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NATIONAL ROAD PRESERVATION BASED ON IRMS METHOD (A CASE STUDY IN JAPURA – PEMATANG REBA IN RIAU PROVINCE)

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Abstract

Japura Airport is one of the nodes of transportation that owned by Inderagiri Hulu (Inhu) Regency. The airport is located 14 km from the Pematang Reba. Pematang Reba is public administration office complex in Inhu Regency. This airport has flights within the province and even flights between provinces adjacent to Riau Province. The road that separates of these two cities is considered as the economic lifeblood of Inhu Regency to Riau Province. In addition, this road has fungtion not only to connect two important locations in Inhu Regency but also as only road access from Riau Province to Jambi Province. Because of the importance of this road, the condition of this road must be always maintained. Through this study, an analysis of the Remaining Structural Life (RSL) of the pavement was carried out to determine the most appropriate recommendations for road preservation work. The IRMS method is the method which used in calculating the remaining structural life (RSL) of the flexible pavement. The data requairement are deflection data from the Falling Weight Deflectometer (FWD), road geometric condition data and Average Daily Traffic (ADT). Through calculations, it was found that the apropriate flexible pavement preservation programs for Jalan Japura to Pematang Reba were divided into 3 types. Firstly, Overlays program are needed for STA 3+ 393 to STA 7+712, STA 8+509 to STA 15+70 and STA 16+510 to 16+819. Secondly, segment from STA 7+930 to STA 8+ 312 needs Reconstruction. Thirdly, STA 15+922 to STA 16+303 needs routine maintenance.

Keywords: Average daily traffic, Deflection, Falling Weight Deflectometer (FWD), Interurban Road Management System (IRMS), Remaining Service Life (RSL)

Introduction

One of the public facilities that help drive the country's economy is the airport (Morrell & Graham, 2017). Japura Airport is one of the transportation nodes owned by Inderagiri Hulu (inhu) Regency. The airport is located 14 km from Pematang Reba, Inhu Regency. Where the land use of Pematang Reba currently functions as a government office complex, Japura Airport serves flights within Riau Province such as to Tempuling airport (Indragiri Hilir) and even flights between provinces adjacent to Riau Province, for example Sultan Thaha Airport in Riau Islands Province (Department of Communication and Information Technology Inhu, 2021). The road that separates the two cities is united as a national road and is considered the economic lifeblood of Inhu Regency to Riau Province. Currently, the airport is actively providing services now and in the future (Hazanawati & Sartono, 2009). Like infrastructure that will be re-functioning, it is necessary to maintain these infrastructure elements so that they remain optimal when operating (Lee et al., 2014), such as roads.

To connect two important locations in Inhu Regency, this road is also the only access from Riau Province to Jambi Province. Because of the importance of this road, the condition of this national road must always be maintained by road owners, one of which is through maintenance (Khan et al., 2017). Because road maintenance is one of the important factors for an efficient road system (Hawa et al., 2013). Roads need improvement to maintain traffic safety and infrastructure quality (Kamenchukov et al., 2018; Liu, 2014). Even if pavements are well designed and constructed, they may require maintenance (A. S. Hasan, K. Tabassum, A.B.Kabir, 2019). The Ministry of Public Works and Public Housing as the owner of this national road must manage the conservation program. As the government takes part in the infrastructure maintenance program (Burningham & Stankevich, 2005; Ipingbemi, 2008). Road preservation is carried out to maintain the service quality of the road pavement structure to provide comfort and safety for road users (Bina Marga, 2019). To carry out maintenance, knowledge of the condition of the road structure is required, through the evaluation of Remaining Service Life (RSL) based on the Falling Weight Deflectometer (FWD) (Gedafa et al., 2010; Setyawan et al., 2015). RSL itself is defined as the remaining useful life of a structural element (Tranggono & Santosa, 2016). By knowing the RSL value, the road owner can determine the priority of the road sections that need to be repaired (Karballaeezadeh et al., 2019; Manoharan et al., 2020).

Ardiansyah, 2020 and Werkmeister have conducted research to calculate RSL based on FWD data. The first research was conducted on the National Road of South Sumatra Province, while the second was in New Zealand. In a study conducted in South Sumatra, Thata Street which separates Mangunjaya Regency - Musi Rawas Regency was used as the object of research. Based on the results of calculations and segmentation on the National Road Section, there are 13 sections that require routine maintenance, 3 sections that require minor rehabilitation, 3 sections that require major type II rehabilitation, 14 sections that require major type I rehabilitation, and 5 sections that need to be reconstructed (Ardiansyah, 2020; Werkmeister & Alabaster, 2007).

