Structural and Functional Evaluation of Flexible Pavement in Indonesia Case Study: Ciasem-Pamanukan Section

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Abstract : The purpose of this research is to evaluate the Structural and Functional performance of one section of the National Road (PANTURA) located in the North Java's Corridor. Two methods were used in this evaluation, the IRMS or Bina Marga's method and the AASHTO-93 method. The Bina Marga's method focused on the evaluation of the Functional Performance, while the AASHTO-93 method was used to analyze the Structural Condition. Some parameters were considered in the Functional analysis that is: IRI (International Roughness Index), PSI (Present Serviceability Index) and SDI (Surface Distress Index), while in the Structural analysis the SN (Structural Number) was used. The result of Functional Analysis using Bina Marga's method showed that all segments in Ciasem-Pamanukan were in good and fair condition, and do not need any structural treatment. However, the results of Structural Analysis show that some points have "zero" Remaining Life and require a 25cm overlay thickness.

Key Words: Present Serviceability Index, International Roughness Index, Surface Distress Index, Bina Marga's method, AASHTO-93 method.

1. INTRODUCTION

The Pavement Management System (PMS) has been defined by AASHTO as a set of tools or methods that assist decision-makers in finding optimum strategies for providing, evaluating and maintaining pavements in a serviceable condition over a period of time (AASHTO, 2001 in Huang, 2012). The Directorate General of Highways, has been implemented the Pavement Management System for National roads In Indonesia since many years ago, with the name of IRMS (Inter-urban Road Management System) (DGBM, 1992).

The objective of this study is to compare the results of pavement evaluation between the IRMS method, which focused only on Functional Performance, with another method which combines the Functional and Structural evaluation, based on the AASHTO-93 method.

PANTURA's Highway is a National-Arterial road, located in North corridor of Java Island, and has a very strategic role in the Transportation mobility from West Java to East

Java vice versa, as shown in Figure 1. This condition will impose a very high of traffic volume and consequently, a very high cumulative axle loading to the pavement structure.

Referring to AASHTO-93 method (AASHTO, 1993), there are two main types of failure which associated to pavement deterioration; those are functional failure and structural failure. Functional failure is a failure where the pavement is unable to carry traffic without causing discomfort to the road users. This failure depends primarily upon the degree of surface roughness or IRI value. Structural failure indicates a breakdown of one or more pavement components, making it incapable of sustaining the loads imposed upon its service life.

The purpose of this research is to evaluate the structural and functional performance of one section in the PANTURA's national road, that is : Ciasem-Pamanukan. In the analysis of Functional Performance, some parameters were used, that is : IRI (International Roughness Index), PSI (Present Serviceability Index) and SDI (Surface Distress Index), while in the analysis of Structural performance using the AASHTO-93 method, the SN (Structural Number) value is calculated and used to analyze the Remaining Life and Overlay Thickness.

2. RESEARCH METHODOLOGY

The working plan of this study can be seen in Figure 2, which is divided into two parallel programs: Functional Analysis and Structural Analysis.

