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Road Improvement Based on The Results of Road Deflection Test on Brigjend. Pol Imam Bachri HP Road Kediri City

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***Abstract*— Roads are vital infrastructure that support community mobility and economic growth. Road damage can reduce comfort, safety, and service life. Over time and with increasing service age, road quality generally deteriorates, as indicated by damage to the pavement structure. Roads with high traffic volumes tend to experience faster surface quality degradation. This condition can lead to discomfort and pose safety risks for road users. One of the damaged road sections in Kediri City is Brigjend. Pol. Imam Bachri Hadi Pranoto Street. The damage includes 30 potholes, which have caused accidents along this road. This road serves as a strategic route for distribution and tourism access to Mount Kelud. This study aims to determine the necessary road improvement efforts based on the results of the Benkelman Beam deflection test. The analysis is conducted to formulate repair actions based on the 2024 Road Pavement Design Manual. The analysis results recommend the implementation of a 70 mm thick overlay to enhance the strength of the existing pavement structure.**

***Keywords*— Road, Road Improvement, Benkelman Beam**

I. INTRODUCTION

Roads play a crucial role in the development of society as essential infrastructure for transportation, serving as a lifeline that connects communities. They hold strategic importance in supporting the achievement of national development goals, including equitable development and distribution of its benefits, stimulating economic growth, and realizing social justice for all Indonesians (Susantio, 2015). Roads are land-based infrastructure that include supporting and complementary structures intended for traffic, which may be located on the ground surface, above it, or below it, excluding railways, lorry tracks, and cable lines (Godinho et al., 2025). This role is emphasized in Law of the Republic of Indonesia Number 38 of 2004 concerning Roads, which states that roads are part of the national transportation system and have a vital function in supporting social, economic, cultural, and environmental sectors.

Improving the quality of road infrastructure plays a crucial role in driving economic growth within a region. The development and maintenance of road networks are essential components of national development, as adequate road infrastructure not only enhances mobility and connectivity between regions but also contributes significantly to economic growth, social development, and the overall improvement of community welfare (Zuria et al., 2024).

According to Susantio (2015) and Fikri (2016), over time and with the increasing service age, road performance tends to deteriorate, as indicated by the emergence of damage to the pavement structure. Roads with high traffic volumes are particularly susceptible to surface quality degradation. This condition may lead to discomfort and safety risks for road users (Evitya, 2020).

Road damage can be caused by various factors, including traffic loads that exceed design capacity, the presence of water, substandard pavement materials, climatic conditions, subgrade instability, and inadequate compaction processes (Sukirman, 1991 as cited in Putra et al., 2022). Road damage in a particular area can hinder the smooth operation of community activities within and around the affected region. Technically, road damage occurs when the pavement exhibits structural and functional failures, ultimately preventing the road from providing optimal service to passing traffic (Ladja et al., 2022).

Brigjend. Pol. Imam Bachri Hadi Pranoto Road is a critical roadway that plays a vital role in facilitating access and supporting the economic activities of the people in Kediri City. In addition to serving as a primary route to the Gunung Kelud tourist area, it also functions as a major distribution corridor for sand materials from Mount Kelud. According to a report by Radar Kediri (2025), Brigjend. Pol. Imam Bachri Hadi Pranoto Road in Kediri City has experienced damage characterized by the presence of potholes at 30 locations. These potholes have contributed to traffic accidents along the road, with the damage worsening during the rainy season. This condition has led to a decline in the level of service provided by this road segment.

Figure 1 Road Condition
Source: Researcher Documentation, 2025

The image illustrates the locations of damage along Brigjend. Pol. Imam Bachri Hadi Pranoto Road in Kediri City. The observed damage can be categorized into several levels of severity. Minor damage, such as small potholes on the road surface, is present at various points along the roadway. In addition, moderate damage is identified in the form of longitudinal hairline cracks on the asphalt surface, indicating potential structural deterioration within the surface layer. Furthermore, severe damage is also evident, characterized by changes in asphalt elevation such as surface depressions or heaving that pose risks to road user comfort and safety. To address these issues, a road improvement analysis using overlay thickness is required.

This integrated approach is highly beneficial for making technical decisions regarding road improvement. By applying the 2024 Road Pavement Design Manual method, this study aims to determine the optimal road treatment strategy to repair existing damage and strengthen the pavement structure to accommodate the planned traffic load effectively.

II. METHODOLOGY

A. Research Design

The type of research conducted in this study is descriptive quantitative. The research was carried out by collecting road deflection test data using the Benkelman Beam method and average daily traffic (ADT) data. The collected data were then analyzed using formulas based on the 2024 Road Pavement Design Manual..

