# Planning of Added Pave Layer Thickness and a Typical Design of the Path for Students Case Study: Serdang Badagai Border Section-Tanjung Kasau

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**Abstract.** The Serdang Bedagai to Tanjung Kasau road is the access road to and from Medan. This crossroad is often used by private vehicles, public vehicles, trucks, etc. The boundary of the Serdang Bedagai to Tanjung Kasau road from km 89 + 200 to km 90 + 200 (1,000 m) experienced some damage, resulting in the road needing to be used optimally. This research method uses the Pd-T-05-2005-B guide, which is a guide for designing overlays for road construction. The research results obtained are as follows: 1) The width of the road pavement is planned to be 3.5 meters with a total of 2 lanes and 2-way vehicle lanes with a design life of 10 years, 2) Overlay with LAPEN pavement of 25 cm and a cover layer of 7 cm thick, and 3) The slope of the road is adjusted to the existing conditions of the road section.

**Keywords:** Pavement Design, Overlay, Typical Road

## 1 Introduction

Road pavement structure construction requires accurate foundation planning so that excessive deformation due to disturbances during construction or the service life of the pavement plan can be avoided. Pavement structure construction requires a work floor as a construction base. Compact all pavement layers to obtain a good working floor so that no water seeps through them. Other things that are taken into consideration are controlling water in the subgrade, creating drainage channels, covering drainage channels and road shoulders, and planning pavement geometry [1]

Rigid pavement is an alternative in planning road construction structures [2]. Rigid pavement designed for soft alluvial subgrade layers must go through additional planning, namely the conditions for curvature development due to permanent deformation [3]. This permanent deformation must be large enough to prevent excessive cracking or cracking in the rigid pavement. In planning, the flexible pavement foundation structure must be lower than that of rigid pavement. The migration of refined grains in the subgrade caused by erosion will impact stiff pavement. The impact of erosion causes not only the movement of refined grains but also

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the effects of water coupling and dynamic stress [4]. Therefore, it is necessary to design the road foundation (sub-grade) and sub-base layer to minimize this problem.

The increasing population movement has profound implications for the growth of organizational areas and industrial areas in North Sumatera Province. This surge in population also brings about a pressing need for transportation facilities and infrastructure to connect access between regions and regions. The growth in transportation facilities and infrastructure, driven by this population movement, has necessitated road and bridge maintenance programs. Therefore, the construction of roads and bridges is not just a matter of infrastructure but a response to the significant changes in our population and its needs.

Overlay (additional layer thickness) for road construction is an alternative used to increase the service life of roads [5]. Requirements in overlay planning must pay attention to planning provisions because if they differ from planning guidelines, they will impact road construction. As a result, the road will not function as it should, reducing the pavement's service life so that it can damage the additional layers that have been made. The overlay will quickly be damaged if the construction planning departs from the guidelines, even though it has just been built (under design), or if the overlay is too thick, it will not be efficient (over-design) [6]

The Serdang Bedagai to Tanjung Kasau road is the access road to and from Medan. This crossroad is often used by private vehicles, public vehicles, trucks, etc. The boundary section of the Serdang Bedagai to Tanjung Kasau road from km 89+200 to km 90+200 experienced some damage, which resulted in the road not being used optimally. Therefore, it is necessary to repair and plan the route. The overlay design is made using flexible pavement using the deflection method.

It is hoped that this research can improve road construction. Therefore, the study aims to obtain a plan for the thickness of the added layer of flexible pavement using the deflection method and to plan a typical road.

## 2 Literature Review

Bina Marga, 1970, states that pavement can be divided into flexible and rigid pavement. Generally, in Indonesia, flexible pavement is used more often than rigid pavement. Asphalt, as a binder for road construction, is a material used in flexible pavement [7]. The surface (ground surface) usually cannot carry the vehicle load on it, so a structure is needed that can take the load and distribute the traffic load to the subgrade. Suppose the road construction serviceability index (Present Serviceability Index) of flexible pavement has reached the optimum value. In that case, several ways exist to solve it, such as overlay (adding a pavement layer), reconstruction, and recycling.

