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Selection analysis of road maintenance methods between the use of slurry seals and spot levelling from service life and construction costs aspects

Tri C. Utomo [a], Catur A. Prastyanto [b*]

Correspondence

[a]Master Student in the Civil Engineering Department, Institut Teknologi Sepuluh Nopember, ITS Campus, Sukolilo, Surabaya 60111, Indonesia.
[b]Lecturer of Civil Engineering Department, Institut Teknologi Sepuluh Nopember, ITS Campus, Sukolilo, Surabaya 60111, Indonesia.

Corresponding author email address: cprastyanto@gmail.com

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Abstract

On national roads with high or equal average daily traffic compared to provincial roads, slurry seals are commonly used to protect the asphalt layer from damage and improve skid resistance. Interestingly, when applied to provincial roads, spot leveling treatments tend to have a longer lifespan than slurry seals, which often deteriorate within the same fiscal year. This creates a contradiction: provincial roads with lower traffic tend to benefit more from spot leveling, while national roads, with higher traffic, favor slurry seals. To address this discrepancy, further research is needed to understand the factors influencing method selection and compare the longevity of these treatments to their construction costs. The study utilized average daily traffic data to assess traffic conditions, surveyed road conditions to determine damage percentages and remaining service life for slurry seals and spot leveling, and then compared these findings with construction expenses. The Cumulative Equivalent Single Axle (CESA) value, reflecting traffic load characteristics, significantly impacts the service life of slurry seals, resulting in a 2.08-year difference and a handling cost of Rp. 12,949.29 per square meter per year. Drainage conditions also affect slurry seal longevity, with a 1.32-year service life gap and handling cost of Rp. 8,097 per square meter per year. Additionally, sidewalk conditions influence slurry seal service life, leading to a 0.52-year gap and a handling cost of Rp. 4,688.39 per square meter per year. Based on the data regarding service life gaps and handling costs, it is evident that the most influential factor on the service life of slurry seals is the Cumulative Equivalent Single Axle (CESA) condition on the road segment where the slurry seal is applied.

Keywords

Slurry seal, spot leveling, service life, lifespan, fiscal year

INTRODUCTION

One of the supporting developments for an area is transportation. In terms of transportation, roads play a crucial role in achieving smooth land transportation. In general, roads function to facilitate the seamless movement of people and goods[1]. Meanwhile, the condition of the road continues to deteriorate over time [2], so Pavement maintenance is an essential activity for the long-term life of pavement structures. Extending the service life of all pavements can be achieved through properly timed and constructed pavement maintenance procedures[3].

In the process of road maintenance, the performance of road pavement will decrease in line with the repetition of the traffic load it serves, the weather or the quality of materials is not good. In terms of maintaining road stability from a decrease in road conditions, efforts to maintain the road are carried out. Road maintenance includes routine maintenance, periodic maintenance, rehabilitation, and reconstruction [4]. Road maintenance is conducted in a preventive and reactive manner [5].

Of the road maintenance activities, what must be done to maintain road conditions every day is to carry out routine maintenance. Routine road maintenance is the activity of caring for and repairing the damage that occurs on road sections with stable service conditions [4]. Road maintenance is a road handling activity, in the form of prevention, maintenance, and repairs needed to maintain road conditions so that they continue to function optimally serving traffic traffic, so that the specified design life can be achieved [6].

Work included in routine road maintenance must include road performance maintenance work to ensure that road pavements, shoulders, drainage systems, road ancillary buildings and road equipment are always maintained at all times and in a solid service condition based on the required performance. This work is also to prevent greater damage by maintaining or repairing pavement and shoulder damage such as sealing, patching, spot leveling, pavement edge repair, asphalt resurfacing, repair cracks, repairing corrugated surfaces (corrugations), and leveling deep rutting to maintain standard road cross slopes [7].

Of the several ways, the repairs that are often carried out by the Public Works Department of Binamarga, East

Java Province are patching and spot leveling. Patches are considered for damage to be replaced with new materials and are better for repair than the previous pavement [8].

