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Road Damage Analysis on the Simpang Nakau – Air Sebakul – SP Betungan Section in Bengkulu City

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Abstract—Traffic volume on the Simpang Nakau – Air Sebakul – Betungan road section is relatively high, with heavy vehicle loads. Over time, pavement structure deteriorates, leading to road surface damage. Although widening and overlay works have been carried out, and patching repairs are frequently done, damage continues to occur. Therefore, a study is needed to optimize material use and repair methods based on applicable standards and cost efficiency. The study aims to identify damage types and evaluate road conditions. Using the Asphalt Institute MS-17 (Pavement Condition Rating/PCR) method, overlays are recommended for segments Sta. 3+600 to 4+050 and Sta. 3+150 to 3+650, while routine maintenance is advised for Sta. 3+500 to 3+700. Based on PtT-01-2002-B, overlays are also suggested for Sta. 28+850 to 30+050, Sta. 3+150 to 3+650, and Sta. 4+500 to 4+700. Pavement thickness varies, with asphalt concrete layers of 23–28 cm and combinations with base layers (LPA) up to 61 cm.

Keywords— Road Damage, Asphalt Pavement. Patching Repair. Overlay Thickness

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A. Intraduction

The Simpang Nakau – Air Sebakul – Betungan road section in Bengkulu City is one of the main routes with relatively high traffic volume and heavy vehicle loads. Over time, the pavement structure has deteriorated due to excessive loads and the aging of construction materials. Although road widening and overlay works have been carried out, along with routine patching repairs, damage continues to occur repeatedly.

This condition highlights the need for a comprehensive evaluation of the types of damage and the effectiveness of the repair methods applied. It is also essential to consider the efficiency of material usage and implementation costs to ensure that road repairs are conducted optimally and sustainably. Therefore, this study aims to analyze the pavement condition using the Pavement Condition Rating (PCR) method from the Asphalt Institute MS-17 and evaluate overlay thickness requirements based on the PtT-01-2002-B method, in order to determine appropriate treatments in accordance with applicable technical standards.

In recent years, the increasing number of heavy vehicles such as trucks and buses has significantly contributed to the accelerated deterioration of road pavements. The Simpang Nakau – Air Sebakul – Betungan corridor serves as a vital link for both urban and intercity transportation, making it highly susceptible to structural fatigue and surface distress. Despite periodic maintenance efforts, the recurrence of damage indicates that current repair strategies may not be adequately addressing the underlying issues, particularly in terms of pavement thickness, subgrade support, and drainage conditions.

Moreover, the lack of a systematic approach in selecting appropriate rehabilitation techniques often leads to inefficient use of resources and suboptimal performance of the repaired sections. By integrating standardized evaluation methods such as the Asphalt Institute's MS-17 and the PtT-01-2002-B design guide, this study aims to provide a more data-driven basis for decision-making in pavement maintenance. The findings are expected to support local authorities in implementing more durable and cost-effective solutions tailored to the specific conditions of each

B. Literature Review

1. Pavement Performance and Deterioration
Pavement structures are subject to continuous stress from traffic loads and environmental conditions. According to Huang (2004), pavement deterioration is a progressive process influenced by factors such as traffic volume, axle load, climate, and subgrade conditions. Common types of damage include alligator cracking, rutting, and potholes, which compromise both structural integrity and user comfort.

2. Pavement Condition Assessment
The Pavement Condition Rating (PCR) method, as outlined in the Asphalt Institute's MS-17 manual, is widely used to evaluate surface distress and determine maintenance needs. This method categorizes pavement condition into numerical scores, enabling engineers to prioritize interventions based on severity and extent of damage (Asphalt Institute, 2007). Visual inspection and systematic scoring help in selecting appropriate rehabilitation strategies.

3. Overlay Design and Rehabilitation Techniques
Overlay is a cost-effective method for extending pavement life. The Indonesian standard PtT-01-2002-B provides guidelines for determining overlay thickness based on traffic load, existing pavement condition, and material properties. Studies by Mubarok et al. (2018) emphasize that accurate thickness design is crucial to prevent premature failure and ensure long-term performance. Combining asphalt concrete with base layers such as crushed aggregate or LPA (Upper Base Layer) enhances structural capacity.

4. Maintenance Strategies and Cost Efficiency
Patching and routine maintenance are often used for localized damage, but without proper evaluation, these methods may lead to recurring issues. Research by Setiawan & Prasetyo (2020) highlights the importance of integrating condition assessment with economic analysis to optimize maintenance planning. Sustainable pavement management requires balancing technical performance with budget constraints.

