446	285,874,595	3,317,035,851
2030	6,812,247,024	517,452,575	6,294,794,449
2031	13,518,466,676	980,218,374	12,538,248,301
2032	28,088,666,852	459,116,281	27,629,550,571
		Total	4,213,529,789

One of the factor to determine the benefits of road maintenance other than VOC is the value of time.The time value is calculated by multiplying the cost per minute by the travel time. The results of the time value and savings for each scenario can be seen in Table 11. Based on table 11 the different between do something and do nothing scenarios are huge costs, do something scenario savings costs more than do nothing scenario for every year.

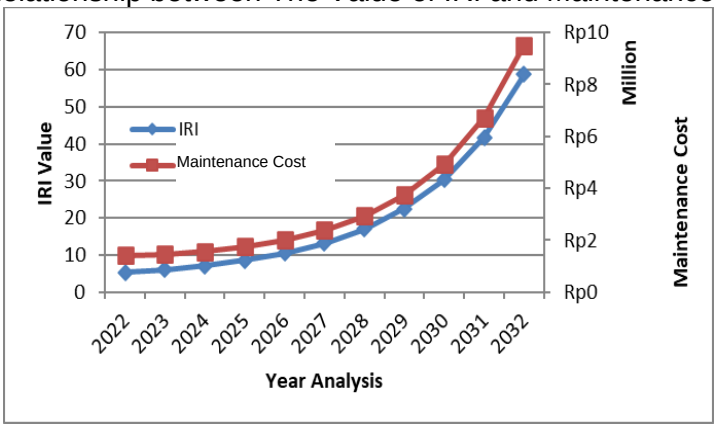
Table 11. Time Value and Savings for Each Scenario

Year	Time Value Do Nothing	Time Value Do Something	Time Value Savings
2022	37,741,329,82	37,741,329,82	0
2023	41,757,772,68	17,467,719,37	24,290,053
2024	46,201,646,51	19,326,638,94	26,875,008
2025	51,118,438,64	21,383,385,26	29,735,053
2026	56,558,477,16	23,659,011,09	32,899,466
2027	62,577,446,10	26,176,809,66	36,400,636
2028	69,236,955,39	28,962,553,05	40,274,402
2029	76,605,171,53	32,044,756,04	44,560,415
2030	84,757,515,28	35,454,967,93	49,302,547
2031	93,777,433,73	39,228,095,52	54,549,338
2032	103,757,254,42	43,402,760,40	60,354,494

DISCUSSION

Based on Table 1, the predicted IRI value in the next ten years in the do nothing scenario increases significantly with the IRI value in 2031 of 58.68 m/km, while the IRI value in the do something scenario 2032 by overlaying once in 5 years is 8.42 m/km. The difference between the predicted IRI values of both scenarios is 50.26 m/km. The pavement condition in 2032 for the do nothing scenario based on the prediction of the IRI value has a “failed” condition which means that the pavement is impassable, while the pavement for the do something scenario has an uneven surface condition. The value of IRI of the do nothing scenario will increase every year if no maintenance is carried out. Figure 4 describes the relationship between the value of IRI and maintenance cost.

Figure 4. The Relationship between The Value of IRI and Maintenance Cost



We planned the maintenance in 2023, 2037 and 2032. From Table 2, the total of budget plan for the next 10 years it costs Rp. 4,168,019,982 by overlaying the surface pavement with 6 cm asphalt. If we do a maintenance once in 5 years, the IRI value and the Vehicle Operation Costs will be decreased that showed in Figure 3 and Table 10.

Net Present Value (NPV) and Benefit Cost Ratio (BCR) is used to determine whether the planned scenario has benefits in the analysis time period with reference to the value of costs and benefits. The cost used is the cost of maintaining the road in the do something scenario. While the benefits used are obtained from the calculation of savings in Vehicle Operational Costs (VOC) and Time Cost savings in the do nothing and do something scenarios. NPV and BCR can be calculated using the formula in equation [5] $\text{NPV} = \text{Benefit} - \text{Costs}$ and [6] $\text{BCR} = \frac{\text{Benefit}}{\text{Costs}}$. The benefits based on the total of VOC savings and the total of time value savings from Table 10 and Table 11. While the costs are based on the pavement maintenance budget plan for the next ten years that calculated in Table 2. based on the data that has been mentioned, the NPV value is:

Benefit = Rp 40,202,787.65
Cost = Rp 3,482,981,760
NPV = Benefit – Cost = Rp 40,202,787.65 – Rp 3,482,981,760
= Rp 36,719,805,905 > 0
BCR = Benefit/Cost = Rp 40,202,787.65/ Rp 3,482,981,760 = $11.54 > 1$

CONCLUSION

This study concludes that road maintenance in the do something scenario is economically feasible in terms of NPV and BCR due to the savings that come from the VOC value and time value of both scenarios. From the results of the analysis that has been done, it can be concluded that the budget plan for the maintenance of the Cangkorah Street in the do-something scenario with overlays 3 times in 10 years from Table 2 is Rp. 4,168,019,982, the actual VOC for the do-nothing scenario from Table 10 was Rp. 57,345,718,978 and the actual VOC for the do-something scenario was 3,132,189,189 with VOC savings was Rp. 54,213,529,789, the time value of the scenario for the next 10 years from Table 11 obtained savings of Rp. 399,241,414, and the feasibility of do-something scenario from an economic point of view shows that the scenario is feasible with a NPV of Rp. 36,674,480,627>0 and a BCR of 11.54 >1. So it can be concluded that the maintenance of Jalan Raya Cangkorah with a do something scenario by overlaying it once every 5 years is said to be "feasible" economically.

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DECLARATION OF CONFLICTING INTERESTS
No potential conflict of interest was reported by the authors.

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