Spot leveling is the work of maintaining the performance of asphalt-covered road pavements which aims to maintain an evenness of the surface of the road pavement (traffic lane) with local leveling. The types of materials used in spot leveling work are asphalt concrete (AC) and hot rolled sheet asphalt (HRS) [9]. The negative effects of spot leveling work on a road surface that only requires slurry seal treatment are as follows: Spot leveling can result in an uneven surface if the repair is not executed properly and evenly. An uneven surface poses risks to vehicles and pedestrians, leading to potential accidents Additionally, it can disrupt the original asphalt's slope and drainage pattern, causing water pooling or flow issues and resulting in further damage over time, particularly during nighttime or adverse weather conditions [10].

Preventive activities are procedures for the maintenance and surveillance of roads, using an approach aimed at pavements with steady service conditions (good and moderate conditions), before experiencing serious damage so that pavement maintenance costs become more effective and efficient, especially on existing roads. it is indicated that a deterioration in condition has been handled through preventive maintenance, delaying the rate of deterioration in the condition of the road pavement. The preventive maintenance of asphalt pavement includes fog seal, chip seal, slurry seal, micro surfacing, and a thin layer of concrete [11].

One material that is often used in flexible pavement preservation is slurry seal. The use of slurry seals in general as a coating in the preservation of flexible pavements, is specifically used on roads that have low to medium distress levels and have narrow crack widths [12]. Slurry Seal is a mixture of emulsified asphalt, fine aggregate, mineral filler, water and other additives which are mixed evenly without heating and spread over the surface of the road pavement with a maximum thickness of 10 mm [13]. Slurry seal is a stable mixture of slow steady emulsion asphalt, fine aggregate with continuous gradation, fillers, and water [14]. The asphalt emulsion can be neat or can be polymer modified. The additives that can be part of the recipe can be Portland cement, hydrated lime, fibres, break control additives, or other fillers [15]

The use of emulsified asphalt slurry covers includes minor repairs to fine cracks, filling cavities, wear, grain release, and improving variations in the texture of pavement surface sections [7].

The results of the Asphalt Institute's report on a project in California cited, estimate the additional life due to the application of slurry seal to be 3 (three) to 5 (five) years with a maximum of 15 (fifteen) years when maintenance is applied as a preventive maintenance measure. In a study in Texas, it was found that slurry seal coatings were more cost-effective than conventional asphalt coatings. Although slurry seals are used on worse-conditioned roads, the results show that on average the cured surfaces have higher skid resistance and slightly better ride quality at a lower total cost than conventional asphalt coatings [16].

On the East Java Provincial Road Section, there were only 2 jobs recorded in the last 3 years for slurry seal work, one of which was on link 219 (Buduan - Bts Bondowoso) in 2019. Meanwhile, on national roads, it is very common to find both jobs such as the Probolinggo-Paiton-Situbondo National Road Section in 2018 and the Gemekan-Kab Jombang National Road Section in 2019.

This is of course a contradictory conclusion between the two methods applied, namely on provincial roads with average daily traffic tending to be lower than national roads using spot leveling treatment which has a longer life while on national roads as arterial roads with average daily traffic which tends to be higher than roads provinces use slurry seals which in observations tend to have a shorter life.

The government, working with road management agencies, requires funds to maintain road stability. Budgeting for road projects involves proposing, discussing, and setting budgets. Establishing project priorities involves lengthy discussions due to varying opinions among decision-makers and limited funds in different regions. To address these issues, decision-makers need a shared understanding to ensure optimal, directed, and transparent allocation of limited regional funds for road management programs [17]

With the problems above, it is necessary to carry out further research on the factors underlying the selection of appropriate maintenance methods, in terms of the service life of the handling results compared to the construction costs incurred, taking into account the factors of traffic characteristics, as well as the conditions of the road shoulders and drainage on sections that be used as an object, so that the proper use of budget funds in the maintenance of flexible pavement roads in the province of East Java.

RESEARCH SIGNIFICANCE

This research can determine the traffic characteristics of each section under review, the service life of the slurry seal or spot leveling implementation, road conditions, road shoulder conditions, drainage conditions on the sections under review, and the influence of traffic characteristics, road shoulder conditions, and road conditions. drainage on service life and construction costs in the area of the Mojokerto Road and Bridge Management Technical Implementation Unit at the Public Works Department of Highways, East Java Province. The benefits expected in this study are through the analysis of traffic characteristics and the condition of the roads on road damage and methods of handling them, problems that arise and steps that can be taken in proper routine maintenance of roads on the roads of East Java Province and can provide information to the Provincial government East Java and related agencies so that it can become input for improving decision making regarding the routine maintenance of roads in East Java Province.

