PLANNING INSPECTION ROAD WITH FLEXIBLE PAVEMENT AT KALIMARAU AIRPORT BERAU - EAST KALIMANTAN

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ABSTRACT

Kalimarau Berau Airport is located in Teluk Bayur District, Berau Regency, East Kalimantan with coordinates 02°00'12 "N and 117°25'52 "E. Kalimarau Berau Airport has a runway with a length of 2,250m x 45m. The absence of facilities that support aviation security and safety at Kalimarau Berau Airport, namely inspection roads, requires planning for the construction of inspection roads using flexible pavement to control the Limited Security Area. This Final Project uses the Road Pavement Design Manual No.03/M/BM/2024 method to determine the thickness of flexible pavement, then validated with SKEP/347/XII/1999. This inspection road planning is planned with a length of 4500 meters and a width of 3 meters. For the cost budget plan in this planning using the Berau Regency Basic Unit Price guidelines in 2022 and the Directorate General of Civil Aviation regulations (PM 78 of 2014). Based on the validation results, the thick value based on the provisions of SKEP / 347 / XII / 1999 obtained the total thickness of the flexible pavement of 0.95 meters with the type of work, namely HRS WC 0.5 m, Class S Crushed Stone Foundation Layer: 0.1 m, Class A Crushed Stone Foundation Layer (3 / 5) : 0.15 m, Class A Crushed Stone Foundation Layer (5/7): 0,2 m. The total budget plan required is Rp. 8,498,000,000.00 (Eight Billion Four Hundred Ninety Eight Million Rupiah).

Keywords: Inspection Road, Pavement Design Manual No.03/M/BM/2024, SKEP/347/XII/1999, Flexible pavement thickness, Budget Plan.

I. INTRODUCTION

Kalimarau Berau Airport is located in Teluk Bayur District, Berau Regency, East Kalimantan, with coordinates 02°00'12 "N and 117°25'52 "E. Kalimarau Airport was established in 1976 with a pioneer category. In 2010 there was construction of a new terminal building equipped with 2 floors and 2 garbarata units. After the construction of the new terminal building, the runway was extended from 1,850 m x 30 m to 2,250 m x 45 m. Furthermore, on October 24, 2014 the new terminal building was inaugurated collectively by the President of the Republic of Indonesia at that time Susilo Bambang Yudhoyono on October 24, 2014 in Balikpapan, East Kalimantan. Kalimarau Berau Airport is a class I airport. One of the Airport Operator Units under the auspices of the Directorate General of Civil Aviation which has become a Public Service Agency (BLU), meaning that the agency was formed to provide the best service for the community. Given that the relocation of the State Capital (IKN) will be carried out to Penajam Paser Regency, East Kalimantan. So that it becomes a positive thing for the future development of East Kalimantan. Of course, with this, Kalimarau Airport must prepare everything with careful preparation. Starting from the preparation of air side facilities and land side facilities, safety facilities and aviation security facilities, basic facilities and supporting facilities. For optimal security and safety of Kalimarau Airport, an inspection road is needed. Based on the findings of the Directorate of Aviation Security audit, conducted on December 2, 2023 at Kalimarau Airport, regarding the absence of inspection road facilities at Kalimarau Airport.

According to SKEP/347/XII/1999 concerning Design Standards for Construction and/or Engineering of Airport Facilities and Equipment states that "Inspection Roads / check roads are built around the airport boundaries and are used for routine inspection of basic airport facilities."

The results of observations in the field, that at Kalimarau Airport there is no inspection road available, so that routine inspection activities are carried out every day directly across runway 01 to runway 19. Carrying out inspection activities by crossing the runway can cause FOD (Foreign Object Debris) to remain on the runway which can endanger the aircraft when taking off or landing and is at risk of runway incursion. Based on the International Civil Aviation Organization (ICAO) Doc.9870, it is explained that Runway Incursion is any event on the runway that involves the improper presence of aircraft, vehicles, objects, or people in a limited area of the airport intended for landing or taking off aircraft. So, any object that improperly enters the restricted area where the aircraft is landing and taking off can increase the risk of an accident in flight, this is what is called runway incursion.

Based on the RTT (Detailed Engineering Design) of the Airport where there is planning for inspection road work. The following is an image of the Kalimarau Airport masterplan, where there is a planning location for making an inspection road.

With the planning of the construction of this inspection road, the author hopes that security at Kalimarau Airport can be maximized, therefore there are inspection road facilities that comply with the provisions for inspection activities so that there are no subsequent findings from the Directorate of Aviation Security. So that flight operations can run well without the risk of runway incursion.

For the size of the inspection road, based on SKEP 347 / XII / 1999 concerning Design Standards for Construction and / or Engineering of Airport Facilities and Equipment, it states that the requirement for the width of the inspection road is 3 - 5.5m. Therefore, the author planned a total length of 4,500 m and a width of 4 m.

This study describes how to plan the design of the inspection road, the calculation of the thickness of the flexible pavement layer of the inspection road using the 2024 road pavement design manual method No.03/M/Bina Marga/2024, the details of the cost budget plan for the construction of the flexible pavement of the inspection road. This research is intended to increase the author's knowledge about the planning of flexible pavement for inspection roads starting from the thickness of the flexible pavement to the cost budget plan to be used, for Kalimarau Berau Airport it can be used as data or archives for consideration of reference for the construction of flexible pavement for inspection roads, for Educational Institutions can add insight and knowledge of cadets / about the application of the theory that has been obtained from pavement courses at the Surabaya Aviation Polytechnic in the Building and Ground Engineering study program, for science can add reference material for science and insight into airport airside facilities, especially regarding the planning of flexible pavement inspection roads, for future research can be used as a development reference for further research that is more relevant.