C. Theoretical Framework

1. Pavement Deterioration Theory
Pavement structures are designed to withstand traffic loads over a specific service life. However, repeated loading from heavy vehicles, environmental factors, and inadequate maintenance can accelerate deterioration. According to Huang (2004), common types of pavement distress include cracking, rutting, and surface disintegration, which reduce ride quality and structural integrity. The rate of deterioration is influenced by factors such as traffic volume, axle load, subgrade strength, and drainage conditions.

2. Pavement Evaluation Methods
To assess pavement condition, standardized evaluation methods are essential. The Pavement Condition Rating (PCR) system developed by the Asphalt Institute (MS-17) provides a systematic approach to quantify surface distress and determine maintenance priorities. PCR scores are based on visual inspection and categorized into condition levels ranging from "excellent" to "failed." This method helps in identifying the most appropriate treatment strategies, such as routine maintenance, overlays, or full reconstruction.

3. Overlay Design and Thickness Determination
Overlay is a common rehabilitation technique used to restore structural capacity and surface quality. The PtT-01-2002-B method is a national guideline in Indonesia for determining overlay thickness based on existing pavement conditions,

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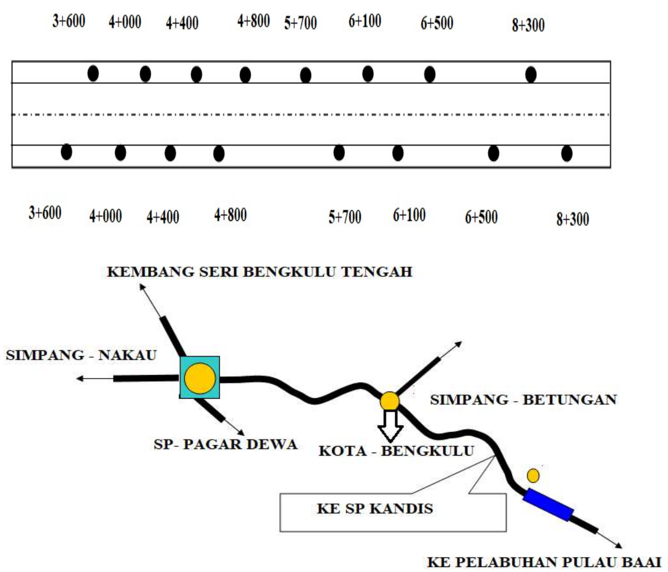
traffic load, and material properties. Proper thickness design ensures that the overlay can effectively distribute loads and extend pavement life. Combining asphalt concrete with base layers such as LPA (Lapisan Pondasi Atas) enhances structural performance and durability.

D. Research Scope and Data Collection

To obtain accurate data on road damage, it is essential to establish a systematic procedure for evaluating and inventorying the types of pavement distress. The road damage survey conducted in this study compiles various types of damage, their locations, and the extent of the affected areas. The condition of the road along the section from Km 3+850 to Km 4+700 was identified through visual inspection at approximately every 100 meters. This evaluation aims to determine the appropriate treatment method—whether overlay, reconstruction, or routine maintenance.

The pavement thickness design for damaged sections is based on primary data collected during the field survey. The scope of this research is limited to the Simpang Nakau – Air Sebakul – Betungan road segment, specifically between Km 18 and Km 35, with a focus on critical spots between Km 3+850 and Km 3+700, as illustrated in Figure 1. Field data such as California Bearing Ratio (CBR) values, base layer thickness, sub-base thickness, and asphalt thickness were collected only at the left and right edges of the existing pavement.



a. Location

The research was conducted along the Simpang Nakau – Air Sebakul – Betungan road segment, specifically between Km 3+850 and Km 4+700, heading from Simpang Nakau toward Pulau Baai, as illustrated in Sketch Figure 3.1. This segment is located within the Bengkulu City area. Field data collection included the following components:

1) Road damage data
2) Daily traffic volume data (Average Daily Traffic/ADT)
3) Asphalt surface layer thickness
4) Base and sub-base layer thickness
5) Field CBR (California Bearing Ratio) data

These data were used to identify variables such as the type of distress and the extent of damage on the pavement.