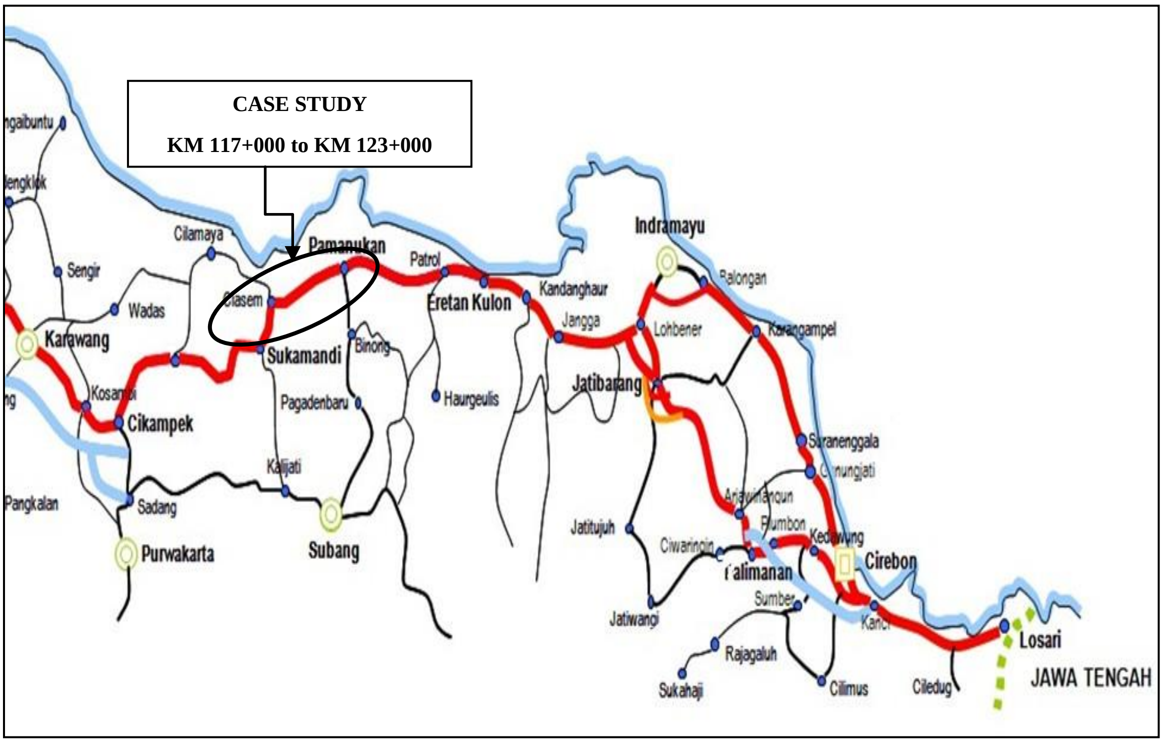


Figure 1. Location of Ciasem to Pamanukan Section

The methodology of Functional analysis consists of:

- The collection of visual condition data from field survey which represents the pavement surface condition.

- The collection of the latest Roughness data (IRI), resulting from IRMS's program, which represent the smoothness of pavement surface.
- Using the formula from Sayers et al. (1986) (see equation 1), the PSI value for each survey-point of IRI can be calculated.