1.1. THEORITICAL FOUNDATION

According to Annex 14 of the (International Civil Aviation Organization), an airport is a certain area on land or water (including buildings, installations and equipment) designated either in whole or in part for the arrival, departure and movement of aircraft. While the definition of an airport is an airfield, including all buildings and equipment that are the minimum completeness to ensure the availability of facilities for air transportation for the community. (International Civil Aviation Organization, 2022).

1.1.1. Road Inspection

According to (Decree of the Directorate General of Civil Aviation of the Ministry of Transportation/347/XII, 1999) on Standards for the Design, Construction and/or Engineering of Airport Facilities and Equipment states that “Inspection Roads / check roads are built around the airport boundaries and are used for routine inspection of basic airport facilities.” Inspection Roads connected by an operation road to the runway at a distance of approximately 500 m must be made taking into account the location of the PKP-PK reservoir.

In accordance with existing regulations for planning inspection roads using the road pavement design manual method consists of 3 structural layers, namely pavement on the original soil surface, pavement on embankments, pavement on excavations. (Road Pavement Design Manual No.03/Manual/Bina Marga/2024., 2024).

1.1.2 Pavement

According to (KP 94 Regulation of the Director General of Civil Aviation, 2015), Pavement is infrastructure consisting of several layers with different strengths and bearing capabilities. Pavement construction is designed, built and maintained to support the loads acting on it and produce flatness, firmness, and safety of flight operations.

1.1.3 Pavement Type

1. Flexible Pavement

Types of hot asphalt mixtures that are widely used as pavement layers include: (KP 94 Regulation of Director General of Civil Aviation, 2015).

a. Asphalt concrete pavement (Laston, AC)

Laston is a surface layer consisting of a mixture of hard asphalt and continuously graded aggregates mixed, spread and compacted under certain hot conditions and temperatures..

b. Thin layer asphalt concrete (Lataston, HRS)

This graded Lataston or Hot Rolled Sheet (HRS) is an asphalt mixture with a relatively high asphalt content than the laston type.

c. Latasir (sand sheet)

Thin layer asphalt sand (latasir) is a cover layer consisting of hard asphalt and natural sand that is continuously graded, mixed and compacted, at a certain temperature with a thickness after being compacted 1 - 2 cm.

d. Macadam Penetration Layer (Lapen)

Lapis penetrasi macadam (lapen) is a pavement layer consisting of uniformly graded locking aggregate.

2. Rigid Pavement

Pavement planning for roads is not only seen from the traffic alone, but also takes into account the age of the plan, and the condition of the road foundation, soil properties, rainfall, and others. The following are the types of rigid pavement: (Decree of Director General of Transportation 94, 2015).

a. Jointed Unreinforced Concrete Pavement (JUCP) or Jointed Cement Concrete Pavement without Reinforcement (BBTT).

b. Jointed Reinforced Concrete Pavement (JRCP) or Cement Concrete Pavement with Reinforcement (BBDT), is a type of cement concrete pavement made with reinforcement, with a rectangular plate size where the length of the plate is limited by the presence of transverse joints.

c. Continoussly Reinforced Concrete Pavement (CRCP) or Continuous Cement Concrete Pavement with Reinforcement (BMDT). A type of cement concrete pavement made with reinforcement and with a continuous length of plate that is only limited by the presence of transverse expansion joints.

d. Prestressed Concrete Pavement or Prestressed Cement Concrete Pavement. A type of continuous cement concrete pavement, without the usual reinforcement but using prestressed cables to reduce the effects of shrinkage, expansion and warping due to changes in temperature and humidity.

e. Steel Fibre Concrete Pavement or Steel Fiber Reinforced Cement Concrete Pavement. A type of continuous cement concrete pavement, without the usual reinforcement but using steel fiber fibers.

1.1.3 Cost Budget Plan (RAB)

The Cost Budget Plan (RAB) is a calculation of the amount of costs required for materials and wages, as well as other costs associated with the implementation of a particular building or project. Planning a building in the form and benefits of its use, along with the amount of costs required for the arrangement of implementation in the field of administration and implementation of work in the field of engineering (Joko, 2018). The volume of inspection road planning work consists of preliminary preparation work for cleaning and measuring the planning location, earthwork, and pavement layer work. The calculation of the cost budget plan is carried out before the construction process.

For the unit price used in the calculation of the cost budget plan for the flexible pavement planning of this inspection road, it uses the basic unit price of Berau Regency in 2022 and PM 78 of 2014 (Ministerial Regulation 78, 2014).

II. METHOD OF CALCULATION

To plan the thickness of flexible pavement using the 2024 Road Pavement Design Manual (Road Pavement Design Manual No.03/Manual/Bina Marga/2024, 2024) requires several stages of completion. The stages of this method are as follows:

2.1. Plan Life

In general, the lowest age plan for flexible pavement is 20 years. The following is the determination of the age plan using this method: (Road Pavement Design Manual No.03/Manual/Bina Marga/2024, 2024)

Table 1 Plan Life of New Road Pavement

Jenis Perkerasan	Elemen Perkerasan	Umur Rencana (tahun)[1]
Perkerasan lentur	Lapisan aspal dan lapisan berbutir[2].	20
	Lapis Fondasi jalan	40
	Semua perkerasan untuk lokasi yanq tidak dimunqkinkan pelapisan ulanq (*overlay*), seperti: jalan perkotaan, *underpass*, jembatan, dan terowongan	
	Lapis Fondasi Berpenqikat Semen, *Cement Treated Based* (CTB)	
Perkerasan kaku	Lapis fondasi atas, lapis fondasi bawah, lapis beton semen, dan fondasi jalan	
Jalan tanpa penutup	Semua elemen (termasuk fondasi jalan)	10

2.2. Selection of Pavement Structures

The selection of the type of pavement to be used will vary based on the traffic volume, the planned life, and the condition of the road foundation. However, the limitations in table 2.2 are not absolute, many things must be considered starting from consideration of the lowest cost over the life of the plan, limitations and practicality in implementation (Road Pavement Design Manual No.03/Manual/Bina Marga/2024, 2024).

