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PLANNING OF RIGID PAVEMENT THICKNESS IN THE CONSTRUCTION OF THE SP. DOOR - Sp. BENAKAT PENUNGKAL REGENCY ABAB LEMATANG ILIR

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ABSTRACT
The access section to Benakat Village, Pali Regency is a special road made by the company, with the condition of the existing land being unpaved with a length of 1,375 meters and a width of 7 meters, and has severe damage triggered by vehicles with excess capacity or ODOL (Over Dimension Over Load)) that pass through that path. The purpose of this study was to determine the results of the calculation of rigid pavement thickness planning by comparing the 1993 AASHTO and 2017 MDPJ methods so that the road Sp. Doors – Sp. Benakat is able to accommodate ODOL vehicles. This study uses AASHTO 1993 and MDPJ 2017 as methods to produce rigid pavement thickness (Rigid Pavement) so that ODOL vehicles can pass. Based on the results of data analysis and calculations, the input indicators in each method are different for each method so that AASHTO 1993 produces a thickness of 35 cm, and in MDPJ it produces a thickness of 28.5 cm
Keywords : *Rigid Pavement, Construction, Road, AASHTO 1993, MDPJ 2017*

1. Introduction

Based on the condition of the Simpang Pintu - Benakat road, Penungkal Abab Lematang Ilir (PALI), it is necessary to build a road that accommodates the load that traverses the section, using concrete/rigid pavement (Rigid Pavement)(Rasol et al., 2020). Concrete/rigid Pavement (Rigid Pavement) is a pavement construction with a binding material in the form of cement with a continuous and continuous type of concrete slab, as well as using or without reinforcement located on the subgrade or part of the foundation layer(Pillay et al., 2021; Chore & Joshi, 2020).

In this study using AASHTO 1993 (American Association of State Highway and Transportation Officials) and MDPJ 2017 (Pavement Design Manual) as methods to produce pavement thickness(Abdollahi et al., 2022; Moharekpour et al., 2022; Nasution et al., 2019; Syuhada et al., 2022). And able to be passed by ODOL (Over Dimension Over Load) vehicles on the design of rigid pavement (Rigid Pavement) in Penungkal Abab Lematang Ilir Regency. The title of this research is Rigid Pavement Thickness Planning for Special Road Construction for the Sp. Doors to Sp. Benakat Penungkal Abab Lematang Ilir Regency.

The problem raised from the background of this research is, how are the results of the calculation of rigid pavement thickness planning (Rigid Pavement) using the 1993 AASHTO and MDPJ 2017 methods on the Simpang Pintu - Benakat road, Pali Regency so that ODOL (Over Dimension Over Load) vehicles can pass it.

The purpose of writing in accordance with the background of writing the thesis is to find out the results of the calculation of the thickness planning of rigid pavement construction (Rigid Pavement) using the AASHTO 1993 and MDPJ 2017 methods as the method used on the Simpang Pintu - Benakat road segment so that it can be passed by ODOL vehicles (Over Dimension Overload)(Anwar et al., 2021; Sugari et al., 2022).

2. Literature Review

Definition of Road In the Law of the Republic of Indonesia Number 22 of 2009, it is recorded that complementary buildings and their equipment are used in public traffic, which are above ground, above ground, below ground. According to the Ministry of Public Works (1997) in the journal Updating the Indonesian Road Capacity Manual, the definition of a road is that there is continuous or permanent development along and/or the entire road, minimum per one side of the road, both land and/or non-land(Sugiarto et al., 2018).

The existence of roads is needed to support economic growth in remote areas. The provision of roads with proper facilities needs to be supported by planned maintenance so that limited resources can be used effectively and efficiently.

Over Dimension Over Load According to Gautama et al. (2022) Over Dimension is the condition of the dimensions of the carrier on the vehicle that has been modified from the vehicle with its standard dimensions, while Over Load is the condition of the vehicle carrying the load exceeding its maximum carrying capacity. According to Iskandar (2008), overloading is a condition, which is done by entrepreneurs to reduce the cost of transporting cargo, to be able to load a lot of cargo in one transport. Drivers of ODOL (Over Dimension Over Load) vehicles will find it difficult to control the vehicle because when the road is down the vehicle speed will increase, on the uphill road the vehicle speed will decrease, requiring a long distance in braking, and the vehicle has an elevation due to the point of gravity so that ODOL (Over Dimension Over Load) vehicle drivers will be uncontrolled in driving and the vehicle's position tends to be easily overturned.