Traffic Survey Duration

The duration of the traffic survey depends on the desired level of accuracy and the design objectives. Generally, it is categorized into three groups:

1. Category A

Traffic surveys in Category A are conducted over 72 hours, divided into 3×4 periods as follows:

- Period 1: 06:00–12:00
- Period 2: 12:00–18:00
- Period 3: 18:00–24:00
- Period 4: 24:00–06:00

2. Category B

Category B surveys are conducted over 36 hours, divided into 2×3 periods:

- Period 1: 06:00–12:00
- Period 2: 12:00–18:00
- Period 3: 18:00–24:00

3. Category C

Category C surveys are conducted over 24 hours, divided into 2×2 periods:

- Period 1: 06:00–12:00
- Period 2: 12:00–18:00

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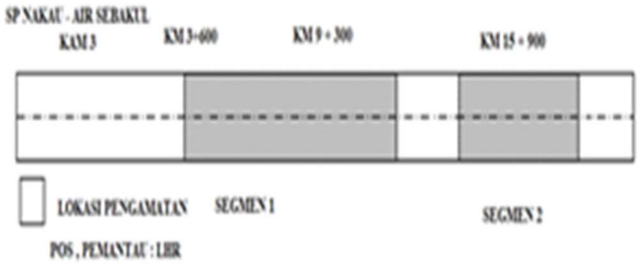


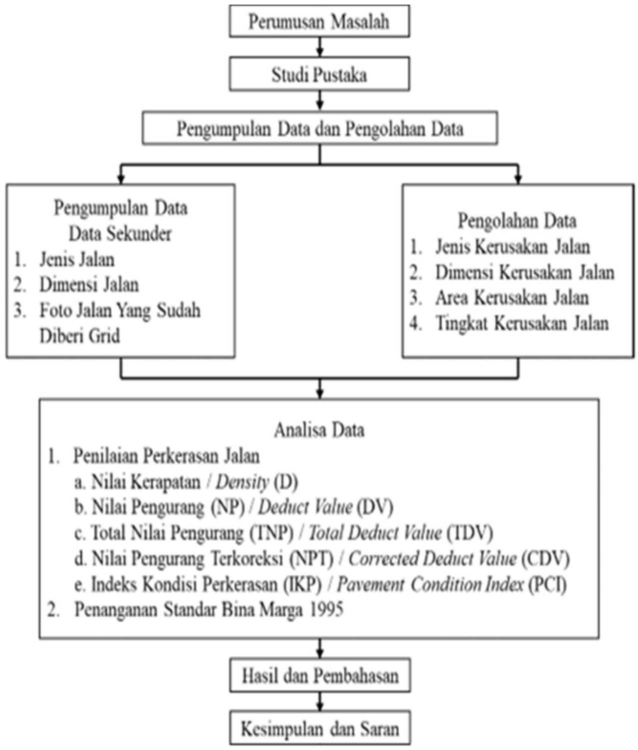
Traffic Survey for Strategic Roads

For strategic roads, traffic surveys may be conducted over a period of 7×24 hours using Category A methodology. Vehicle counts must be recorded separately for each traffic direction, except in cases where the road is one-way. The survey should include high-traffic days, and at busy intersections, data collection must be carried out during peak hours—morning, midday, and afternoon—simultaneously with traffic counts at other points along the road segment.

The defined peak hours are as follows:

1. Morning peak: 07:00–09:00
2. Midday peak: 12:00–14:00
3. Afternoon peak: 14:00–16:00

Traffic design parameters such as traffic class, vehicle classification, growth rate, and axle load must be obtained or reasonably assumed based on realistic field data collected during the survey.



E. Results and Discussion

Figure 4 illustrates the segments where the road damage survey and data collection were conducted. The damaged road segments include:

- Segment 1: Sta. 3+850 to 4+050
- Segment 2: Sta. 4+150 to 4+650
- Segment 3: Sta. 5+500 to 5+700

These segments represent the areas where road damage was observed and where field data were collected.

Survey and Test Locations

The survey locations indicate the specific points where test pits were excavated. These test pits were used to conduct Dynamic Cone Penetrometer (DCP) tests to determine the California Bearing Ratio (CBR) of the subgrade soil, as well as to measure the thickness of the base and sub-base layers. The selected test points are considered representative of the damaged road areas. A total of sixteen test pits were excavated along both the left and right sides of the existing pavement.

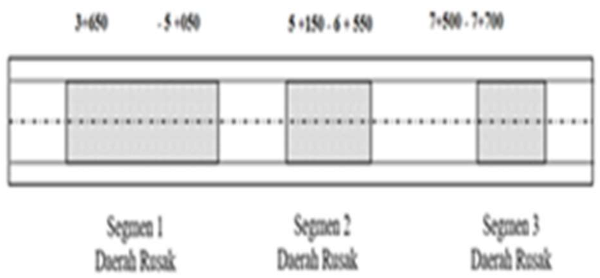


Figure 5. Sketch of Test Pit Locations

The percentage (%) of road damage for each segment/station (sta.) is presented in Table 1. Table 1 shows the percentage of pavement damage observed in each segment based on field survey results.