Table 2 Selection of Pavement Types

Struktur Perkerasan	Bagan Desain	ESA5 (juta) dalam 20 tahun				
		0 - 1	1 - 4	4 - 10	>10 – 30	>30
AC modifikasi	3, 3A, 3B	-	-	-	-	2
AC dengan CTB					2	-
AC Modifikasi dengan CTB					-	2
AC dengan lapis fondasi agregat	3, 3A, 3B	-	1, 2	1, 2	2	-
HRS tipis di atas lapis fondasi agregat	4	2	2	-	-	-
Burda atau Burtu dengan lapis fondasi agregat	5	3	3	-	-	-
AC/HRS dengan lapis fondasi *Soil Cement*	6	2	2	-	-	-
AC/HRS dengan lapis fondasi agregat dan perbaikan tanah dasar (dengan stabilisasi semen)	7	2	2			
Perkerasan kaku dengan lalu lintas berat	8	-	-	-	2	2
Perkerasan kaku dengan lalu lintas rendah	8A	-	-	1, 2	-	-
Perkerasan tanpa penutup (Japat dan jalan kerikil)	9	1	-	-	-	-

2.3. *Analysis of Traffic Volumes*

An important parameter in pavement structural analysis is the traffic data required to calculate the traffic load carried by the pavement over the planned life. The load is calculated from the traffic volume in the survey year which is then projected forward over the life of the plan. The first year volume is the traffic volume during the first year after the pavement is expected to be constructed or rehabilitated.

The main elements of traffic load in design are:

a. The traffic volume for each vehicle class.

b. Commercial vehicle axle load expressed in standard axle equivalent load (ESAL).

The traffic volume analysis was based on surveys obtained from:

a. Traffic survey, with a minimum duration of 7 x 24 hours1. The survey can be conducted manually according to the Traffic Enumeration Survey Guidelines (Pd T-19-2004-B) or according to more recent guidelines or surveys using equipment with the same approach.

b. Previous traffic survey results.

c. Approximate value for roads with low traffic.

In traffic analysis, the determination of peak hour traffic volume and Annual Average Daily Traffic (LHRT) refers to the Indonesian Road Capacity Guidelines (PKJI). The determination of the LHRT value is based on traffic volume survey data by considering the k factor.

Traffic volume forecasting should be done realistically. Fabrication of traffic data to improve economic justification should not be done for any purpose. If there is any doubt about the traffic data, the technical planner should conduct an independent rapid survey to verify the data. (Road Pavement Design Manual No.03/Manual/Bina Marga/2024, 2024).

2.4. *Vehicle Type*

Sistem klasifikasi kendaraan ditunjukkan pada tabel jenis kendaraan. Beban gandar kendaraan penumpang dan kendaraan ringan sampai sedang memiliki beban gandar yang cukup kecil sehingga tidak berpotensi menimbulkan kerusakan struktural pada perkerasan. (Road Pavement Design Manual No.03/Manual/Bina Marga/2024, 2024).

2.5. *Traffic Growth Factors*

Traffic growth factors should be based on historical growth data or a correlation formulation with other applicable growth factors. If not available, the following table may be used:

Table 3 Traffic Growth Rate Factor(1)(%)

	Jawa	Sumatera	Kalimantan	Rata-rata Indonesia
Arteri dan perkotaan	4,80	4,83	5,14	4,75
Kolektor *rural*	3,50	3,50	3,50	3,50
Jalan desa	1,00	1,00	1,00	1,00

$$R = \frac{(1+0{,}01)^{UR}-1}{0{,}01\,i} \quad (1)$$

Description:

R : Traffic growth multiplier

i : Annual traffic growth rate (%)

UR : Umur rencana (tahun)

$$R = \frac{(1+0{,}01i1)^{UR1}-1}{0{,}01\,i} + (1+0{,}01i_1)^{(UR-1)}(1+0{,}01i_2)\left\{\frac{(1+0{,}01i1)^{(UR1-UR1)}-1}{0{,}01\,i2}\right\} \quad (2)$$

Description :

R : cumulative traffic growth multiplier

i1 : annual growth rate of period 1 traffic (%)

i2 : annual growth rate of period 2 traffic (%)

UR : total plan life (years)

UR1 : plan life period 1 (year)

2.6. *Traffic on the Plan Lane*

The plan lane is one of the traffic lanes of a road section that accommodates the most commercial vehicle traffic (trucks and buses). The traffic load on the plan lane is expressed in cumulative standard axle load (ESA) by taking into account the direction distribution factor (DD) and the commercial vehicle lane distribution factor (DL).

For two-way roads, the directional distribution factor (DD) is generally taken as 0.50 except in locations where the number of commercial vehicles tends to be higher in one particular direction.

The lane distribution factor is used to adjust the cumulative load (ESA) on roads with two or more lanes in one direction. On such roads, while most commercial vehicles will use the outer lanes, others will use the inner lanes. The road distribution factors shown in Table. (Pavement Design Manual No.03/Manual/Bina Marga/2024, 2024)

Table 4 Lane Distribution Factor

Jumlah Lajur Tiap Arah	Kendaraan Niaga Pada Lajur Desain (% Terhadap Populasi Kendaraan Niaga)
1	100
2	80
3	60
4	50

2.7. *Load Equivalent Factor*

In pavement design, traffic loads are converted to standard loads (ESA) using the Equivalent Load Factor (Vechile Damage Factor). The pavement structural analysis is performed based on the cumulative number of ESAs on the plan lanes over the plan life.