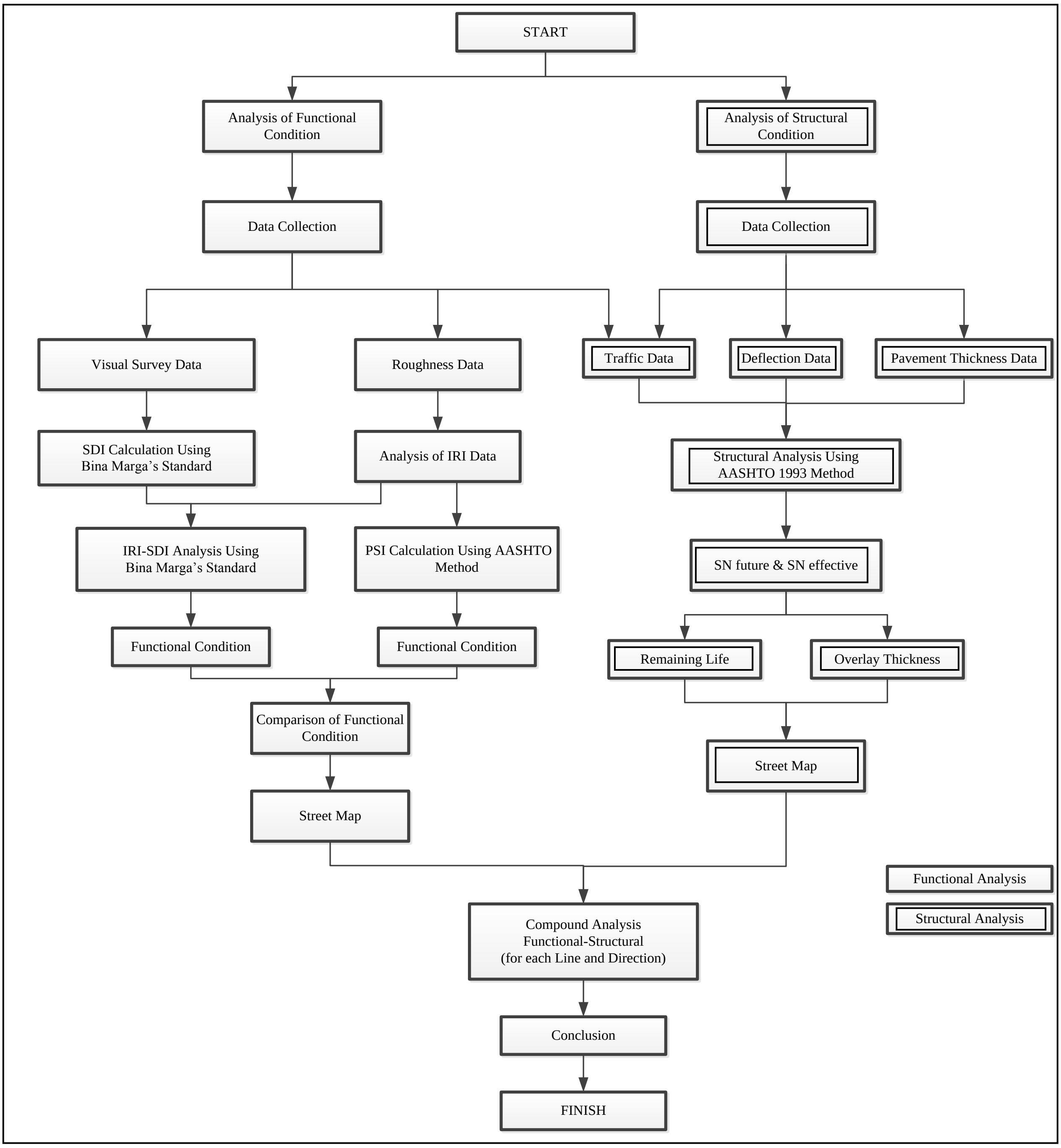


Figure 2. Flow Chart of Research Method

- Using the result of visual condition survey, the SDI (Surface Distress Index) value for each survey-point can be determined (see Table 1).

- In the same section (Ciasem-Pamanukan), the PSI value and the IRI-SDI value were applied in order to obtain the Functional condition for each survey-point.
- Finally the Functional condition based on the PSI value and the IRI-SDI value can be compared and analyzed, in order to determine the Pavement Maintenance Strategy for those sections, with an objective to carry traffic safely, conveniently and economically over its extended life. Three options of Pavement Maintenance Strategy are Routine Maintenance, Periodic Maintenance and Reconstruction.

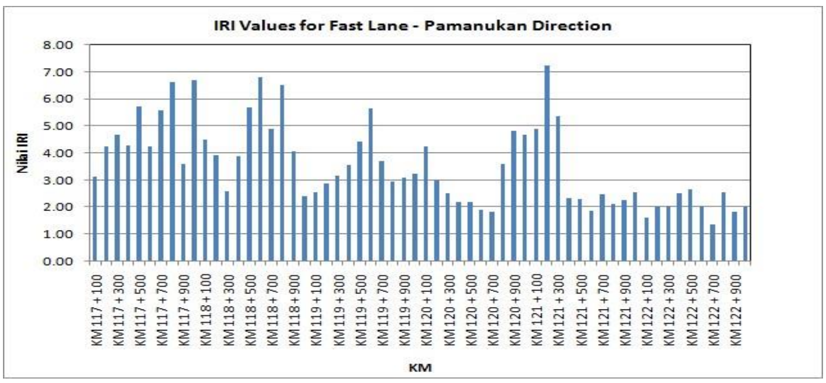
The Methodology of Structural analysis consists of :

- The collection of some principal data in the Ciasem-Pamanukan section, which consists of traffic data (AADT) for two directions, the axle-loading data resulted from WIM survey in 2010, the FWD's deflection data, the pavement thickness data and the pavement temperature data.
- The average Traffic Growth was calculated based on the "time series" AADT data.
- The Truck Factor for each vehicle type was calculated using the axle-loading data.
- The cumulative ESAL actual and the "future" cumulative ESAL will be determined considering the AADT data, the average growth factor and the Truck Factor for each vehicle.
- Hence, the AASHTO-93 method can be applied to obtain the SN_f and SN_{eff} (future and effective values, respectively), the Remaining life (RL) of those sections, and the overlay thickness for several survey-point.

