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# Structural Evaluation of Flexible Pavement with 2017 Road Pavement Design Manual (MDP) and 2017 Austroads Method (Case Study: Tanah Runtuh - Tawaeli National Road Section)

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**Abstract**

*National roads in urban and rural areas use flexible pavement in general. If damage occurs on the pavement, structural road maintenance can be analyzed. The most commonly used evaluation for structural pavements is conducting a deflection survey using the Falling Weight Deflectometer (FWD) tool, where the results from the deflection evaluation can be used to determine the overlay. This research aims to conduct a structural evaluation of the Tanah Runtuh – Tawaeli National Road section and determine the required overlay thickness using the 2017 MDP and Austroads method. The road segment is divided into STA 10+000 to 12+656 and STA 14+400 to 18+700. The required overlay thickness using the 2017 MDP for average pavement temperatures of 47°C, 42°C, 41°C, 38° C, and 35°C is 80 mm for both segments. The required overlay thickness using Austroads method is 114mm and 98mm for a temperature of 47°C, 105mm for a temperature of 42°C, 97mm for a temperature of 41°C, 85mm for a temperature of 38°C, and 83mm for a temperature of 35°C. The analysis results using the 2017 MDP is not affected by the pavement temperature, meanwhile the overlay thickness from the Austroads method show that the pavement temperature affects the required overlay thickness.*

**Key words:** Flexible pavement, deflection, FWD, overlay thickness, MDP 2017, austroads.

**Abstract**

*Jalan nasional di perkotaan maupun luar kota masih umum menggunakan perkerasan lentur. Apabila terjadi kerusakan pada perkerasan dapat dilakukan pemelihaaran jalan secara struktural pada perkerasan tersebut. Evaluasi yang paling umum digunakan untuk struktural perkerasan adalah dengan melakukan survey lendutan dengan menggunakan alat Falling Weight Deflectometer (FWD) yang mana hasil dari evaluasi lendutan dapat digunakan untuk menentukan lapis tambah (overlay). Penelitian ini bertujuan untuk melakukan evaluasi struktural pada ruas jalan Nasional Tanah Runtuh – Tawaeli dan menentukan tebal lapis tambah menggunakan metoda Manual Desain Perkerasan Jalan 2017 dan Austroads. Ruas dibagi menjadi 2 (dua) segmen yaitu segmen STA 10+000 s/d 12+656 dan STA 14+400 s/d 18+700. Kebutuhan tebal lapis tambah menggunakan metoda MDP 2017 untuk nilai temperatur rata-rata perkerasan 47°C, 42°C, 41°C, 38°C, dan 35°C adalah 80 mm untuk kedua segmen. Kebutuhan tebal lapis tambah dengan menggunakan metoda Austroads adalah 114 mm dan 98 mm untuk temperatur 47°C, 105 mm untuk temperatur 42°C, 97 mm untuk temperatur 41°C, 85 mm untuk temperatur 38°C, dan 83 mm untuk temperatur 35°C. Hasil analisis dengan menggunakan metoda MDP 2017 tidak dipengaruhi oleh temperatur perkerasan, sementara tebal overlay yang dihasilkan dari metoda Austroads menunjukkan bahwa temperatur perkerasan mempengaruhi tebal overlay yang dibutuhkan.*

**Key words:** Flexible pavement, deflection, FWD, overlay thickness, MDP 2017, austroads.

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# 1. Introduction

National roads are the link between provincial capitals and national strategic roads. In addition, national roads can also play an important role in the economic development in the surrounding area. Therefore, the construction of a road must be considered carefully, because it will impact the accessibility and socio-economic activities, thus it can develop properly.

It is common for national roads in urban and rural areas to use flexible pavement, where the binder used is asphalt. This pavement layer can carry and distribute the traffic load to the subgrade. Furthermore, it has flexibility and can create comfort for vehicles passing on it. If damage occurs on the pavement that causes it to be unable to serve properly, structural and functional road maintenance can be carried out.

One structural evaluation that can be conducted is a deflection survey. The most commonly used deflection survey in Indonesia is by using the Falling Weight Deflectometer (FWD) where the results of the deflection evaluation can be used to determine the value of overlay (Jiang et al., 2022; Singh et al., 2020) . Overlay planning is divided into several methods, which are the empirical method, the mechanistic method, and the mechanistic-empirical method. The empirical method is the first one used, by collecting data from a series of tests both in the laboratory and in the field. The mechanistic method is a structural calculation method based on stress, strain and deformation as a result of loading. The mechanistic-empirical method is a combination of the empirical method and the mechanistic method, where the material characteristics are sought from the laboratory or field and the pavement response model analytically.

