EVALUASI PERHITUNGAN TEBAL PERKERASAN HOTMIX PENINGKATAN RUAS JALAN DOLOK SANGGUL SILIMBAT TAPANULI UTARA

SKRIPSI

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ABSTRACT

Road is a land transportation infrastructure which is very important to support development activities and accelerate regional development in an effort to achieve the level of prosperity and welfare of the people. This study aims to analyze the thickness of the pavement layer of the hot mix road in the field and to compare the results of the calculation evaluation using component method analysis. The research method in this study uses the analysis of planning calculations with the Component Analysis Method based on the Flexible Pavement Thickness Planning Guidelines Pt T-01-2002-B which refers to the AASHTO Guide design of pavements structures in 1993. Based on the calculation results obtained in the component method shows the pavement thickness value. path a1 = 13.5 cm, a2 = 15 cm, and a3 = 10 cm. The pavement thickness value in the field is greater than the pavement thickness value in the calculation results. This is due to environmental adjustment factors because it has areas with high rainfall so that the economic life of the road is planned to be achieved Determination of road pavement calculations, especially in determining the number of LHR where the road is a district road that is rarely traversed by heavy vehicles, then the determining factor for heavy vehicles assumed vehicle.

***Keywords**: Hotmix Pavement, Component Method, Road Section*

CHAPTER I

INTRODUCTION

1.1. Background of Study

Roads are land transportation infrastructure that plays a very important role in the transportation sector and supports the people's economic growth rate. In highway construction planning, the thickness of the pavement must be determined as well so that the planned road can provide the maximum possible service to traffic following the function and period ofthe plan. In line with this information, the construction of the access road will later connect rural transportation routes from across Sumatra to the operational location.

Road pavement construction is growing rapidly at this time along with the rampant infrastructure development in Indonesia. Road pavement is a mixture of aggregate and binder used to serve traffic loads. The aggregate used is crushed stone or split stone or river stone or other materials. The binding material used is asphalt, cement, or clay.

Up to these days, in Indonesia, the majority of electricity supply is fulfilled by utilizing non-renewable energy sources such as fuel oil, natural gas, and coal. Meanwhile, the utilization of renewable energy sources that can be utilized including sun, water, wind, geothermal, biomass, and biogas is still very minimal.

The effectiveness and efficiency of funds invested in flexible pavement depend on the accuracy of the pavement mix used following the tropical conditions of Indonesia. There are two dominant types of damage experienced by flexural compression in tropical climates, namely cracks and plastic yielding. For this reason, in terms of choosing and planning a mix of pavements, attention must be given to the flexible pavement that has been implemented so that it can be used for traffic loads according to the period of the plan.

One type of flexible pavement is a surface layer that has several types of layers, both structural and non-structural layers. The structural layer functions as a layer that supports and spreads the vehicle load received by the pavement, in the vertical loads, horizontal loads, and brake forces. The requirements that should be met include the capability to carry loads without any damage. Based on these reasons, the researcher aims to study "The Evaluation and Calculation of Hotmix Pavement Thickness at Dolok Sanggul Silimbat Road Section in North Tapanuli Province"

1.2. Objectives of Study

This study aims to evaluate the specifications and parameters to determine the thickness of the Hotmix pavement layer for the new road improvement of the road section at Dolok Sanggul Silimbat, North Tapanuli province by using Component Method Analysis.

1.3. Formulation of Study

Based on the background of the study and the objectives of the study, the formulation of this study can be seen as follows:

1. Does the analysis of the pavement thickness calculation for the Hotmix road section of the Dolok Sanggul Silimbat meet the requirements based on the component analysis method?
2. Is the calculation of the Hot-mix pavement thickness in the field following the results of the calculations that will be carried out in the study?

1.4. Limitation of Study

This study is limited to the calculation of the pavement thickness using the component analysis method:

1. In determining the number of vehicles, the data were obtained based on the assumption of vehicles that passed through the road section based on the provisions of the Public Works Department of Highways
2. The LHR value and road (California Bearing Rate) CBR were determined based on the results of studies in the field.
3. The evaluation of the calculation of the thickness of the pavement layer is carried out by using the component analysis method and the Indonesian Road Capacity Manual (MKJI)

1.5. Theoretical Framework

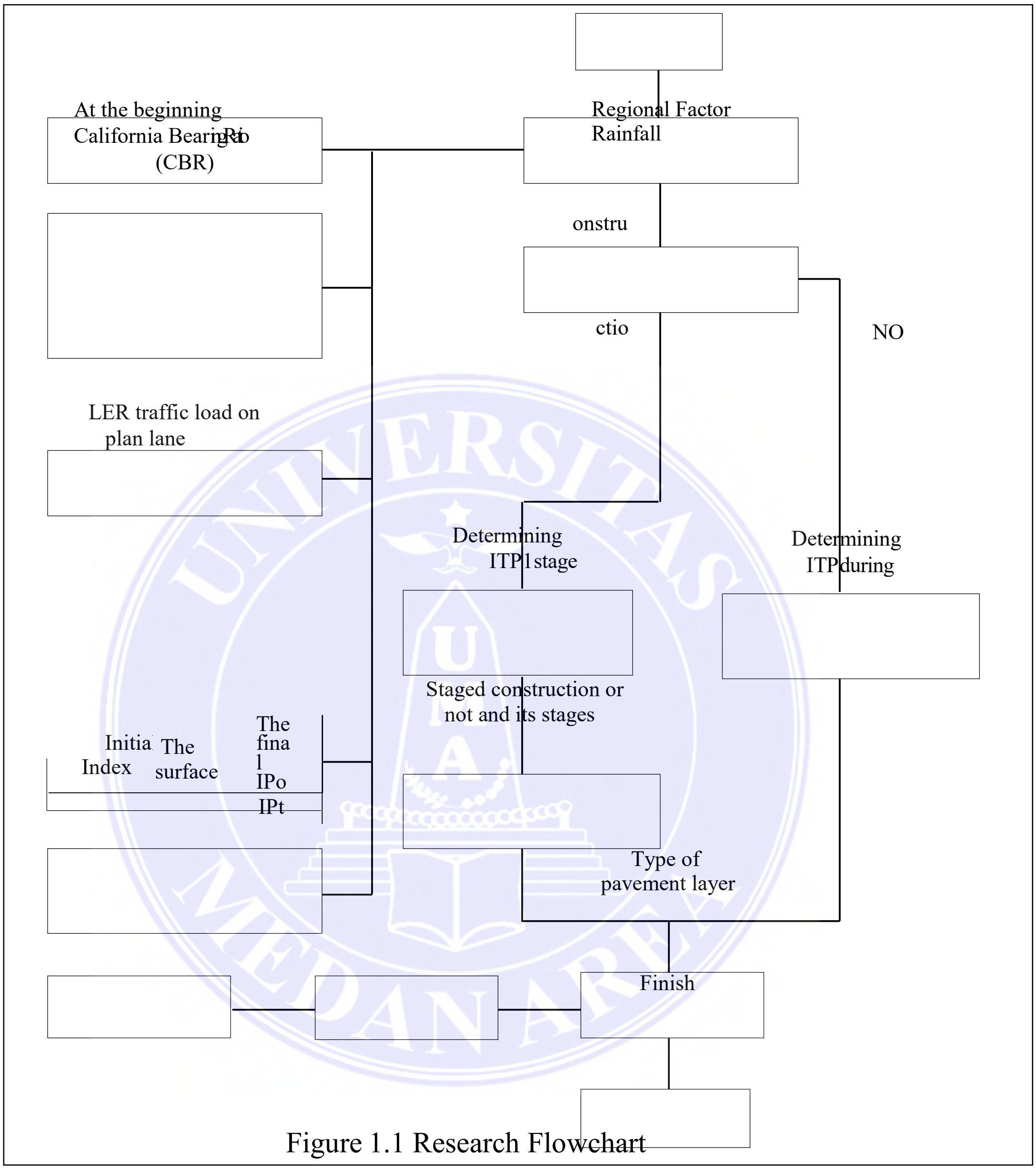


Figure 1.1 Research Flowchart

Source: Analisa Data 2019

CHAPTER II

LITERATURE REVIEW

2.1 General Description

Pavement construction consists of layers that are placed on top of the compacted subgrade. These layers function as receivers of traffic loads and distribute them to the lower layers. The distribution of vehicle loads is transferred and distributed to the pavement through the contact area of the wheels in the form of a concentrated load Po. The load is received by the pavement layer and distributed to the subgrade to become P1 which is smaller than the data supported by the subgrade. As shown in Figure 2.1 below.