In addition, Tranggono and Santosa, 2016 calculated RSL on uneven pavement surface conditions. From his research, it can be concluded that the RSL model from this study can be used in estimating the functional RSL value based on the value of the International Roughness Index (IRI) in the future. The relationship between RSL and IRI is based on an exponential function. This decline in functional conditions can be described by a non-linear graph with an exponential pattern (Tranggono & Santosa, 2016).

Izzah, 2019 also carried out RSL calculations to determine the most appropriate type of road preservation for the East Cross Road segment in Palembang City. The data used in this study is the deflection data from the FWD device. RSL analysis using the 1993 AASHTO method and obtained RSL values between 2 to 4 years. The most appropriate preservation activity for this road based on the remaining life is overlay (IZZAH, 2018)

Prediction of RSL Value is a basic concept of road pavement management. Knowing the condition of the pavement in the future is the main key for making decisions in planning road pavement maintenance (Elkins et al., 2013).

This study aims to calculate RSL and provide recommendations for flexible pavement preservation programs on National Roads, especially in Japura – Pematang Reba. Conservation activities will be divided into several segments based on the similarity of RSL values.

Research Method

IRMS (Interurban Road Management System) is an integrated road network management system for the development of national roads (Kairupan et al., 2012). IRMS assists road owners in planning, programming and budgeting efficiently and effectively (Sarika et al., 2018). By using IRMS road owners can collect and have information on the current condition of the road network entirely (Dewandaru, 2020). In addition, road owners can develop targeted and optimal road maintenance strategies and policies based on limited funding (Alawiya et al., 2016). Furthermore, through the use of IRMS, road owners can estimate the impact and effects of the policies that will be chosen (KIAT, 2019)

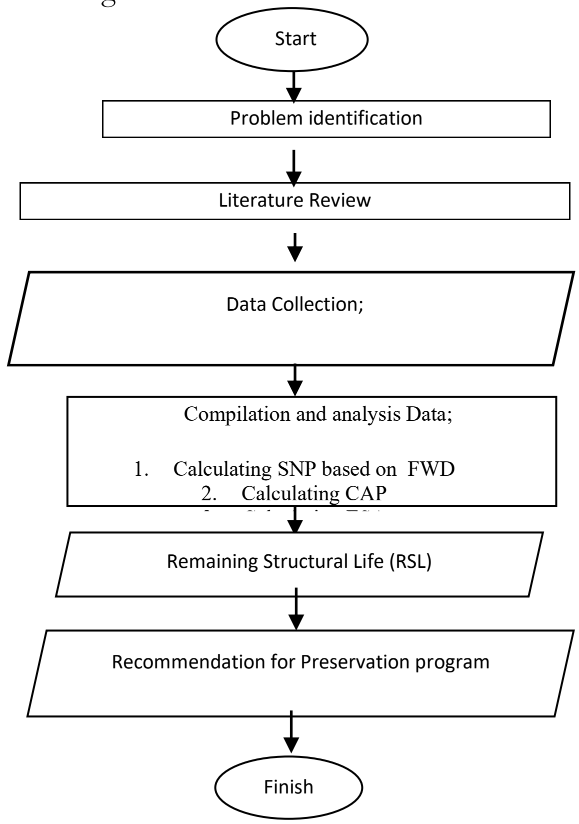
Falling Weight Deflectometer (FWD) is a special tools that is use to calculate the surface deflection of a road pavement system (Alshibli et al., 2005). The deflection value from this device can be used to calculate additional layer thickness, load transfer efficiency and also the RSL (Mun Park et al., 2002). This FWD device consists of 7 geophones (d0 to d7), a loading plate with a diameter of 30 cm, a load cell, an odometer, a temperature sensor, and a processor (Hardwiyono, 2012). D0 sensor is located in the midle of loading plate(Noureldin A, Zhu K, Li S, 2003). The load is lifted and dropped at a certain height so that it may hits the rubber buffer which then produces a deflection on the pavement surface. This deflection is read by the geophone sensor through the electronic circuit system on the processor **(kushdianto)** (Binamarga, 2019; Kusdhianto & Chalid, 2021).

Deflection data collection can be done during the daylight or at night. However, it is necessary to pay attention on road traffic flow conditions so that the data recording process does not make congestion and even traffic accidents (Iqbal et al., 2020).

The process of recording deflection data can be carried out even though the traffic conditions during observation point are high (Irawan et al., 2017). The effect of the vehicle load near the observation point will not interfere with the readings because the sensor is equipped with a device capable of calibrating the reading noise during the recording of deflection data.