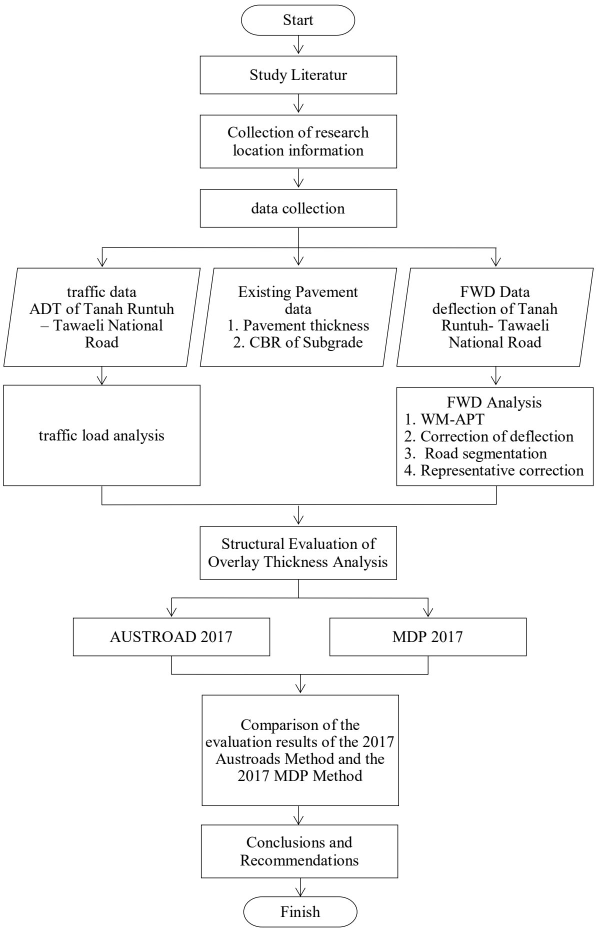


**Figure 1. Research flowchart**

In this research, the mechanistic method by Austroads (Austroad, 2017) and MDP (PUPR, 2017) were used to find out how to evaluate the structural conditions in the research area reviewed in this research, namely the Tanah Runtuh – Tawaeli National Road Section with Section number 18, Palu City. The total length of the evaluated road section is 9.08km with the 4/2 UD road type and a pavement width of 9m.

# 2. Research Methodology

## 2.1 Preparation stage

The preparation stage was carried out before data collection. The preparation stage is as follows:

1. The determination of topic and objectives of the research
2. Literature review related to the research topic
3. Preparation of research methodology in accordance with research topic and objectives
4. Determination of segments to be reviewed.

## 2.2 Data collection stage

The data collected is secondary data, where the data collected was obtained from field or laboratory test results. The data collected is as follows:

1. Pavement structural data
2. Deflection data from Falling Weight Deflectometer test results
3. Existing pavement data
4. Traffic Data

## 2.3 Data analysis stage

The secondary data obtained was then analyzed and adjusted with the methods that would be used.

a. Traffic Volume Analysis

Annual traffic volume data was used to obtain the CESAL (Cumulative Equivalent Single Axle Load) value.

b. Structural Condition Analysis

Structural condition analysis was conducted to obtain the overlay thickness using 2017 MDP method and Austroads method, in accordance with the data obtained.

c. Overlay Thickness Analysis

Overlay thickness analysis was conducted based on 2018 MDP method and Austroads method with design chart method.



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### 2.4 Suggestions and cnclusions-drawing stage

After the results of the two methods have been obtained, which is regarding the overlay thickness, conclusions were drawn according to the results obtained. The conclusions obtained are used as material in providing suggestions containing recommendations and additions that can be made to the results of the analysis or as useful information for improvement in further research in the future.

## 3. Data Presentation

Data used in this study are traffic data, VDF (vehicle damagae factor) data, Deflection Data, and existing pavement structure.

### 3.1 Traffic data

The traffic data used is the 2019 LHR data which is a secondary data obtained from Central Sulawesi National Road Implementation Agencies (BPJN). The traffic data is in **Table 1.**

### 3.2 VDF data

The VDF Data used is The VDF data used is secondary data obtained from the 2017 Pavement Design Manual Supplement. The VDF data is presented in **Table 2.**

### 3.3 Deflection data

The deflection data used is the survey data using the Falling Weight Deflectometer which was conducted on the Tanah Runtuh – Tawaeli National Road section. The deflection data obtained is also secondary data from the Central Sulawesi BPJN. The data can be seen in **Figure 2**.

**Table 1. Traffic volume data** (Central Sulawesi BPJN, 2019)

| Vehicle Type | Year |
|---|---|
| | 2019 |
| AADT | 5555 |
| Group 2 | 3692 |
| Group 3 | 264 |
| Group 4 | 942 |
| Group 5a | 10 |
| Group 5b | 10 |
| Group 6a | 50 |
| Group 6b | 493 |
| Group 7a | 58 |
| Group 7b | 1 |
| Group 7c | 35 |

**Table 2. VDF** (MDP supplement, 2020)

| Vehicle Group | VDF 4 | VDF 5 |
|---|---|---|
| Group 5b | 1,2 | 1,3 |
| Group 6a | 0,5 | 0,4 |
| Group 6b | 1 | 1,2 |
| Group 7a | 17,4 | 18,2 |
| Group 7c | 24,9 | 32,8 |