The Pavement Condition Rating (PCR) values obtained were then compared with standard PCR indicators to determine the appropriate type of treatment. The relationship between pavement condition ratings and recommended treatment actions based on the survey results is shown in Table 2.

Table 2. Pavement Condition Rating (PCR) and Treatment Indicators

No	Segmen/STA/Data jenis Kerusakan	Luas Kerusa kan (m2)	Luas terhadap Panjang Jalan (m2/Panjang Segmen)	Persent ase kerus kan (%)
1	**3+850 - 5+050 (1.200,00 m)**			
	Kerusakan Jalur lalu lintas:			
	-Retak buaya	439,00	439,00	6,10
	-Lubang	792,85	792,85	11,01
	-Jembul	13,50	13,50	0,19
	-Retak memanjang	10,00	10,00	0,83
	-Retak-retak	34,00	34,00	0,47
	-Retak-retak rambut memanjang	7,20	7,20	0,10
	JUMLAH	1296,55	1296,55	18,7
	Kerusakan			
	-Kelainan kemiringan	1.279,35	1.279,35	17,77
	JUMLAH	1.279,35	1.279,35	17,77
2	**5+150 - 5+500 (500,00 m)**			
	Kerusakan Jalur lalu lintas:			
	-Retak buaya	14,00	14,00	0,47
	-Lubang	852,00	852,00	28,40
	-Jembul	15,00	15,00	0,30
	JUMLAH	881,00	881,00	29,17
	Kerusakan			
	-Kelainan kemiringan	881,00	881,00	29,17
	JUMLAH	881,00	881,00	29,17
3	**6+500- 6+700 (200,00 m)**			
	Kerusakan Jalur lalu lintas:			
	-Retak buaya	54,00	54,00	4,50
	-Lubang	162,00	162,00	13,50
	JUMLAH	216,00	216,00	18,00
	Kerusakan			
	-Kelainan kemiringan	216,00	216,00	18,00
	JUMLAH	216,00	216,00	18,00

Note:

Damage Percentage Classification:

- Very Minor: 0%–5%
- Minor: 5%–20%
- Moderate: 20%–40%
- Severe: >40%

According to the Asphalt Institute MS-17, the Pavement Condition Rating (PCR) is calculated as:

PCR = 100 – Total Distress Value

The total distress value is the sum of all individual distress scores observed within a block or station (sta.). This compiled value reflects the overall condition of the pavement and is used to determine the appropriate maintenance or rehabilitation strategy.

No	BLOK/S TA	PANJ ANG (M)	PCR	INDIKA TOR	PENANGANAN
 1	3+600 3+973	123.00	78.00	30-80	LAPIS TAMBAHAN
2	3+973 4+050	77.00	91.00	80-100	PEMELIHARAA N RUTIN
3	4+050 4+151	101.00	89.00	80-100	PEMELIHARAA N RUTIN
4	4+151 4+250	99.00	94.00	80-100	PEMELIHARAA N RUTIN
5	4+250 4+350	100.00	85.00	80-100	PEMELIHARAA N RUTIN
6	4+350 4+450	100.00	82.00	80-100	PEMELIHARAA N RUTIN
7	4+450 4+540	100,00	89.00	80-100	PEMELIHARAA N RUTIN
8	4+540 4+650	100,00	91.00	80-100	PEMELIHARAA N RUTIN
9	4+650 4+750	100,00	92.00	80-100	PEMELIHARAA N RUTIN
10 .	4+750 4+852	100.00	92.00	80-100	PEMELIHARAA N RUTIN
11 .	4+852 4+950	98.00	81.00	80-100	PEMELIHARAA N RUTIN
12 .	4+950 5+050	100.00	83.00	80-100	PEMELIHARAA N RUTIN
	Panjang	898.00 -			
13 .	5+150 5+250	100.00	85.00	80-100	PEMELIHARAA N RUTIN
14 .	5+250 5+335	85.00	89.00	80-100	PEMELIHARAA N RUTIN
15 .	5+335 5+435	100.00	76.00	80-100	LAPIS TAMBAHAN
16 .	5+435 5+550	115.00	85.00	80-100	PEMELIHARAA N RUTIN
17 .	5+550 5+650	100.00	85,00	80-100	PEMELIHARAA N RUTIN
	Panjang	500.00			
18 .	5+500- 5+608	108.00	85.00	80-100	PEMELIHARAA N RUTIN
19 .	5+608- 5+700	92.00	85.00	80-100	PEMELIHARAA N RUTIN
	Panjang	200.00			
	PANJANG	1,900.00			
		-			

Once all damage on the existing pavement has been properly addressed, the overlay can be applied using the specified thickness. After the overlay is completed, the shoulders should be constructed using hard shoulder materials. By using materials that meet the required technical specifications, the pavement optimization goals can be successfully achieved.