Heaviest Axle Load (MST) Determination of MST is shown to optimize the construction budget with efficient transportation. Vehicles of medium length and maximum width with a size of 18000 x 2500 mm and MST 8ton have a limited license with operating areas on arterial and collector roads, and have restrictions on not crossing on environmental and local roads. Long and large vehicles have a maximum width and length of 2500 x 18000 mm and MST 10ton which is only permitted to pass on arterial roads(Helmi et al., 2019).

Definition of Pavement construction on the road is in the form of a layer right between the original soil layer and the vehicle's wheels/tyres, and has a function to serve transportation. During its service life, the damage that occurs is not so significant. Pavement construction also has several functions, namely preventing the soil and the layers that make up the pavement from experiencing excessive stretching and pressure caused by traffic loads(Salehi et al., 2021; Jamshidi, A., & White).

The following layers or typical structures on rigid pavements can be shown in Figures 1.

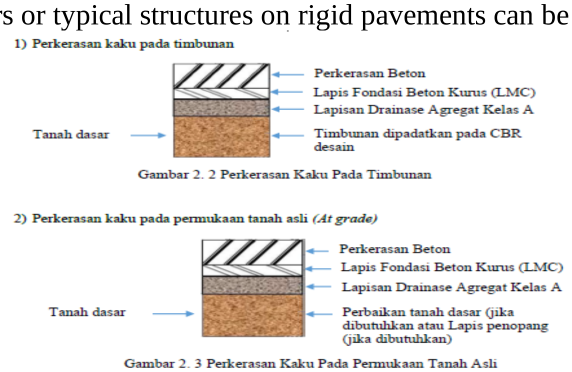

Fig 1. Typical Structures on Rigid Pavements

Design of Rigid Pavement Thickness Rigid pavement thickness is a dimension of the size of the concrete slab on a pavement. In determining the thickness of rigid pavement (Rigid Pavement) has indicators of each method that can be used in determining the design and calculation of rigid pavement thickness, so that the resulting thickness can accommodate the load of vehicles that will pass through the road and produce efficient and economic values according to the capacity of the road. designed. Two (2) methods were used in this rigid pavement thickness study, namely the American Association State of Highway and Transportation Officials (AASHTO 1993) and the Road Pavement Design Manual (MDPJ 2017).

Design of Rigid Pavement Thickness AASHTO Method 1993 AASHTO 1993 (American Association of State Highway and Transportation Officials) is a modified method derived from AASHTO 1986. The 1993 AASHTO method uses empirical and graphical methods based on traffic analysis over the design life.

Rigid Pavement Reinforcement and Jointing Techniques Rigid pavement in the form of concrete slabs is equipped with various connections, such as shrinkage joints, longitudinal joints, implementation joints, and expansion joints, as shown in Figure 2.

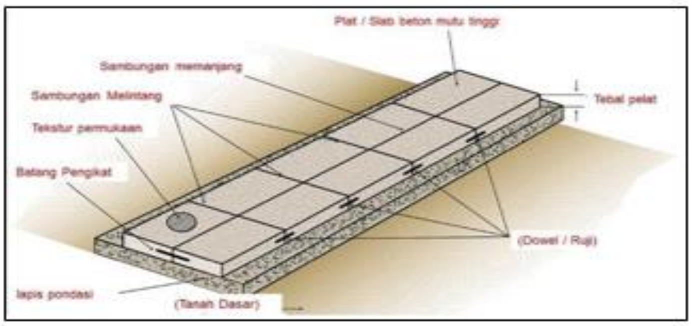

Fig 2. Types and Locations of Rigid Pavement Reinforcement
Source: PUPR Rigid Pavement Training Module, 2017

The function of reinforcement in rigid pavement is to monitor cracks, and not to withstand traffic loads. Resistance to traffic loads is expressed by the flexural tensile strength of concrete. Shrinkage of rigid pavements results from shrinkage of concrete during the hardening process, as well as swelling and shrinking caused by the influence of temperature. The need for longitudinal reinforcement can be calculated by the following equations.