METHODOLOGY

In this research, a completion methodology is needed to explain the stages of the work to be carried out. This methodology starts from the initial work to the final work of the research. With the aim, the research in this thesis has been carried out according to the plan and carried out according to the correct principles.

A. DATA COLLECTION

The data collected consisted of 2 types of data, namely primary data and secondary data. The following is an explanation of each of these data:

- Primary data is data obtained directly by going to the field of the study location and is usually obtained by field survey methods for road conditions in the handling area. The data taken are as follows:
  - Data on the handling area of slurry seal/ spot leveling.
  - Damage data after handling slurry seal/ spot leveling.
  - Road shoulder condition data.
  - Data on drainage conditions.

  With the following data collection steps:
  - Determine the data collection segment according to the work data provided by the relevant agency.
  - Recording the handling area using the dashboard camera to then take measurements.
  - Eliminate work data that has been done with overlay work/if the spot leveling/slurry seal handling is closed by new handling.
  - Measurement according to the segment and extent of damage that occurs.
  - Record road shoulder conditions and drainage conditions.
  - Record year-to-year damage via Google Street at the location according to the results of the data collection from the camera recording.
- Secondary data is data obtained from the results of studies/requests for data from relevant agencies:
  - Map of road sections.
  - Average daily traffic of Provincial Roads and National Roads, to analyze the characteristics and loads in calculating the remaining service life.
  - Survey road conditions before handling.
  - Type of handling and handling fee Per m^2.

B. TRAFFIC CHARACTERISTICS ANALYSIS

Through the secondary data obtained, namely traffic survey data (data from related agencies), it is possible to obtain the volume of traffic passing through the road sections under review. The traffic volume in vehicle units is converted into standard load form Cumulative Equivalent Single Axle (CESA) using the Vehicle Damage Factor. Pavement structural analysis was carried out based on the cumulative number of CESA in the existing lanes throughout the design life [7].

With the calculation steps, namely:

- Average daily traffic data obtained from secondary data from related agencies.
- Average Daily Traffic data is simulated in 2018-2021 using the assumption of traffic growth.
- Enter data and calculate according to the Cumulative Equivalent Single Axle (CESA) formula.

C. PERCENT OF DAMAGE AND REMAINING SERVICE LIFE

The steps for collecting road segment condition data are as follows:

- Tabulating the segmentation of slurry seal and spot leveling work.
- Tabulating damage data from dashboar camera with parameter from provincial road management system[19]
- Calculating the total damage to the handling area every year from the age of 0 years of handling through the Google Street application.
- Projecting 100% damage by projecting year-by-year job damage data compared to CESA with linear regression.[20]

$$y = ax^2 + bx + c \tag{1}$$

Where:
x = CESA Conditions Per Year;
y = road damage condition per year.

- Projecting 100% damage is projected to occur in what year it will take place, with linear regression.

$$y = ax + b \tag{2}$$

Where:
x = Years of work;
y = CESA.

D. ROAD SHOULDER CONDITIONS AND DRAINAGE CONDITIONS

The steps for collecting road segment condition data are as follows:

- Tabulating the segmentation of slurry seal and spot leveling work.
- Record the condition of the road shoulder, and drainage.
- The parameters used are as follows:
- Road shoulder condition: dirt road shoulder width ≤ 1m; 1-2 m wide dirt road shoulders; Dirt road shoulder width ≥ 2 m; Paved shoulder width ≤ 1m; Paved road shoulders 1-2 m wide; Paved shoulder width ≥ 2 m.
- Drainage condition: no drainage; functioning soil drainage; soil drainage and not functioning/ clogged; hardened drainage function; drainage is hardened and not working/clogged
- Note the conditions according to no. 3 on each of the road segments studied accordingly.