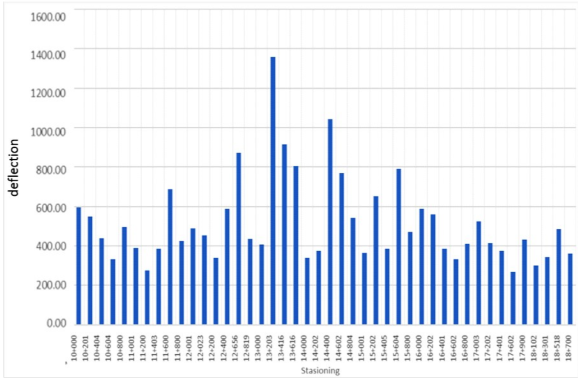


**Figure 2. Deflection data**

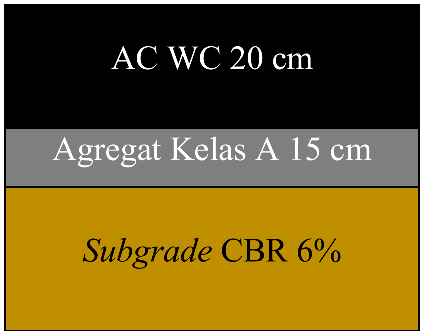


**Figure 3. Existing pavement structure**

### 3.4 Existing pavement structure

The existing pavement structure data was obtained from Central Sulawesi National Road Implementation Agencies (BPJN). The existing pavement structure data is presented in **Figure 2**.

## 4. Data Analysis

There are 3 data analyzes conducted, namely the design traffic load calculation analysis, deflection analysis, and overlay thickness analysis. Data analysis was done using the Austroads method and 2017 MDP method.

**Table 3. Analysis of ESA4 traffic load with 2017 MDP method**

| Vehicle Group | ADT 2019 | DD | DL | R | VDF4 | ESA4 |
|---|---|---|---|---|---|---|
| Group 2 | 3692 | 0,5 | 0,8 | 12,432 | - | - |
| Group 3 | 264 | 0,5 | 0,8 | 12,432 | - | - |
| Group 4 | 942 | 0,5 | 0,8 | 12,432 | - | - |
| Group 5a | 10 | 0,5 | 0,8 | 12,432 | - | - |
| Group 5b | 10 | 0,5 | 0,8 | 12,432 | 1,2 | 21781,02 |
| Group 6a | 50 | 0,5 | 0,8 | 12,432 | 0,5 | 45636,43 |
| Group 6b | 493 | 0,5 | 0,8 | 12,432 | 1 | 895614,9 |
| Group 7a | 58 | 0,5 | 0,8 | 12,432 | 17,4 | 1827272 |
| Group 7b | 1 | 0,5 | 0,8 | 12,432 | - | - |
| Group 7c | 35 | 0,5 | 0,8 | 12,432 | 24,9 | 1581847 |
| | | | | | **Total** | **4.372.152** |



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Tabel 4. Analysis of ESA5 traffic load with 2017 MDP method

| Vehicle Group | ADT 2019 | DD | DL | R | VDF5 | ESA5 |
|---|---|---|---|---|---|---|
| Group 2 | 3692 | 0,5 | 0,8 | 12,432 | | |
| Group 3 | 264 | 0,5 | 0,8 | 12,432 | | |
| Group 4 | 942 | 0,5 | 0,8 | 12,432 | | |
| Group 5a | 10 | 0,5 | 0,8 | 12,432 | | |
| Group 5b | 10 | 0,5 | 0,8 | 12,432 | 1,3 | 23596,11 |
| Group 6a | 50 | 0,5 | 0,8 | 12,432 | 0,4 | 36509,14 |
| Group 6b | 493 | 0,5 | 0,8 | 12,432 | 1,2 | 1074738 |
| Group 7a | 58 | 0,5 | 0,8 | 12,432 | 35,6 | 3738557 |
| Group 7b | 1 | 0,5 | 0,8 | 12,432 | | |
| Group 7c | 35 | 0,5 | 0,8 | 12,432 | 32,8 | 2083718 |
| | | | | | **Total** | **6.957.118** |

## 4.1 Design traffic load calculation with MDP 2017

In the 2017 MDP method, the calculation parameters used are as follows.

a. ADT (average daily traffic)
b. VDF (vehicle damage factor)
c. DD (directional distribution)
d. DL (lane distribution)
e. i (traffic growth)
f. R (traffic growth multiplier)

The design traffic load in 2017 MDP is called CESA (Cummulative Equivalent Standard Axle), where later the CESA4 value will be obtained which is used for damage due to permanent deformation, and CESA5 will be used for damage due to fatigue. The calculation of ESA4 and ESA5 can be seen in **Table 3** and **Table 4**.

## 4.2 Design traffic load calculation with austroads 2017 method

The parameters used in calculating the design traffic load with Austroads method are as follows.

a. AADT (Annual Average Daily Traffic*)*
b. DF (direction factor) or direction distribution factor
c. %HV (average percentage of heavy vehicle)
d. LDF (lane distribution factor)
e. CGF (cumulative growth factor)

Traffic load in Austroads is usually called DESA (Design Equivalent Standard Axle) where from the results of this DESA, 2 parameters based on damage type will be obtained. The DESA value will be multiplied by the SAR/ESA multipliers, which are DSAR5 (Design number of Standard Axle Repetition for Fatigue of Asphalt) and DSAR7 (Design number of Standard Axle Repetition for Rutting and Permanent Deformation).

