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Consistency Testing of Light Weight Deflectometer (LWD) Tool Pusjatan on Composite Road (Case Study of Road Section Soreang New Ring Road, Bandung Regency)

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ABSTRACT

In an era of rapid technological and infrastructural development, the quality of roads is critical to ensuring efficient and safe mobility. Composite roads, which consist of a mixture of different types of construction materials, have become an attractive option in road development in various regions. However, to ensure the success of composite roads, structural consistency and performance must be considered. A Light Weight Deflectometer (LWD) is a device used to measure the instability of road layers by applying surface pressure and measuring the resulting deflection. Although the use of LWD is common in the road construction industry, specific research on LWD consistency testing of composite roads is limited. This study investigates and analyzes the consistency of LWD on composite roads to improve the understanding of its performance. The results of the study on composite pavements conducted at three points with 30 trials showed a coefficient of variance of less than 5%. This result indicates very strong data consistency. Based on these consistency values, the LWD is acceptable, but it needs to be correlated with other tools to determine its validity. If the consistency and correlation meet the requirements or are less than 5%, LWD has a good chance of being used in composite pavements.

Keywords: *Compound Road; Light Weight Deflectometer (LWD); Consistency Testing.*

INTRODUCTION

In an era of rapid technological and infrastructure development, the quality of roads is critical to ensure efficient and safe mobility [7], [9], [18]. Composite roads, which consist of a mixture of different types of construction materials, have become an attractive option in road development in various regions [13], [17]. The advantages of composite roads lie in their better structural strength and durability compared to conventional roads, as well as their ability to withstand fluctuating traffic loads [8], [12], [16].

However, to ensure the successful implementation of composite roads, structural consistency and performance must be considered. Consistency testing of composite pavements is critical in understanding the material characteristics and the ability of such pavements to withstand heavy traffic loads [4], [10], [11]. Composite pavements have demonstrated optimal strength to create cost-effective pavement options that can withstand excessive traffic [2], [5], [14]. Composite pavements are known as rigid or flexible structures in various countries, and have been maximally applied on roads with heavy traffic, as they are able to withstand more than 50

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million equivalent single axle loads (ESAL) [1], [11], [15].

Although composite pavements have many advantages, the main challenge is achieving stability and consistency that meet the requirements of technical standards. These pavements combine a rigid layer with a paved layer on the surface to create a dense and firm layer that bears the traffic load. Therefore, a careful inspection process is required to ensure that the quality of the composite pavement meets the requirements of the technical standards.

One commonly used testing method is the Light Weight Deflectometer (LWD). LWD is a device used to assess the instability of road layers by applying surface pressure and measuring the resulting deflection. Although the use of LWD is common in the road construction industry, specific studies on LWD consistency testing of composite roads are limited [3], [6].

This study aims to test the consistency of the Pusjatan LWD tool on composite roads with a case study on the Soreang New Ring Road, Bandung Regency. The consistency of LWD testing is very important to ensure that the data obtained is accurate and reliable for composite road quality evaluation. This study involved multiple measurement points and statistical analysis of the coefficient of variation of the measurement results.

Considering the important role of roads in transportation patterns and the capacity of using LWD as a deflection testing tool, this research is expected to make a significant contribution to the field of civil engineering, particularly in the understanding and application of LWD test equipment on composite pavements. This observation is expected to contribute useful data for the development of more efficient and durable road infrastructure.

METHODS

The study was conducted on Jalan Lingkar Baru Soreang, a composite pavement road connecting the Soroja Toll Road in Soreang, Bandung Regency. Observations were conducted for two months, from March to April 2024. The test used Pusjatan's Light Weight Deflectometer (LWD) to assess the condition of the road layer by collecting deflection data at three points 25 meters apart, each point tested 30 times.

Figure 1. Research Location

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The research procedure began with preparation, including determining the road section, checking the equipment, preparing personnel, and checking the test site. The Pusjatan LWD apparatus was placed on a flat road surface to ensure data consistency. Measurements were taken with Geophone 1 at 200 mm and Geophone 2 at 900 mm from the main load point. The load was dropped at five predetermined height levels.

Figure 2. Field Testing of LWD Tools

The equipment used included a Pusjatan LWD, a processing/acquisition unit and a laptop. Configuration was done by connecting the USB extension cable from the LWD to the laptop and ensuring that the detected ports match the settings in the LWD2017 software. Data was collected and analyzed using the LWD2017 software, with data capture steps including geophone distance input, load dropping, and data storage.