E. ANALYSIS OF THE INFLUENCE OF TRAFFIC CHARACTERISTICS, ROAD SHOULDER CONDITIONS, AND DRAINAGE CONDITIONS ON SERVICE LIFE AND CONSTRUCTION COSTS

According to Iman Soeharto, project cost estimation plays an important role in project implementation. In the early stages, it is used to find out how much money is needed to build a project. Cost estimates are distinguished from budgets in that cost estimates are limited to the tabulation of costs required for a particular project activity or the project as a whole. One method is to use a list of price indexes and previous project information, namely by looking for comparative figures between prices at a time (year certain price) to the price at the time (year) used as the basis. Also, the use of data from manuals, hand-books, catalogs, and periodical publications, is very helpful in estimating project costs [18].

- The steps taken to analyze the effect of traffic characteristics, road shoulder conditions and drainage conditions on service life and construction costs are:

- Tabulating the results of the characteristic analysis of traffic conditions and working age conditions, road shoulder conditions, and drainage conditions.
- Calculating the cost of construction/m^2/projected service life.
- Setting a valid variable influences on the handling service life.

F. RESULT AND DISCUSSION

After analyzing the existing data, the results of the research will be obtained which consist of:

- The condition of the traffic load of each road segment studied.
- Conditions for the age of work, road shoulder conditions, drainage conditions and
- Effect of traffic characteristics, work life, road shoulder conditions, and drainage conditions on service life and handling construction costs.

G. PROVINCIAL ROAD SPOT LEVELING HANDLING DATA

Spot leveling handling data obtained from the Public Works Office of Binamarga, East Java Province. As for the initial condition of the pavement before handling, it must first be tabulated to sort out the data that includes handling that can be handled with slurry seal work, that is, if the type of damage to fine cracks, needs to be filled in cavities, wear and tear, grain release, and needs repair of texture variations, while the condition of spot leveling that cannot be replaced is when the damage has reached structural damage, and in the data on spot leveling handling on provincial roads given all the damage is loose aggregate and fine cracks/ voids.

H. NATIONAL ROAD SLURY SEAL HANDLING DATA

Data for handling slurry seals provided by National Road Implementation Center Jawa Bali. The process of selecting the data used will be carried out at the analysis stage of service life and the percentage of damage.

I. TRAFFIC CHARACTERISTICS ANALYSIS

Traffic load analysis is obtained from the volume of traffic that passes through the road sections under review. Traffic volume that is still in vehicle units is converted into standard load form Cumulative Equivalent Single Axle (CESA) using the Vehicle Damage Factor. This aims to determine the characteristics of the traffic load on provincial roads and national roads.

J. CESA PROVINCIAL ROAD

The Cumulative Equivalent Single Axle (CESA) analysis of provincial roads is calculated from average daily traffic (secondary data) obtained from DPU Binamarga, East Java Province. The data obtained is average daily traffic 2019 so it is projected to become average daily traffic 2018-2022 which is the year the primary data for road conditions were taken. In the annual Cumulative Equivalent Single Axle (CESA) formula, the one-year period is 365, the data collection is taken according to the data collection date so that the day is adjusted to the number of days.

Table 1 CESA provincial road link 157

Year	CESA 5
2019	2.466
2020	4.989
Tahun 2021	7.630

Table 2 CESA provincial road link 158

Year	CESA 5
2019	40.966
2020	76.971
2021	100.702
2022	143.180

Table 3 CESA provincial road link 159

Year	CESA 5
2019	2.466
2020	4.989
2021	7.630
2022	10.364

K. CESA NATIONAL ROAD

The Cumulative Equivalent Single Axle (CESA) analysis for national roads is calculated from the average daily traffic obtained from the Java-Bali BBPJN. The data obtained is the average daily traffic between 2018 and 2020 so it is projected to become the 2018-2022 average daily traffic which is the year the primary data for road conditions was taken.

Table 4 CESA national road link 21

Year	CESA 5
2019	292.128
2020	378.407
2021	830.817

Table 5 CESA national road link 22

Year	CESA 5
2019	77.413
2020	207.194
2021	618.280

Table 6 CESA national road link 23

Year	CESA 5
2019	87.637
2020	322.267
2021	700.050

Table 7 CESA national road link 24.11K

Year	CESA 5
2019	67.598
2020	248.547
2021	539.907

Table 8 CESA national road link 25.12K

Year	CESA 5
2019	88.262
2020	141.839
2021	301.446

Table 9 CESA national road link 40

Year	CESA 5
2021	600.040
2022	1.014.876

Table 10 CESA Jombang City National Road - Mojokerto Regency

Year	CESA 5
2021	388.311
2022	864.481

From the data for the entire Cumulative Equivalent Single Axle (CESA) table on both provincial and national roads for the four year 2018 until 2021 range, the highest CESA on national roads in 2021 will be on the Link 21 national road, namely 830,817, while the CESA data on Link 158 provincial roads is 100,702. So characteristically the traffic load on national roads is indeed much greater.