## 4.3 Comparison of traffic load calculation with the 2017 MDP method and austroads method

In the calculation of traffic load both with 2017 MDP method and Austroads method, the 2019 traffic

Table 5. Analysis of traffic load calculation with austroads method

| Vehicle Group | AADT | LDF | DF | CGF | DESA |
|---|---|---|---|---|---|
| Group 5b | 10 | 0.8 | 0.5 | 12.432 | 18150.853 |
| Group 6a | 50 | 0.8 | 0.5 | 12.432 | 91272.861 |
| Group 6b | 493 | 0.8 | 0.5 | 12.432 | 895614.949 |
| Group 7a | 58 | 0.8 | 0.5 | 12.432 | 105015.650 |
| Group 7b | 1 | 0.8 | 0.5 | 12.432 | 2333.681 |
| Group 7c | 35 | 0.8 | 0.5 | 12.432 | 63527.986 |
| | | | | **Total** | **1.175.916** |

Table 6. SAR/ESA value

| No. | Damage Type | Damage Index | SAR/ESA Value |
|---|---|---|---|
| 1 | Fatigue Asphalt | SAR5/ESA | 2.1 |
| 2 | Rutting & Permanent Deformation | SAR7/ESA | 9.5 |

Table 7. Recapitulation of design traffic load with austroads method

| No. | DESA | DSAR5 | DSAR7 |
|---|---|---|---|
| 1 | 1.175.916 | 2.410.628 | 11.053.610 |

counting results data on Tanah Runtuh – Tawaeli National Road is used. Due to the limited data obtained, the traffic growth value used is the value set by the 2017 Pavement Design Manual, which is 4.75%. In the analysis of traffic load calculation using the 2017 MDP method, it is necessary to have a VDF (Vehicle Damage Factor) value where the VDF data used is the value issued by the 2017 Pavement Design Manual through the Pavement Design Manual Supplement for the Gorontalo, Central Sulawesi, and North Sulawesi areas. After that, for the calculation using the Austroads method, SAR/ESA value is needed to get the DSAR5 and DSAR7 values.

From the data, the traffic load value was obtained. Based on the 2017 MDP method the value of the traffic load is expressed in CESA (Cummulative Equivalent Standard Axle), where there are 2 CESA values: CESA4 of 4.372.152 and CESA5 of 6.957.118. The CESA4 is used for damage due to permanent deformation and CESA5 is used for damage due to fatigue cracking or fatigue. Meanwhile, for the Austroads method, the traffic load is expressed in DESA (Design Equivalent Standard Axle) where the DESA value obtained is 1.175.916 which is then from this one DESA value, DSAR5 (Design number of Standard Axle Repetition for Fatigue of Asphalt) of 2.410.628 and DSAR7 (Design number of Standard Axle Repetition for Rutting and Permanent Deformation) of 11.053.610 would be obtained.

## 4.4 Deflection analysis with 2017 MDP method

Similar to the Austroads method, the deflection analysis with the 2017 MDP method also uses 5



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different temperature values. Deflection analysis with 2017 MDP method will generate a representative deflection of $D_0$ for damage based on permanent deformation and $D_0 - D_{200}$ for damage based on cracking due to fatigue. The segmentation is divided into 2 : segment 1 : 10+000 to 14+202 and segment 2 : 14+400+18+700. The result can be seen in **Figure 4** for $D_0$ deflection and **Figure 5** for lendutan $D_0 - D_{200}$ deflection.

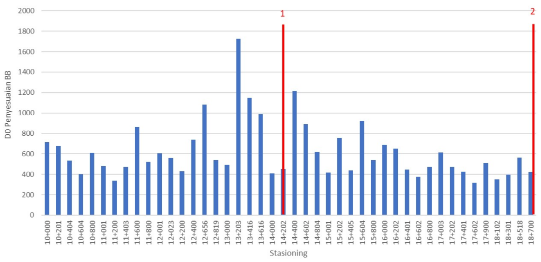

**Figure 4. $D_0$ deflection segmentation with AMPT 47°C**

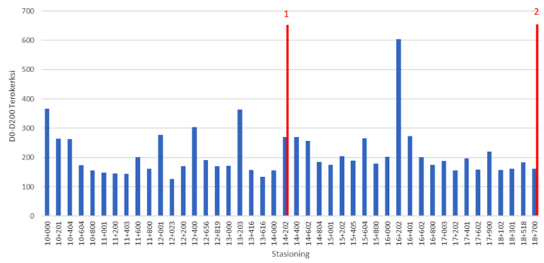

**Figure 5. D0 – D200 deflection segmentation with AMPT 47°C**

### 4.5 Deflection analysis with austroads method

Structural evaluation of the flexible pavement for the Tanah Runtuh – Tawaeli National Road section would be carried out using deflection from the results of the FWD test and would use 5 (five) different average pavement temperature values, where the first is the temperature value from the WMAP analysis on the Austroads method, then the temperature value set by the 2017 MDP, which is 42°C for coastal areas, 41°C as the average temperature in Indonesia, and 38°C for mountainous areas and 35°C as the lowest limit for pavement temperatures.