Accurate design requires accurate traffic load calculations. A well-designed and executed axle load study or survey is the basis for a reliable ESA calculation. Therefore, axle load surveys should be conducted whenever possible.

Table 5 VDF Value of Each Type of Commercial Vehicle Based on Vehicle Type of Load

KALIMANTAN TIMUR

Kondisi	Kelas Kendaraan	Gol 5B	Gol 6A	Gol 6B	Gol 7A1	Gol 7A2	Gol 7A3	Gol 7B1	Gol 7B2	Gol 7B3	Gol 7C1	Gol 7C2A	Gol 7C2B	Gol 7C3	Gol 7C4
VDF4	Faktual	1,2	0,5	1,8	-	6,7	-	-	-	-	4,2	6,9	1,8	0,6	-
	Normal	1,2	0,5	0,6	-	3,8	-	-	-	-	3,2	5,3	1,8	0,6	-
VDF5	Faktual	1,3	0,4	2,3	-	10,7	-	-	-	-	5,8	9,9	2,6	0,5	-
	Normal	1,3	0,4	0,5	-	4,9	-	-	-	-	4,0	6,9	2,6	0,5	-

2.8. *Cumulative Standard Axis Load*

Cumulative Standard Axle Load (CESAL) is the cumulative sum of the design traffic axle loads on the design lanes over the life of the plan, determined as follows: Using the VDF of each commercial vehicle:

$$CESAL = (\Sigma LHRJK \ x \ VDFJK) \ x \ 365 \ x \ DD \ x \ DL \ x \ R) \quad \text{............} (3)$$

Description:

LHRJK :Average daily traffic of each type of commercial vehicle (units of vehicles a day)

VDFJK :Load Equivalent Factor (Vechile Damage Factor) for each type of commercial vehicle

DD : Direction distribution factor

DL : Lane distribution factor

CESAL :Cumulative equivalent standard axle load over the life of the plan

R :Cumulative traffic growth multiplier

2.9. *Road Foundation Design*

The three most important factors in pavement design are traffic, subgrade and water. In addition, in the case of pavements that have to be constructed in areas with problematic soils such as peat, expansive soils and soft soils, the characteristics of the soil concerned are a very important factor as ordinary subgrade analysis cannot produce a pavement with the expected performance.

2.10. *Soil Design CBR*

Subgrade improvements may include selected backfill materials, lime stabilization, or cement stabilization. Pavement widening in excavations usually involves the formation of a narrow or irregular subgrade that makes stabilization difficult. In such cases it is best to repair with selected backfill material. In planning, if lime or cement stabilization is selected, the bearing capacity of the material (CBR) is selected as the smallest of the following three values. (Pavement Design Manual No.03/Manual/Bina Marga/2024, 2024).

a. 4-day soakage bearing capacity of the stabilized material.

b. four times the bearing capacity of the original soil before stabilization;

c. bearing capacity obtained from the following formula:

$CBR_{stabilisasi} = CBR_{original\ land} \times 2^{(stabilization\ layer\ thickness\ in\ mm)150}$........................(4)

2.11. Expansive Soil

Expansive soils are soils with a swelling potential of more than 2.5% (measured by SNI 1744:2012 submerged CBR test at optimum moisture content and 100% dry density). Expansive soils are classified based on their swelling potential and Weighted Plasticity Index (WPI) which is divided into Low, Moderate, High, Very High, and Extreme. Expansive soils are classified as having Potential Development. (Road Pavement Design Manual No.03/Manual/Bina Marga/2024, 2024).

2.12. Capping Layers

The minimum thickness of the support layer to achieve a design CBR of 6% was used for the development of the pavement thickness Design Catalog. If the support layer is to be used for construction vehicles, a thicker support layer may be required. (Pavement Design Manual No.02/Manual/Bina Marga/2024, 2024)

2.13. Flexural Pavement Foundation Design

In (Ministry of Public Works and Housing; Directorate General of Highways, 2024) great emphasis is placed on subgrade improvement, by looking at the condition of the subgrade CBR and the CESAL value that the pavement will receive. (Road Pavement Design Manual No.02/Manual/Bina Marga/2024, 2024).

Tabel 6 Desain Fondasi Jalan Minimun

CBR Tanah Dasar (%)	Kelas Kekuatan Tanah Dasar	Uraian Struktur Fondasi	Perkerasan Lentur – Beban Lalu Lintas Pada Jalur Rencana Dengan Umur Rencana 40 Tahun (Juta ESA5) <10	Perkerasan Lentur – Beban Lalu Lintas Pada Jalur Rencana Dengan Umur Rencana 40 Tahun (Juta ESA5) >10	Perkerasan Kaku
			Tebal Minimum Perbaikan Tanah Dasar (mm)		
5	SG5	Perbaikan tanah dengan material timbunan pilihan (CBR ≥ 10%)	200	200	200
4	SG4				
3	SG3		300	400	400
2,5	SG2,5			600	600
• Kekuatan tanah dasar < 2,5% atau tanah lunak			Untuk tebal tanah lunak > 1 m harus ditangani dengan penanganan geoteknik, sedangkan untuk ketebalan ≤ 1 m dapat diganti tanah timbunan dengan tebal minimum yang sama dengan ketentuan dan berlaku untuk tanah SG2,5 Bagan Desain ini.		
• Tanah ekspansif			Penanganan sesuai dengan kajian geoteknik terhadap besaran potensi pemuaian dengan ketebalan penutup tidak kurang dari 600 mm berupa material dengan potensi pemuaian tidak lebih besar dari 1,5%. Di atas lapis penutup tersebut harus ditambahkan lapis perbaikan SG2,5.		

2.14. Design of Pavement Thickness

Pavement design is based on planned traffic loads and lowest cost considerations. Pavement thickness design is based on ESA values of rank 4 and rank 5 depending on the deterioration model and design approach used. Use the appropriate ESA value as input in the planning process.