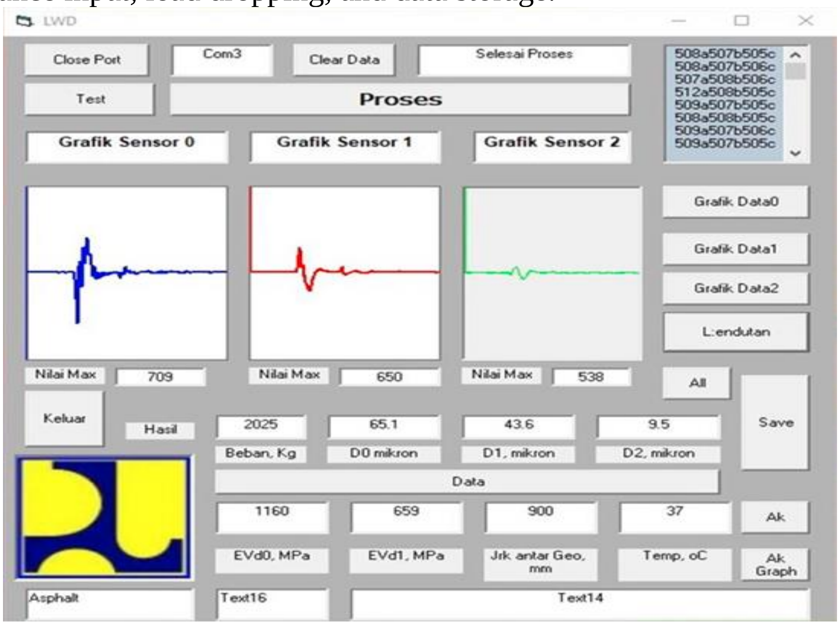

Figure 3: Software view of the LWD2017 tool

The calculation method involved processing the deflection data to obtain the coefficient of variation, Smean value, and standard deviation. The analyzed data was entered into table and graph formats in Microsoft Excel, and the mean value and coefficient of variation were calculated. The consistency of the LWD was calculated using certain equations, and if the results met the standards (less than 40 microns for equation 2.10 and 20 microns for equation 2.11), then the test results were considered valid.

The research flow chart includes tool preparation, testing at specific points, data processing using ADC, and consistency calculation. If the consistency value meets the requirements, the Pusjatan LWD is considered effective for testing composite roads.

RESULTS AND DISCUSSION

Testing at point 1 was carried out 30 times. The weather when testing is sunny. Testing at point 2 was carried out 30 times. The weather when testing is after rain and road conditions are still wet. Testing at point 3 was carried out 30 times. The weather when testing is after rain and the road conditions are dry. To facilitate data management, the raw data obtained in the field is then converted into data format:

Table 1. Coefficient of Variance of Testing point 1

Load (Kg)	D0 (Micron)	D2 (Micron)
12	51.99	26.77
	Std Dev: 2.12	Std Dev: 0.99
	CV: 4.08%	CV: 3.70%

From the table above, it can be seen that the load given is stable at 12 Kg, the deflection of the loading center (D0) ranges from 48 to 54.8 microns, while at D2 the value is smaller at 26.6 to 29.1 microns. This is influenced by the difference in distance between geophone (D0) and geophone (D2), namely D0 the distance is 0 mm, because it is at the center of the loading, while the distance of D2 from D0 is 90 cm from the loading center.