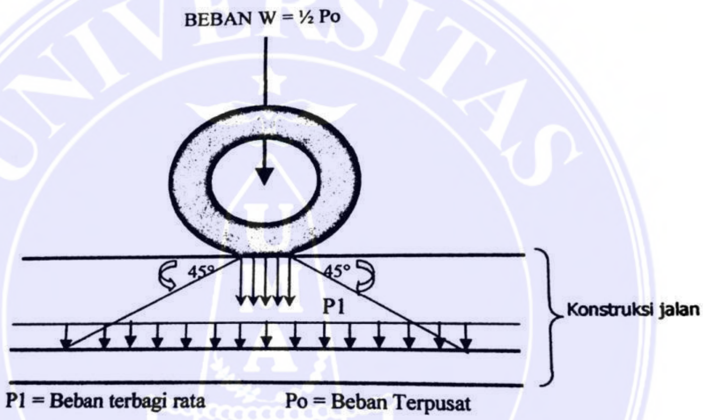


Figure 2.1 Wheel Load Distribution Through Road Pavement Layer
Source: Silvia Sukirman 2010

To simplify the problem, the pyramidal load distribution can be assumed to have horizontal plane angles. The distribution occurs slightly larger than the top of the pavement layer. The traffic load working on the pavement construction is in the form of a vertical force from the vehicle load. Due to the nature of the distribution of forces, the charge received by each layer is different, and the lower the force received, the smaller (Silvia Sukirman 2010)

2.2 Types of Road Pavement Construction

Based on the binder material, road pavement construction can be distinguished into:

a. Flexible pavement. Flexible pavement is a pavement that uses asphalt as a binder. The pavement layer functions to carry and spread the traffic load to the subgrade so that the pavement strength is obtained from the thick layers of the sub-foundation, the top foundation, and the surface layer. The main materials in the flexible pavement structure are soil, aggregate, asphalt, and filler materials such as lime, clay, or fly ash as shown in Figure 2.2.

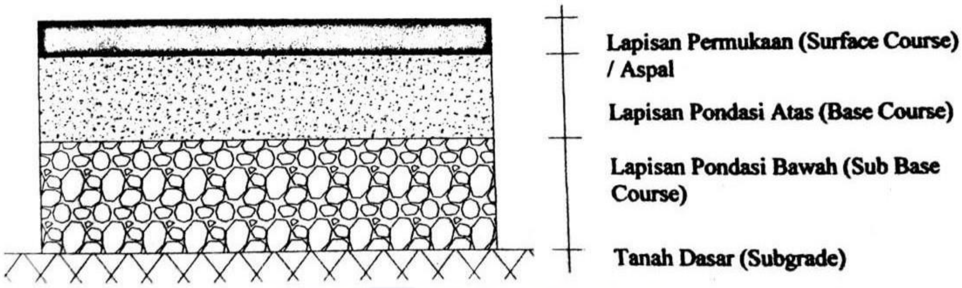
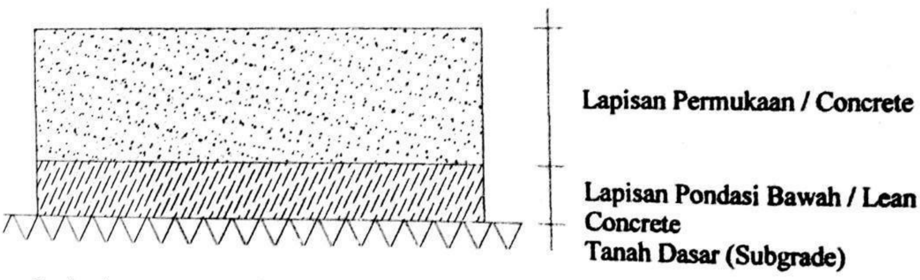


Figure 2.2 Flexible Pavement Construction

Source: SNI, 2010

b. Rigid Pavement Construction is a pavement that uses cement and water as a binder. Concrete slabs with or without reinforcement are placed on the subgrade with or without a sub-base layer. The traffic load is mostly supported by the concrete slab and distributed over a fairly large area of subgrade soil as shown in Figure 2.3

Figure 2.3 Rigid Pavement Construction



Source: SNI, 2010

c. Composite Pavement Construction combines Flexible Pavement with Rigid Pavement, namely Pavement that uses cement and asphalt as a binder for the sub-base concrete slab. Then the plate is coated with asphalt as a surface layer which is placed on the subgrade with or without a layer as shown in Figure 2.4:

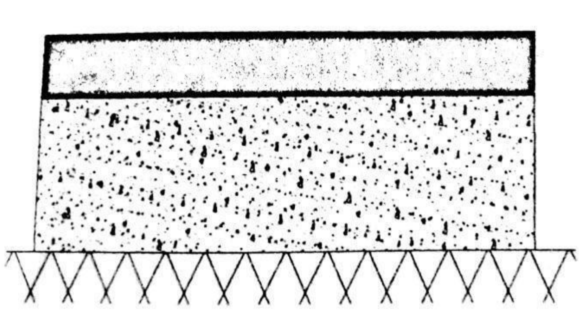


Figure 2.4 Composite Pavement Construction

Source: SNI, 2010

Table 2.1 Differences between Flexible Pavement and Rigid Pavement

No	Differences	Flexible Pavement	Rigid Pavement
1.	Binder	Asphalt	Cement+Water
2.	Repetition of Wheel Loads	If there are wheel loads, there will be deflections on the surface of the pavement, and if there are no wheel loads, it will return to its original shape.	If there are wheel loads, the surface will remain stiff but over time there will be cracks on the surface.
3.	The decline of subgrade	The road will be undulating following the ground	that acts as a beam above the placement
4.	Constructi on strength	In terms of flexible pavement, the construction strength is determined by the thickness of each layer and the bearing capacity of the subgrade	In terms of rigid pavement, it is more determined by the strength of the concrete slab itself (subgrade is not so decisive)
5.	Service index	The best service index is only after construction, after that it decreases with time and traffic frequency.	The service index remains good for most of the life of the plan, especially if properly executed and maintained.
6.	Temperatur e changes	The modulus of strength changes, and a small internal tension arises.	The modulus of strength does not change, a large internal tension arises.
7.	Period of the plan	The period of the plan is relatively short 5-10 years	The period of the plan can reach 20 years
8.	Maintenance costs	The maintenance costs incurred are approximately twice as high as that of rigid pavements.	Relative maintenance costs do not exist
9.	Resistance to drainage conditions	Difficult to withstand poor drainage conditions	Can withstand worse conditions.

Source: SNI 2010

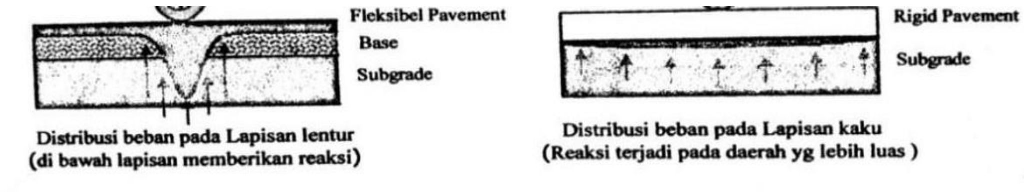


Figure 2.5. Distribution of Forces on Flexible Pavement and Rigid Pavement
Source: SNI 2010

Information:

a. For flexible pavements, it can be thought of as a thick "t" sheet of rubber that is draped over the subgrade. The pressure due to the load received by the layer is transmitted to the subgrade. The amount of pressure received by the subgrade depends on the stiffness of the rubber. The more flexible the rubber, the smaller the pressure spread, so the greater the pressure that the subgrade must bear with its stiffness to support the load (traffic) it receives it also has a stiffness that can support the load even though it is not as strong as a steel sheet.

b. For rigid pavement, it can be imagined as a thick steel plate “t” which is placed on top of the subgrade layer. Due to the stiffness of the steel, the area of the pressure distribution becomes larger, so that the pressure carried by the subgrade becomes smaller. Indonesian Road Development Association Module (HPJI.2010)

2.3 Road Classification

To facilitate the regulation, supervision, and responsibility for the implementation/operation and maintenance of roads, the roads in Indonesia are classified. Classification is made into four groups and more details on the division of road classes can be seen in table 2.2. and 2.3 :

Table 2.2 Road Classification (Type 1)

System	Function	Class Planning	Speed of Plan Km/Hour
First	Artery	1	100,80
	Collector	2	80,60
Second	Artery	2	80,60

Source: SNI 2010

Table 2.3 Road Classification (Type II)

System	Function	DTV (SMP)	Class Planning	Speed Plan Km/Hour
First	Artery	-	1	60
	Collector	>10000	1	60
		>10000	2	60,40
Second	Artery	>20000	1	60
		<20000	2	60,40
	Collector	>6000	2	60,40
		<6000	3	40,20
	Local	>500	3	40,20

Source: SNI 2010

According to the new traffic law, road classes are based on the volume and characteristics of traffic following geometric planning No. 13 of 1970. According to this, road classes can be classified in table 2.4 as follows:

Table 2.4 Road Classification According to LHR

Function	Class	LHR (smp)
First	I	>20000
Second	II A	60000-20000
	II B	1500-8000
	II C	<2000
Connector	III	-

Source: SNI 2010

Table 2.5 Road Classification According to MST

Function	Class	The heaviest axle load (mst)
Artery	I	>10 T
	IIA	10 T
	IIIA	8 T
Collector	IIIA	8 T
	IIIB	-

Source: SNI 2010

2.4 Road Pavement Structure

The part of the road pavement is layers of material that are selected and worked according to certain requirements according to the type and function to spread the wheel load of the vehicle in such a way that it can be supported by the subgrade within the limits of its carrying capacity. Generally, the pavement consists of subgrade, subbase course, base course, and surface course.

