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An Overview of The Flexible Pavement Planning on The Jayapura-Angkasa-BASE-G-Dok II road section

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ABSTRACT

Easy access to properly maintained road infrastructure is essential for the efficient flow of goods and services. Significant economic growth within a region or within the range of services offered will be the outcome of this transport operating smoothly. In light of this, the Papuan Provincial Government is carrying out a Road Planning initiative with the objective of improving the transportation and mobilization links between the metropolis of Jayapura and outlying settlements, and vice versa. In order to do this, the Papuan Provincial Government, acting through the Office Public Works of Road and Bridges Field, has scheduled the building of land transportation infrastructure, particularly roads. These budgets are derived from the Papua Province's Regional Budget of APBD/IINFRASTRUCTURE for the 2017 Fiscal Year. The Bina Marga Method will be used in this study to determine the composition and thickness of the projected pavement layer. Field surveys, supplier surveys, and comparable contract surveys are some of the methods used in this study to collect information and findings that support the hypothesis of a relationship between the variables. According to the research results, we can use 7.5 cm thick LASTON MS 744 as a surface course, 20 cm thick Class A break stone (CBR 100%) as a base course, and 12 cm thick Sirtu class A (70% CBR) as a subbase course.

1. INTRODUCTION

When public roads are implemented, their utilization should be maximized for the benefit of the populace, especially to stimulate national economic growth and keep it from being impeded by insufficient road transportation infrastructure. Considering urban activity services can help achieve this. The presence of sufficient road infrastructure is essential for the growth of any given area or region. The seamless flow of transportation, both in terms of products and services, is significantly impacted by the availability of road infrastructure in good shape. The seamless flow of transportation, both in the form of products and services, is significantly impacted by the availability of road infrastructure in excellent shape. A region or area within the service coverage will see substantial economic growth as a result of this efficient transportation network.

Infrastructure and facilities for land transportation are thought to be crucial in raising people's standards of living in Jayapura City and Papua Province as a whole. They can also increase an area's isolation from other places while facilitating the movement of goods and services to and from cities within a region. A more seamless mobilization of commodities and services will boost the economic growth of the community.

A phase of technical planning activities was conducted for this reason with the goal of gathering technical data and information that will be used as reference by the government when construction is later implemented. Finding the right kind and thickness of flexible pavement for the Jayapura-Angkasa-Base G-Dok II road segment is the goal of this study.

2. LITERATURE REVIEW

2.1 General Review

A description of the general and technical planning principles, planning techniques, and planning examples are all included in this flexible pavement thickness planning guideline. The pavement thickness planning outlined in the pavement planning guidelines is limited to bonded loose graded pavement construction materials, such as crushed stone and granular materials. This planning recommendation is applied to:

1. New pavement planning;
2. Overlay planning;
3. Stage construction planning.

To determine the strength of the current pavement, apply these flexible pavement thickness planning guidelines first to the examination and research of laboratory and field test findings. If alternative pavement thickness planning techniques can be supported by the findings of professional testing, they may be employed in addition to the ones outlined in this guideline.

2.2 Flexural Pavement Structure

The subbase course, base course, and surface course are the three main parts of a flexible pavement construction. Pavement layer layout is shown in Figure 1.