The basis of the design procedure for flexible pavements with paved mixtures used in this manual is the mechanical characteristics of materials and mechanistic analysis of pavement structures. This method relates the inputs of wheel load, pavement structure and material mechanical properties, to the outputs of pavement response to wheel load such as stress, strain or deflection.The basis of the design procedure for flexible pavements with paved mixtures used in this manual is the mechanical characteristics of materials and mechanistic analysis of pavement structures. This method relates the inputs of wheel load, pavement structure and material mechanical properties, to the outputs of pavement response to wheel load such as stress, strain or deflection.

The modulus of the unbounded granular material not only depends on the intrinsic modulus value of the material but is also determined by the stress acting on the layer and the stiffness of the layers below it. The higher the stress the higher the modulus of the granular material. Accordingly, the thicker and stiffer the overlying layers, the lower the stress acting on the surface of the grained layer and the lower the modulus. Furthermore, the deeper the layer, the lower the modulus value. The rate of decrease in the modulus value of the graded layer is also affected by the modulus of rigidity of the subgrade. In the pavement structural analysis, the graded layer is divided into five sub-layers with the same thickness and the modulus value getting smaller and smaller.

2.15. Implementation Issues Affecting Design

To produce a good pavement, the required construction quality must be achieved. Poor execution cannot be corrected by making “pavement design adjustments”. The limitations of compaction and segregation determine the thickness of the pavement structure. Planners should be aware of these limitations, including the allowable layer thickness.

The pavement structure requires sufficient edge bearing capacity, especially when located on soft or peaty soils. Provisions for edge bearing capacity should be detailed in the contract drawings.

Boxed construction refers to a pavement structure with a graded pavement layer that cannot drain water except through a subsurface drainage system. Boxed construction should only be used when there is no other option.

In urban and interurban areas, rectangular pavement construction is generally required. Pavement in rectangular excavations should follow the provisions outlined in this chapter. Pavement construction with excavations shall be provided with subsurface drainage system, including subsurface drainage in lateral direction for wide edges.

The planner should consider the effect of the rainy season on implementation activities especially in alluvial areas which tend to become saturated during the rainy season. There is generally no guarantee that construction can be carried out during the dry season, therefore the design should consider the subgrade conditions during the wet season.

Designs that need to be carried out with through traffic (such as widening works) should consider practical excavation depths and safety. These conditions may limit the type of pavement that can be used. Longitudinal joints especially in rigid pavements should not be placed in the wheel path of vehicles. Special equipment and skills are required for Burtu and Burda works, stabilization, cement treated base and cement concrete pavements, use of modified bitumen which require special materials and equipment. These works are recommended to be carried out by contractors who have experience and access to the necessary resources.(Pavement Design Manual No.03/Manual/Bina Marga/2024, 2024).

III. RESEARCH METHODS

3.1 Flow Charts

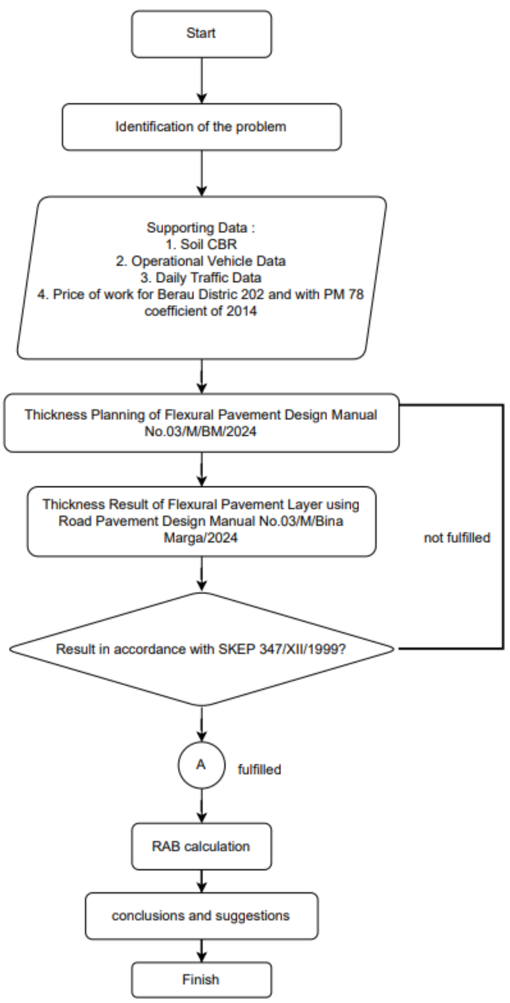


Figure 1 Flow Chart

3.2 Identification of The Problem

Kalimarau Berau Airport is located in Teluk Bayur District, Berau Regency, East Kalimantan, with coordinates 02°00'12 "N and 117°25'52 "E. Berau is a regency known for its natural beauty, so Berau is a strategic area in terms of transportation connections.

The object studied in this research is the absence of an inspection road at Kalimarau Airport so that it is made a finding by the Directorate of Security audit. The importance of the inspection road for flight safety so that the planning of flexible pavement of the inspection road is needed.

3.3 Support Data

In this research, data is needed for data processing. Data collection was carried out by direct observation at Kalimarau Berau Airport during the implementation of On The Job Training from October 02, 2023 to February 29, 2024 and also data from Kalimarau Berau Airport.