2.4.1. Subgrade

The subgrade is the original soil surface, excavated surface, or embankment surface which is the basis for laying other pavement parts. The road pavement is placed on the subgrade, so the overall quality and durability of the pavement construction cannot be separated from the nature of the subgrade. A good subgrade for road construction is a subgrade originating from the location itself or nearby, which has been compacted to a certain level of density so that it has a good bearing capacity and the ability to maintain volume changes during the service period despite differences in environmental conditions and local soil types. The nature of each type of soil depends on the texture, density, water content, environmental conditions, and so on.

The strength and durability of road pavement construction are highly dependent on the properties and bearing capacity of the subgrade. It is understood that the determination of the bearing capacity of the subgrade based on the evaluation of laboratory tests cannot cover all the details of the properties and bearing capacity of the subgrade from a certain place along a section of the road. Such corrections will be provided on the plan drawings or have been mentioned in the implementation specifications.

In general, problems concerning subgrade are changes in the permanent shape of certain soil types as well as the swelling properties of certain soil types due to changes in water content, if the carrying capacity of the soil is uneven and difficult to determine with certainty in areas with very different soil types and positions. Great deflection and development during and after traffic loading from certain soil types. Additional compaction due to traffic loading and the resulting settlement is on coarse-grained soil that is not properly compacted at the time of implementation.

The maximum dry density (αd) determined from the test results and the thickness of the base soil density is a minimum of 11-15 cm based on the Indonesian Road Development Association Module (HPJI)).

The bottom layer of a minimum of 15 cm is compacted to 90% of the maximum dry density. Base soil from native soil and minerals have compacted a minimum of 100% of the maximum dry density to a depth of 30 cm below the surface of the base soil. This work is controlled by quality control in the field in the form of sand cone testing or visually (Indonesian Road Development Association Module (HPJI)).

Cohesive subgrades, i.e. cohesive subgrades with a plastic index of less than 25, and a minimum thickness of 15 cm above must be compacted to reach 95% of the minimum density. for subgrade and native soil, it is recommended to compact it to reach 100% of the maximum dry density. During compaction, care should be taken that the moisture content does not differ by more than 20% from the optimum moisture content

that strives for an even subgrade bearing capacity. If there is a difference in the bearing capacity that supports the subgrade evenly and if there is a marked difference in bearing capacity between adjacent subgrades, it is necessary to try to change the thickness of the pavement layer in an oblique and even manner. It is recommended to have a transition distance of 10 meters starting from the border of the change in the bearing capacity of the soil towards a better bearing capacity of the subgrade as the repairment of subgrade to support wheel loads of large tools.

In fieldwork, the bearing capacity of the subgrade does not support the passperiod oflarge equipment, appropriate methods must be adapted according to local conditions so that the wheel load of large tools can be supported by the subgrade. This subgrade improvement can be in the form of an additional sub-base layer beyond that calculated for the required pavement thickness. The bearing capacity of the subgrade can be estimated using the results of the California Bearing Rate (CBR) examination.

2.4.2. *Subbase Course*

The subbase layer is the pavement layer that is located between the top foundation layer and the subgrade. The subbase layer serves as part of the pavement construction to spread the wheel load to the subgrade. This layer must be strong enough, having a California Bearing Rate (CBR) of 20% and a plasticity index of < 10%.

In terms of efficient use of materials, sub-base material is relatively cheap compared to the pavement layer above it. Reducing the thickness of the overlying layer is more expensive. Infiltration layer so that groundwater does not collect in the foundation. The first layer so that the work can run smoothly. Layer to prevent fine soil particles from subgrade to the surface of the top foundation layer.

The types of subbase layers commonly used in Indonesia are well-graded aggregates and are distinguished into class A sirtu/pitrun, B class sirtu/pitrun, C class sirtu/pitrun. Class A sirtu/pitrun are graded coarser than class B sirtu/pitrun, and class B sirtu/pitrun is coarser than class C sirtu/pitrun.

For stabilization, there are several methods such as aggregate with cement (Cement Treated Subbase), aggregate stabilization with lime (lime treated subbase), soil stabilization with cement (Cement Subbase Soil), and soil stabilization with lime (Soil Lime Stabilization).

2.4.3. Base Course

The pavement layer located between the sub-base layer or with the subgrade if not using the sub-base and surface layers is called the Base Course.

The function of the top layer of the foundation is as a part of the pavement that supports the wheel load and spreads the load to the lower layer. This functions as an infiltration layer for sub-base layers and as a cushion against surface layers.

The material used for the top layer of the foundation is a material that is quite strong. For the top layer of foundation without a binder generally use a material with a CBR> 50% and a plasticity index <4%. Natural materials such as crushed stone, crushed gravel, and soil stabilization with cement and lime can be used as the top foundation layer. The type of top foundation layer commonly used in Indonesia is well-graded aggregate which is distinguished into class A crushed stone, class B crushed stone, class C crushed stone, and class B crushed stone better than class C crushed stone. The above layer can be obtained from the specifications given by the general specifications of the Ministry of Highways of the Republic of Indonesia.

2.4.4. *Surface Course*

The surface course is the layer that is in contact with the vehicle load, because of direct contact with the vehicle load, this layer experiences pressure, shear, and torque at the same time so this layer must not only be strong, it must also be stable and have good durability.

This layer must have high stability to withstand wheel loads during the service period, including a waterproof pavement layer so that rainwater that falls on it does not seep into the lower layer and weakens the layer and also acts as a Wearing Course, a layer that is directly depressed due to friction brakes so they are easy to wear. To fulfill this function, generally, the surface layer is made using an asphalt binder to produce a waterproof layer with high stability and long durability.

The types of surface layers commonly used in Indonesia include non-structural layers, which function as wear and water-resistant layer, namely one-layer asphalt burtu, which is a cover layer consisting of a layer of asphalt sprinkled with one layer of a uniformly graded aggregate, with a thickness of max 2cm. Burda (two layers of asphalt), is a cover layer consisting of a layer of asphalt sprinkled with aggregate which is sprinkled twice successively with a maximum thickness of 3.5 cm. Latasir, a thin layer of asphalt sand, is a covering layer consisting of a layer of asphalt and graded natural sand mixed, spread, and compacted at a certain temperature with a solid thickness of 1-2 cm. Latasbun (top layer of Asbuton soil), is a cover layer consisting of a mixture of Asbuton and softening material with a certain ratio mixed coldly with a solid thickness of max 1 cm. Lataston thin layer of asphalt concrete, known as Hot Roller Sheet (HRS), is a cover layer consisting of a mixture of a lime graded aggregate, mineral filler, and hard asphalt in a certain ratio, which is mixed and compacted in a hot state. Thick solid between 2 s / d 3.5 cm. Lataston generally consists of two types, namely: foundation layer lataston (HRS-Base) and surface layer lataston (HRS-Wearing Coarse).

The type of surface layer mentioned above, although non-structural, can increase the durability of the pavement against quality degradation, thereby increasing the overall service life of the pavement construction. This type of pavement is mainly used for road maintenance. Indonesian Road Development Association Module (HPJI)).

The structural layer functions as a layer that holds and spreads the wheel load. Macadam Penetration (Lapen), is a pavement layer consisting of principal aggregate and locking aggregate with open and uniform grades bound by asphalt by spraying on top and compacting layer by layer. On top of this lapen is usually given a layer of asphalt with an aggregate cover. The thickness of a single layer can vary from 4cm to 10 cm. Lasbutag is a layer on road construction consisting of a mixture of aggregate, asphalt, and softener which is stirred, spread, and compacted coldly. A thick layer of solid between 3 s / d 5 cm. Alston (asphalt concrete layer), is a layer on road construction consisting of a mixture of hard asphalt with aggregate that has continuous gradations, mixed, spread, and compacted at a certain temperature. Laston consists of three kinds of mixtures, laston layer asu (AC-WC), laston layer binder (AC-BC), and laston layer foundation (AC-Base). The maximum size of aggregate for each mixture is 19 mm, 25 mm, and 37.5 mm. when the asphalt mixture is spread more than one layer, the entire asphalt mixture must not be less than the tolerance of each mixture, and the nominal design thickness.