ASmin= 0,14 % x cross-sectional area of concrete

$$As = \frac{11{,}76\ h\ L\ f\ a}{fs} \qquad (1)$$

$As_{installed}$ = Segment length/reinforcement distance × ¼ × π × d^2 (2)

Road Pavement Design Manual Method (MDPJ 2017), The 2017 Road Pavement Design Manual (MDPJ) method is a complement to the Pd-T-14-2003 pavement design guideline for rigid pavements, with sharpening in aspects: determination of design service life, determination of minimizing discounted life cycle costs, considerations of construction practicality, and use efficient material.

Analysis of Fatigue and Erosion, Fatigue analysis is an analysis of pavement failure due to repeated loading. Meanwhile, erosion analysis is an analysis of pavement behavior under the influence of the road shoulder. The repeatability value of fatigue strength is determined by a nomogram, which is affected by the tension and the load-per-wheel ratio.

The repetition value of fatigue verification is determined by a nomogram, shown in Figure 3.

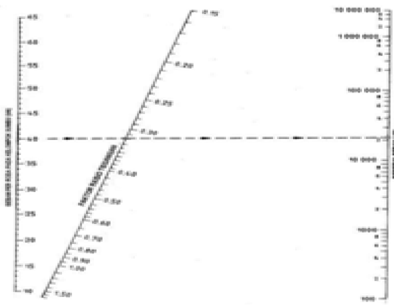

Fig 3. Repetition Value of Fatigue Verification

3. Research Methods

Research sites, The research location is on the Simpang Pintu – Simpang Benakat road, Talang Ubi District, Penungkal Abab Lematang Ilir (PALI) Regency, South Sumatra Province, which is shown in Figure 3.1. Geographically it is located 2o50` – 3o30` South Latitude, and 103o30` – 104o20` East Longitude. PALI Regency with the capital city of Talang Ubi is a new area resulting from the expansion of Muara Enim Regency, with topographic conditions in the form of a swamp area directly meeting the Musi River flow.

This research flow chart is a basic framework of thinking to form an orderly workflow, and as a guide for the thesis preparation process, which is shown in Figure 4

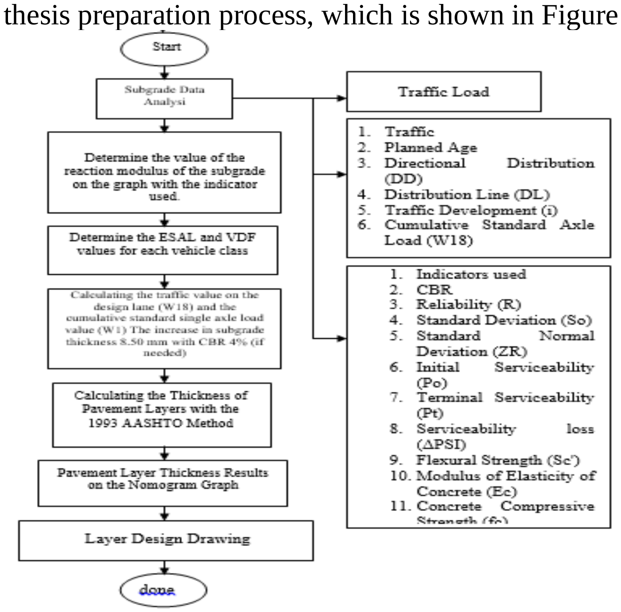

Fig 4. Research Flowchart

The analytical method used to analyze this research is the method of the American Association State of Highway and Transportation Officials (AASHTO 1993) and the Road Pavement Design Manual (MDPJ 2017). In the 1993 AASHTO analysis method, there are indicators for calculating the thickness of the rigid pavement used, shown in Figure 5. In the 2017 MDPJ analysis method, the pavement thickness calculation procedure used is described in Figure 6.