L. SERVICE LIFE ANALYSIS, ROAD SHOULDER CONDITIONS, AND DRAINAGE CONDITIONS

L.1. DAMAGE PERCENT AND SERVICE LIFE

The steps for collecting road segment condition data are as follows:

- Tabulating the segmentation of slurry seal and spot leveling work.
- Tabulating damage data
- Calculating the total damage to the handling area every year from the age of 0 years of handling via BlackVue and google street applications.
- Projected 100% damage by projecting year-by-year job damage data compared to the CESA
- Projecting 100% damage is projected to occur in what year it will take place.

Table 11 Percentage of damage of 2020 maintenance work using slurry seal

Fisrt KM	-	Last KM	Position	Damage 2021	Damage 2022
59+100	-	59+200	L	15,17%	66,67%
59+375	-	59+500	L	23,67%	56,67%
59+400	-	60+500	R	21,55%	53,33%
61+000	-	61+225	L	35,02%	66,67%
61+000	-	61+250	R	7,87%	51,35%
61+600	-	63+000	R	7,81%	17,13%
63+000	-	63+076	L	25,44%	76,67%
63+096	-	63+143	L	0,71%	7,09%
59+100	-	59+200	L	15,17%	66,67%
		Average		**17,15%**	**49,45%**

Table 12 Percentage of damage of 2018 maintenance work using slurry seal

First KM	-	Last KM	Position	Damage 2019	Damage 2020	Damage 2021
196+303	-	196+367	R	17,92%	26,88%	79,69%
195+036	-	195+095	L	10,84%	21,80%	58,13%
194+998	-	195+036	L	15,48%	22,06%	58,82%
194+875	-	194+980	L	16,33%	28,57%	78,57%
194+180	-	194+245	R	14,29%	28,57%	57,14%
193+787	-	193+853	R	6,94%	20,83%	69,44%
193+000	-	193+098	R	8,33%	33,33%	90,85%
167+590	-	167+637	R	12,00%	30,00%	80,00%
167+437	-	167+578	R	11,64%	29,09%	75,65%
167+335	-	167+423	R	10,68%	46,29%	93,70%
167+224	-	167+269	R	6,00%	27,00%	75,01%
167+116	-	167+201	R	5,02%	20,09%	70,31%
167+029	-	167+106	R	5,71%	22,83%	97,40%
157+225	-	157+250	R	4,71%	18,82%	48,24%
157+200	-	157+225	R	14,71%	35,29%	88,24%
157+071	-	157+096	R	0,00%	29,41%	58,82%
156+652	-	156+803	R	0,00%	15,15%	45,45%
144+692	-	144+782	R	0,00%	15,15%	60,61%
140+814	-	141+044	R	5,19%	9,34%	34,39%
140+215	-	140+305	R	13,32%	16,58%	44,88%
133+291	-	133+431	R	2,99%	14,93%	59,70%
131+400	-	131+486	R	6,01%	12,01%	45,05%
		Average		**8,55%**	**18,48%**	**54,64%**