In planning the flexible pavement inspection road at Kalimarau Airport, the following data are required:

1. Masterplan data and Detailed Engineering Design (RTT) 2015 Kalimarau Airport. This data is used as a planning reference.
2. CBR data comes from the Dynamic Cone Penetrometer Test conducted on December 22, 2023.
3. Operational vehicle data obtained from the aerodrome manual of Kalimarau Berau Airport.
4. Daily traffic data is obtained from the author's direct observations in the field.
5. The basic unit price of wages and materials was taken from the basic unit price document of Berau Regency in 2022 and PM 78 in 2014.
6. Calculation of road length planning is adjusted to the application of conditions in the field and refers to existing regulations.
7. Calculation of the thickness of the flexible pavement of the inspection road based on the instructions for planning the thickness of the flexible pavement of the road with the 2017 Road Pavement Design Manual method (Number.02/Manual/Bina Marga/2017). If the results of pavement thickness have been obtained using the 2017 Road Pavement Design Manual (Number.02/Manual/Bina Marga/2017), then verify whether it is in accordance with existing regulations, namely SKEP/347/XII/1999.

3.4 Planning of Pavement Thickness

In planning the thickness of the inspection road pavement at Kalimarau Airport using the Road Pavement Design Manual Method (Number.02/Manual/Bina

Marga/2017). The calculation begins with the selection of the plan age, the selection of the pavement structure, the calculation of the traffic volume, namely according to the LHRT = (Number of Vehicles in 1 year)/365 formula equation for calculating annual average daily traffic, then the LHRT = (Number of Vehicles in 1 year)/ (Number of observation days) formula equation for calculating average daily traffic, determining the design of the road foundation, determining the design of the thickness of the pavement, if the final result has been found, it must be verified with the SKEP/347/XII/1999 regulation.

3.5 *Calculation of Cost Budget Plan*

When the final results have been determined, the next step is to plan the cost budget that will be used in planning the construction of inspection roads at Kalimarau Airport Berau. The unit price used in this planning is the Basic Unit Price of Berau Regency in 2022 and PM 78 in 2014.

3.6 *Research Time*

The research time was carried out during the implementation of On The Job Training from October 02, 2023 to February 29, 2024, the following is the time for conducting research starting from the preparation stage, the data collection stage to the writing stage

3.7 *Existing Conditions*

Based on existing conditions, there is no inspection road at Kalimarau Berau Airport. The daily inspection is carried out by crossing runway 01 to 19. For the lay out of Kalimarau Berau Airport, it can be seen in the attachment.

3.8 *Desired Condition*

With the planning of the construction of this inspection road, the author hopes that security at Kalimarau Airport can be maximized, therefore there are inspection road facilities that are in accordance with the provisions for inspection activities so that there are no subsequent findings from the Directorate of Aviation Security. So that flight operations can run well without the risk of runway incursion.

4. RESULT AND DISCUSSION

4.1 *Desired Condition*

Daily traffic data on inspection road planning at Kalimarau Airport can be seen in the table below.

Table 7 Daily Traffic Data Recapitulation

Day	Light Vehicle	2 Axis Truck
Monday	5	2
Tuesday	5	2
Wednesday	5	2
Thursday	5	2
Friday	5	2
Saturday	5	2
Sunday	5	2
Total	**35**	**14**
Average	**5**	**2**

Number	Type of Vechile	Total Vechile / Week	Average Number of Vehicles a day (LHR)
1	Light Vechile	35	5
2	2 Axis Truck	14	2
Jumlah		**49**	**7**

Based on the 2024 Bina Marga Pavement Design Manual related to traffic for inspection road traffic planning at Kalimarau Airport is planned as follows:

1. Road Type: Village
2. Age Plan (UR): 20 Years
3. Traffic Growth (i) : 1%
4. Vehicle Distribution : One two-way lane
5. Distribution Factor: 100%

4.2 *Desired Condition*

The Vechile Damage Factor (VDF) is the accumulation of the equivalent numbers of the front vehicle wheel axis and the rear vehicle wheel axis. Can be seen in the table. Based on the Vechile Damage Factor (VDF) table contained in the Road Pavement Design Manual Method No.03/Manual/Bina Marga/2024, it is known that:

1. Pickup vehicles are classified as group 4
2. Medium Truck 2 Axis classified group 6B

Then determine the value of the Vechile Damage Factor (VDF) of each type of commercial vehicle based on the table

Table 8 Commercial Vehicle VDF values by load type and region

KALIMANTAN TIMUR

Kondisi	Kelas Kendaraan	Gol 5B	Gol 6A	Gol 6B	Gol 7A1	Gol 7A2	Gol 7A3	Gol 7B1	Gol 7B2	Gol 7B3	Gol 7C1	Gol 7C2A	Gol 7C2B	Gol 7C3	Gol 7C4
VDF4	Faktual	1,2	0,5	1,8	-	6,7	-	-	-	-	4,2	6,9	1,8	0,6	-
	Normal	1,2	0,5	0,6	-	3,8	-	-	-	-	3,2	5,3	1,8	0,6	-
VDF5	Faktual	1,3	0,4	2,3	-	10,7	-	-	-	-	5,8	9,9	2,6	0,5	-
	Normal	1,3	0,4	0,5	-	4,9	-	-	-	-	4,0	6,9	2,6	0,5	-

Based on the Vechile Damage Factor (VDF) table above, it is calculated that pickup vehicles are classified with group 4 with a VDF value of 4, and VDF 5 (normal) worth 0. While 2 axle trucks are classified as group 6B with a VDF value of 4 (normal) worth 0.6 and VDF 5 (normal) worth 0.5.

Based on the Traffic Growth Factor table equation, it is determined that the village road in Kalimantan is at 100%. The following is the formula used in determining traffic growth:

$$R = \frac{(1+0{,}01\ i)^{UR}-1}{0{,}01\ i}$$

$$R = \frac{(1+0{,}01\ i)^{UR}-1}{0{,}01\ i}$$

$$R = \frac{(1+0{,}01\ x\ 0{,}01)^{20}-1}{0{,}01\ x\ 0{,}01}$$

R = 20

Therefore, the R value for traffic growth is 20.