In the deflection analysis, it will be found that there is a segmentation division, based on the type of representative Deflection and Curvature. **Figure 6** is segmentation for representative Deflection and **Figure 7** is segmentation for representative Curvature.

To obtain the Characteristic Deflection (CD) value, standardization is needed, which is shown in **Table 10**. Meanwhile the standardization factor for CC is shown in **Figure 8**.

Based on **Table 10**, standardization factor for Deflection is 1.1 because the deflection test tool used is an FWD tool.

**Table 8. Representative $D_0$ deflection with AMPT on different temperature**

| AMPT | Segment | Average $D_0$ | Coeff of Variation | Representative $D_0$ | Representative $D_0$ |
|---|---|---|---|---|---|
| | | µm | % | µm | mm |
| 47°C | 1 | 570.023 | 28.332 | 835.688 | 0.836 |
| | 2 | 520.065 | 28.381 | 762.864 | 0.763 |
| 42°C | 1 | 523.45 | 24 | 729.808 | 0.73 |
| | 2 | 476.012 | 24 | 661.702 | 0.662 |
| 38°C | 1 | 519.353 | 24 | 724.097 | 0.724 |
| | 2 | 470.723 | 24 | 654.35 | 0.654 |
| 35°C | 1 | 506.898 | 28 | 743.143 | 0.743 |
| | 2 | 458.039 | 28 | 666.481 | 0.666 |

**Tabel 9. Representative $D_0 - D_{200}$ deflection with AMPT on different temperature**

| AMPT | Segment | Average $D_0$ | Coeff of Variation | Representative $D_0$ | Representative $D_0$ |
|---|---|---|---|---|---|
| | | µm | % | µm | mm |
| 47°C | 1 | 189.377 | 28.098 | 189.377 | 0.189 |
| | 2 | 198.059 | 18.798 | 198.059 | 0.198 |
| 42°C | 1 | 178.856 | 28 | 178.856 | 0.179 |
| | 2 | 162.298 | 19 | 162.298 | 0.162 |
| 38°C | 1 | 163.469 | 28 | 163.469 | 0.163 |
| | 2 | 145.858 | 18 | 145.858 | 0.146 |
| 35°C | 1 | 159.455 | 27.326 | 159.455 | 0.159 |
| | 2 | 143.037 | 16.065 | 143.037 | 0.143 |



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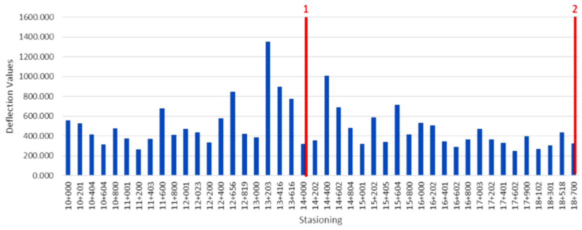


Figure 6. Segmentation for deflection

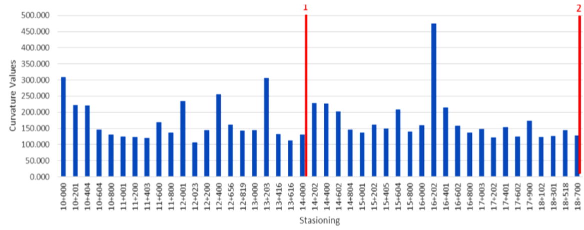


Figure 7. Segmentation for curvature

**Table 10. Standardization factor for deflection** (Austroads, 2019)

| Deflection Measurement Device | Deflection Standardization Factor |
|---|---|
| Deflectograph, 80 kN single axle with dual tyres | 1.2 |
| TSD, 50 kN dual tyres | 1.2 |
| Falling Weight Deflectometer, 40 kN load | 1.1 |

**Table 11. CD and CC values based on standardization factor for WMAPT with different temperature**

| WMAPT | Segment | $D_{representative}$ | | Characteristic Deflection | Characteristic Curvature |
|---|---|---|---|---|---|
| | | Deflection | Curvature | | |
| | | mm | | mm | mm |
| 47°C | 1 | 0.547 | 0.205 | 0.603 | 0.205 |
| | 2 | 0.469 | 0.184 | 0.517 | 0.184 |
| 42°C | 1 | 0.563 | 0.237 | 0.619 | 0.237 |
| | 2 | 0.507 | 0.198 | 0.558 | 0.198 |
| 41°C | 1 | 0.557 | 0.225 | 0.614 | 0.225 |
| | 2 | 0.506 | 0.191 | 0.557 | 0.192 |
| 38°C | 1 | 0.499 | 0.215 | 0.55 | 0.216 |
| | 2 | 0.49 | 0.192 | 0.539 | 0.192 |
| 35°C | 1 | 0.481 | 0.216 | 0.53 | 0.217 |
| | 2 | 0.473 | 0.191 | 0.521 | 0.192 |

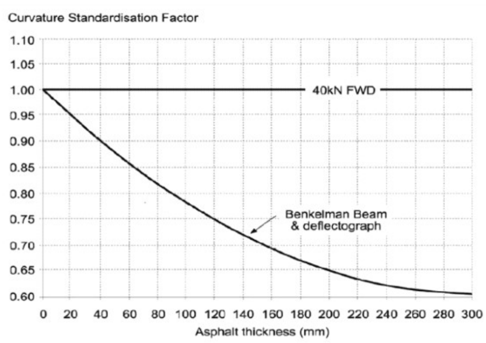


**Figure 8. Standardization factor for curvature**
(Austroads, 2008)

Next, based on **Figure 8**, the standardization factor for curvature using the FWD tool is 1.