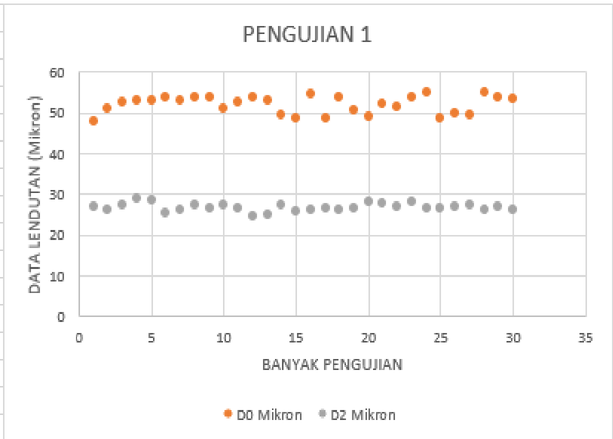

Figure 4. Testing Chart at Point 1

The graph shows that the deflection value of D0 is the highest compared to D2, which has the lowest value. This is due to the distance of the geophone from the loading center: the closer the geophone position, the higher the deflection value. D0 is at the loading center and therefore has the highest value, while D2, which is 900 mm away from the center, has the lowest value. Geophone D1 was not used in the composite pavement test because its deflection value was too small, indicating a good pavement. Therefore, the consistency test only used geophones D0 and D2. After testing at point 1, the same procedure was repeated at points 2 and 3 with 30

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tests at each point using the Pusjatan LWD tool.

The following is the calculation of the average value, standard deviation value and coefficient of variance at the first test point:

1. Average (X Bar) deflection value at the first test point.

$$\bar{x}\ (DO) = 48 + 51.1 + 52.5 + 52.9 + \cdots / \ 30 = 51.99\ mikron$$

$$\bar{x}\ (D2) = 27.1 + 26.2 + 27.2 + 29.1 + \cdots / \ 30 = 26.77\ mikron$$

2. Standard Deviation value at the first test point.

$$\sigma\sigma\ (D0) = \sqrt{\frac{(48 - 51.99)^2 + (51.1 - 51.99)^2 + (52.5 - 51.99)^2 \ldots}{30 - 1}} = 2.12$$

$$\sigma\ (D2) = \sqrt{\frac{(27.1 - 26.77)^2 + (26.2 - 26.77)^2 + (27.2 - 26.77)^2 \ldots}{30 - 1}} = 0.99$$

3. Coefficient of Variance (CV) value at the first test point.

CV (D0) = (2.12/51.99) X 100% = 4.08 %
CV (D2) = (0.99/26.77) X 100% = 3.70 %

Table 2. Coefficient of variance of testing point 2

Load (Kg)	**D0 (Micron)**	**D2 (Micron)**
12	44.11.00	25.49.00
	Std Dev: 1.59	Std Dev: 0.75
	CV: 3.60%	CV: 2.95%

The table shows that with a steady load of 12 Kg, the deflection at the loading center (D0) ranges from 41.8 to 47.8 microns, while at D2 it ranges from 23.8 to 27.1 microns. This difference is due to the distance between the geophones: D0 is at the loading center (0 mm), while D2 is 90 cm from the center.

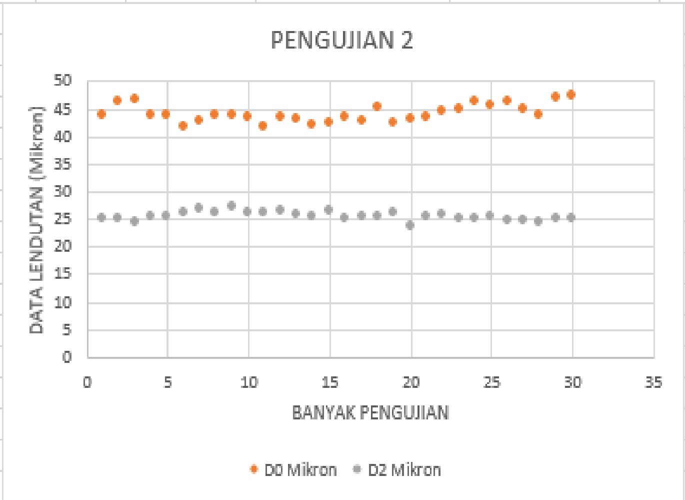

Figure 5. Testing Chart at Point 2

The graph shows that the deflection of geophone D0, which is at the loading center, is higher than that of D2, which is located 90 cm from the center. The closer the geophone is to the loading center, the higher the deflection value. Geophone D1 was not used because the resulting deflection value was too small to read, indicating that the composite pavement in this

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study was excellent. Therefore, only geophones D0 and D2 were used in the test. After the second test point, the test continued at the third point with the same procedure, i.e. 30 tests using the Pusjatan Light Weight Deflectometer (LWD).