2.5 Traffic

The thickness of the pavement layer is determined by the load to be carried, which means the traffic flow on the road. The amount of traffic flow can be obtained from the current traffic analysis so that data is obtained regarding the number of vehicles that want to use the road, the type of vehicle and the number of each type, the configuration of each type of vehicle, the load of each vehicle axle.

Estimates of traffic factors over the life of the plan, among others, are based on economic and social analysis of the area.

2.6.1. Traffic Volume

The number of vehicles wishing to use the road is expressed in terms of traffic volume. Traffic volume is defined as the number of vehicles that pass an observation point during a unit of time. For pavement thickness planning, traffic volume is expressed in vehicles/day/2 directions for non-separable two-way roads and separate 1-way or 2-way vehicles/day.

2.6.2. Traffic Growth Factors

The number of vehicles using the road is increasing from year to year. Factors influencing traffic growth are regional development, increasing welfare, and increasing the ability to buy public vehicles. Traffic growth factor expressed in percent per year.

2.6. Component Method Analysis, Bina Marga (1987)

In designing roads using the flexible pavement, Indonesia uses the Component Analysis Method, Bina Marga determines the thickness of the pavement using the method only applies to construction pavements that use granular materials such as granular, crushed stone other materials.

In this Bina Marga method, there are several terms and parameters used to plan the pavement thickness for each flexural layer. The terms used include the number of lanes and Vehicle Distribution Coefficient (C), Design Period (Indonesian: Umur Rencana [UR]), Surface Index (Indonesian: Indeks Permukaan [IP]), Equivalent Number (E), Annual Average Daily Traffic (Indonesian: Lalu Lintas Harian rata-rata [LHR]), Surface Equivalent Pass (LEP), Final Equivalent Pass (LEA), Middle Equivalent Pass (LET), Subgrade, Sub-base Layer, Foundation Layer, Surface Layer, Regianao Factor (FR), Pavement Thickness Index (ITP).

2.6.1. Traffic Plan

Traffic data is the main basis for planning highways. This plan includes the geometry and thickness of the highway pavement. Data on the amount of traffic can be obtained from the calculation of vehicles that pass per day / in 2 directions. Daily traffic from each type of vehicle was determined at the beginning of the design life, for each vehicle calculated for both directions on roads without a median or in each direction on roads with a median.

The average daily traffic (LHR) of each vehicle type is determined at the beginning of the design period, which is calculated for two directions on a road without a median or for each direction with a median using the following formula:

Where:

i = traffic growth

n = design period

2.6.2. Vehicle Axle Load Equivalent Figure (E)

Road construction works receive traffic loads that are passed through the wheels of vehicles. The amount of load applied depends on the total weight of the vehicle, the axle configuration, the field of contact between the wheels and the gear, and the speed of the vehicle. Thus the effect of each vehicle on damage is not the same. Therefore, there needs to be a standard load so that all other loads can be equalized to the standard load.

The weight of the vehicle is transferred to the road pavement through the vehicle wheels located at the end of the vehicle axle. Each type of vehicle has a different axle configuration. The front axle is a single axle, and the rear axle can be a stump or dual axle. Thus each vehicle will have a different equivalent number. In highway planning, the equivalent number needs to be known by dividing the vehicle into 2 types a single axle or dual axle.

The types of vehicles that will use the road vary in size, total weight, configuration, and axle load. Therefore, the traffic volume is grouped into several groups represented by 1 type of vehicle per group. The grouping of these vehicles is passenger cars, including all types of vehicles weighing 2 tons, buses, 2 axles trucks, 3 axles trucks, 5 axles trucks, semi-trailers as in Figure 2.6 below;

Figure 2.6 Axle Load Distribution From Different Types of Vehicles

KONFIGURASI SUMBU & TIPE	BERAT KOSONG (ton)	BEBAN MUATAN MAKSIMUM (ton)	BERAT TOTAL MAKSIMUM (ton)	UE 18 KSAL KOSONG	UE 18 KSAL MAKSIMUM	○ RODA TUNGGAL PADA UJUNG SUMBU ● RODA GANDA PADA UJUNG SUMBU
1,1 HP	1,5	0,5	2,0	0,0001	0,0005	50% 50%
1,2 BUS	3	6	9	0,0037	0,3006	34% 66%
1,2L TRUK	2,3	6	8,3	0,0013	0,2174	34% 66%
1,2H TRUK	4,2	14	18,2	0,0143	5,0264	34% 66%
1,22 TRUK	5	20	25	0,0044	2,7416	25% 75%
1,2+2,2 TRAILER	6,4	25	31,4	0,0085	3,9083	18% 28% 27% 27%
1,2-2 TRAILER	6,2	20	26,2	0,0192	6,1179	18% 41% 41%
1,2-2,2 TRAILER	10	32	42	0,0327	10,1830	18% 28% 54% (27% 27%)

Source : Silvia Sukirman, 2010

In determining the value of the equivalent number of the axle of the vehicle as shown in table 2.7. following:

Table 2.6 Equivalent Figures (E) Vehicle Axle Load

Load S	mbu		
Kg	Lb	Single Axle	Dual Axle
1000	2205	0, 0002	0,0000
2000	4409	0,0036	0, 0003
3000	6614	0,0183	0,0016
4000	8818	0,0577	0,0050
5000	11023	0,1410	0,0121
6000	13227	0,2923	0,0251
7000	15342	0,5415	0,0466
8000	17636	0,9238	0,0795
8160	18000	1, 0000	0,0860
9000	19841	1,4798	0,1237
10000	22045	2,2555	0,1940
11000	24250	3,3023	0,2840
12000	26454	4,6770	0,4022
13000	28659	6,4419	0,5540
14000	30683	8,6647	0,7452
15000	33068	11,4184	0,9820
16000	35272	14,7815	1,2712

Source: SNI-2010

2.6.3. Number of Columns and Vehicle Distribution Coefficient (C)

The planned lane is one of the traffic lanes of a road segment, which accommodates the largest traffic. If the road does not have a lane boundary sign, then the number of lanes is determined by the width of the pavement as shown in table 2.7 below:

Table 2.7 Number of Planned Paths Based on Pavement Width

No.	Pavement Width	Number of Columns
1	L<5,5 m	1 Column
2	5,5 m<L<8,25 m	2 Column
3	8,25 m < L < 11,25 m	3 Column
4	11,25 m < L < 15,00 m	4 Column
5	15,00 m < L < 18,75 m	5 Column
6	18,75 m < L < 22,00 m	6 Column

Source: SNI-2010

The vehicle distribution coefficient (C) for light and heavy vehicles passing in the planned lane is determined in the following table 2.9.

Table 2.8 Vehicle Distribution Coefficient (C)

	Number of Veh			
	One Way			
Light 2 ways vehicl es 1 way n heavy 2 ways 1 line	1,00	1,00	1,00	1,00
2 ways	0,60	0,50	0,70	0,50
3 ways	0,40	0,40	0,50	0,475
4 ways	-	0,30	-	0,45
5 ways	-	0,25	-	0,425
6 way	-	0,20	-	0,40

Source: SNI-2010

Information:
Light vehicles: total weight < 5 tons (eg Passenger Cars, Pick Ups, etc.)
Heavy vehicles: total weight > 5 tons (e.g. Buses, Tractor Trucks, Trailers, etc.)

2.6.4. Equivalent Pass

a. Initial Equivalent Pass

The LEP (Initial Equivalent Pass) is the mean equivalent number of passes of a single axle weighing 8.16 tonnes on the design line, which is assumed to occur at the beginning of the design life. LEP is calculated by the formula:

$$\Sigma$$

Information:

LEP = Initial Equivalent Pass

C = Vehicle distribution coefficient

E = Equivalent Number

b. Final Equivalent Pass (LEA)

The LEA (final equivalent pass) is the mean equivalent number of single axle passes of 8.16 tonnes on the design line which is expected to occur at the end of the design life. LEA can be calculated using the following formula:

Σ

Information:
LEP = Initial Equivalent Pass
C = Vehicle distribution coefficient
E = Equivalent Number
UR = Design Period

c. Middle Equivalent Pass (LET)

LET (Middle Equivalent Pass) is the average daily equivalent number of passes of a single axle weighing 8.16 tonnes on the design line which is expected to occur in the middle of the design life. LET can be calculated using the following formula:

d. Planned Equivalent Pass (LER)

LER is the average daily equivalent number of passes of a single axle of 8.16 tonnes on the design line which is expected to occur during the design life. LER can be calculated using the following formula:

Information

FP = adjustment factor

FP = -

2.6.5. Bearing Capacity of Subgrade and CBR (California Bearing Rate)

The basic soil support (DDT) is determined based on the correlation graph as shown in the following figure:

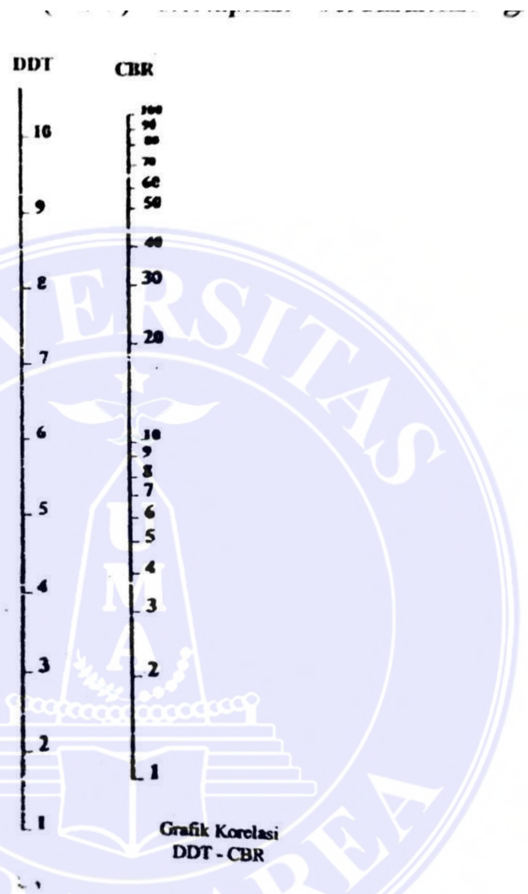


Figure 2.7 DDT Correlation Graph

Source: SNI 2010

What is meant by CBR price here is the price of field CBR or laboratory CBR. If field CBR is used, the subgrade sample is taken using a tube (Undisstrubed) and checked for the CBR value. Can also measure directly in the field (rainy season/wet condition).

Field CBR is usually used for overlay planning. if carried out according to the Light Density Test (SKBI 3.3 30.1987/UDC 624.131.53 (02) as needed. Laboratory CBR is usually used for planning the construction of new roads. Meanwhile, it is recommended to base the bearing capacity of the soil only on the measurement of the CBR value.

The strength and durability of road pavement construction are highly dependent on the properties and strength of the bearing capacity of the subgrade. There are several ways to determine the strength of the subgrade, one of which is the CBR method, which is to measure the CBR value of the soil in question. Measurement of the value of v CBR can be done directly in the field, namely with a CBR jack, DCP, and others, or in the laboratory. If it is carried out in a laboratory, then taking the test material used in an undisturbed soil tube.

2.6.6. Pavement Thickness Index

The calculation of pavement thickness can be determined by a pavement thickness index (ITP). This type of pavement is related to what has been described in the form of pavement construction structure so that we get the coefficient of the relative strength of each material and its uses. ITP can be obtained from the corresponding IP and IPo nomogram obtained using FR, LER over the design life of the DDT (Soil Carrying Capacity) that has been obtained.

2.6.7. Determining Pavement Thickness Index

To determine the thickness of the pavement can be calculated using the following equation:

The value of the relative coefficient (a) for each material and its use as a surface layer, sub-base layer, is determined by correlation according to the Marshall Test value (for materials with asphalt), compressive strength (for materials stabilized with cement or lime) and CBR (for subbase material).

The minimum surface layer thickness requirements for each pavement thickness index (ITP) value for each material used can be seen as shown in table 2.10 below:

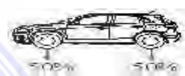
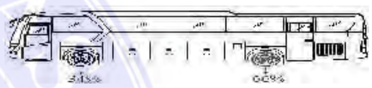
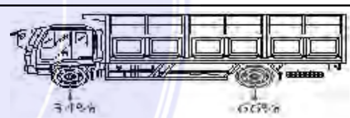
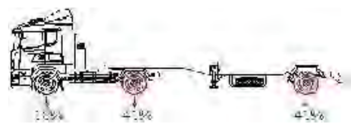
Table 2.9 Minimum Surface Layer Thickness Limits

ITP	Minimal Thickness (cm)	Materials
< 3,00	5	Protective Layer Buras/Burtu/Burda
3,00 – 6,70	5	Lapen/Aspal Macadam. HRA,Asbuton, laston
6,70 – 7,49	7,5	Lapen/Aspel Macadam, HRA, Asbuton, Laston
7,50 – 9,99	7,5	Asbuton, Laston
10,00	10	Laston

Source : SNI-2010

The vehicle load axle configuration can be described in full in the table below:

Table 2.10 Vehicle Axle Load Configuration

Axle Configuration And Type	Empty Weight (Ton)	Maximum Load Weight (Ton)	Max Total Weight	UE 18 KSAL Empty	UE 18 KSAL Maximum	 Single Wheel at Axle End
1,1 HP	1,5	0,5	2,0	0,0001	0,0005	
1,2 Bus	3	6	9	0,0037	0,3006	
1,2 L Truk	2,3	6	8,3	0,0013	0,2174	
1,2 H Truk	4,2	14	18,2	0,0143	5,0264	
1,22 Truk	5	20	25	0,0044	2,7416	
1,2 +2,2 Trailer	6,4	25	31,4	0,0085	3,9083	
1,2–2 Trailer	6,2	20	26,2	0,0192	6,1179	
1,2–2 Trailer	10	32	42	0,0327	10,1830	

Source: (SNI- 2010)

2.7 Road Function

Based on the function of roads, roads in Indonesia can be divided into several types, including:

i. Local Road is a road that serves as local transport with the characteristics of close travel, and the number of entrances is not limited, and the passing vehicles have a slow speed.

ii. Collector Road is a road that serves the collection or division transport with the characteristics of a limited number of entrances, moderate travel, and vehicles passing through the road have moderate speed.

iii. iii. Arterial Road is a road that serves public transport with the characteristics of long-distance travel, the number of entrances is limited in use, and passing vehicles have a high speed.

iv. iv. Toll Road is a road that serves free transport or traffic with the characteristics of long-distance travel, the number of entrances is very limited, and passing vehicles have a very high speed. Usually, toll road users will be charged toll charges according to the type of vehicle.

2.8 The Design Period

According to (Sukirman 1999), the design period is the number from the time the road is opened for vehicular traffic until a structural repair is required until a pavement overlay is required. During the period of planning, pavement maintenance must still be carried out, such as non-structural layers that function as wear layers. The design life for new flexible pavements is generally 20 years and for road improvements 10 years.

2.9 Traffic Growth Value

According to Sukirman (1999), the value of traffic growth is the number of vehicles using the road increases from year to year. Factors that affect the growth of traffic are regional development, increased community welfare, increased ability to buy vehicles, and so on. Traffic growth factors are expressed in percentages/year.

2.10 Average Daily Traffic and Equivalent Traffic Formulas

The average daily traffic (LHR) of each vehicle type is determined at the beginning of the design period which is calculated for two directions on a road without a median or each direction on a road with a median. Average daily traffic (LHR) can be calculated with a formula:

$LHR_{initial}\ UR = LHRo \times (1+i)\ UR$…............................. (3.4)

Information:
I = Traffic growth value
UR = The length of the road pavement implementation.
LHRo = Average daily traffic before the pavement is worked.

To calculate the final LHR value can be determined by the formula: LHR

final UR $= LHR_{initial} UR \times (1+i)\ UR$ ....(3.5)

Information:

I = Traffic growth value.

UR = Length of road pavement implementation

The starting equivalent pass (LEP) can be calculated by the formula

LEP = initial LHR UR x C x E (3.6)

Information:

C = Vehicle coefficient

E = Vehicle equivalent number

The final equivalent pass (LEA) can be calculated by the formula

LEA = UR final LHR x C x E (3.7)

Information:

C = Vehicle coefficient

E = Vehicle equivalent number

The middle equivalent pass (LET) can be calculated by the formula LET = (3.8)

Information:

FP = Adjustment Factor

FP =

2.11 Bearing Capacity of Subgrade and CBR

The price of CBR referred to here is the price of field CBR or laboratory CBR. If field CBR is used, the subgrade sample is taken using a tube (Undisturb), then soaked and checked for the CBR value. The value of the bearing capacity of the subgrade or DDT is one of the components in determining the thickness of the road pavement.

The base soil support or DDT is determined based on the correlation graph.