This research is focused on the National Road Japura – Pematang Reba section, in Inderagiri Hulu Regency. This road has a length of 14 km and a width of 7 meters with the condition of the shoulder of the road without pavement. The data requirements in this study are deflection data from the FWD tool, road geometric condition and Average Daily Traffic (ADT) data. Those data obtained from a instansional survey from Satker P2JN PUPR Riau Province which had conducted a survey beforehand. The method used in predicting the remaining life of the pavement is IRMS V3 method. The deflection data is used to calculate the value of the Structural Number of Pavement (SNP). Furthermore, the SNP value is used to calculate the residual structural capacity of the pavement (CAP). The research flowchart is shown in Figure 1.

Figure 1. Research Flowchart



Results and Discussion

To determine the remaining structural life (RSL) of the pavement, there are several things that must be calculated Such as Structural Number of Pavement (SNP), which is a function of the pavement deflection. Pavement defection data is get by road condition survey. The outcomes of this survey is deflection data that occurred in pavement during measuring prossess. After SNP determined, Remaining pavement structural capacity (CAP) can be calculated as a function of SNP. Moreover, after CAP value determined The Remaining Structural Life (RSL) can be calculated. RSL represents of remaining pavement life in years. Besides, RSL can be used to choose preservation programs that needed based on actual condition (KIAT,2019).

Inorder to calculate SNP, SNP value can be calculated from reading data d0 of the FWD device with a load of 50 KN using equation 1 below;

$$SNP = \frac{167}{d0^{0,57}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where;

SNP : Structural Number of Pavement

d0 : d0 sensor FWD deflection.

Structural number (SNP) is extensively used to determine the structural capacities of certain flexible pavements (Horak et al., 2014). By using Equation 1 the SNP value can be calculated. Take roads on STA 3+493 as an example. the deflection value from the FWD device (d0) is 137,2 mm. Then the structural value of the pavement can be calculated by Equation 1 as follows;

$$SNP = \frac{167}{137{,}2^{0,57}} = \frac{167}{16{,}53} = 10{,}102$$

the results of other SNP calculations are presented in Table 1 below;

Table 1. SNP Value

STA	d0 (mm)	SNP	STA	d0 (mm)	SNP
3+493	137,2	10,102	9+306	180,1	8,651
3+885	103,1	11,889	9+502	146,3	9,739
4+113	132,9	10,287	9+711	240,2	7,342
4+310	127,4	10,538	9+841	144,4	9,812
4+516	99,3	12,147	11+201	107,3	11,622
4+730	112,7	11,301	11+329	151	9,565
4+931	126,1	10,6	11+517	134	10,239
5+111	213,3	7,856	11+727	119	10,956
5+306	146	9,751	11+908	102,1	11,956

STA	d0 (mm)	SNP	STA	d0 (mm)	SNP
5+510	154,4	9,445	12+108	125,5	10,629
5+724	111,1	11,394	12+321	129,1	10,459
5+914	271,4	6,848	12+514	108,5	11,548
6+122	142,7	9,879	12+729	143,5	9,847
6+319	154,3	9,448	12+916	110,1	11,452
6+514	377,3	5,676	13+144	135	10,196
6+717	185,9	8,496	14+760	164,5	9,11
6+909	313,5	6,308	14+945	112,6	11,307
7+108	202,2	8,099	15+150	337,1	6,052
7+315	362,3	5,808	15+306	174,1	8,82
7+511	203,9	8,06	15+508	125,6	10,624
7+721	304,8	6,41	15+709	104,1	11,824
7+930	589,5	4,401	15+922	81,9	13,556
8+124	487,1	4,907	16+106	89,2	12,912
8+312	630,2	4,237	16+303	87,9	13,021
8+509	198,4	8,187	16+510	166,5	9,047
8+706	115,9	11,122	16+727	177,9	8,712
8+906	153,6	9,473	16+819	210,2	7,922
9+116	137,1	10,107			

Furthermore, by using the SNP value in Table 1 above, the calculation of the Remaining Pavement Capacity (CAP) value can be determined by equation 2 below

$$CAP = \left\{\frac{[SNP-(k_i \times 1{,}05)]}{[k_g \times 2{,}135]}\right\}^{\frac{1}{k_c \times 0{,}175}} \ldots\ldots\ldots\ldots (2)$$

Where;

CAP : Remaining Structural Capacity, in millions of equivalent standard axles (ESAs)

SNP : Structural Number of Pavement

ki, kg, kc : Calibration factors for different pavement types

In calculating the CAP, the value of the calibration factor (k) from the above equation is referred to from table 2