The following is the calculation of the average value, standard deviation value and coefficient of variance at the second test point:

1. Average (X Bar) deflection value at the second test point.
$$\bar{x}\ (DO) = 43.8 + 46.4 + 46.6 + 43.9 + \cdots / \ 30 = 44.11\ mikron$$
$$\bar{x}\ (D2) = 25.2 + 25.2 + 24.5 + 25.3 + \cdots / \ 30 = 25.49\ mikron$$
2. Standard Deviation value at the second test point.
$$\sigma\ (D0) = \sqrt{\frac{(43.8 - 44.11)^2 + (46.4 - 44.11)^2 + (46.6 - 44.11)^2 \ldots}{30 - 1}} = 1.59$$
$$\sigma\ (D2) = \sqrt{\frac{(25.2 - 25.49)^2 + (25.2 - 25.49)^2 + (24.5 - 25.49)^2 \ldots}{30 - 1}} = 0.75$$

Coefficient of Variance (CV) value at the second test point.

CV (D0) = (1.59/44.11) X 100% = 3.60 %
CV (D2) = (0.75/25.49) X 100% = 2.95 %

Table 3. Coefficient of variance of testing point 3

Load (Kg)	D0 (Micron)	D2 (Micron)
12	45.68	26.18.00
	Std Dev: 2.04	Std Dev: 1.00
	CV: 4.46%	CV: 3.83%

From the table above, it can be seen that a steady load of 12 Kg produces deflections ranging from 42.3 to 49.3 microns at D0 (the loading center), while at D2 (90 cm from the center) the deflections range from 24.3 to 28.2 microns. This difference is due to the distance between geophones D0 and D2 from the loading center.

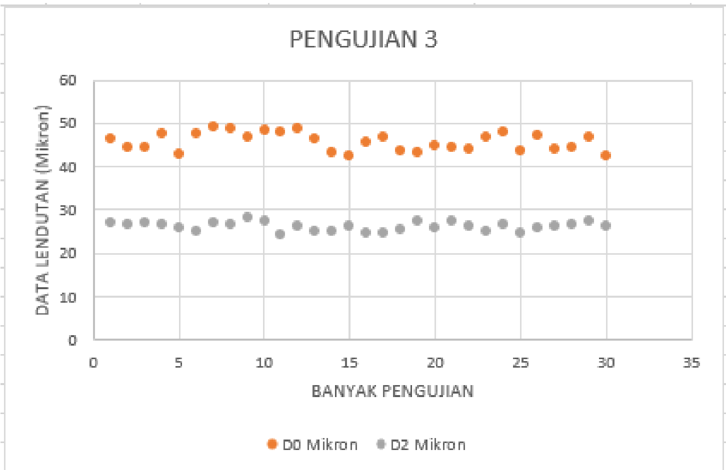

Figure 6. Testing Chart at Point 3

The graph shows that the deflection at D0, which is at the loading center, is higher than that at

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D2. The deflection of D2, which is located 90 cm from the center, is lower. This is because deflection increases as the geophone (sensor) gets closer to the loading center and decreases as it gets further away. Geophone D1 was not used because the deflection results were too small to read, indicating that the composite pavement was very good. Therefore, only D0 and D2 were used in the test.

The following is the calculation of the average value, standard deviation value and coefficient of variance at the third test point:

1. Average (X Bar) deflection value at the third test point.

$$\bar{x}\ (DO) = 46.5 + 44.3 + 44.4 + 47.4 + \cdots / \ 30 = 45.68\ mikron$$

$$\bar{x}\ (D2) = 27.1 + 26.5 + 27.2 + 26.6 + \cdots / \ 30 = 26.18\ mikron$$

2. Standard Deviation value at the third testing point.

$$\sigma\ (D0) = \sqrt{\frac{(46.5 - 45.68)^2 + (44.4 - 45.68)^2 + (47.4 - 45.68)^2 \ldots}{30 - 1}} = 2.04$$

$$\sigma\ (D2) = \sqrt{\frac{(27.1 - 26.18)^2 + (26.5 - 26.18)^2 + (27.2 - 26.18)^2 \ldots}{30 - 1}} = 1.00$$

3. Coefficient of Variance (CV) value at the third testing point.

CV (D0) = (2.04/45.68) X 100% = 4.46 %
CV (D2) = (1.00/26.18) X 100% = 3.83 %

To test the consistency of the composite pavement using the Pusjatan LWD, the coefficient of variance of the three test points is required. The smaller the coefficient of variance, the more consistent the data. The calculation of the coefficient of variance involves the average and standard deviation. The following is a recapitulation of the calculations carried out.