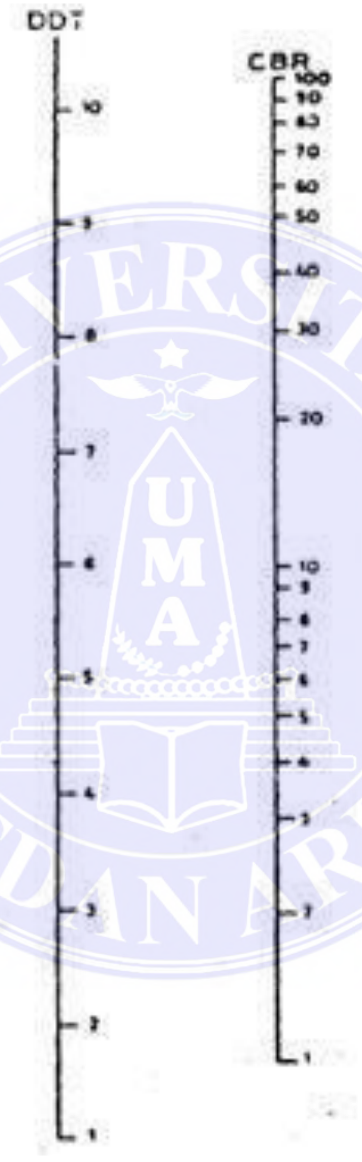


Figure 2.8 Nomogram Correlation Between CBR and DDT
Source: SNI 2010

The representative price of the number of reported CBR prices is determined as follows:

a. Determining the lowest CBR value.
b. Determining how many CBR values are equal to and greater than each CBR value.
c. The highest number is expressed as 100% CBR. The other amount is a percentperiod of100%
d. Graph the relationship between the CBR price and the percentperiod ofthe amount.
e. The representative CBR value is obtained from the figure of 90 %.

2.12 Regional Factor

Regional factors are field conditions including soil permeability, drainage equipment, alignment form, and the percentperiod ofvehicles weighing 13 tons and stopped vehicles, while climatic conditions include average rainfall per year. Thus, in determining the thickness of this pavement, regional factors are only influenced by the shape of the alignment (slopes and bends), the percentperiod ofheavy and stopped vehicles, and climate (rainfall). For the calculation of the percentperiod ofheavy vehicles can use the formula:

$$\%\ \text{Kendaraan Berat} = \frac{L \quad k \qquad\qquad b}{L \quad k \qquad\qquad t} \times 100\% \text{.........(3.11)}$$

Table 2.11 Regional Factors

Rainfall	Grade I (<6 %) % Vehicles Heaviness ≤30%	Grade I (<6 %) % Vehicles Heaviness > 30%	Grade II (6-10 %) % Vehicles Heaviness ≤30%	Grade II (6-10 %) % Vehicles Heaviness > 30%	Grade III (>10 %) % Vehicles Heaviness ≤30%	Grade III (>10 %) % Vehicles Heaviness > 30%
Climate I < 900 mm/year	0,5	1,0-1,5	1,0	1,5-2,0	1,5	2,0-2,5
Climate II ≥ 900 mm/year	1,5	2,0-2,5	2,0	2,5-3,0	2,5	3,0-3,5

Source: (SKBI) – 2010

1) Road Drainage

Drainage is one part of the development of irrigation related to flood management (Float Protection), while irrigation aims to provide water supply to plants. Drainage can also be interpreted as an effort to control surface water in relation to the direction of discharge of surface water. The types of drainage according to their formation consist of: a) Natural drainage is formed naturally, there are no supporting buildings. b). Artificial drainage (Artificial Drainage) is made with a specific purpose, and requires a special building According to the shape of the road drainage construction:

1. Open channels accommodate and drain the surface water and other wastes with open construction.
2. Closed canals accommodate and drain dirty surface water of canal construction embedded below the ground surface.

1. The drainage system is a series of water structures that function to reduce and or dispose of excess water from an area to water bodies of rivers and

lakes or artificial infiltration places. In the design of the road drainage system based on the presence of surface and subsurface water, the road drainage design is divided into:

2. Surface drainage is useful for draining water from the environment in the form of city waste and rainwater and water from the road.
3. Sub Surface Drainage (Sub Surface Drainage) is useful for draining underground flow conditions at a certain height so that it can flow and not interfere with building construction. The subsurface drainage system aims to lower the groundwater level and prevent and remove infiltration water from the area around roads and road surface or water rising from the road subgrade.

Surface water design can be done through land design where water will flow on the road construction section, if the road is in an area adjacent to the land slope, flow conditions are needed by installing a water catcher channel before it falls to the land slope and installed open channels on the right and left of the road. Open channels are channeled to the lowest area with the help of closed channels to avoid damage to the graded layer and pavement subbase in Figure 2.9

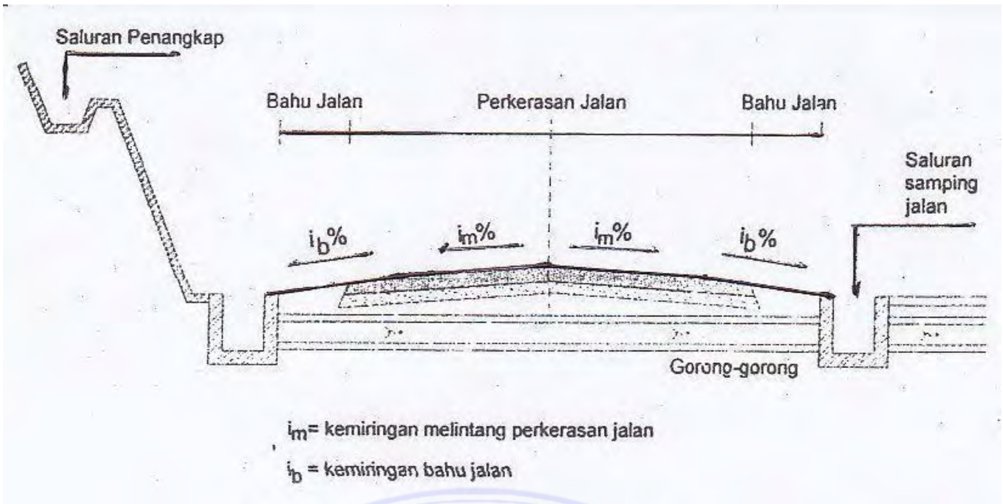


Figure 2.9 A Typical Road Drainage System With a Flow Control System from Land Slopes That Causes Dam Damage

Source; PP 2006

Some things that need to be considered in planning surface drainage include a Road route plot on a topographic map Plot this route to know the picture/topographic conditions along the road trail to be planned so that it can help in determining the shape and slope that will affect the flow pattern. Inventory of drainage building data.

This data is used for planning the road drainage system without disturbing the existing drainage system. Channel segment length, in determining the length of the channel segment, is based on the slope of the road route and the presence or absence of water discharge places such as rivers, reservoirs, and others. The service area is used to estimate the capacity of rainfall or to estimate the volume of surface runoff to be accommodated by the channel. This area includes the area of half the road body, the width of the road shoulder, and the area around it for urban areas of approximately 10 m while for outside the city depending on the topography of the area.

1. Coefficient of Flow

   This figure is influenced by land use conditions in the service area. The flow coefficient will affect the flow rate so that the channel capacity can be estimated. Therefore, topographic maps and field surveys are needed.

2. Runoff Factor

   Is a factor/number multiplied by the Run-Off coefficient, usually with the aim that the channel's performance does not exceed its capacity due to a too wide drainage area?

3. Concentration Factor

   That is the longest time required for the entire service area to distribute water flow simultaneously (runoff) after passing certain points.

4. Hydrological Analysis and Water Flow Debit

   Analyze maximum daily rainfall data in one year (obtained from BMG) with a repeat period in accordance with its purpose (drainage channel is taken 5 years) to determine the intensity of rainfall in order to calculate the discharge of water flow.

   a. Typical Road Surface Drainage Systems

The road surface drainage system technically consists of the cross-slope of the pavement and road shoulders, side ditches, and culverts. Figure 2.10