The result of deflection calculation using the Austroads method is used to obtain the Characteristic Deflection (CD) value to obtain the overlay thickness based on damage due to permanent deformation, and to obtain the Characteristic Curvature (CC) value to obtain the overlay thickness based on cracking due to fatigue.

### 4.6 Comparison of deflection analysis using 2017 MDP method and austroads method

The deflection analysis with both methods is the same using 5 (five) different values of average pavement temperature. The following is a recapitulation of the results of the deflection calculation using the two methods.

Based on **Table 12** and **Tabel 13** there is a decrease in representative deflection value along with decreasing temperature value which is the reference in the analysis of the deflection calculation. In addition, the deflection value would be used in the overlay thickness analysis where the representative $D_0$ deflection and CD would be used for the overlay thickness based on permanent deformation, while representative $D_{-0}$ – $D_{200}$ deflection and CC would be used for overlay thickness based on fatigue due to cracking.

### 4.7 Overlay thickness analysis with 2017 MDP method

Overlay thickness analysis with 2017 method used the Falling Weight Deflectometer (FWD) deflection approach. Similar to the Austroads method, the 2017 MDP also takes into account the damage due to fatigue



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Table 12. Recapitulation of representative deflection results using MDP 2017 method

| Temperature | Representative $D_0$ (mm) | | Representative $D_0$ - $D_{200}$ (mm) | |
|---|---|---|---|---|
| | Segment 1 | Segment 2 | Segment 1 | Segment 2 |
| 47°C | 0.836 | 0.763 | 0.189 | 0.198 |
| 42°C | 0.730 | 0.662 | 0.179 | 0.162 |
| 41°C | 0.724 | 0.654 | 0.175 | 0.156 |
| 38°C | 0.771 | 0.677 | 0.163 | 0.146 |
| 35°C | 0.743 | 0.666 | 0.159 | 0.143 |

Table 13. Recapitulation of representative deflection results using austroads method

| Temperature | CD (mm) | | CC (mm) | |
|---|---|---|---|---|
| | Segment 1 | Segment 2 | Segment 1 | Segment 2 |
| 47°C | 0.651 | 0.585 | 0.251 | 0.223 |
| 42°C | 0.619 | 0.558 | 0.237 | 0.198 |
| 41°C | 0.614 | 0.557 | 0.225 | 0.192 |
| 38°C | 0.550 | 0.539 | 0.216 | 0.192 |
| 35°C | 0.530 | 0.521 | 0.217 | 0.192 |

cracking using ESA5 traffic loads and also permanent deformation using ESA4 traffic loads. In the deflection approach, damage due to fatigue cracking is represented by $D_0 - D_{200}$ and damage due to permanent deformation is represented by $D_0$.

To obtain the overlay thickness with $D_0$ representative deflection and ESA4, the graph in **Figure 10** may be used, and to obtain the overlay thickness with $D_0 - D_{200}$ representative deflection and ESA5, the graph in **Figure 11** may be used.

The results of the overlay thickness analysis based on damage due to permanent deformation is presented in **Table 14** and the results of the overlay thickness analysis based on damage due to fatigue cracking is presented in **Table 15.**

## 4.8 Overlay thickness analysis with austroads method

The overlay thickness analysis uses the results of representative deflection, so there 5 different thickness values would be obtained.

In Austroads method, the overlay thickness is obtained based on CD value and CC value. For the CD value, the following graph was obtained.

Based on the graph in **Figure 11**, what affects the value of design deflection is the value of traffic load where the traffic load used is DSAR7 value of 11.053.610 so that a design deflection value of 0,85 mm is obtained. In the Austroads method, if the design deflection value is greater than the CD value, then there is no need for an overlay. In the previous sub-chapter, it was found that the CD value for all segments was not more than 0.85. The CD result on both segments was not more than the design deflection value so that an overlay is not needed.