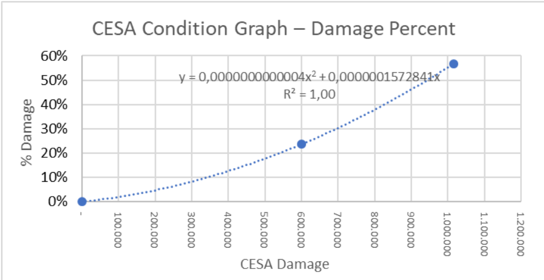

Figure 1 CESA condition graph – damage percent

Table 13 Age projection of work plan

Year	KM	Position	Handling Type	Service Life (Th)
2020	59+100	L	Slurry Seal	2,29
2020	59+375	L	Slurry Seal	2,67
2020	59+400	R	Slurry Seal	2,76
2020	61+000	L	Slurry Seal	2,64
2020	61+000	R	Slurry Seal	2,50
2020	61+600	R	Slurry Seal	5,69
2020	63+000	L	Slurry Seal	1,95
2018	196+303	R	Slurry Seal	3,69
2018	195+036	L	Slurry Seal	4,50
2018	194+998	L	Slurry Seal	4,64
2018	194+875	L	Slurry Seal	6,80
2018	194+180	R	Slurry Seal	5,41
2018	193+787	R	Slurry Seal	3,88
2018	193+000	R	Slurry Seal	3,38
2018	167+590	R	Slurry Seal	3,69
2018	167+437	R	Slurry Seal	3,86
2018	167+335	R	Slurry Seal	3,38
2018	167+224	R	Slurry Seal	3,80
2018	167+116	R	Slurry Seal	3,82
2018	167+029	R	Slurry Seal	3,22
2018	157+225	R	Slurry Seal	5,21
2018	157+200	R	Slurry Seal	3,49
2018	157+071	R	Slurry Seal	5,40
2018	156+652	R	Slurry Seal	4,92
2018	144+692	R	Slurry Seal	4,02
2018	140+814	R	Slurry Seal	5,51
2018	140+215	R	Slurry Seal	5,53
2018	133+291	R	Slurry Seal	4,01
2018	131+400	R	Slurry Seal	4,76

Road damage data for handling slurry seals in 2020 according to what happened on the largest national road occurred in year 2 in 2022, the largest damage was 67% and the smallest damage was 7%. Road damage data for handling slurry seals in 2018 according to what happened on the largest national road occurred in year 4 in 2021, the biggest damage was 97% and the smallest damage was 15%. From Figure 1, the graph of the CESA condition - percent damage is obtained by the equation:

$$Y = 0,0000000000004\, x^2 - 0,0000001572841\, x \quad (3)$$

$$100\ \% = 0,0000000000004\, x^2 - 0,0000001572841\, x \quad (4)$$

The CESA value for 100% breakdown condition is 1,306,962.

Table 14 Projected service life of slurry seal

Year	KM	Position	Handling Type	Service Life (Th)
2020	59+100	L	Sidewalk	Drainage is hardened and not working/clogged
2020	59+375	L	Sidewalk	There isn't any
2020	59+400	R	Sidewalk	Drainage is hardened and not working/clogged
2020	61+000	L	Sidewalk	Drainage is hardened and not working/clogged
2020	61+000	R	Sidewalk	Drainage is hardened and not working/clogged
2020	61+600	R	Sidewalk	Drainage is hardened and functioning
2020	63+000	L	Sidewalk	Drainage is hardened and not working/clogged
2020	63+096	L	Sidewalk	Drainage is hardened and not working/clogged
2018	196+303	R	Dirt road shoulder width ≥ 2m	Drainage is hardened and functioning
2018	195+036	L	Sidewalk	Drainage is hardened and functioning
2018	194+998	L	Sidewalk	Drainage is hardened and functioning
2018	194+875	L	Sidewalk	Drainage is hardened and functioning
2018	194+180	R	Sidewalk	Drainage is hardened and functioning
2018	193+787	R	Sidewalk	Drainage is hardened and functioning
2018	193+000	R	Sidewalk	Drainage is hardened and not working/clogged
2018	167+590	R	Sidewalk	Drainage is hardened and not working/clogged
2018	167+437	R	1-2m wide dirt road shoulders	Drainage hardened, inlet closed
2018	167+335	R	The shoulder of the dirt road is 1-2m wide	Drainage hardened, inlet closed
2018	167+224	R	1-2m wide dirt road shoulders	Drainage hardened, inlet closed
2018	167+116	R	Wide dirt road shoulders 1	Drainage hardened, inlet closed
2018	167+029	R	1-2m wide dirt road shoulders	No drainage, newly built 2021
2018	157+225	R	1-2m wide dirt road shoulders	No drainage, newly built 2021
2018	157+200	R	Dirt road shoulder width ≥ 2m	Drainage is hardened and functioning
2018	157+071	R	Dirt road shoulder width ≥ 2m	Drainage is hardened and functioning
2018	156+652	R	Dirt road shoulder width ≥ 2m	Does not work
2018	144+692	R	Dirt road shoulder width ≥ 2m	Does not work
2018	140+814	R	Dirt road shoulder width ≥ 2m	Drainage is hardened and functioning
2018	140+215	R	Dirt road shoulder width ≥ 2m	Soil drainage works
2018	133+291	R	Dirt road shoulder width ≥ 2m	Soil drainage works
2018	131+400	R	The shoulder of the dirt road is 1-2m wide	Soil drainage works