3. DATA PRESENTATION

3.1 Roughness Data

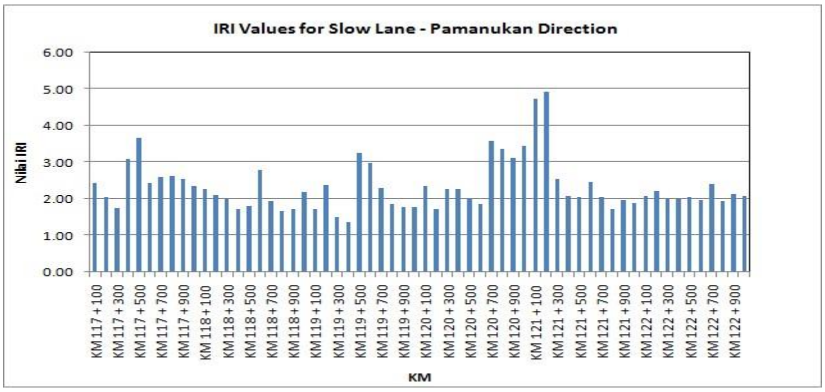
Roughness data, in the form of "International Roughness Index" (IRI), was collected every year using NAASRA Roughometer and then compiled in the IRMS Database Program. The IRI data will be transformed to PSI value, considering the formula proposed by Sayers et al. (1986) as shown in equation 1.



Source: PUSJATAN 2011

Figure 3.IRI Values for Pamanukan Direction – Fast Lane

The IRI value for Pamanukan direction in the fast lane and slow lane can be seen in Figure 3 and Figure 4 respectively. Regarding the Figure 3 and Figure 4 above, it can be concluded that the IRI value in the fast lane was relatively higher than that in the slow lane for both directions.



Source: PUSJATAN, 2011

Figure 4.IRI Values For Pamanukan Direction – Slow Lane

3.2 Surface Condition Data

The surface condition data of pavement was collected from visual survey using the standard Road Condition Survey (RCS) form. The collected data will then be used to obtain the Surface Distress Index (SDI) as proposed by the Bina Marga's method. For example, the results of surface condition data for Pamanukan direction is shown in Table 1.

Table 1. Pavement Surface Distress for Pamanukan Direction

Road Section	Crack Area Total	Crack Wide Average	Hole Total	Rutting Depth Average	Pavement Type
KM 117+000 – KM 118+000	0	0	0	0	Flexible
KM 118+000 – KM 119+000	0	0	< 10/km	1 cm	Flexible
KM 119+000 – KM 120+000	< 10 %	1 mm	0	1 cm	Flexible
KM 120+000 – KM 121+000	0	0	0	0	Flexible
KM 121+000 – KM 122+000	< 10 %	1 mm	< 10/km	0	Flexible
KM 122+000 – KM 123+000	0	0	< 10/km	0	Flexible

Source: Actual Survey, 2011

3.3 Traffic Data

The actual traffic data was classified into ten vehicle categories, based on Bina Marga's Classification, i.e. vehicle category 2 until vehicle category 7C. For example, the distribution of traffic data for Pamanukan direction is shown in Table 2.

Table2.Traffic Volume for Pamanukan Section

Segment	Year	AADT (Vehicle/Day)										Total Vehicles
		Light Vehicles				Heavy Vehicles						
		Cat 2	Cat 3	Cat 4	Cat 5A	Cat 5B	Cat 6A	Cat 6B	Cat 7A	Cat 7B	Cat 7C	
Subang –Pamanukan*	2008	2786	3443	1967	325	575	1391	1770	443	50	159	12907
Cikampek – Pamanukan*	2009	3722	4597	2627	495	34	2111	1807	1040	83	402	16918
Subang –Pamanukan*	2010	2645	3306	1914	435	830	1458	1872	561	118	215	13352

Source: PUSJATAN, 2009 Notes : * data source from IRMS's database.

The Ratio for heavy vehicles between fast lane and slow lane were marked about 60% to 40%, whereas for light vehicles the Ratio were between 55% to 45% (see Table 3). It can be said that the heavy vehicles in PANTURA National Road prefer to use fast lane rather than slow lane. However, this phenomenon is contradictive with the regular lane distribution in the arterial road in Indonesia.