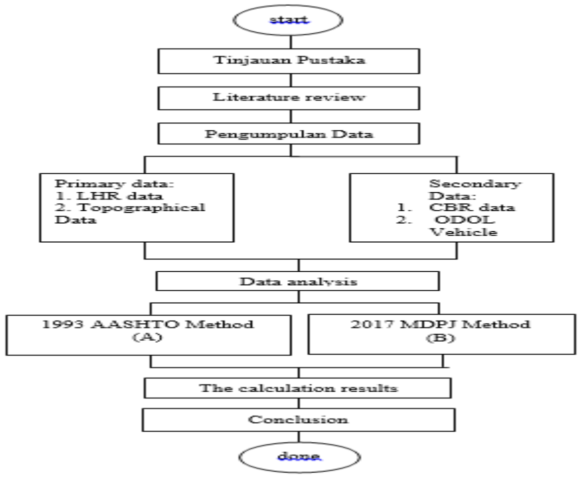

Fig 5. AASHTO Analysis Method

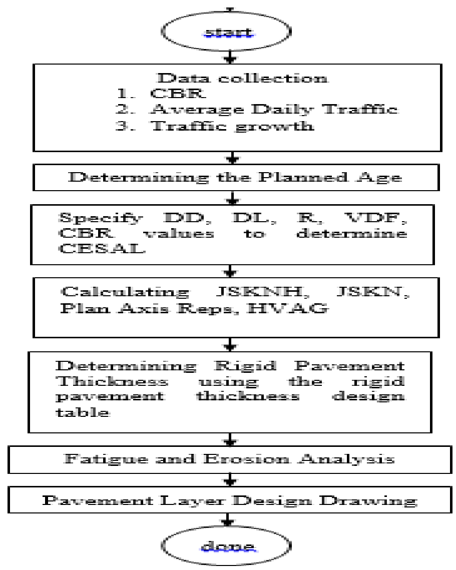

Fig 5. Flowchart of Pavement Thickness Design MDPJ 2017 Method

4. Results and Discussions

Analysis of Rigid Pavement Method AASHTO 1993

Based on the traffic analysis obtained, it is necessary to calculate the rigid pavement planning using AASHTO 1993 (American Association of State Highway and Transportation Officials).

1993 AASHTO Traffic Indicator Data

1) Planned Life (UR)

The design life taken is 20 years for high volume rural road conditions which can be shown in Table 2.4. The traffic growth factor figure (i) used for the Sumatra region is 4.83%, because there is no LHR data in the previous year. Then the design life (R) is calculated by Equation 2.1, so that the R value is obtained at 32.47805639.

Analysis on Traffic Load

Classification of the Heaviest Axis Load (MST) according to the type of road to be planned based on Table 2.1. The road to be built is a Class I arterial road with a maximum vehicle width of 2.50 meters, and a maximum vehicle length of 18 m, with the heaviest axle load >10 tons.

the value of the excess axle load on the front and rear wheels is calculated using Equation 4.1 as follows: (4. 1)

RD and RB1 = 1.00 + 1.00 × (no % overload in group 1)
= 1.00 tons (Vehicle Class 2)
To calculate the excess vehicle load, the following calculations are carried out.
Because the 7A vehicle class that passes is an ODOL (Over Dimension Over Load) vehicle, a calculation is carried out using the percentage value of the overloaded vehicle as follows:
Normal Vehicle Weight Group 7A = 25 tons
Group 7A Excess Vehicle Weight = 56 tons
Then the percentage figure is obtained,
= Excess vehicle weight – normal vehicle weight × 100 (4.2)
= 56.00 – 25.00 × 100%
= 124.00 %

K9RD = RDNormal + (RDNormal × Percentage of overload)
= 6.25 + (6.25 × 124.00%)
= 14.00 tons (Vehicle Class 7A)

K9RB1 = K9RB2 = RBNormal + (RBNormal × Percentage of overload)
= 9.38 + (9.38 × 124.00%)
= 21.01 tons (Vehicle Class 7A)

Equivalent Axle Load (EAL)
In the EAL calculation, the axle load used is the excess axle load with the load that has been divided based on the configuration of the wheel load in each vehicle class, then the calculation is carried out using Equation 2.2 as follows.
K2RD = (1/5.40)^4 = 0.00118 (Vehicle Class 2)
K2RB = (1/5.40)^4= 0.00118 (Vehicle Class 2)
4) Vehicle Damage Factor (VDF)
The magnitude of the excess axle load is transformed into equivalent axle load, so that the total load on each axle in each group is summed, and this number is the value of the Vehicle Damage Factor (VDF).