Table 15 Spot Levelling

Year	KM	Position	Handling Type	Service Life (Th)
2018	39+178	L / R	Shoulder width of dirt road ≥ 2 m	Drainage is hardened and not working/clogged
2018	39+400	L	Shoulder width of dirt road ≥ 2 m	Drainage is hardened and not working/clogged
2018	39+480	R / L	Shoulder width of dirt road ≥ 2 m	Drainage is hardened and not working/clogged
2018	52+995	R / L	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2018	53+500	R / L	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2018	50+900	R / L	Paved shoulder width ≤ 1m	Paved drainage works
2018	51+750	R / L	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2018	50+540	R / L	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2018	50+755	R / L	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2018	49+567	L / R	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2018	49+665	L / R	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2020	52+825	L	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2020	53+090	R / L	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2020	52+271	R	Paved shoulder width ≤ 1m	Soil drainage works
2020	52+760	R / L	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2020	52+825	R	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2020	52+947	R / L	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2020	53+209	R / L	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2020	52+147	R	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2020	52+152	R / L	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2020	52+271	R	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2020	53+231	R	Shoulder width of dirt road ≥ 2 m	Soil drainage works
2020	54+260	L	Paved shoulder width ≤ 1m	Soil drainage works
2020	54+278	L / R	Paved shoulder width ≤ 1m	Soil drainage works
2020	54+500	L / R	Paved shoulder width ≤ 1m	Soil drainage works

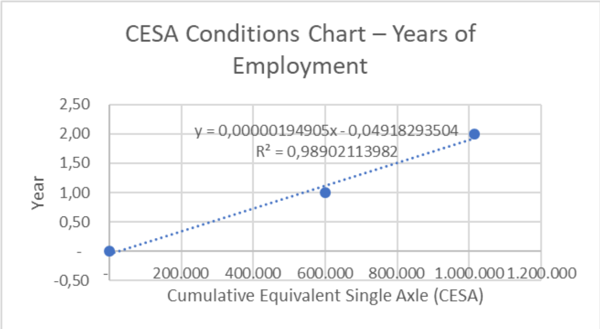

Figure 2 CESA conditions chart – years of employment

From Fig 2. Graph of CESA conditions - Years of work age, the equation is obtained:

$$Y = 0.00000194905\,x - 0.04918293504 \quad (5)$$

$$Y = 0.00000194905 * (1.306.962) - 0.04918293504 \quad (6)$$

CESA value in 100% damage condition, work life is 2.5 years. As for the above calculations, the overall service life projection is calculated according to the calculation example tabled in Table 19.

L.2. ROAD SHOULDER CONDITIONS, AND DRAINAGE CONDITIONS

Tabulating Road Shoulder conditions and Drainage Conditions according to segmentation of slurry seal and spot leveling work obtained from related agencies.

M. ANALYSIS OF THE INFLUENCE OF TRAFFIC CHARACTERISTICS, ROAD SHOULDER CONDITIONS, DRAINAGE CONDITIONS ON SERVICE LIFE AND CONSTRUCTION COSTS

The construction cost for slurry seal work is Rp. 76,500 /m^2 suitable and spot leveling per tonne (5cm thick) = Rp. 1,550,000 or equivalent to Rp. 178,250 /m^2.

The handling cost per m^2/year is obtained by dividing the work cost per m^2 by the number of years the work has served. An example of calculating a slurry seal job with a price per m^2 = Rp. 76,500 divided by 10 years of service = Rp. 7,650 / m^2 / year.

Service life data and slurry seal construction costs are correlated to obtain handling costs per yr/m^2. From the data with the highest and lowest CESA, grouped by blocked and functioning drainage, grouped according to the condition of the sidewalk shoulder and dirt road shoulder, while the spot leveling correlation cannot be displayed because service life cannot be simulated because there is no damage data for 2020.