Table 3.Total AADT based on Primary Survey

Total	AADT (Vehicle/Day)					
	Light Vehicles		Heavy Vehicles		Vehicles Total	
	Amount	%	Amount	%	Amount	%
Pamanukan Direction - Slow Lane	5776	44.8	5144	39.9	10920	44.8
Pamanukan Direction - Fast Lane	7117	55.2	7734	60.1	14851	55.2
Total - Pamanukan Direction	12893	100	12878	100	25771	100
Ciasem Direction -Slow Lane	3295	44.1	3716	40.6	7011	42.2
Ciasem Direction -Fast Lane	4173	55.9	5434	59.4	9607	57.8
Total- Ciasem Direction	7468	100	9150	100	16618	100

Source: Actual Survey, 2011

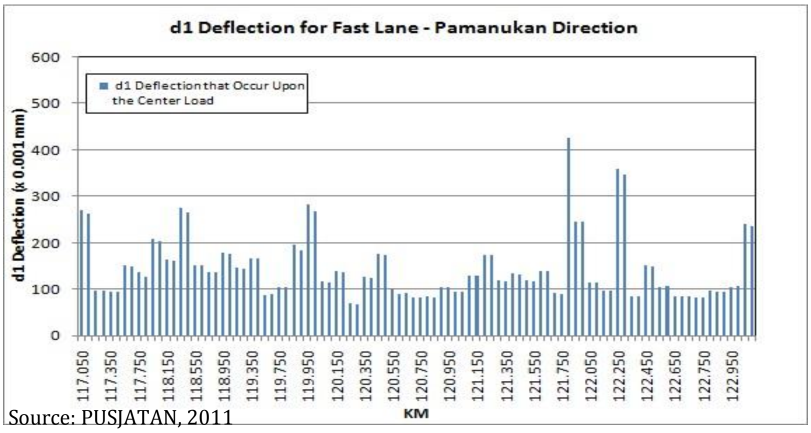
3.4 Axle Load Data

The vehicle axle load data was obtained from WIM (Weight-in-Motion) survey. It is similar to a gross weight survey for moving vehicle, and the weight proportion for each vehicle tires was determined by analyzing the dynamic pressure of each tires. The vehicle axle load data used in this research are resulted from WIM Survey at Cirebon-Losari section in 2010, at Cikampek-Pamanukan section in 2009 and at Pamanukan-Eretan kulon section in 2006.

The Truck Factor value for vehicle category 6B,7A and 7C are calculated from data obtained by WIM Survey at Cirebon-Losari section and at Cikampek-Pamanukan section, while the Truck Factor for vehicle category 2,3,4,5A,5B,6A and 7B are calculated from data obtained by WIM Survey at Pamanukan-Eretan kulon section.

3.5 FWD's Deflection Data

The deflection data were obtained from survey in 2011 using the Falling Weight Deflectometer (FWD) equipment. The instrument is supported with 25 inch dish load, 200 kg ballast load and 26 inch high falls. Each deflectometer is placed among 0, 200, 300, 450, 600, 900, 1200, 1500 and 1800 mm for pavement with total thickness more than 700 mm. These FWD's deflection data will be used in structural analysis and combined with the AADT data, axle load (WIM) data and pavement thickness. For example, the d_1(maximum deflection) of FWD deflection data for Pamanukan direction in fast lane is shown in Figure 5.