B. Research Location and Time

The research was conducted along Brigjend. Pol. Imam Bachri Hadi Pranoto Road in Kediri City. The study was carried out over a period of six months, starting from the literature review, data collection, to analysis. The literature review was conducted over a span of two months, data collection took three months, and the analysis and conclusion stages were completed within four months. The location of this studi presents on the Figure 1.

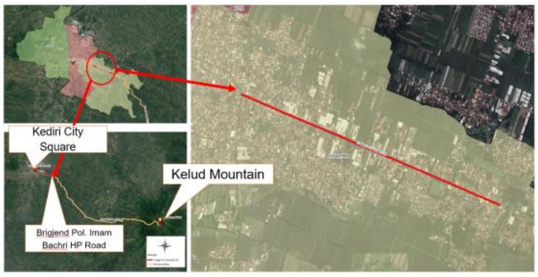

Figure 2 Research Location
Source: DPUPR Kediri City, 2025

C. Data Collection

The data collected in this study are categorized into two types: primary data and secondary data, as detailed below:

1. Primary Data
   Data obtained through direct measurements and surveys at the research site are referred to as primary data. The primary data used in this study include the following:

a) Indetification road damage
b) Road Deflection Test (Benkelman Beam)
   The road deflection test data in this study were obtained using the Benkelman Beam (BB) method. This test was conducted to determine the magnitude of elastic deflection caused by traffic loads on the pavement. The following are several documentation images taken during the road deflection survey using the Benkelman Beam (BB).

Figure 3 Road Deflection Survey
Source: Researcher Documentation, 2025

The results of the deflection test measurements can be seen in the following table.

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Table 1 Benkelman Beam Test Result

Sta	Load [kN]	D_0 [µm]	D_{200} [µm]	Field Temperature [^{o}c]	Existing Asphalt Thickness [mm]
0+000	117.68	750	320	39	150
0+250	117.68	990	380	39	150
0+500	117.68	980	390	39	150
0+750	117.68	880	360	39	150
1+000	117.68	1070	430	39	150
1+250	117.68	1240	520	39	150
1+500	117.68	1280	510	39	150
1+750	117.68	1140	460	39	150
2+000	117.68	1050	420	39	150
2+250	117.68	1150	460	39	150

Source: Researcher Analysis, 2025

The table presents the results of pavement deflection testing using Benkelman Beam which has been converted to Falling Weight Deflectometer (FWD).

2. Secondary Data

a) Average daily traffic (ADT) Data

Table 2 Annual Average Daily Traffic (AADT)

Vehicle types	ADT (2 Direction)	ADT2025
Type 1-4	16819	17,408
Type 5 A	37	38
Type 5 B	25	26
Type 6 A	159	165
Type 6 B	210	217
Type 7A1	115	119
Type 7B2	15	16

Source: DPUPR Kediri City, 202

The Average Daily Traffic (ADT) volume increased from 17,380 to 17,989 vehicles in 2025, representing a growth of approximately 3.5%. The increase occurred across all vehicle types, with light vehicles remaining the dominant category..

D. Analysis Method

The road improvement analysis is selected based on the type and condition of the existing damage. The steps of the road improvement analysis are as follows..

1. Road damage identification Data collected from field surveys were processed and analyzed using Microsoft Excel software.

2. Road Deflection Test

The Benkelman Beam test is used to measure deflection on the asphalt surface. The testing device is placed between the left/right dual wheels of a truck with an 8.2-ton rear axle load. Dial gauge readings are taken twice: once when the truck moves forward by 0.2 meters, and again when it moves 6 meters away from the Benkelman Beam device.

3. Determinationof Road Improvement

The overlay analysis involves traffic analysis and overlay design, detailed as follows:

Traffic Analysis

- Calculate the cumulative traffic growth factor (R),
- Determine the directional distribution factor (DD),
- Determine the lane distribution factor (DL),
- Determine the Vehicle Damage Factor (VDF),
- Determine the design life of the road,
- Calculate the cumulative equivalent standard axle load (CESAL) over the design life.

Overlay Design Analysis

Determine the minimum overlay thickness to meet the following criteria:

- Profile correction to reduce the IRI value to 3 m/km
- Superelevation correction
- Requirements based on maximum deflection

Determining the minimum overlay thickness, if a thin overlay meets both the structural requirements and is capable of reducing the International Roughness Index (IRI) to 3 m/km, it can be chosen as the primary option. However, if the thin overlay does not meet either criterion, an alternative overlay that satisfies the structural requirements and achieves the target IRI value of 3 m/km should be used.