1. Determine Lane Distribution Factor (DL)
   Referring to table 2.4, the lane distribution factor can be determined that the value of the distribution factor for a 1-lane 2-way road is 100% or DL = 1.
2. Determining the Direction Distribution Factor (DD)
   In accordance with the provisions of the 2024 Bina Marga Pavement Design Manual for two-way roads, the distribution factor is 0.50. Cumulative Equivalent Single Axle Load (CESAL) can be determined by the formula:

CESAL = (ΣLHRJK x VDFJK) x 365 x DD x DL x R)............... (3)

From the results of the above calculations, the Cumulative Equivalent Single Axle Load (CESAL) value during the life of the plan (20 years) is obtained in the table below.

Table 9 Calculation Result CESAL

Vehicle Type	LHR (2 Directions) 2024	VDF 4	VDF 5	ESA4	ESA5
Light Vehicle	5	0	0	-	-
2 Axis Truck	2	0,6	0,5	4.380	3.650
Total CESAL				**4.380**	**3.650**

So it can be seen that the value of CESAL4 is 4,380, then for CESAL5 it is 3,650.

4.3 *Plan Lifespan*

To determine the pavement can be based on the volume of vehicles, the age of the plan, and the condition of the road foundation. CESAL5 pavement type selection can be determined in the table. Based on the CESAL5 value of 3,650 ESAL.

Based on the table above, the CESAL5 value of 0.01 million is in the range of 0-0.5 million, the pavement structure is selected to improve the cement stabilized subgrade thick mm foundation layer with Design parameter 7 in table 2.2 equation. From the results of previous calculations obtained 20-year ESA value of 3,650, then the ESA value is between 0 - 0.5 million. Since the development planning is a flexible pavement planning, the type of cement stabilized subgrade improved pavement is selected. The pavement type was also selected based on the existing CBR value.

4.4 *Foundation Design Plan*

The CBR value of the soil is obtained from the Kalimarau Berau Airport. Tests conducted to obtain the CBR value with the DCP (Dynamic Cone Penetrometer) method. Calculation of subgrade CBR with the graphical method can be done by sorting the data starting from the smallest to the largest data. Can be seen in the table.

Table 10 Average CBR Data

Number.	Number Test	Time	Test Type	Date	Result	Specification	Description.
1.	DCP-001	15.00 Wita	DCP TEST	22-Dec-23	6.69	6.00	Pass
2.	DCP-002	15.18 Wita	DCP TEST	22-Dec-23	7.80	6.00	Pass
3.	DCP-003	15.25 Wita	DCP TEST	22-Dec-23	6.75	6.00	Pass
4.	DCP-004	15.35 Wita	DCP TEST	22-Dec-23	7.75	6.00	Pass
5.	DCP-005	15.47 Wita	DCP TEST	22-Dec-23	6.89	6.00	Pass
6.	DCP-006	15.58 Wita	DCP TEST	22-Dec-23	6.25	6.00	Pass
Average CBR					**7.02**		

From the results of the subgrade CBR research, the Design CBR that has been obtained has different values in each segment. Next, after knowing the CESAL5 value and the subgrade CBR value of 7%, the foundation determination is based on table 2.8 regarding the road foundation design table. It can be seen from the table that if the condition of the subgrade CBR value is 10% or more, there is no need for soil improvement before pavement work is carried out.

4.5 *Determine The Pavement Design*

Based on CESAL5 calculations. For the selection of the type of pavement used, namely the design chart of 7 pavements with improved cement stabilized subgrades based on the Bina Marga Design Manual Method 2024 in the table.

Table 11 Pavement Thickness Value

	STRUKTUR PERKERASAN[1]		
	SC1	SC2	SC3
	Beban Sumbu 20 tahun pada lajur desain (ESA4 x 10^6)		
	< 0,1	0,1- 0,5	> 0,5 – 4
	Ketebalan lapis perkerasan (mm)		
HRS WC, AC WC	50*		
Lapis Fondasi Agregat Kelas A	160	220	300
Lapis Fondasi Agregat Kelas B	110	150	200
Stabilisasi tanah asli hingga mencapai CBR ekuivalen 6%	160	200	260

Based on the table above, the thickness of the foundation layer with a CBR value of 7% is obtained as follows:

1. HRS WC = 50 mm (asphalt mixture)
2. Class A Aggregate Foundation Layer = 160 mm
3. Class A or B2 Aggregate Foundation Layer = 110 mm
4. Stabilized soil (6% CBR on soils with CBR ⩾ 3%)3 = 160 mm

The results of the calculation of the thickness of flexible pavement using the Road Pavement Design Manual Method No.03 / Manual / BM / 2024 validated with the minimum dimensions in SKEP / 347 / XII / 1999 can be seen in the table below.

Table 12 Validation of Pavement Thickness Results with SKEP/347/XII/1999

Layer Based on Pavement	Design Manual No.03/M/BM/2024 Layer Based on SKEP/347/XII/1999	Used (m)
HRS WC = 0.05 m (paved mix)	Surface Layer = 0.05 m	Surface Layer = 0.05 m
Class A Aggregate Foundation Layer = 160 mm = 0.16 m	Foundation Layer = 0.1 m	Foundation Layer (Class S Crushed Stone) = 0.1 m
Class B Aggregate Foundation Layer = 110 mm = 0.11 m	Foundation Layer = 0,15 m	Foundation Layer (Crushed Stone 3/5 Class A) = 0.15 m
Stabilized soil (6% CBR on soil with CBR ≥ 3%) = 160 mm = 0.16 m	Bottom Layer (Sirtu) = 0.2 m	Foundation Layer (Crushed Stone 5/7 Class B)= 0.2m

4.6 *Cost Budget Plan*

After the acquisition of flexible pavement, the next round of the cost budget plan. Before the cost budget plan, first attach a bestek related to the description of the contents in the cost budget plan. The cost budget plan includes types of preparatory work, earthwork, inspection road work. For unit price analysis can be seen in the appendix. The unit price refers to the HSPK of Berau Regency in 2022. The following is a table of bestek descriptions, planning volumes, and a recapitulation of the cost budget plan for the Kalimarau Berau Airport inspection road planning.