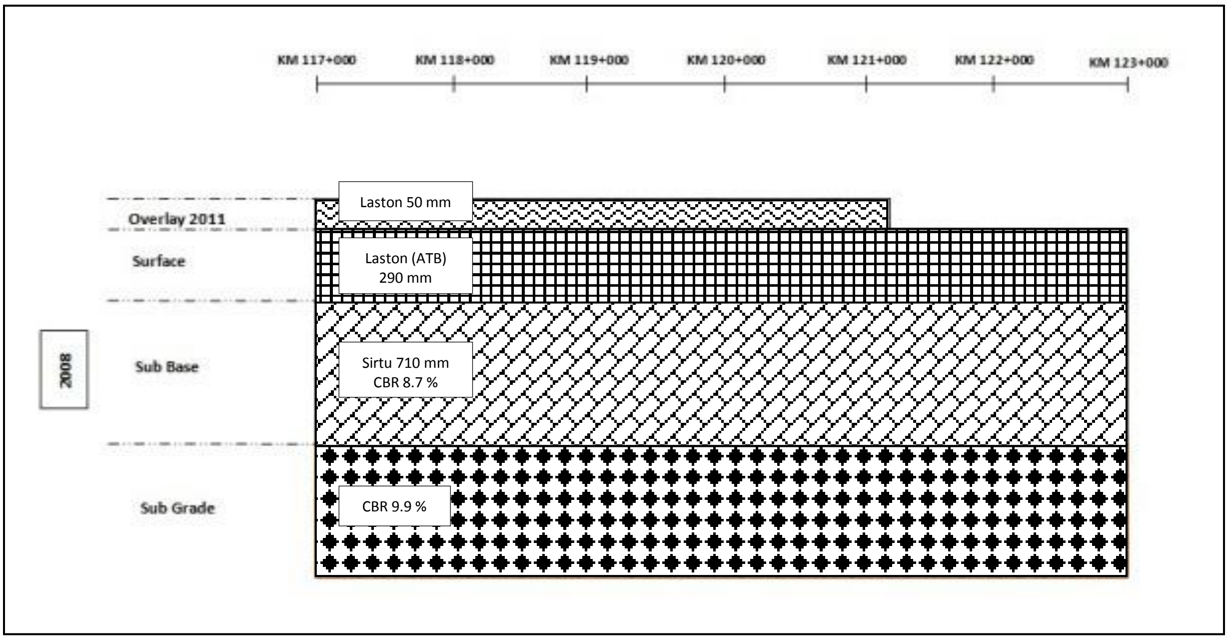


Source: PUSJATAN, 2011

Figure 5. Deflection d_1 for Pamanukan Direction – Fast Lane

3.6 Pavement Thickness Data

Regarding the result of test-pit survey in 2008 and the report of pavement maintenance program in 2011, the pavement thickness in Ciasem-Pamanukan section (Km 117+000 to Km 123+000) consist of Subgrade layer, Subbase layer, Surface layer and an overlay thickness applied in 2011. For example, the pavement thickness for Pamanukan direction - fast lane is shown in Figure 6.



Source: PUSJATAN, 2011

Figure 6.Pavement Thickness for Pamanukan Direction - Fast Lane

4. DATA ANALYSIS

4.1 Functional Analysis using Bina Marga's Method

Sayers, et al. (1986) proposed the formula to calculate the PSI value in function of IRI value (see Equation 1), considering the crack failure, patching and rutting that have been included in the IRI value.

$$PSI = 5 \times e^{(-0,18 \times IRI)} \quad (1)$$

Where : PSI = Present Serviceability Index
IRI = International Roughness Index

Sayers, et al. (1986), proposed also the pavement condition based on the PSI value, as shown in Table 4.

Table 4. Pavement Condition Based on PSI Value

PSI	**Condition**
$4 \leq PSI < 5$	Very Good
$3 \leq PSI < 4$	Good
$2 \leq PSI < 3$	Fair
$1 \leq PSI < 2$	Bad
$0 < PSI < 1$	Very Bad

Source: Sayers, et al. (1986)

Some of distress parameters were needed for visual checking approach. Those are wide distress total, wide distress average, hole total and vehicle rutting depth average. All of those parameters will be checked and noted by three surveyors using the *Road Condition Survey* (RCS) form. After the survey complete, the *Surface Distress Index* (SDI) value will then be calculated using the Bina Marga's Criteria (see Table 5).

Table 5. The Bina Marga's Criteria for SDI Value

Total Crack Area	**SDI (1)**	**Average Crack Wide**	**SDI (2)**
< 10 %	5	< 1 MM (SMOOTH)	(1)
10 -30 %	20	1 -3 MM (MEDIUM)	(1)
> 30 %	40	> 3 MM (WIDE)	(1) x 2
Total Pothole	**SDI (3)**	**Average Rut Depth**	**(4)**
< 10 / KM	(2) + 15	< 1 CM	(3) + 2.5
10 -50 / KM	(2) + 75	1 -3 CM	(3) + 10
> 50 / KM	(2) + 225	> 3 CM	(3) + 20

Source: DGBM, 1992

According to Bina Marga's method, the functional pavement condition can be determined by combining the IRI value and the SDI value (see Table 6).