Table 2. K Factors to Modify Default Capacity Relationship

Pavement Type Group	ki	kg	kc
Thin Asphalt Unbound	1.65	0,642	2.1
Thin Asphalt Stabilised	1.7	0.7	2.8
Full Depth Asphalt	0.6	1.6	0.8

(KIAT, 2019)

The value of the remaining pavement capacity (CAP) can be calculated by using the full depth Asphalt pavement group type with ki value is 0.6; kg value is 1.6; and the value of kc is 0.8. full depth Asphalt is a pavement structure in the form of a thick layer of asphalt that is placed directly on the subgrade. This full depth asphalt is used for road with high traffic loads(Nono, 2011).

The CAP value describes the remaining capacity of a pavement expressed in terms of road raffic load.

For example, at STA 3+493, the SNP value is 137.2 mm. While the K factor value of the Full depth asphalt type has ki value of 0.6; the value of kg is 1.6; and the value of kc is 0.8. Then CAP can be calculated by equation 2 as follows

$$CAP = \left(\frac{137{,}2-(0{,}6 \times 1{,}05)}{1{,}6 \times 2{,}135}\right)^{\frac{1}{0{,}8 \times 0{,}175}} = 1458{,}38$$

The CAP calculation for each STA is then presented in Table 3 below;

Table 3. Value of CAP

STA	CAP	STA	CAP
3+493	1458,38818	9+306	444,6208

STA	CAP	STA	CAP
3+885	5011,57797	9+502	1103,109
4+113	1674,50404	9+711	124,4663
4+310	2011,09569	9+841	1167,682
4+516	5889,12684	11+201	4220,591
4+730	3415,88181	11+329	961,1753
4+931	2102,4119	11+517	1615,69
5+111	210,895592	11+727	2701,163
5+306	1113,00922	11+908	5226,007
5+510	872,239027	12+108	2146,265
5+724	3633,05575	12+321	1898,882
5+914	72,1196066	12+514	4023,253
6+122	1229,40912	12+729	1199,877
6+319	874,707706	12+916	3777,398
6+514	16,2147192	13+144	1564,399
6+717	386,810869	14+760	661,349
6+909	37,6725577	14+945	3428,981
7+108	267,09653	15+150	27,10911
7+315	19,5201501	15+306	515,8905
7+511	257,402203	15+508	2138,879
7+721	42,7820409	15+709	4807,829
7+930	2,02588996	15+922	13436,49
8+124	4,97682177	16+106	9327,477
8+312	1,47366423	16+303	9932,286
8+509	290,420898	16+510	627,2909
8+706	3027,25215	16+727	469,2698
8+906	892,229226	16+819	225,0096
9+116	1463,01274		

The calculation of the RSL value requires the calculation of the design traffic load (ESA). For the calculation of the ESA value using the following Equation 3 taken from the 2017 MDP

ESA =ADT × $VDF\ Factual$× 365 days × DD × DL × R ……………….(3)

Where;

DD : Vehicle Distribution = 1,0

DL : Lane Distribution = 0.25 (2 Lane 2 direction)

R : Design life

VDF : Vehicle damage factor.

The ESA calculation uses data on the number of vehicles obtained from the ADT survey. ADT data is obtained from the results of a traffic counting survey that conducted by the Satker P2JN Ministry of Public Work and Housing.

VDF is a multiplier to convert the number of commercial vehicles like passanger car, Bus (5B), light two axle truck (6a), heavy two axle truck (6b), light three axle truck (7A), medium three axle truck (7B), heavy three axle truck (7C) with different axle loads and axle configurations into the number of repetitions of standard axle loads. The results of the ESA4 calculation are shown in Table 4 below.

Tabel 4. Value of ESA 4

Type of Vehicle	Total Number	VDF	CESA 1 Year
Passanger Car	8.135		-
5B	54	1	

			9.933
6A	412	0,5	37.595
6B	830	4,6	696.425
7A	741	7,4	1.000.335
7B	29	13	67.786
7C	36	9,6	62.822
	Total		1.874.896

Passenger cars are not taken into account because it is considered insignificant in reducing pavement conditions.

After Calculating the ESA value, RSL can be determine. Furthermore, RSL is a remaining number of years that pavement will be functionally and structurally able to serve traffic.(Thomas, 2010) the calculation of RSL can be done using Equation 4 below.

$$RSL=\frac{LN(\frac{CAP\times r+ESA\times(1+r)}{ESA}}{LN(1+r)}-1 \quad .... (4)$$

Where;

RSL = Remaining Structural Life (in years)
CAP = Remaining capacity in MESAs
ESA = Annual loading per lane in MESAs
r = Growth rate of traffic

Traffic growth factor value based on where the road is located and the function of the road. National Road Japura - Pematang Reba is in Sumatra island with the function of the road as an arterial road. The selected traffic growth factor value is 4.83 which is obtained from Table 5 below.