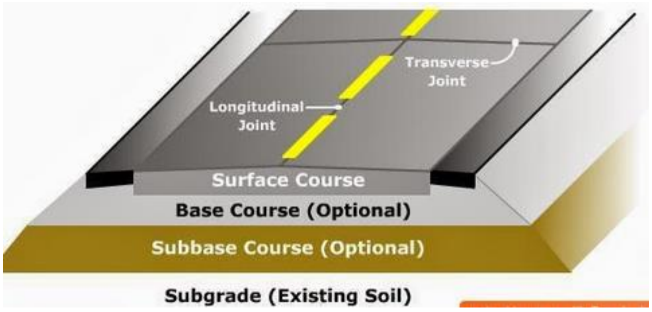


Figure 1. Pavement layer arrangement

2.3 Definitions, Abbreviations and Terms

1. **Vehicle Axis Axle Load Equivalent Number (E)**
   A number that expresses the ratio of the level of damage caused by a vehicle's single-axle axle load path to the level of damage caused by one path of a standard single-axle load of 8.16 tons (18,000 lb).
2. **Surface Index (IP)**
   A number used to express the unevenness and firmness of the road surface in relation to the level of service for passing traffic.
3. **Structural Number (SN)**
   An index derived from the analysis of traffic, subgrade and environmental conditions that can be converted into pavement layer thickness using the appropriate relative strength coefficient for each material type of each layer of the pavement structure.
4. **Coefficient Drainage**
   A factor used to modify the relative strength coefficient as a function of how well the pavement structure can overcome the negative influence of water ingress into the pavement structure.
5. **Lane Plan**
   One of the traffic lanes of a highway system that carries the most traffic. Typically, the plan lane is either one lane of a two-lane highway or the outer edge of a multi-lane highway.
6. **Cold Mixed Asbuton Layer (LASBUTAG)**
   A mixture consisting of coarse aggregate, fine aggregate, Asbuton, stabilizer, and filler (if required) that is mixed, spread, and cold compacted.
7. **Asphalt Concrete Layer (LASTON)**
   A road construction layer consisting of coarse aggregate, fine aggregate, filler, and hard asphalt mixed, spread, and compacted in a hot state at a certain temperature.
8. **Makadam Penetration Layer (LAPEN)**
   A pavement layer consisting of open and uniformly graded base and locking aggregates bonded by hard asphalt by spraying over it and compacting it layer by layer and if it is to be used as a surface layer, it needs to be treated with asphalt with stone cover.
9. **Surface Layer**
   The uppermost part of the pavement.
10. **Foundation Layer**
    The part of the pavement that lies between the surface layer and the sub-base layer (or the subgrade if no sub-base layer is used).
11. **Bottom Foundation Layer**
    The part of the pavement that lies between the foundation layer and the subgrade.
12. **Reliability**
    The probability that a particular damage type or combination of damage types in the pavement structure will remain lower or within the allowable range during the plan life.
13. **Subgrade**
    The original ground surface or the surface of the excavation or the surface of the compacted embankment and is the subgrade for the placement of other pavement parts.
14. **Plan Life (UR**
    The amount of time in years from the time the road is opened to the time when major repairs are required or a new surface layer is deemed necessary.
15. **Falling Weight Deflectometer (FWD)**
    A non-destructive tool for measuring the strength of pavement structures.

3. RESEARCH METHOD

3.1 General

1. In order to adequately accomplish the goals of the study, a research method is required. In order to get accounted-for answers, the research technique entails performing scientific investigation on a problem, case, symptom, or phenomena. The field survey method, the Liverance survey, and comparable contract surveys are used in this study to collect information that confirms the existence of a relationship between the variables. This approach can be used both within and outside of the lab. We used a formula technique to process the survey in this study. In general, there are three main regions that our tasks must be finished.
2. Field Survey which includes:
   a. Reconnaissance Survey
   b. Topography Measurement:
   c. Traffic Survey/Traffic forecasting;
   d. Soil and Construction Material Investigation; and
   e. Hydrological Survey.
3. Road Engineering Planning, including:
   a. Geometric;
   b. Pavement Structure;
   c. Drainage; and
   d. Other Road Appurtenances.

3.2 Location and Time of Research

The Jayapura-Angkasa-Base "G" road stretch, which is situated inside the administrative boundaries of Jayapura city, is the focus of this two-month research project. Geographically, the activity is located at positions 20 31' 51.9" N-S 1400 43' 11.5" East at its starting point and 20 31' 54.9" N-S 1400 43' 11.5" East at its finishing point. The research location in Jayapura City is depicted in Figure 2.

Figure 2. Research location

3.3 Data Collection Technique

In Jayapura City and Jayapura Regency, we apply data collection techniques on material transportation vehicles, material entrepreneurs, and projects. Since we employ the same materials and sources for several things, we treat the material testing results as secondary data. The following are the materials used in this study: A preliminary survey, sometimes referred to as a reconnaissance survey, is conducted at the start of the research project at the work site with the goal of locating the work site for use as comparison material for field surveys and literature studies, as well as technical feasibility study material. We separate the secondary data collection from BBPJN-X Jayapura into multiple phases for the reconnaissance survey.

1. Literature Study
2. Coordination with relevant agencies.
3. Planning discussion in the field.
4. Geometric survey recon
5. Topographic Survey Recon
6. Geological and Geotechnical Survey Recon.
7. Preliminary survey of wages, unit prices and equipment.
8. Recon of road complementary buildings.
9. Recon hydrological/hydraulics survey.