In the beginning of this research, it was underlined that the focus of this research is to compare the result of functional analysis with that of structural analysis. Therefore, the segmentation for those two analyses should be the same. The segmentation for Pavement (Functional) Condition will follow the segmentation resulting from FWD deflection data for both directions.

Table 6. The Pavement Condition Based on IRI and SDI Values

IRI (m/km)	SDI			
	< 50	50 - 100	100 - 150	> 150
< 4	GOOD	MEDIUM	LIGHT DAMAGE	HEAVY DAMAGE
4 - 8	MEDIUM	MEDIUM	LIGHT DAMAGE	HEAVY DAMAGE
8 - 12	LIGHT DAMAGE	LIGHT DAMAGE	LIGHT DAMAGE	HEAVY DAMAGE
> 12	HEAVY DAMAGE	HEAVY DAMAGE	HEAVY DAMAGE	HEAVY DAMAGE

Source: DGBM, 1992

Based on the functional analysis by using Table 4 and Table 6, the pavement condition for each segmentation in Ciasem-Pamanukan section (Km 117+000 to Km 123+000) can be summarized. For example, the pavement condition in both fast lane and slow lane, for Pamanukan direction, are presented in Table 7 and Table 8.

Table 7. Pavement Condition (IRI and SDI) for Pamanukan Direction - Slow Lane

Segment	KM	Distance (Km)	Condition of Pavement Based on PSI	Condition of Pavement Based on IRI-SDI
1	117.000 - 117.100	0.100	GOOD	GOOD
2	117.100 - 121.200	4.100	GOOD	GOOD
3	121.200 - 122.000	0.800	GOOD	GOOD
4	122.000 - 122.100	0.100	GOOD	GOOD
5	122.100 - 122.200	0.100	GOOD	GOOD
6	122.200 - 123.000	0.800	GOOD	GOOD

Table 8. Pavement Condition (IRI and SDI) for Pamanukan Direction- Fast Lane

Segment	KM	Distance (Km)	Condition of Pavement Based on PSI	Condition of Pavement Based on IRI-SDI
1	117.000 - 117.150	0.150	FAIR	GOOD
2	117.150 - 117.750	0.600	BAD	FAIR
3	117.750 - 118.350	0.600	BAD	FAIR
4	118.350 - 119.750	1.400	BAD	FAIR
5	119.750 - 119.950	0.200	FAIR	GOOD
6	119.950 - 121.200	1.250	FAIR	GOOD
7	121.200 - 121.750	0.550	FAIR	GOOD
8	121.750 - 121.850	0.100	GOOD	GOOD
9	121.850 - 121.950	0.100	GOOD	GOOD
10	121.950 - 122.150	0.200	GOOD	GOOD
11	122.150 - 122.250	0.100	GOOD	GOOD
12	122.250 - 122.950	0.700	GOOD	GOOD
13	122.950 - 123.000	0.050	GOOD	GOOD

Regarding the result in Table 8**,** an important difference is shown between the PSI criteria and IRI-SDI criteria for several point-surveys. It can be concluded that the PSI parameter has a higher criteria than the IRI-SDI parameter. Accordingly, the Bina Marga's method recommends the treatment action resulting from the combination of the IRI value and SDI value as shown in Table 9.

Table 9. Treatment Strategy Based on IRI and SDI Values

IRI (m/km)	SDI			
	< 50	50 - 100	100 - 150	> 150
< 4	ROUTINE	ROUTINE	PERIODIC	IMPROVEMENT
4 - 8	ROUTINE	ROUTINE	PERIODIC	IMPROVEMENT
8 - 12	PERIODIC	PERIODIC	PERIODIC	IMPROVEMENT
> 12	IMPROVEMENT	IMPROVEMENT	IMPROVEMENT	IMPROVEMENT

Source: DGBM, 1992.

Referring to the results of functional analysis using the IRI and SDI parameters, it is obtained that the entire segment in Ciasem-Pamanukan section needs only a treatment of Routine Maintenance.

The street map of pavement condition based on the PSI's parameter and IRI-SDI's parameter for Ciasem-Pamanukan section is shown in Figure 7 and Figure 8.