Segmen /STA	Jenis Keusakan	Penaggulangan Kerusakan	Evaluasi		Surpace	Surpace - LPA	Prosedur Pelaksanaan
			Asphal Institute MS-17	Metode Pt-012002-B			
3+850 s/d 4+050	Retak buaya Lubang Simbol R.M RR.M RR.RB.M	Lapis Tambahan (overlay)	Lapis Tambahan (overlay) PCR+79	Lapis Tambahan (overlay) SN=9,04 SNeff=9,04	Asb=23	Asb=7 lpa=46	.-Patching, sealing dan buras/latasit .-overlay .-hard .-shoulder
4+150 s/d 4+650	Retak buaya Lubang Simbol	Lapis Tambahan (overlay)	Lapis Tambahan (overlay) PCR+79	Lapis Tambahan (overlay) SN=9,35 SNeff=4,20	Asb=24	Asb=7 lpa=49	.-Patching, .-overlay .-hard .-shoulder
5+500 s/d 5+700	Retak buaya Lubang	Lapis Tambahan (overlay)	Pemiliha raan rutin PCR+79	Lapis Tambahan (overlay) SN=10,62 SNeff=4,20	Asb=28	Asb=7 lpa=61	.-Patching, .-overlay .-hard .-shoulder

Keterangan
R.M : Retak memanjang
RR.M : Retak - retak memanjang
RR.RB.M : Retak - retak rambut Memanjang
Asb : Aspal buton

Pavement Strength Optimization

To achieve optimal pavement strength for a planned service life of five (5) years after the application of an overlay, the overlay thickness must follow the results of the pavement thickness analysis for each segment/station (sta.) as described in the previous sub-section on pavement thickness optimization. However, before applying the overlay, all existing pavement damage must first be repaired according to the type of distress observed. The types of damage and their corresponding treatments are as follows:

1. Alligator cracking, potholes, and upheavals should be repaired using patching. After patching, the surface should be covered with asphalt concrete.
2. Longitudinal and hairline cracks should be treated with crack sealing, followed by a surface layer of sheet asphalt (buras) or sand seal (latasir).

Conclusion

Based on the results of this study, the total length of the research area is 1,900 meters, consisting of:

- 1,200 meters in Segment Sta. 3+850 to Sta. 4+050
- 500 meters in Segment Sta. 4+150 to Sta. 4+650
- 200 meters in Segment Sta. 5+500 to Sta. 5+700

The percentage and types of pavement damage observed in each segment are as follows:

- Segment Sta. 3+850 to Sta. 4+050:
  - Alligator cracking: *unspecified*
  - Potholes: 11.01%
  - Upheaval: 0.19%
  - Longitudinal cracks: 0.83%

  - Fine longitudinal cracks: 0.47%
  - Hairline longitudinal cracks: 0.10%
  - Total damage: 18.70%
- Segment Sta. 4+150 to Sta. 4+650:
  - Alligator cracking: 0.47%
  - Potholes: 3.40%
  - Upheaval: 0.30%
  - Total damage: 29.17%
- Segment Sta. 5+500 to Sta. 5+700:
  - Alligator cracking: 4.50%
  - Potholes: 13.50%
  - Total damage: 18.00%

Based on the evaluation using the Asphalt Institute MS-17 (Pavement Condition Rating/PCR) method, the recommended treatments are:
a) Segment Sta. 3+850 to Sta. 4+050: Overlay
b) Segment Sta. 4+150 to Sta. 4+650: Overlay
c) Segment Sta. 5+500 to Sta. 5+700: Routine maintenance

According to the PtT-01-2002-B pavement thickness evaluation method, the recommended treatments are:
a) Segment Sta. 3+850 to Sta. 4+050: Overlay
b) Segment Sta. 4+150 to Sta. 4+650: Overlay
c) Segment Sta. 6+500 to Sta. 6+700: Overlay

For pavement optimization, the most effective overlay thicknesses are:
a) Segment Sta. 3+850 to Sta. 4+050: 7 cm asphalt concrete + 46 cm base (LPA)
b) Segment Sta. 4+150 to Sta. 4+650: 7 cm asphalt concrete + 49 cm base (LPA)
c) Segment Sta. 6+500 to Sta. 6+700: 7 cm asphalt concrete + 61 cm base (LPA)

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