Table 5. Value of traffic flow growth factor

	Jawa	Sumatera	Kalimantan	Average
Arterial Road	4,8	4,83	5,14	4,75
Rural Collector Road	3,5	3,5	3,5	3,5
Country Road	1	1	1	1

(Bina Marga, 2017)

RSL value is obtained from predictive analysis of the remaining years measured based on the latest condition surveys, in the form of deflection surveys, traffic surveys and others. The remaining structural life of the pavement is expressed in the number of years (Vepa et al., 1996). The remaining life of the pavement can make it easier for road owners to determine the type of road preservation activities. Pavement that has a low RSL value means that it can serve shorter traffic flow compared to roads that have a higher RSL value. The greater the RSL value, the road can serve road users longer with better conditions. From the RSL value obtained, the road owner can determine the priority program for road pavement preservation. The types of road preservation programs are distinguished based on the RSL value. With a RSL value of less than 1, the appropriate type of road repair is Reconstruction. If the RSL value is in the range 1 to 5, the right type of preservation activity is an additional layer. RSL value is greater than 5, the recommended type of repair activity is routine maintenance (KIAT,2019). The following Table 6 displays the types of repairs.

Table 6. Type of preservation work

RSL Value	Preservation
RSL < 1	Reconstruction
1≤RSL< 5	Overlay
RSL> 5	Routine Maintanance

RSL Value from the calculation of Equation 3 and Equation 4 above can be presented in Table 7 below.

Table 7. Result of calculation of RSL

STA	RSL (Year)	Preservation
3+493	4,03	Overlay
3+885	4,73	Overlay
4+113	4,10	Overlay
4+310	4,21	Overlay
4+516	4,82	Overlay
4+730	4,51	Overlay
4+931	4,23	Overlay
5+111	2,93	Overlay
5+306	3,87	Overlay
5+510	3,73	Overlay
5+724	4,54	Overlay
5+914	2,33	Overlay
6+122	3,93	Overlay
6+319	3,74	Overlay
6+514	1,51	Overlay
6+717	3,27	Overlay
6+909	1,97	Overlay
7+108	3,07	Overlay
7+315	1,61	Overlay
7+511	3,04	Overlay
7+721	2,04	Overlay
7+930	0,56	Recon
8+124	0,93	Recon
8+312	0,45	Recon
8+509	3,11	Overlay
8+706	4,44	Overlay
8+906	3,75	Overlay
9+116	4,03	Overlay
9+306	3,35	Overlay
9+502	3,87	Overlay
9+711	2,63	Overlay
9+841	3,90	Overlay
11+201	4,63	Overlay
11+329	3,79	Overlay
11+517	4,08	Overlay
11+727	4,38	Overlay
11+908	4,75	Overlay
12+108	4,24	Overlay
12+321	4,18	Overlay

STA	RSL (Year)	Preservation
12+514	4,60	Overlay
12+729	3,92	Overlay
12+916	4,57	Overlay
13+144	4,07	Overlay
14+760	3,58	Overlay
14+945	4,51	Overlay
15+150	1,79	Overlay
15+306	3,44	Overlay
15+508	4,24	Overlay
15+709	4,70	Overlay
15+922	5,29	Routine
16+106	5,08	Routine
16+303	5,11	Routine
16+510	3,55	Overlay
16+727	3,38	Overlay
16+819	2,97	Overlay

From Table 7 above, it can be seen that the RSL value and preservation programs of each STA are different. For instance, At STA 3+493 it has an RSL value 4,03. Preservation programs that suitable for this STA are Overlay. At STA 7+930 the RSL value is 0,56. With that small value, it can be interpreted that the condition of the road is already damaged and requires reconstruction work. At STA 15+922 the RSL value is 5,29. This stasioning need routine maintenance.

Through analysis and calculations, it can be concluded that the flexible pavement maintenance activities on Nasional Road Japura to Pematang Reba were divided into 3 types;

1. Overlays program are needed for STA 3+ 393 to STA 7+712, STA 8+509 to STA 15+70 and STA 16+510 to 16+819.
2. Reconstruction work needed for STA 7+930 to STA 8+ 312.
3. Routine maintenance needed for STA 15+922 to STA 16+303.

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