VDF = EAL (2.6)

• VDF K2 = RFront + RRear1
= 0.00118 + 0.00118 = 0.002352

5) Variable Direction and Lane Distribution
In general, the Variable Directional Distribution (DD) used is 0.5 (AASHTO 1993 pp. II – 9), while the Lane Distribution Variable (DL) used is a maximum of 100%, in the number of lanes in one direction there are two lanes shown in Fig. Table 2.5.

6) Equivalent Single Axle Load (ESAL)
After the Vehicle Damage Factor (VDF) and Equivalent Axle Load (EAL) values are obtained, the ESAL value is calculated using Equation 2.7 as follows.

• W18' K2 = 373 × 0.002352 × 365 = 320.22605
• W18' K3 = 121 × 0.008481 × 365 = 374.56747

To get the ESAL (Equivalent Single Axle Load) value for each type of vehicle class, calculations are carried out with Equation 2.8 as follows, with the R value being the design life:

18ESAL = DD × DL × W18’ × R

• K2 = 0.5 × 1 × 320.22605 × 32.4780653937 = 5200.15979
• K3 = 0.5 × 1 × 374.56747 × 32.4780653937 = 6082.61176
K4 = 0.5 × 1 × 41381.41431 × 32.4780653937 = 671993.95379
• K5 = 0.5 × 1 × 101.38935 × 32.4780653937 = 1646.46446
• K7 = 0.5 × 1 × 754336.91815 × 32.4780653937 = 12249698,48374
• K8 = 0.5 × 1 × 897660.93260 × 32.4780653937 = 14577141.19564
• K9 = 0.5 × 1 × 10056071.01538 × 32.4780653937 = 163300820,76839
• K10 = 0.5 × 1 × 327713,48486 × 32,4780653937 = 5321748,52108
+
Total 18 ESAL 196,134,332.16
LOG(10) 18ESAL 8.29255

The total value of ESAL (Equivalent Single Axle Load) from each type of group is added up and gets a value of 196,134,332.16. And calculated Log (10) 18ESAL and get a value of 8.29255.

1993 AASHTO Rigid Pavement Reinforcement and Joints
As for the calculation indicators on continuous concrete reinforcement with reinforcement, Equations 2.17, 2.18 and 2.19 are used, among others:
Longitudinal Reinforcement
Plate Thickness = 35 cm
Plate Width = 3.5 m
Plate Length = 5 m
Coefficient of friction with subbase (F) = 1.8 (Table 2.15)
Allowable tensile strength of steel = 240 MPa (Table 2.14)
Asmin = 0.14% of the concrete cross-sectional area
= 0.14% × 350 cm × 500
= 245 mm2/m

As〗_necessary=(11.76 h L fa)/fs
As〗_necessary=(11.76 × 1.8 × 5 × 350)/240=154.35 mm〗^2/m^1

As necessary requirements = 154.35 mm2/m Asmin = 245 mm2/m
It is planned to use threaded reinforcement with a diameter of D13-250. To determine the diameter of the reinforcement can be seen in Appendix 4.
Asters = 500/distance × × × d2
Asterpairs = 500/250 × 0.25 × 3.14 × 132
= 265.33 mm2/m > Asmin = 245 mm2/m

Transverse Reinforcement
Plate Thickness = 35 cm
Plate Width = 3.6 m
Plate Length = 5 m
Coefficient of friction with subbase (F) = 1.8 (Table 2.15)