Flexible pavement is a road pavement construction using asphalt as the binding material. Theoretically, road pavement is part of several layers spread over the subgrade (surface) surface after compacting. These layers receive the vehicle load and are distributed to the layers below. [1]. The flexible pavement structure consists of several parts (layers) as a construction, namely surface (surface layer), base course (upper foundation layer), subbase course (lower foundation layer), and subgrade (subgrade layer). As shown in Figure 1 below

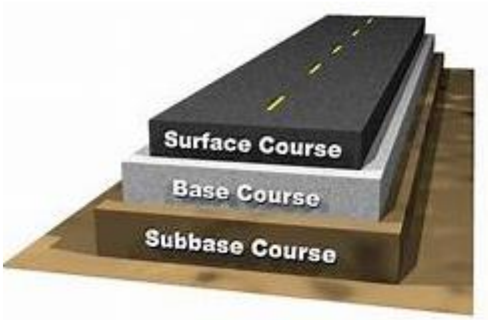


**Fig. 1.** Arrangement of Highway Flexible Pavement Layers
Source: AASHTO [8]

Figure 2. The following illustrates the vehicle load that passes through the pavement, which is imposed on the road pavement in the form of a uniform load on the wheel contact area. The load is received directly by the surface layer (surface course) and spreads down to the subgrade layer. Each layer will experience a force as a result of the resistance force of the subgrade layer to the traffic load it receives. The nature of the load is that it does not accumulate at one point; in other words, it will spread further down the layer so that the impact will decrease from one layer to another layer below it.

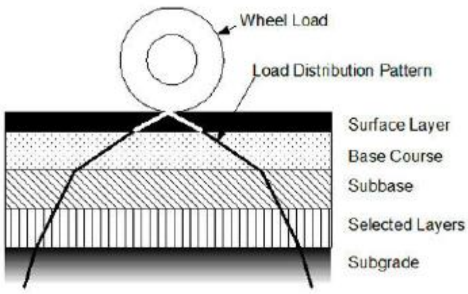


**Fig. 2.** Geometric Planning Standards
Source: Dirjen Bina Marka, [9]

Guidelines for Planning Layer Thickness to Add Flexible Pavement using the Pd Deflection Method. T-05-2005-B states that the definition of overlay thickness is an additional pavement layer placed on the existing pavement structure [10]. The aim is to increase the structural strength of existing pavement construction to provide excellent service to the designed traffic until the planned life.

Guidelines for Planning Layer Thickness to Add Flexible Pavement using the Pd Deflection Method. T-05-2005-B states that the definition of overlay thickness is an additional layer of pavement installed on top of the existing pavement construction to increase the strength of the existing pavement structure so that it can serve the planned traffic over the coming period.

The Pd-T-05-2005-B method is a guideline for designing overlays (added layer thickness) for road construction. This guideline determines the norms and steps for calculating the thickness of the added layer for flexible pavement construction based on the load strength of the pavement structure which is described by the deflection method. The Cumulative Equivalent Standard Axles (CESA) method is used to analyze traffic loads. The CESA value can be calculated using the following formula [10]:

$$CESA \ = \sum_{Tractor-trailer}^{MP} m \ x \ 365 \ x \ E \ x \ C \ x \ N \quad (1)$$

$$CESA \ = \ ESA \ x \ 365 \ x \ R \quad (2)$$

Information:
CESA = Accumulated standard axle load equivalents
M = Number of each type of vehicle
365 = Number of days in one year
E = Equivalent axle load
C = Vehicle distribution coefficient
N = Factors relating to plan age
ESA = Equivalent Single Axle
R = Traffic growth factors

Planning with the deflection value is the return deflection value obtained from the Benkelman Beam test evaluation, which must be corrected for temperature, groundwater level factor, and test load [11]. The analysis uses a formula

$$d_B = \ 2 \ x \ (d_3 - d_1) \ x \ F_t \ x \ C_a x \ \ (FK_{B-BB}) \quad (3)$$

Information:
$d_B$ = direct deflection (mm)
$d_1$ = deflection when the object load is at the measurement point
$d_3$ = deflection when the load is at a distance of 6 meters from the measurement point
$F_t$ = Deflection adjustment factor at standard temperature $35^0$ C
$C_a$ = Land surface influence factors
$FK_{B-BB}$ = Benkelman Beam test load correction factor

## 3 Methodology

The methodology used in this research is depicted in the research flow chart in Figure 3 below