Data was obtained on the highest CESA on the Bts road section. Regency. Jombang – Gememakan and Bts. Jombang City - Bts Mojokerto Regency, the average service life is 2.93 years and the handling fee is Rp. 28,867.59 /m^2/year and on the lowest annual CESA data on the Link 25.12K and 25.11K sections is 5.01 years and the handling fee is Rp. 15,918.30 /m^2/year. So it can be concluded that the CESA value or traffic load characteristics greatly affect the service life of the slurry seal. With a service life gap of 2.08 years and a handling fee per year of Rp. 12,949.29 /m^2/year.

Obtained data on clogged drainage, the average service life is 3.02 years and the handling fee is Rp. 25,412.28 /m^2/year and the data on functioning drainage is 4.34 years and the handling fee is Rp. 17,314.63 /m^2/year. So it can be concluded that drainage conditions greatly affect the service life of the slurry seal. Under the condition of a service life gap of 1.32 years and a yearly handling fee of Rp. 8,097 /m^2/year.

Obtained data on Sidewalk Shoulders, the average service life is 3.61 years and the handling fee is Rp. 22,347.38 /m^2/year and the data on functioning drainage is 4.13 years and the handling fee is Rp. 17,678.98 /m^2/year. So it can be concluded that drainage conditions greatly affect the service life of the slurry seal. With the condition of a service life gap of 0.52 years and a handling fee per year of Rp. 4,688.39 /m^2/year.

From the gap data on service life conditions and handling costs, the thing that has the most influence on the life and service life of the slurry seal is the CESA condition on the segment where the slurry seal is applied.

CONCLUSIONS

From the results of the research that has been done, it can be concluded as follows:

- From the overall CESA data on Provincial roads and National roads spanning 4 years in 2018 until 2021, the highest CESA on National roads in 2021 is on Link 21 National roads, namely 830,817, while CESA data on Link 158 Provincial roads is 100,702.
- Road damage data for handling slurry seals in 2020 according to table 4.18 which occurred on the largest national road in year 2 in 2022, the largest damage was 67% and the smallest damage was 7%. Road damage data for handling slurry seals in 2018 which occurred on the largest national road occurred in year 4 in 2021, the largest damage was 97% and the smallest damage was 15%.
- Obtained data on the highest CESA on the Bts road section. Regency. Jombang – Gememakan and Bts. City of Jombang - Bts Kab Mojokerto, the average service life is 2.93 years and the lowest annual CESA data on Link 25.12K and 25.11K sections is 5.01 years. So it can be concluded that the CESA value or traffic load characteristics greatly affect the service life of the slurry seal. With a service life gap of 2.08 years. Obtained data on clogged drainage, the average service life is 3.02 years and the data on functioning drainage is 4.34 years. So it can be concluded that drainage conditions greatly affect the service life of the slurry seal. With the condition of the service life gap of 1.32 years. Obtained data on Sidewalk Shoulders, the average service life is 3.61 years and the data on functioning drainage is 4.13 years. So it can be concluded that drainage conditions greatly affect the service life of the slurry seal. With the condition of the service life gap of 0.52 years.
- Data on the highest CESA on the Bts road section. Regency. Jombang – Gemekan and Bts Jombang City - Bts Mojokerto Regency, handling fee Rp. 28,867.59 /m^2/year and on the lowest annual CESA data on the Link 25.12K and Link 25.11K sections the handling fee is Rp. 15,918.30 /m^2/year. So it can be concluded that the CESA value or traffic load characteristics greatly

affect the service life of the slurry seal handling costs per year Rp. 12,949.29 /m^2/year. Data on clogged drainage handling fee Rp. 25,412.28 /m^2/year and on the data on the drainage function the handling fee is Rp. 17,314.63 /m^2/year. So it can be concluded that drainage conditions greatly affect the service life of the slurry seal. With the condition of handling fees per year Rp. 8,097 /m2/year. Data on Shoulder Road Sidewalk handling fee Rp. 22,347.38 /m^2/year and on the data on the drainage function the handling fee is Rp. 17,678.98 /m^2/year. So it can be concluded that the condition of the pavement greatly affects the service life of the slurry seal. With the condition of handling fees per year Rp. 4,688.39 /m^2/year.

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