Based on the results of the previous calculations, the following is a recapitulation of the average deflection value at three (3) test points using the Pusjatan LWD tool:

Tabel 4. Recapitulation of Average Deflection or Deflection Values

Testing Point	**D0**	**D2**
	(Mikron)	**(Mikron)**
Testing 1	51.99	26.77
Testing 2	44.11	25.49
Testing 3	45.68	26.18

Based on the results of the previous calculations, the following is a recapitulation of the results of the standard deviation value of field testing from the three test points:

Table 5. Recapitulation of LWD Testing Standard Deviation

Testing Point	**D0**	**D2**
	(Mikron)	**(Mikron)**
Testing 1	02.12	0,06875
Testing 2	01.59	0,0520833

Testing 3	02.04	01.00

Based on the results of the previous calculations, the following is a recapitulation of the results of the coefficient of variation value of the three test points in the field:

Tabel 6. Varian Coefficient (%) G0 Vs G2

Testing Point	D0 (Mikron)	D2 (Mikron)
Testing 1	4.08 %	3.70 %
Testing 2	3.60 %	2.95 %
Testing 3	4.46 %	3.83 %

This study was designed to evaluate the consistency of Pusjatan's Light Weight Deflectometer (LWD) in application to composite pavements. The focus of the research was on the Soreang New Ring Road section in Bandung Regency, an area that has relevant composite road characteristics for this test. This road is an important part of the local infrastructure that connects various regions, so ensuring the quality and consistency of the pavement is crucial.

To obtain representative data, tests were conducted at three different points along the same road section. At each point, 30 trials were conducted to ensure that the data obtained accurately reflected the real conditions. Each trial was measured using the LWD tool to assess how consistent the deflection produced by the tool was on the composite pavement.

The coefficient of variance (CV) was used as the primary metric to assess data consistency. CV is a statistical measure that indicates the relative variation in the data, which is important for determining how reliable and consistent the test results from the LWD tool are. By analyzing the coefficient of variance, this study aims to evaluate the extent to which the LWD tool can provide consistent results under various test conditions, and whether the tool is acceptable for use in composite pavement testing in general.

Based on the calculation results, the highest coefficient of variance obtained from the test at D0 was 4.46%, while that at D2 was 3.83%. This coefficient of variance is an important indicator to assess the consistency of the data generated during the test. In the context of composite pavement testing, there is no definitive standard to set an acceptable limit for the coefficient of variance. Therefore, the coefficient of variance results obtained from this study provide an initial overview of the performance of the Pusjatan Light Weight Deflectometer (LWD) in its practical application.

The coefficient of variance measured from the three test points shows consistent results and is below 5%. This indicates that the data obtained during the test is still within the acceptable range, indicating that the LWD tool is capable of providing reliable and consistent results. In comparison, a previous study by Nazzal (2014) showed that the coefficient of variance in asphalt pavement testing reached 4%, indicating that the coefficient of variance in composite pavements obtained in this study is relatively small and shows good consistency.

Thus, the results of this study indicate that the Pusjatan LWD tool has good potential for use in composite pavement consistency testing. The findings support the applicability of the LWD in composite pavement quality evaluation and provide a strong basis for further use of the tool in field testing. In addition, the results of this study can serve as a reference for the development of better testing standards and for the improvement of future pavement quality evaluation methods.

CONCLUSIONS

According to the calculation of the coefficient of variance in tests 1, 2 and 3, the coefficient of variation obtained in D0 is 4.08%, 3.06% 4.46% and D2 is 3.70%, 2.95% 3.83%. with the largest values in D0 and D2 are 4.46% and 3.83%, but because there has been no research on the coefficient of variation in the use of the Pusjatan LWD tool on composite roads, the coefficient of variance limit for composite pavement cannot be determined. The coefficient of variance is an indicator in determining data consistency. The lower the coefficient of variance number, the more consistent the data will be taken during the test. From the research on composite pavement that has been carried out at 3 points with 30 trials, the coefficient of variance obtained is still less than 5% and it can be said that the coefficient of variance obtained is of small value. With a coefficient of variance of less than 5%, the consistency of LWD on composite roads is acceptable and this LWD tool has the opportunity to be used on Composite pavement.

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