Allowable tensile strength of steel = 240 MPa (Table 2.14)
Asmin = 0.14% of the concrete cross-sectional area
= 0.14% × 350 cm × 500
= 245 mm2/m.
As〗_necessary=(11.76 h L fa)/fs
As〗_necessary=(11.76 × 1.8 × 5 × 350)/240=154.35 mm〗^2/m^1
As necessary requirements = 154.35 mm2/m Asmin = 245 mm2/m
It is planned to use threaded reinforcement with a diameter of D13-250. To determine the diameter of the reinforcement can be seen in Appendix 4.
Asters = 500/distance × × × d2
Asterpairs = 500/250 × 0.25 × 3.14 × 132
= 265.33 mm2/m > Asmin = 245 mm2/m

Transverse Shrink Connection (Dowel)
The diameter of the dowel selected is 38 mm, with a length of 450 mm, and a spacing of 300 mm for a concrete slab thickness of 35 cm.
4) Tie Bar
Specifications on the tie bar (rod), calculated by Equation 2.23.
Diameter = 16 mm (Minimum Quality BJTU-24 Diameter 16 mm)
Distance = 75 cm
Length = (38.3 × 1.6) + 75
= 70 cm

From the calculation of reinforcement, threaded reinforcement with a diameter of 13 mm with a distance of 250 mm is used, for the installation of longitudinal reinforcement. For transverse reinforcement in 1993 AASHTO slab thickness, dowel sizes are 38 mm in diameter, 450 mm in length, and 300 mm in installation spacing. Tie bar installed is 16 mm in diameter, 70 cm in length, and 75 cm in installation distance.

Calculation of Road Construction Planning MDPJ 2017 Method

The description of the 2017 MDPJ road pavement planning procedure is referred to in the design chart to achieve maximum, optimal, and economical results on rigid pavements.

Method Comparison

Construction of the road segment Sp. Doors – Sp. Benakat Penungkal Abab Lematang Ilir (PALI) Regency uses rigid pavement, because it can accommodate excess vehicle loads or ODOL (Over Dimension Over Load) that will cross this road later. Sp. road rigid pavement design. Doors – Sp. Benakat uses several methods, namely: AASHTO 1993 (American Association State of Highway and Transportation Officials) and MDPJ 2017 (Pavement Design Manual). In this study, we will find out between the 1993 AASHTO method or the 2017 MDPJ method which can calculate excess vehicle load or ODOL. The results of the analysis obtained from the equations of the 1993 AASHTO method get a slab thickness of 35 cm, a thickness of the upper foundation layer in the form of lean concrete of 10 cm, and the thickness of the lower foundation with class A aggregate of 15 cm. In the analysis of the thickness of the slab which was carried out on the Nomogram graph of the 1993 AASHTO method, from the accuracy of reading the graph, the thickness of the concrete slab was 34 cm. The results of the MDPJ analysis (Manual Pavement Design) obtained a slab thickness of 28 cm, with a thickness of the top foundation (lean concrete) of 10 cm, and the thickness of the sub foundation 15 cm.

5. Conclusion

Based on the results of data analysis, after calculating the rigid pavement using the 1993 AASHTO and MDPJ 2017 methods on the Simpang Pintu – Simpang Benakat road, Penungkal Abab Lematang Ilir Regency, when viewed from the input indicators in each method, several conclusions can be drawn. which are as follows: For pavement thickness using the 1993 AASHTO method, the thickness of the concrete slab is 35 cm thick, with a Lean Concrete (LC) layer of 10 cm and a thickness of class A aggregate foundation as thick as 15 cm. As for the calculation of rigid road thickness, the 2017 Road Pavement Design Manual, on roads with heavy traffic, the thickness of the concrete slab is 28.5 cm, Lean Mix Concrete (LMC) is 15 cm thick, and the class A aggregate foundation layer is 15 cm thick. The results of the research on the calculation of rigid road planning carried out concluded that the method that can accommodate rigid pavement planning with excess vehicle weight or ODOL (Over Dimension Over Load) vehicles is AASHTO 1993, so vehicles with excessive loads or vehicles Over Dimension Over Load can pass through the Simpang Pintu – Simpang Benakat road which was built as a special road.

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