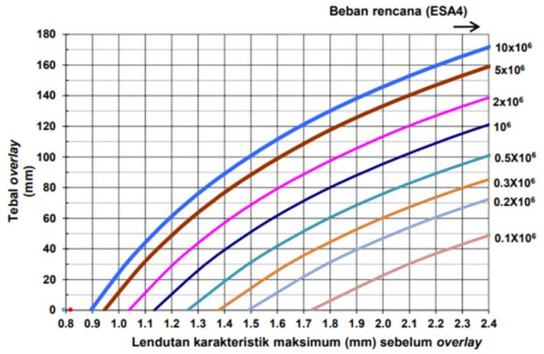


**Figure 9. Overlay solution based on benkelman beam rebound deflection** (MDP, 2017)

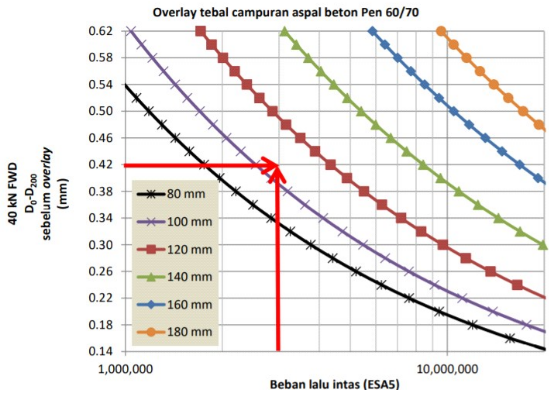


**Figure 10. Overlay thickness of conventional asphalt to prevent fatigue cracking on AMPT ≥ 35°C**

Table 14. Recapitulation of the results of overlay thickness analysis using 2017 MDP method for damage due to permanent deformation

| Temperature | 2017 MDP Overlay Thickness (mm) | |
|---|---|---|
| | Segment 1 | Segment 2 |
| 47°C<br>42°C<br>41°C<br>38°C<br>35°C | Overlay not needed | Overlay not needed |

Tabel 15. Recapitulation of the results of overlay thickness analysis using 2017 MDP method for damage due to fatigue

| Temperature | 2017 MDP Overlay Thickness (mm) | |
|---|---|---|
| | Segment 1 | Segmen 2 |
| 47°C | 80 | 80 |
| 42°C | 80 | 80 |
| 41°C | 80 | 80 |
| 38°C | 80 | 80 |
| 35°C | 80 | 80 |

After obtaining the design deflection value, the next step is to determine the overlay thickness value for damage due to fatigue cracking where the graph of deflection characteristic before overlay for WMAPT > 35°C was used, in accordance with 2008 Austroads, shown in **Figure 12.**



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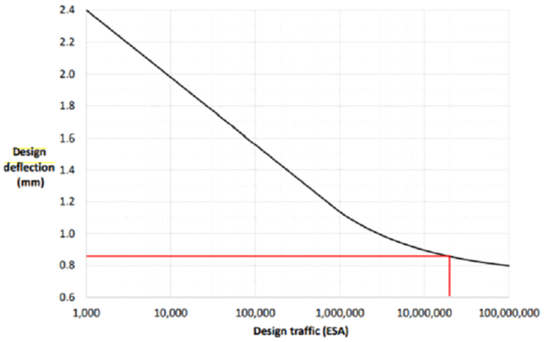


**Figure 11. Design delfection for damage due to permanent deformation** (Austroads, 2019)

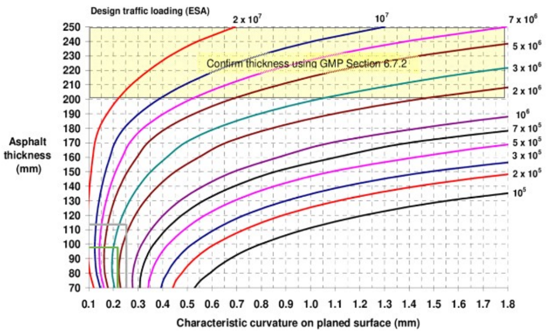


**Figure 12. Overlay thickness based on deflection characteristic** (Austroads, 2008)

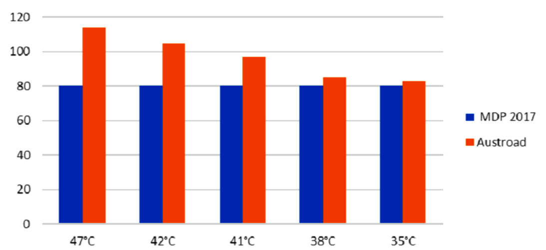


**Figure 13. Comparison of overlay thickness on segment 1 based on damage due to fatigue for 2017 MDP method and austroads method**

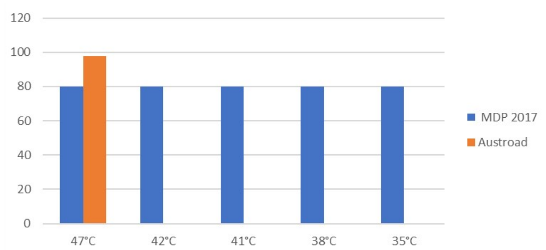


**Figure 14. Comparison of overlay thicknes on segment 2 based on damage due to fatigue for 2017 MDP method and austroads method**

### 4.9 Comparison of overlay thickness analysis results with 2017 MDP method and austroads method

To obtain the overlay thickness value, both methods use the approach with deflection from FWD test results. The following is the overlay thickness results that have been analyzed using both methods.