4. RESULTS AND DISCUSSION

4.1 Pavement Thickness Planning Data

The pavement thickness planning data utilized in the study are essential data that have a major impact on the pavement thickness computation and estimation process on the Jayapura-Angkasa-Base "G-Dok II Road." The following statistics are utilized in pavement thickness planning:

1. Pavement thickness for 2 lanes and 2 directions
2. Average rainfall is estimated to be 2500 - 3000 mm/year
3. Construction period (n1) = 1 year
4. Plan life (n2) = 10 years
5. Traffic growth rate (i1) = 2%
6. Traffic growth rate (i2) = 7% 7.

The thickness of the pavement layer is determined by the load and traffic flow on the road. The amount of traffic flow can be obtained from:

1. Analyze the current traffic, so as to obtain data regarding:
   a. Number of vehicles intending to use the road;
   b. Types of vehicles and the number of each type;
   c. Axis configuration of each type of vehicle;
   d. The load of each vehicle axis.
2. Estimates of traffic growth factors over the life of the plan are based, among other things, on economic and social analysis of the area. In developing countries including Indonesia, traffic analysis that can support planning data with sufficient accuracy is difficult to carry out, because:
   a. Lack of required data;
   b. It is difficult to predict future developments because there is no master plan in most parts of Indonesia;

4.2 CBR Subgrade Design

The ability of the subgrade to support the weight above it is measured by the California Bearing Ratio, or CBR. The CBR for the subgrade soil of the "G-Dok II Road" connecting Jayapura, Angkasa, and Base is shown in Table 1. The design CBR determination is shown in Table 2, and a graph displaying the 90% design CBR computation is shown in Figure 3.

Table 1. CBR Subgrade

STA	0+000	0+200	0+400	0+600
CBR (%)	8	7	6	7
STA	0+800	1+000	1+200	1+400
CBR (%)	7	7	6	6
STA	1+600	1+800	2+000	2+200
CBR (%)	7	6	6	7
STA	2+400	2+600	2+800	3+000
CBR (%)	8	8	7	5
STA	3+200	3+400	3+450	
CBR (%)	5	8	8	

Table 2. Determination of Design CBR

CBR (%)	Equal or greater amount	Equal or greater percentage
5	19	19/19 × 100% = 100%
6	17	17/19 × 100% = 89,47%
7	12	12/19 × 100% = 63,16%
8	5	5/19 × 100% = 26,32%

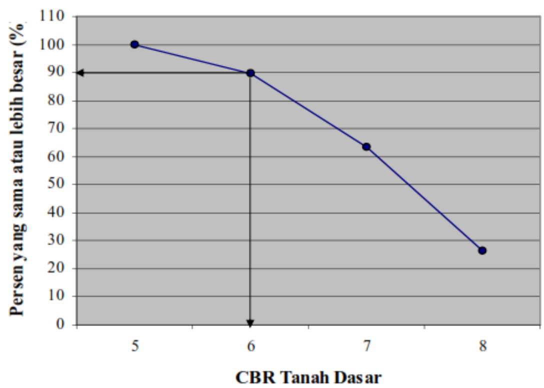


Figure 2. 90% Design CBR Determination Chart

From Figure 3 above, the 90% CBR data is 6%. Example calculation of passenger car vehicle type:

$LHR_p = (LHR_s \times (1 + i1)^{n1}$
$= (900 \times (1 + 0{,}02)^{1}$
$= 918$

$LHR_A = (LHR_p \times (1 + i2)^{n2}$
$= (910 \times (1 + 0{,}07)^{10}$
$= 1806$

The quantity of vehicles seeking to use the route is expressed by the traffic volume. The number of cars that pass an observation site in a certain amount of time is known as the traffic volume. For 2-way unseparated roads, we express traffic volume as vehicles/day/2-way in pavement layer thickness planning; for one-way or 2-way separated routes, we express traffic volume as vehicles/day/1-way. Since the part connects settlements in the region and its environs, we base our estimate of the traffic volume in this road and bridge planning on a survey of the people who live nearby or will travel the section. Additional computations are shown in Table 3.