III. RESULT

A. Analisis Beban Sumbu Standar (ESA)

Table 3 Analysis of Design Lane Traffic Load

Vehicle types	VDF 4	VDF 5	ESA 4	ESA 5
	Factual	Factual	2025-2035	2025-2035
Type 1-4	-	-	-	-
Type 5 A	-	-	-	-
Type 5 B	1,20	1,30	95.059,479	102.981,102
Type 6 A	0,50	0,40	249.424,083	199.539,266
Type 6 B	2,70	3,70	1.774.657,702	2.431.938,332
Type 7A1	10,30	16,50	3.704.750,497	5.934.794,486
Type 7B2	18,20	26,70	857.248,092	1.257.611,213
Sum of ESA			**6.681.139,85**	**9.926.864,40**

Source: Researcher Analysis, 2025

The Average Daily Traffic (ADT) volume increased from 17,380 to 17,989 vehicles in 2025, representing a growth of approximately 3.5%. The increase occurred across all vehicle types, with light vehicles remaining the dominant category. Articulated trucks recorded the highest percentage increase, reaching 6.7%.

Table 4 Benkelman Beam Test Data

Sta	Load [kN]	D_0 [µm]	D_{200} [µm]	Field Temperature [^{o}c]	Existing Asphalt Thickness [mm]
0+000	117.68	750	320	39	150
0+250	117.68	990	380	39	150
0+500	117.68	980	390	39	150
0+750	117.68	880	360	39	150
1+000	117.68	1070	430	39	150
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2+000	117.68	1050	420	39	150
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Source: Researcher Analysis, 2025

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Table 4 The table presents the results of pavement deflection testing using Benkelman Beam which has been converted to Falling Weight Deflectometer (FWD) at several observation points (STA) ranging from STA 0+000 to STA 2+250. At each point, a load of 117.68 kN was applied under a constant field temperature of 39°C. These test results were subsequently used for deflection analysis calculations, as shown in Table 5..

Table 5 Deflection Analysis

STA	D_0 normal	D_{200} normal	D_{0-200} normal	AMPT / Field Temp
0+000	254.93	108.77	146.16	1.05
0+250	336.5	129.16	207.34	1.05
0+500	333.11	132.56	200.54	1.05
0+750	299.12	122.37	176.75	1.05
1+000	363.7	146.16	217.54	1.05
1+250	421.48	176.75	244.73	1.05
1+500	435.08	173.35	261.73	1.05
1+750	387.49	156.36	231.13	1.05
2+000	356.9	142.76	214.14	1.05
2+250	390.89	156.36	234.53	1.05

Source: Researcher Analysis, 2025

The results of the pavement deflection analysis are based on normalized values derived from Falling Weight Deflectometer (FWD) testing data at several observation points (STA). The parameters presented include the normalized deflection at the center of the load (D_0 normal), the deflection at a distance of 200 mm from the load center (D_{200} normal), and the difference between them (D_0–D_{200} normal), which reflects the structural response of the pavement layers to dynamic loading.

The D_0 normal values range from 254.93 to 435.08 µm, while the D_{200} normal values vary between 108.77 and 173.35 µm. The deflection difference (D_0–D_{200} normal) indicates the rate of deflection reduction with increasing distance from the load center, ranging from 146.16 to 261.73 µm. A constant correction factor for temperature or thickness (AMPT/T. Layer) of 1.05 was applied at all points. This data provides an overview of the structural condition of the pavement and serves as a basis for evaluating and determining the necessary pavement reinforcement.

Table 6 Deflection Analysis

Sta	D0 Factor Correction Temp	D_{0-200} Factor Correction Temp	D_0 Corrected	D_{0-200} Corrected	D0 Adjustment to FWD
0+000	1.03	1.04	262.58	152	181.18
0+250	1.03	1.04	346.6	215.63	239.15
0+500	1.03	1.04	343.1	208.56	236.74
0+750	1.03	1.04	308.09	183.82	212.58
1+000	1.03	1.04	374.61	226.24	258.48
1+250	1.03	1.04	434.12	254.52	299.55
1+500	1.03	1.04	448.13	272.19	309.21
1+750	1.03	1.04	399.11	240.38	275.39
2+000	1.03	1.04	367.61	222.7	253.65
2+250	1.03	1.04	402.62	243.91	277.8
Sum				2,219.98	2,543.73
Average				222	254.37
Standart Deviation					39.02
Variation Coefficien					15.30%
Characteristic Deflection					318.56