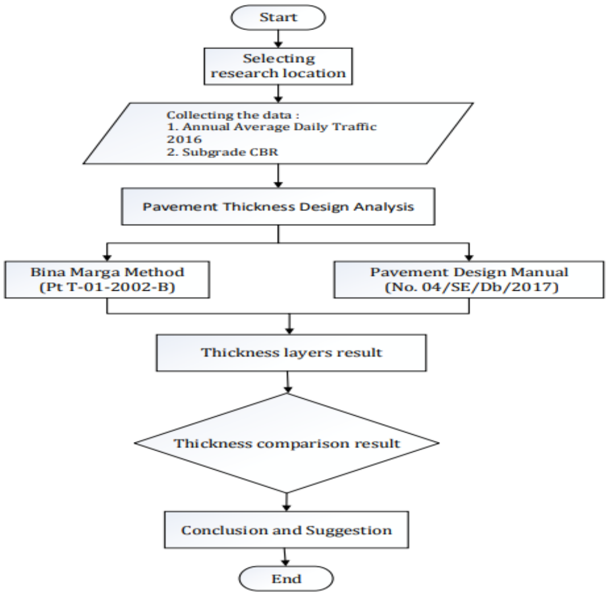


Figure 3. Research Flow chart

## 4 Result

The location for planning the thickness of the additional layer of flexible pavement using the PD T-05-2005-B deflection method is on the 1 km Serdang Bedagai-Tanjung Kasau border road. The planned road function is an arterial road used during the dry season. The existing data obtained is as follows:

No link = 3107,0
Section name = Serdang Bedagai-Tanjung Kasau
Boundary = 89+400 – 90+400
Road function = Arteri
CESA Value = 120.248,494
Test Load (ton) = 8,66
Season = drought
Average thickness of asphalt < 10 cm
WAMPT = 28-320 C

**Table 1.** Benkelman Beam Test Data

| Km | Test Load (Ton) | $d_1$ (mm) | $d_2$ (mm) | $d_3$ (mm) | $t_u$ (ºC) | $t_p$ (ºC) |
|---|---|---|---|---|---|---|
| 89+400 | 8,66 | 9 | 15 | 15 | 28 | 32 |
| 89+600 | 8,66 | 9 | 15 | 15 | 28 | 32 |
| 89+800 | 8,66 | 10 | 19 | 19 | 28 | 32 |
| 90+000 | 8,66 | 15 | 11 | 11 | 28 | 32 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 90+200 | 8,66 | 11 | 16 | 16 | 28 | 32 |
| 90+400 | 8,66 | 9 | 16 | 16 | 29 | 31 |

Table 1 states that the deflection results at several points tested with a test load were 8.66. The results stated that at KM 90+000, it produced a maximum deflection of 15 mm, and at KM 89+400, it produced a maximum deflection of 19 mm.

Determine the return deflection value ($d_B$) [12]

$$d_B = 2\ x\ (d_3 - d_1)\ x\ F_t\ x\ C_a x\ (FK_{B-BB}) \qquad (4)$$

Informatian:

$d_B$ = return deflection value (mm)

$d_1$ = deflection under load at the measurement point

$d_2$ = deflection when the load is at a distance of 6 m from the measurement point

$F_t$ = Explosion adjustment factor to standard temperature 35 $_0$C

= 4,184 x $T_L^{-0,4233}$ for $H_L$ < 10 cm = 0,982

= 14,785 x $T_L^{-07373}$ for $H_L$ > 10 cm = 1,186

Information:

$T_L$ = The asphalt layer temperature is from measurement results or predicted by calculation

$T_L$ = 1/3 ($T_p$ + $T_t$ +$T_b$) = 30, 667$^0$C

$T_p$ = asphalt surface temperature = 32$^0$C

$T_t$ = middle temperature of the asphalt layer = 30$^0$C

$T_b$ = asphalt bottom temperature = 30$^0$C

Ca = land surface influence factors (seasonal factors) =1,2

= 1,2 if the inspection is carried out during the dry season or the ground water level is low

= 0.9 if the inspection is carried out during the rainy season or the ground water level is high

$FK_{B-BB}$ = 77,343 x (Beban uji dalam ton)$^{-2,0713}$ = 0,884

$$dB_3 = \frac{\sum_1^n d}{n_s} \qquad (5)$$

$dB_3$ = average deflection during a walking session

d = deflection value ($d_b$) or direct deflection ($d_t$) for each road section inspection point