Table 3. Value LHR_s, LHR_p, LHR_A

No.	Vehicle Type	LHR_s (Vehicle)	$LHR_p = (LHR_s \times (1 + i_1)^{n_1})$ (Vehicle)	$LHR_A = (LHR_p \times (1 + i_2)^{n_2})$ (Vehicle)
1	Passenger Cars	900	918	1806
2	Mini Bus	327	334	657
3	Bus	60	61	120
4	Pick Up	427	436	858
5	Micro Truck	207	211	415
6	2 Axles Truck	94	96	189

LHRs = Average daily traffic of each vehicle type
LHRp = Initial average daily traffic
LHRA = Final average traffic

Table 4. Equivalent number for each vehicle type

No.	Vehicle Type	Axis Load (Ton)	Equivalent Number (E)
1	Passenger Cars	2 (1 + 1)	0,0002 + 0,0002 = 0,0004
2	Mini Bus	2 (1 + 1)	0,0002 + 0,0002 = 0,0004
3	Bus	8 (3 + 5)	0,0183 + 0,1410 = 0,1593
4	Pick Up	2 (1 + 1)	0,0002 + 0,0002 = 0,0004
5	Micro Truck	8 (3 + 5)	0,0183 + 0,1410 = 0,1593
6	2 Axles Truck	13 (5 + 8)	0,1410 + 0,9238 = 1,0648

The quantity of vehicles seeking to use the route is expressed by the traffic volume. The number of cars that pass an observation site in a certain amount of time is known as the traffic volume. For 2-way unseparated roads, we express traffic volume as vehicles/day/2-way in pavement layer thickness planning; for one-way or 2-way separated routes, we express traffic volume as vehicles/day/1-way. Since the part connects settlements in the region and its environs, we base our estimate of the traffic volume in this road and bridge planning on a survey of the people who live nearby or will travel the section. Additional computations are shown in Table 3.

An 18,000-pound (8.16-ton) double-wheeled, single-axle load is the standard load. The axle load equivalent number E indicates that all other vehicle loads with different axle loads are comparable to the standard axle load. The vehicle equivalent number is a number that, in the event that the vehicle made a single pass with an 8.16-ton single axle, would show how many passes it would take to create the same amount of damage or decrease in surface index. Example of value calculation LEP, LEA, LET dan LER:

LEP $= \left(\sum_{j=1}^{n} LHR_p \times C_j \times E_j\right)$
$= (918 \times 0{,}50 \times 0{,}0004)$
$= 0{,}1836$

LEA $= \left(\sum_{j=1}^{n} LHR_A \times C_j \times E_j\right)$
$= (1806 \times 0{,}50 \times 0{,}0004)$
$= 0{,}3612$

LEP $= \left(\frac{1}{2} \times (\sum LEP + \sum LEA)\right)$
$= \left(\frac{1}{2} \times (70{,}1238 + 138{,}0206)\right)$
$= 104{,}0722$

LER $= \left(LET \times \frac{UR}{10}\right)$
$= \left(104{,}0722 \times \frac{UR10}{10}\right)$
$= 104{,}0722$

The subsequent calculations can be seen in Table 5.

Table 5. LEP, LEA, LET, LER value

No.	Transportation type	LEP $\left(\sum_{j=1}^{n} LHR_p \times C_j \times E_j\right)$	LEA $\left(\sum_{j=1}^{n} LHR_A \times C_j \times E_j\right)$	LET $\left(\frac{1}{2} \times \left(\sum LEP + \sum LEA\right)\right)$	LER $\left(LET \times \frac{UR}{10}\right)$
1	Passenger Cars	0.1836	0.3612	104.0722	104.0722
2	Mini Bus	0.0668	0.1314		
3	Pick Up	0.0872	0.1716		
4	Bus	1.8697	3.6780		
5	Micro Truck	16.8061	3.0548		
6	Truck 2 Axles	51.1104	100.6236		
Total		70.1238	138.0206	104.0722	

Information: Cj (Medium Vehicle) = 0.50
Ej = Equivalent Number
LEP = Initial Equivalent Traffic
LEA = Final Equivalent Traffic
LET = Center Equivalent Traffic
LER = Cross Equivalent Plan

The vehicle's wheels, which are located at the extremities of its axes, are what move the weight of the vehicle onto the surface. The arrangement of the axes varies depending on the kind of vehicle. There is just one wheel axis in the front, and there can be one or two in the back. As a result, the equivalent number for each kind of vehicle will equal the total of the comparable values for the front and back axes. The placement of the vehicle's weight point affects each axis' burden, which varies depending on the vehicle's load. For instance, a truck with an empty weight of 4.2 tons has a front axis configuration of a single wheel single axis and a rear axis configuration of a double wheel single axis. The maximum weight of the vehicle is 18.2 tons. The load distribution is 34% on the front axis and 66% on the rear axis.