Source: Researcher Analysis, 2025

Table 6 presents the results of further analysis of pavement deflection data that have been corrected based on the temperature correction factor (Temp Correction Factor) for the parameters D_0 and D_{200}. The D_0 and D_{200} values corrected for temperature were then used to calculate the final values adjusted to the Falling Weight Deflectometer (FWD) standard. The corrected D_0 values range from 262.58 to 438.13 µm, while the corrected D_{200} values range from 152 to 258.42 µm. The adjustment of D_0 values to the FWD standard resulted in final values ranging from 181.18 to 303.65 µm. The average adjusted D_0 value is 254.73 µm, with a standard deviation of 39.02 µm and a coefficient of variation of 15.30%, indicating a moderate degree of data dispersion. Based on these calculations, the characteristic deflection value is determined to be 318.56 µm, which serves as a fundamental parameter in evaluating pavement structural strength and designing the overlay thickness.

B. Overlay Analysis

The analysis using the 2024 Road Pavement Design Manual method yielded the following values:

D0 average, $\overline{D_0}$	= 0,25 mm
Standart Deviation, s	= 0,039 mm
Variation Coeficien	= 15,30 %
D0 representative	= 0,32 mm
D0 – D200 average	= 0,22 mm
ADT 2034	= 6.681.139,85 ESA4
	= 9.926.864,40 ESA5

These values are then plotted into the overlay thickness determination graph, as shown in Figure 4 and Figure 5 below.

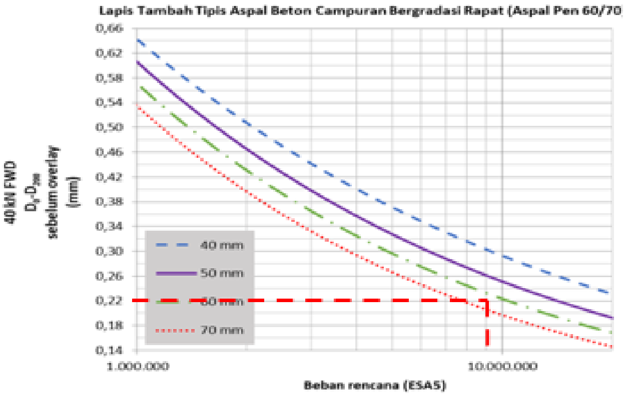

Figure 4 Determination of Overlay Thickness (Thin)
Source: Researcher Analysis, 2025

This graph is utilized to determine the required overlay thickness based on the target deflection value after reinforcement and the projected cumulative traffic loading. The intersection of the red horizontal and vertical guide lines represents the calculated values that reflect the actual conditions, namely the characteristic deflection and design traffic load. From the graph, it can be observed that for a design load of approximately 10 million ESAL and a target deflection of around 0.22 mm, the required overlay thickness falls within the range of 70 mm, as indicated by the dashed red curve. This information serves as a reference in designing the pavement overlay thickness to ensure it can sustain traffic loads over the intended design life.

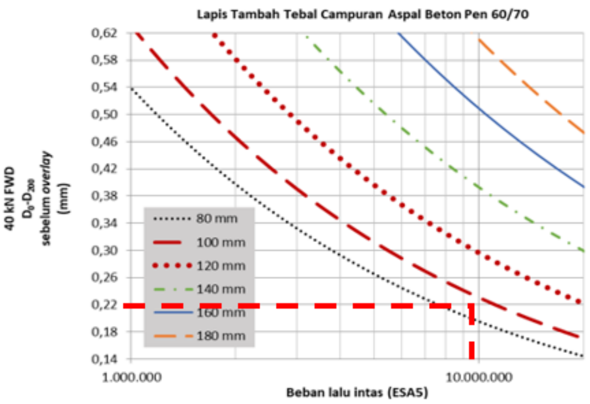

Figure 5 Determination of Overlay Thickness (Thick)
Source: Researcher Analysis, 2025

Based on the overlay thickness determination graph, an overlay thickness of 100 mm was initially identified. However, to enhance the structural capacity of the existing pavement to adequately support the anticipated traffic loads, the implementation of an overlay is required. The analysis results indicate that an overlay thickness of 70 mm satisfies both structural criteria—resistance to permanent deformation and fatigue cracking—as well as the minimum thickness requirement to reduce the International Roughness Index (IRI) value. Therefore, the recommended minimum overlay thickness for the pavement design is 70 mm.

IV. CONCLUSION

Based on the evaluation results, the recommended treatment includes localized repairs such as crack rehabilitation, pothole patching, and rut correction due to wheel path deformation. Furthermore, to enhance the structural capacity of the existing pavement in accommodating the projected traffic loads as outlined in the design plan, the implementation of an overlay with a thickness of 70 mm is recommended.

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