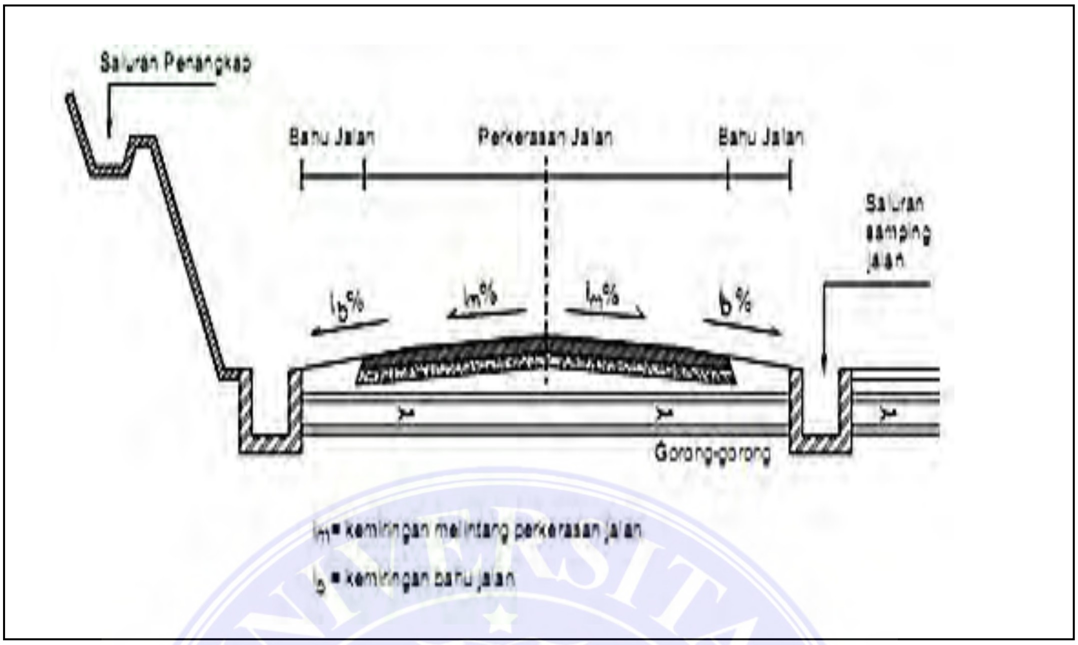


Figure 2.10Typical Road Drainage System on Source Porous Pavement; WA et al 2010

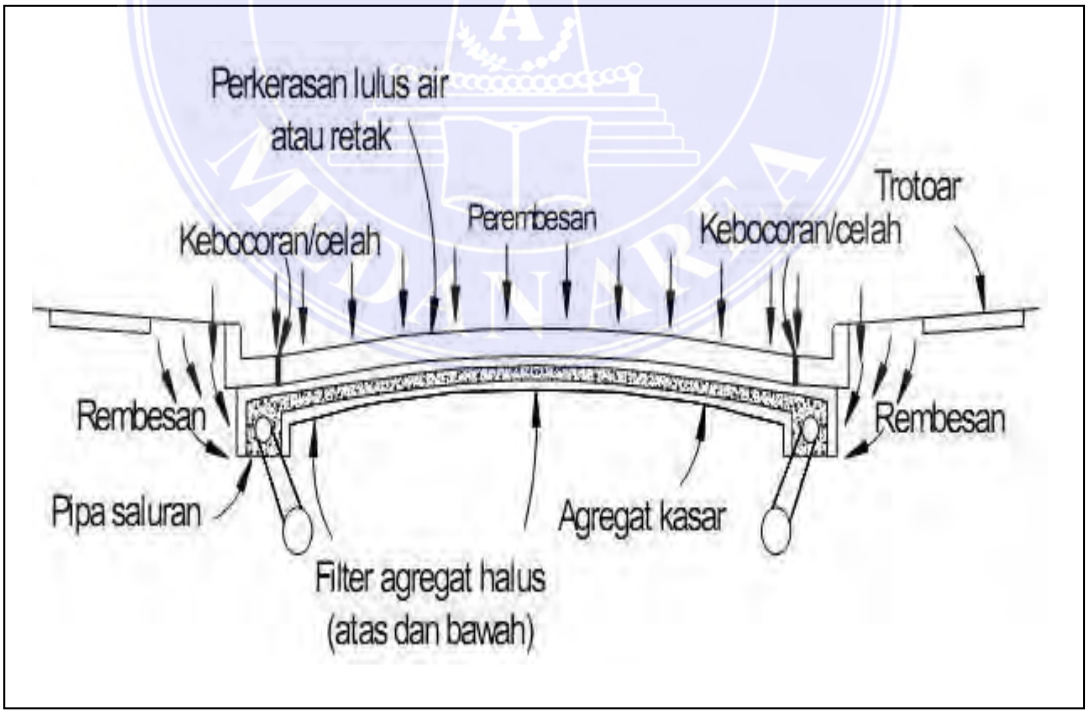


Figure 2.11 Typical Drainage for Low-Source Surface Water; HPJI 2010

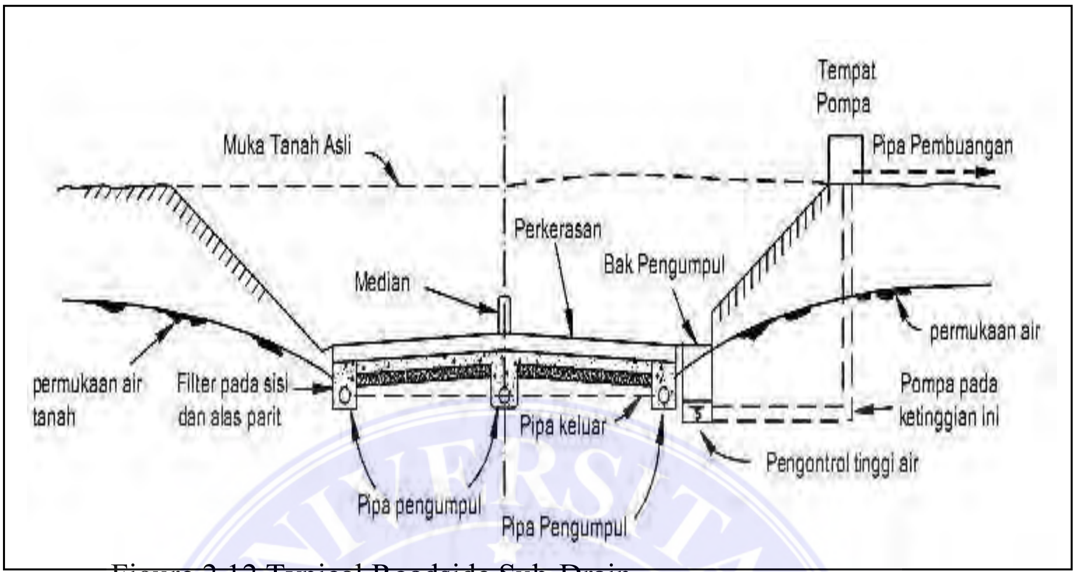


Figure 2.12 Typical Roadside Sub-Drain

Source; HPJI 2010

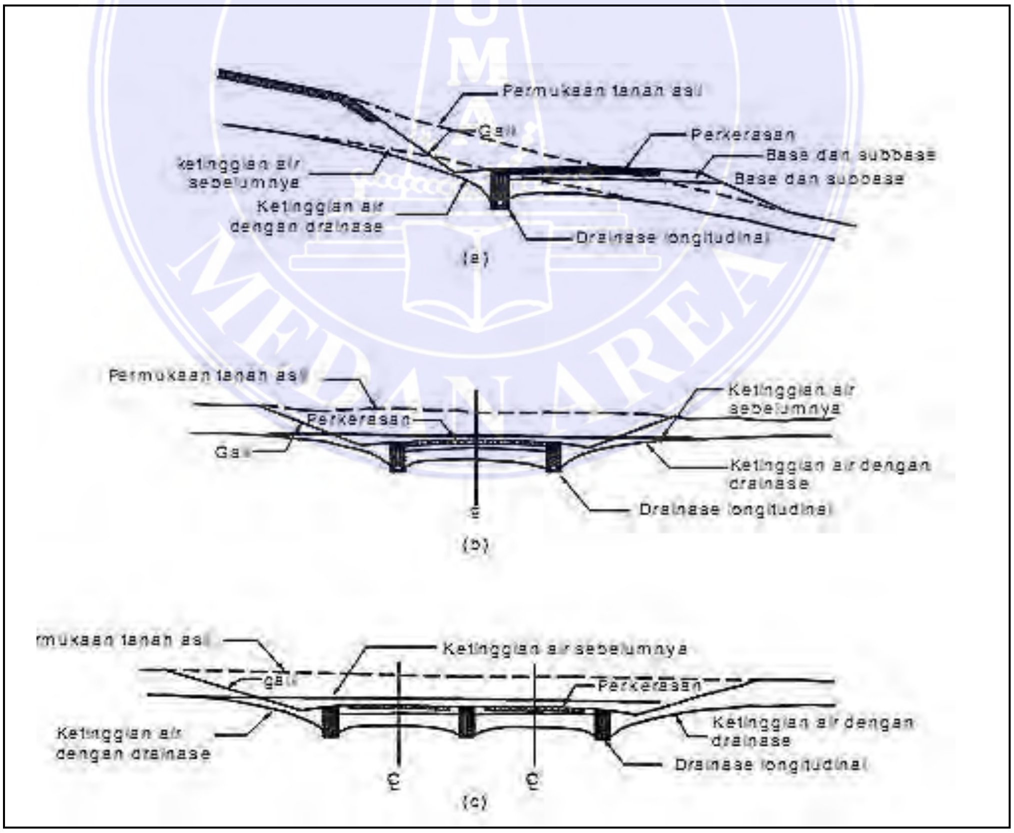


Figure 2.13 Typical Cross-Road Sub-Drain
Source; HPJI 2010

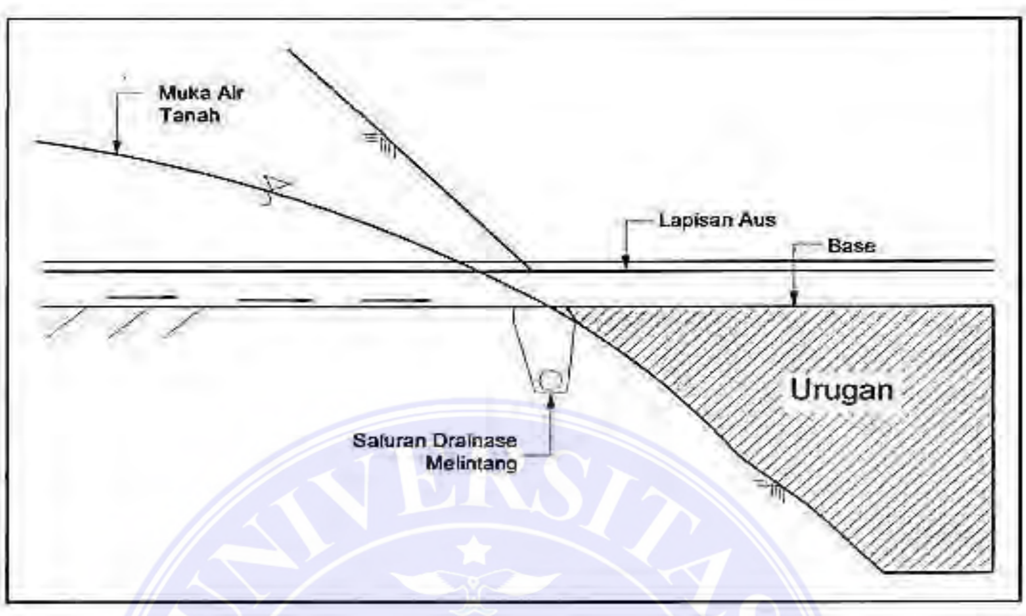


Figure 2.14 Typical Sub-Drain Crossing Source Road; HPJI 2010

b. Drainage Plan Scheme

Here is a simple flow diagram for planning road drainage. stages are performed by plotting the road route of the surface water overflow with the estimated height of the land on the road STA, the catchment area of the flow, and the land area

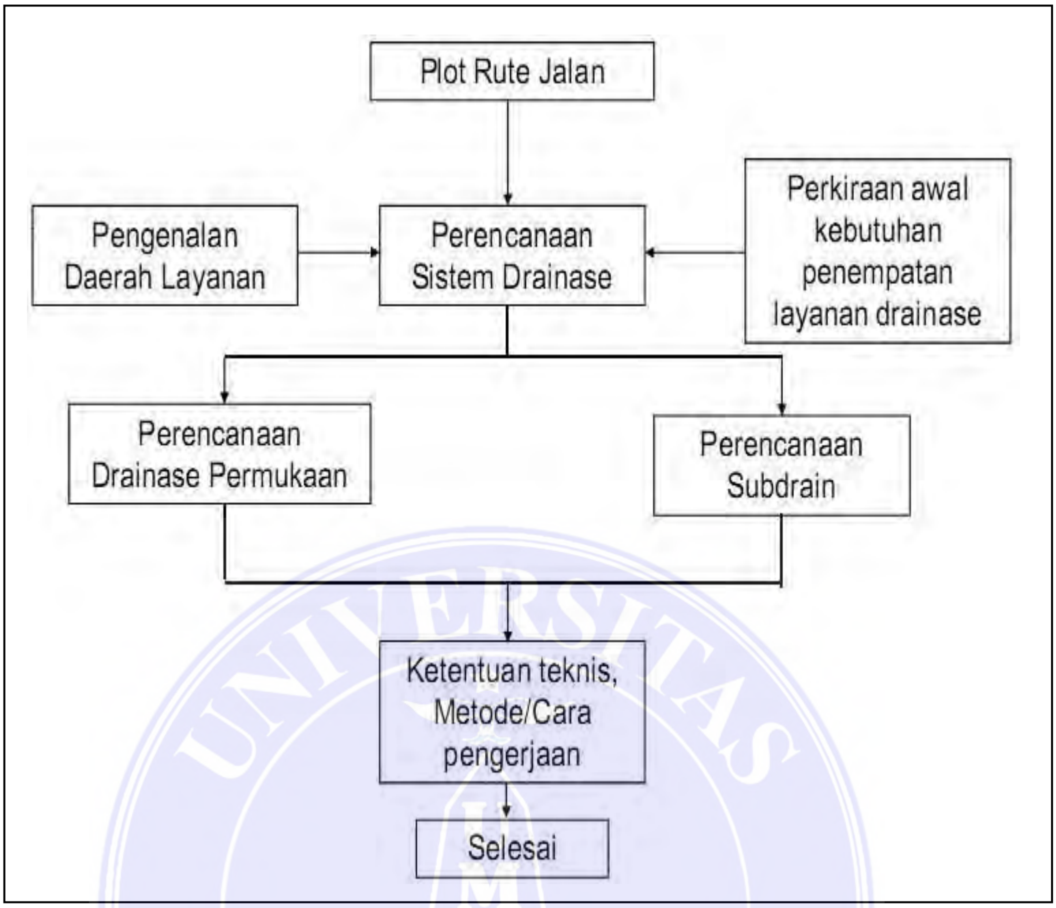


Figure 2.15 Drainage Plan Scheme
Source: Data Analysis 2019

e. Road drainage plan

There are many difficulties in drainage work in the area because landslides often occur in that area because the area is located in hills that have unstable soil structures. In this development, there are many processes carried out, namely: Construction of slabs on slopes that are easy to collapse, and the soil is dredging with a step system. tiered to reduce soil slope pressure. Construction of road drainage due to standing water on the road The construction of road drainage is adjusted to the direction of the slope of the road so that water flows easily. Construction of closed canals was carried out by reducing water and placing them under the road. In figure 2.16

Figure 2.16 Drainage Construction Used For Water Drainage From Areas Owned By Roads That Are Often Damaged

Source; HPJI 2010

CHAPTER III

RESEARCH METHOD

3.1. Location

Hotmix Pavement Road Improvement at Dolok Sanggul Silimbat Road is one of the districts in North Sumatra province. This is road section is one of the main and potential accesses used to connect several villages on the outskirts of Lake Toba. The development of the times and the growth in the level of demand for transportation needs in rural areas must of course be prepared for the existing facilities and infrastructure in the countryside, which aims to increase and build access roads to the outskirts of Lake Toba later the flow of land transportation, especially in rural areas, runs smoothly in increasing economic growth in the area. figure 3.1.

Figure 3. 1 Map of Humbang Hasundutan Regency
Source: Google

Figure 3. 2. Location Map of Dolok Sanggul District, Kab. Humbang Hasundutan
Source: *www.Wikipedia.com*

3.2. Primary Data