The results obtained for the planning of Berau Kalimarau Airport inspection road work have inspection road work dimensions with a length of 4,500 meters and with a width of 3 meters. The inspection road planning work consists of preparatory work consisting of project signage, mobilization and demobilization, measurement before and after, then earthworks namely clearing and grubbing, and inspection road work itself, namely class B crushed stone foundation layer work (5/7), class A crushed stone foundation layer work (3/5), class S crushed stone foundation layer work, HRS WC work. The final result of the calculation of the Rerlncana Budget Cost (RAB) is Rp. 8,498,000,000.00 (Eight Billion Four Hundred Ninety Eight Million Rupiah).

Table 13 Bestek Descripsion

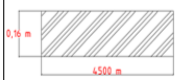
Number	Job Description	Volume	Figure	Description
1.	Measurement Work	L=p x 1 = 4500 x 3 m =13500 m^2	Drawings of work volumes are in the appendix	Measurement work is carried out according to the planning area.
2.	Clearing and Grubbing Work	L=p x 1 =4500 x 3 m =13500 m^2	Drawings of work volumes are in the appendix	Clearing and grubbing work is carried out according to the planning area.
3.	Aggregate Foundation Layer Work A	V=p x 1 x t =4500 x 3 x 0,16 m =2160 m^3		The materials used in this foundation layer work use class A aggregates.
4.	Aggregate Foundation Layer Work B	V=p x 1 x t =4500 x 3 x 0,11 m =1485 m^3		The materials used in this foundation layer work use class B aggregates.
5.	HRS-WC Work	V=p x 1 x t x γ =4500 x 3 x 0,05 m x 2,35 =1586 m^3		The materials used in the work of thin layer asphalt concrete with hot mix asphalt with the use of graded aggregate senjang (mixture of coarse and fine aggregates).

Table 14 Recapitulation of Cost Budget Plan

RECAPITULATION OF COST BUDGET PLAN				
NUMBER	JOB DESCRIPTION	Volume	Type of Work	Total
A	PREPARATORY WORK	1,00	Project Signage Mobilization and Demobilization Measurement Direksi Keet Clearing and Grubbing Work	Rp186.728.752,10
C	INSPECTION ROAD WORK	1,00	Class B Crushed Stone Foundation Layer Work (5 Class A Crushed Stone Foundation Layer Work (3 Class S Crushed Stone Foundation Layer Work HRS WC Work	Rp7.469.211.677,84
	SUB TOTAL			Rp7.655.940.429,94
	PPN 11%			Rp842.153.447,29
	GRAND TOTAL			Rp8.498.093.877,23
	RENEWAL			Rp8.498.000.000,00
Amount: Eight Billion Four Hundred Ninety Eight Million Rupiahs				

5. RESULT AND SUGGESTION

5.1 Result

After the calculation using the Road Pavement Design Manual Method No.03 / Manual / Bina Marga / 2024, Bina Marga, 2024. It can be concluded that:

1. The design of flexible pavement thickness used in the planning of flexible pavement of the inspection road is adjusted to the calculation results of the Road Pavement Design Manual No.03/Manual/Bina Marga/2024 method, Bina Marga, 2024 which has been calculated by the procedure of calculating daily traffic, age plan, determining the type of pavement, design foundation plan, determining the design of pavement thickness. However, after validation with SKEP/347/XII/1999, the value of the thickness of the flexible pavement used is the value of the thickness based on SKEP/347/XII/1999 which is used is the value of the thickness of the flexible pavement which is considered greater.

2. Flexible pavement planning of 4500 meters long and 3 meters wide inspection road where based on LHR calculations the CESAl5 value is 3,650 and for a plan life of 20 years. The CESAL5 value of 0.01 million is in the range of 0-0.5 million, so the pavement structure is selected to improve the cement stabilized subgrade thick mm foundation layer graded with Design parameter 7 in the table equation is planned for each layer thickness, namely HRS WC = 50 mm = 0.05 m (asphalt mixture), Class A Aggregate Foundation Layer = 160 mm = 0.16 m, Class B Aggregate Foundation Layer = 110 mm = 0.11 m, Stabilized soil (CBR 6% on soils with CBR ≥ 3%) = 160 mm = 0.16 m . Then the results of the calculation of the thickness of the road flexural pavement using the Road Pavement Design Manual Method No.03 / Manual / BM / 2024 are validated with the minimum dimensions of the pavement based on SKEP / 347 / XII / 1999, the results of the thickness of the pavement layer are obtained:

   a. HRS WC: 0,5 m
   b. Class S Crushed Stone Foundation Layer: 0.1 m
   c. Class A Crushed Stone Foundation Layer (3/5): 0,15 m
   d. Class B Crushed Stone Foundation Layer (5/7): 0,2 m

3. Budget Plan Cost (RAB) obtained results of Rp. 8,498,000,000.00 (Eight Billion Four Hundred Ninety Eight Million Rupiah), calculated in accordance with the results of the pavement thickness value obtained.

5.2 Suggestion

Based on the results of the existing conclusions, the following suggestions are obtained:

1. To improve flight safety and security, the airport management should immediately realize the inspection road construction work. So that the implementation of inspection activities can be carried out without disrupting flight movements.

2. It is necessary to review the data on the Basic Unit Price of Berau Regency for the last time issued in a fairly old year, namely 2022. The unit price is considered inaccurate in the HSPK in 2022 because each year must experience inflation.

3. Future research can add geometry design calculations.

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