As a result, weigh-post data or the results of weighing surveys conducted in the selected area should serve as the foundation for the planning equivalent number. Studies in this field have shown a relationship between the year of observation and the corresponding number's magnitude. Terrain, vehicle type, and road function can all be used to distinguish between comparable figures. The corresponding number's annual growth is likewise depicted on the graph; this number will eventually reach its maximum value.

It is evident that bridges with limited load-carrying capacity are unlikely to hold the weight of a truck, even though trucks can carry larger loads. The kind and weight of the load that heavy vehicles carry is significantly influenced by the activities taking on in the vicinity. Different types and weights of cargo are transported by trucks in industrial zones compared to plantation areas. Vehicle loads may rise in step with the neighbourhood's development around the route.

4.3 Pavement Thickness Determination

4.3.1 ITP (Pavement Thickness Index) Calculation

Figure 4 shows the correlation between DDT (Soil Supportability) and CBR (California Bearing Ratio).

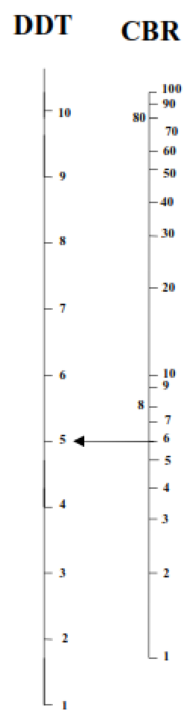


Figure 3. Correlation between DDT and CBR

1. Based on the figure above the CBR value of 6 obtained DDT value of 5
2. Class III Highway, Collector Road classification
3. Determination of regional factor (FR) values

$$\% \text{ Heavy Vehicle} = \frac{Number\ of\ Heavy\ Vehicles}{LHR_S} \times 100\%$$
$$= \frac{361}{2015} \times 100\%$$
$$= 17{,}92\%$$

$$\text{Slope} = \frac{Point\ elevation\ B - Point\ elevation\ A}{Distance\ A - B} \times 100\%$$
$$= \frac{1650-1350}{3450} \times 100\%$$
$$= 8{,}69\% < 10\%$$

Rainfall is classified as >900 mm when it falls between 2500 and 3000 mm annually. Table Percentage of heavy trucks and those that stop and climate in MKJI, 1997 is included in climate II. The value of FR = 2.0 is found by comparing the percentage of heavy trucks and slope in the Table.

4.3.2 Surface Index (IP) Determination

Determination of surface index in pavement thickness planning is very important to know the value of surface thickness index (ITP).

1. Indeks Permukaan Awal (IP_0)

Planned surface layer LASTON MS 744 with Roughness > 1000 mm/km obtained IP0 = 3.9 - 3.5.

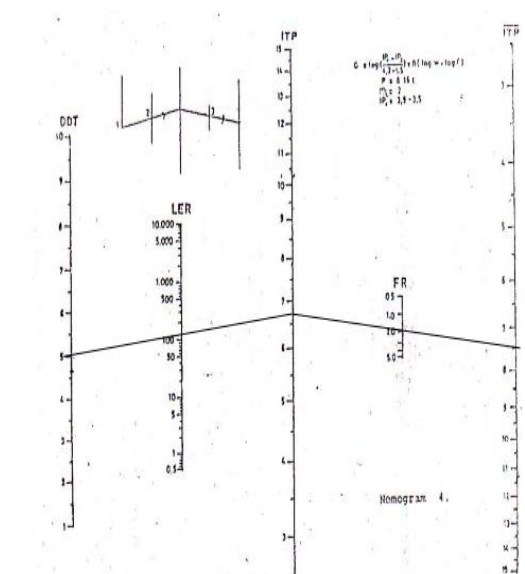
2. Index of Surface Finish (IPT)
   a. Collector Road
   b. LER = 104 (Based on calculation result)

From the surface index table at the end of the planned life, a value of IPT = 2.0 was obtained.

4.3.3 Finding the Index Price of Pavement Thickness (ITP)

IP_0	= 3.9 – 3.5
IP_T	= 2.0
LER	= 104
DDT	= 4.8
FR	= 2.0

The values of IP0, IPT, LER, DDT, and FR are the parameters that are used to calculate the value or cost of the pavement thickness index (ITP). With a road width of 6.0 meters, the anticipated age for calculating the pavement thickness in this study is 10 years.