General data is a data collection that includes primary data and secondary data, is a data collection by conducting interviews with consultants or contractors, library book collection data, and other supporting data.

3.3. Secondary Data

General data are field data collection obtained from supervisory consultants, which include data, LHR, CBR, Soft-drawing and road maps, project documentation, and other supports.

3.4. Data Collection Methods

In carrying out the calculation analysis in determining the thickness of the new pavement layer for the Dolok Sanggul section STA + 0.000-100 to STA + 100-325. The data used in this calculation is the same as that used by the field planner or the consultant. In writing this research, several ways were carried out to collect the data needed to support this task to be completed. Primary Data is the provision of data and data users to obtain cross-sectional images, the arrangement of pavement layers, and other supporting data related to the calculation of the thickness of the pavement layers.

Secondary data is supporting data obtained from interviews or data obtained directly in the field or related parties such as the local Department of Transportation (LLAJR).

CHAPTER V

CONCLUSION AND SUGGESTION

5.1. Conclusion

From the results of the evaluation of the calculations carried out by the component analysis method in the road planning at Dolok Masihul Silimbat in North Tapanuli starting from STA +0.00-+100, to STA +100.00 +325.0 , the following results are obtained:

1. Thickness of the pavement A_1 = 13,5 cm, A_2= 15 cm, dan A_3= 10 cm.
2. When compared to the calculation results obtained with the results in the field, there are differences in pavement thickness. The thickness of the pavement in the field is thicker. This is probably due to environmental adjustment factors because it has an area with high rainfall so that the planned economic life of the road can be achieved3. Determination of road pavement calculations, especially in determining the number of LHR where the road is a district road that is rarely passed by heavy vehicles, then the determining factor for heavy vehicles, vehicle data is only assumed.

5.2. Suggestion

1. There is a need for synergistic coordination between the Regional Government of Humbang Hasundutan Regency and North Tapanuli Regency to maintain the life of the road (OP) considering the condition of the road is located between the district borders.

2. It is hoped that the community and related agencies will work together to participate in maintaining the road design period so that it can be achieved as planned.