The overlay thickness for damage due to fatigue obtained with 2017 MDP Method has the same value, which is 80 mm for both segments. Meanwhile, the overlay thickness using Austroads method has varying

**Table 16. Recapitulation of deflection calculation result with austroads method for damage due to fatigue**

| Temperature | Austroads Overlay Thickness (mm) | |
|---|---|---|
| | Segment 1 | Segment 2 |
| **47°C** | 114 | 98 |
| **42°C** | 105 | 0 |
| **41°C** | 97 | 0 |
| **38°C** | 85 | 0 |
| **35°C** | 83 | 0 |

**Table 17. Recapitulation of deflection calculation result with austroads method for damage due to permanent deformation**

| Temperature | Austroads Overlay Thickness (mm) | |
|---|---|---|
| | Segment 1 | Segment 2 |
| **47°C** | | |
| **42°C** | | |
| **41°C** | Overlay not needed | Overlay not needed |
| **38°C** | | |
| **35°C** | | |

**Table 18. Comparison of overlay thickness analysis results based on damage due to fatigue with austroads method and 2017 MDP method**

| Temperature | 2017 Method Overlay Thickness (mm) | | Austroads Method Overlay Thickness (mm) | |
|---|---|---|---|---|
| | Segment 1 | Segment 2 | Segment 1 | Segment 2 |
| **47°C** | 80 | 80 | 114 | 98 |
| **42°C** | 80 | 80 | 105 | 0 |
| **41°C** | 80 | 80 | 97 | 0 |
| **38°C** | 80 | 80 | 85 | 0 |
| **35°C** | 80 | 80 | 83 | 0 |

**Table 19. Comparison of overlay thickness result analysis based on damagae due to permanent deformation with 2017 MDP method and austroads method**

| Temperature | 2017 MDP Method Overlay Thickness (mm) | | Austroads Method Overlay Thickness (mm) | |
|---|---|---|---|---|
| | Segment 1 | Segment 2 | Segment 1 | Segment 2 |
| **47°C** | | | | |
| **42°C** | | | | |
| **41°C** | Overlay not needed | Overlay not needed | Overlay not needed | Overlay not needed |
| **38°C** | | | | |
| **35°C** | | | | |



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values. For all overlay thickness based on permanent deformation, there is no need for overlay.

## 5. Discussions

After analyzing with Austroads method and 2017 MDP Method, each of these methods can be discussed. The discussion for both methods is as follows.

1. The discussion for 2017 MDP method is as follows.
   a. The Vehicle Damage Factor used has taken into account the load due to permanent deformation and cracking due to fatigue, so that when traffic load analysis is conducted, the value has been divided according to the damage that had occurred.
   b. The deflection analysis used may use the approach with FWD test results.
   c. In deflection analysis, the $D_0$ value needs to be adjusted to the Benkelman Beam deflection so that an advanced analysis can be conducted.
   d. Overlay thickness analysis was conducted with the design chart method so that it could be directly used easily but there could also be inaccuracies.
   e. The overlay thickness obtained has a consistent value despite using different average pavement temperature (AMPT) values because the resulting deflection values did not have a much wide range.

2. The discussion for the 2017 Austroads Method is as follows.
   a. In the traffic load analysis, the Austroads method has taken into account the load due to damage due to permanent deformation and fatigue.
   b. For the deflection analysis, an approach with the FWD (Falling Weight Deflectometer) test may be conducted to obtain the required overlay thickness value.
   c. In the deflection analysis for Characteristic Deflection, the design deflection is only affected by the DSAR7 value without being affected with the temperature value, so all design deflections obtained are the same.
   d. The overlay thickness analysis used chart analysis to get the required overlay thickness, so that it is easier, but it can also be less accurate.
   e. The overlay thickness obtained varied for every temperature based on fatigue.
   f. From the analysis results, it could be seen that the different WMAPT values can produce different overlay thickness values, where a difference of one temperature value can change the resulting overlay thickness.

From the results of the analysis above, the 2017 Pavement Design Manual (MDP) and Austroads methods each have their own advantages and disadvantages, so that these two methods can be used as a reference in calculating structural evaluation and determining the value of overlay thickness for Indonesia.

## 6. Conclusions

From the results of the research that has been conducted for the Tanah Runtuh – Tawaeli National Road section using the Austroads method and the 2017 Pavement Design Manual, the following conclusions can be drawn:

1. In the deflection analysis using the Austroads method, two types of deflection characteristics were produced according to their respective damage, namely Characteristic Deflection for damage due to permanent deformation and Characteristic Curvature for damage due to fatigue cracking.
2. In the deflection analysis using the 2017 MDP, two representative deflections were obtained, namely representative $D_0$ for damage due to permanent deformation and representative $D_0$-$D_{200}$ for damage due to fatigue.
3. From the results of the deflection analysis using the 2017 MDP and Austroads methods, the segmentation division is divided into two sections where the first section starts from STA 10+000 to 12+656 and the second section starts from ST.
4. In the overlay analysis using the Austroads method, it is found that the thickness values vary for each temperature on the fatigue damage, while for permanent deformation damage there is no need for an overlay with a design life of 10 years.
5. The overlay thickness obtained from the analysis results with Austroads methods are 114 mm and 98 mm for WMAPT 47°C, 105 mm for WMAPT 42°C, 97 mm for WMAPT 41°C, 85 mm for WMAPT 38° C, and 83 mm for WMAPT 35°C.
6. From the results of the analysis, it is found that the temperature difference can affect the value of the overlay thickness produced.
7. In the overlay analysis using the 2017 Pavement Design Manual method, the overlay thickness is consistent with 80 mm for all segments for fatigue damage, while for permanent deformation damage there is no need for an overlay during the design life of 10 years.

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