$n_s$ = number of road checkpoints

The results of the analysis of correction factor calculations can be seen in Table 2 below

Table 2. FK Analysis

| KM | Test Load (ton) | $d_1$ (mm) | $d_2$ (mm) | $d_3$ (mm) | $t_u$ (°C) | $t_p$ (°C) | WAMPT $t_t$ (°C) | FK | $d_B$ (mm) | $d_{B2}$ (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| 89+400 | 8,66 | 0 | 9 | 15 | 28 | 32 | 1,28 | 1,13 | 0,36 | 0,13 |
| 89+600 | 8,66 | 0 | 9 | 15 | 28 | 32 | 1,28 | 1,06 | 0,34 | 0,11 |
| 89+400 | 8,66 | 0 | 10 | 19 | 28 | 32 | 1,28 | 1,06 | 0,43 | 0,18 |
| 90+000 | 8,66 | 0 | 15 | 11 | 28 | 32 | 1,28 | 1,21 | 0,28 | 0,08 |
| 90+200 | 8,66 | 0 | 11 | 16 | 28 | 32 | 1,28 | 1,06 | 0,36 | 0,13 |
| 90+400 | 8,66 | 0 | 9 | 16 | 27 | 31 | 1,32 | 1,06 | 0,36 | 0,13 |
| | | | | | | | ns | | 6 | 0,76 |

| | |
|---|---|
| $\frac{\sum_1^n d}{n_s}$ | 2,12 |
| $d_{rata\text{-}rata}$ | 0,19 |
| Deviasi | 0,046 |
| FK | 24,018 % |

$d_{reff}$ = deflection representing the road section = 0,29
= dR +1,64 s, for collector roads
= dR + 1,28 s, for local roads
$d_{plan}$ = design deflection of a road section = 22,208 CESA$^{-0,2307}$ = 0,30

$$H_0 = \frac{[L_n\ (1{,}0364\ +\ L_n(D_{bov})\ -\ L_n(D_{aov})]}{0{,}6}\ =\ 0{,}41$$

Information:

| | | |
|---|---|---|
| $H_o$ | = | the thickness of the added layer before being corrected for the annual average pavement temperature of a particular area |
| $d_{bov}$ | = | deflection before overlay ($D_{representative}$) |
| $d_{aov}$ | = | deflection after overlay ($D_{plan}$) |
| $F_o$ | = | pavement thickness correction factor = 0,5032 x EXP $^{(0,0194 \times TPRT)}$ = 1,11 |
| TPRT | = | annual average pavement temperature |
| $FK_{TBL}$ | = | Adjustment layer thickness correction factor |
| | = | 12,51 x MR$^{-0,333}$ = 1,00 |
| MR | = | Resilience Modulus (MPa) |
| AC-WC | = | MR 2000 MPa |
| $H_t$ | = | Layer thickness after correction for annual average pavement temperature and Thickness Add adjustment |
| | = | $H_o$ x $F_o$ x $FK_{TBL}$ = -0,25 cm |

## 5 Discussion

The analysis using various formulas above can be explained from Figure 5 below, and the detailed planning picture can be seen in Figures 6- 8 below.

The Serdang Bedagai-Tanjung Kasau boundary road is planned to be 7 m wide, with each lane from the centerline of 3.5 meters. The slope of the road is adjusted to the existing road so that the typical road slope varies between 2-4%. Road shoulders and sidewalks are still available on this road, considering that the road area can still accommodate road shoulders and sidewalks, the thickness of the overlay according to the plan is 25 cm with the surface of the Lapen being 7 cm thick.