Sumber : *Petunjuk Perencanaan Tebal Perkerasan Lentur Jalan Raya dengan Metode Analisa Komponen SKBI 2.3.26. 1987.*

Figure 4. Nomogram 4

By looking at Nomogram 4 in Figure 5, the ITP = 6.7 and ITP = 7.5 values are obtained. The pavement layer arrangement is planned as follows:

1. Surface Course, with ITP 7.5 obtained :
   D_1 = 7,5 cm
   a_1 = 0,40 (LASTON MS 744)
2. Base Course, with ITP 7.5 obtained:
   D_2 = 20 cm
   a_2 = 0,14 Crushed Stone Class A CBR 100%)
3. Subbase Course, with minimum thickness =10 cm
   D_3 = …
   a_3 = 0,13 (Sirtu/Pitrun Class A CBR 70%)

Where:

a_1, a_2, a_3 : Relative Coefficient of Pavement Material (SKBI 2.3.26 1987)

D_1, D_2, D_3 : Thickness of each surface layer

Then the thickness of the lower foundation layer (D3) can be found with the following equation:

$\underline{ITP} = (a_1 \times D_1) + (a_2 \times D_2) + (a_3 \times D_3)$

$7{,}3 = (0{,}40 \times 7{,}5) + (0{,}14 \times 20) + (0{,}13 \times D_3)$

$7{,}3 = 5{,}8 + 0{,}13.\ D_3$

$D_3 = \dfrac{7{,}3 - 5{,}8}{0{,}13}$

$D_3 = 11{,}54 \text{ cm} \sim 12 \text{ cm}$

The minimum thickness for the lower foundation is 10 cm, 12 cm is used.

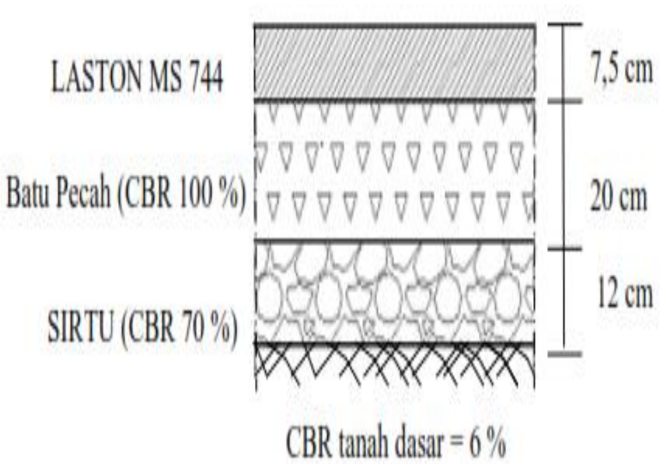


Figure 5. A-A section of pavement arrangement

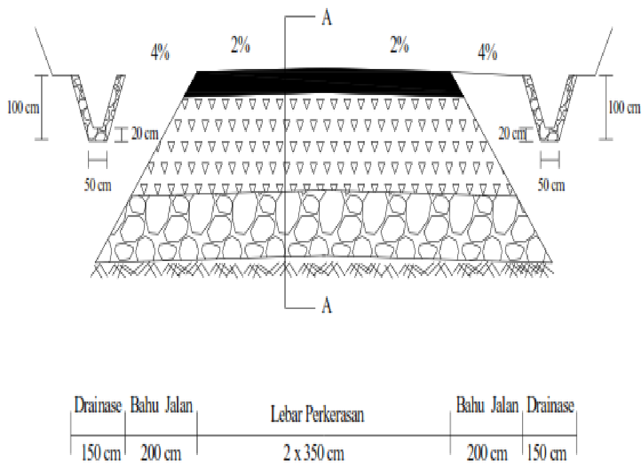


Figure 6. Typical Cross Section

5 CONCLUSION

Based on the data processing and analysis that has been done, the conclusions that the author gets are as follows:

1. The type of material used is:
   a. *Surface Course* : LASTON MS 744
   b. *Base Course* : Class A crushed stone (CBR 100%)
   c. *Sub Base Course*: Sirtu Grade A (CBR 70%)
2. With the calculation obtained dimensions with the thickness of each layer:
   a. *Surface Course* : 7,5 cm
   b. *Base Course* : 20 cm
   c. *Sub Base Course* : 12 cm

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