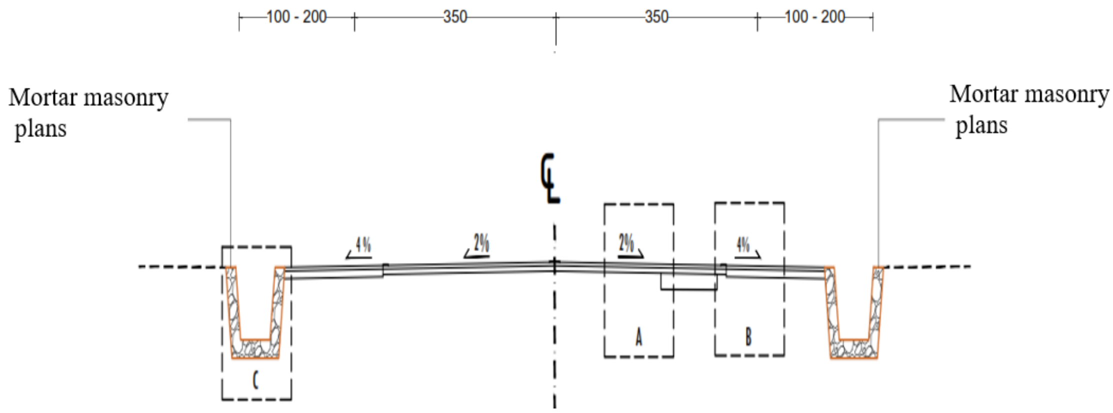


**Fig. 5.** Typical Design of the Serdang Badagai - Tanjung Kasau Boundary Section

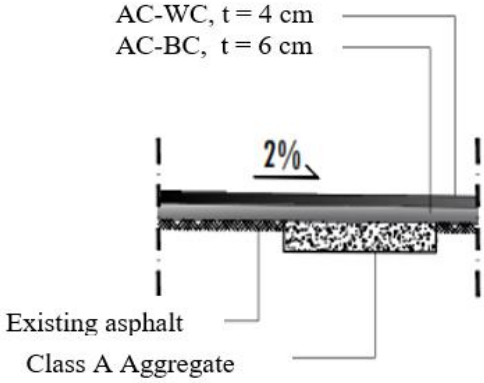


**Fig. 6.** Typical Detail A

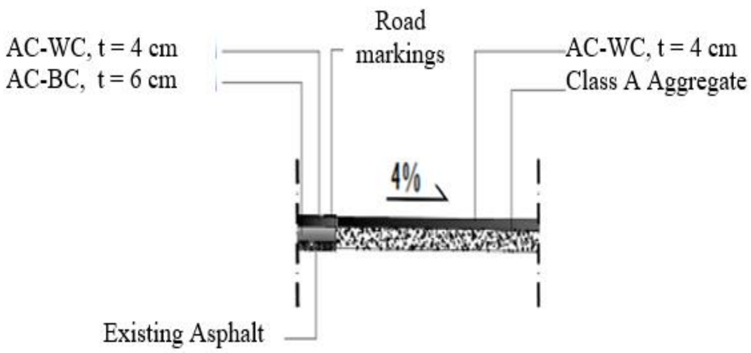


**Fig. 7.** Typical Detail B

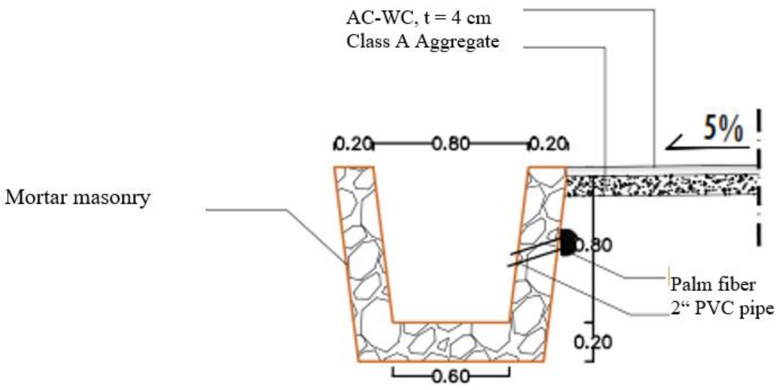


**Fig. 8.** Typical Detail C

## 6 Conclusion

From the results of the research carried out, conclusions were drawn

a. The width of the road pavement is planned to be 3.5 meters with a total of 2 lanes and 2-way vehicle lanes with a design life of 10 years.
b. Overlay with 25 cm of LAPEN pavement and a cover layer of 7 cm thick
c. The slope of the road is adjusted to the existing conditions of the road section

The things that can be recommended are:

a. The overlay design must take into account the conditions of the research field being carried out, in order to avoid various problems in the field [13].
b. To increase the service life of road sections, routine and periodic maintenance should be followed

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