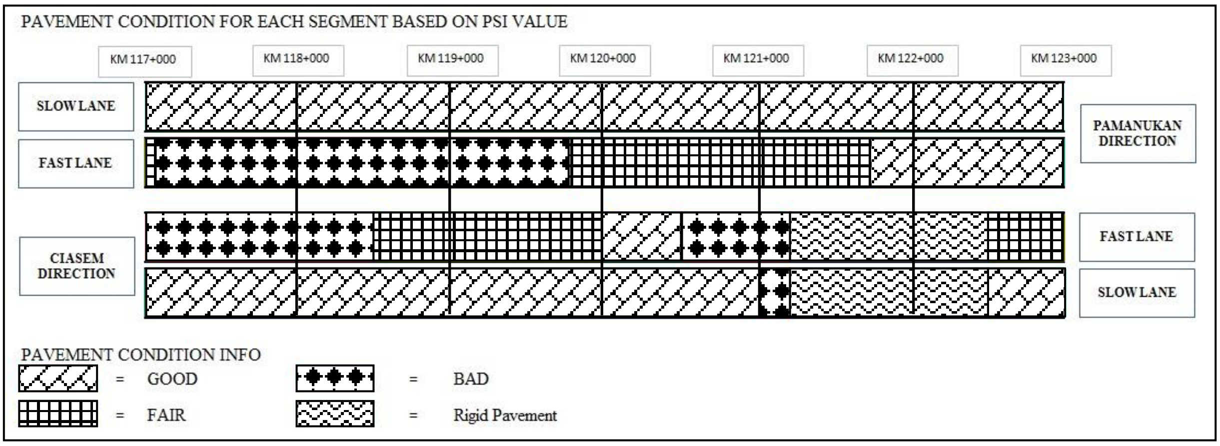


Figure 7. The Street Map of Pavement Condition Based on PSI's Parameter

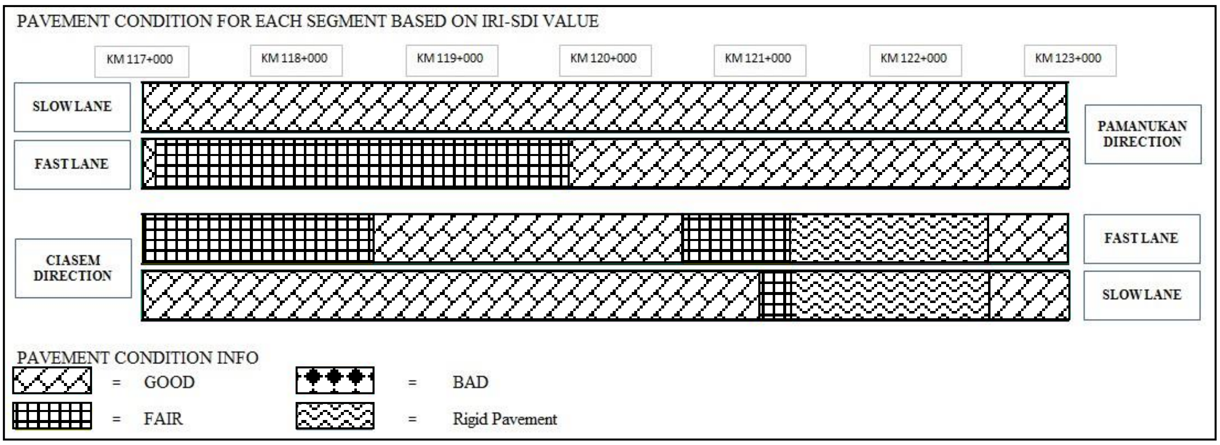


Figure 8.The Street Map of Pavement Condition Based on IRI-SDI's Parameter

4.2 Traffic Analysis

The average traffic growth was calculated based on traffic volumes (AADT) from 2008 until 2011 using the Increment Method. This traffic analysis considered the traffic growth for both light vehicles and heavy vehicles. The light vehicles consist of "category vehicle 2" until "category vehicle 5A", whereas the heavy vehicles consist of "category vehicle 5B" until "category vehicle 7C". For example, the result of traffic growth calculation for Pamanukan direction is presented in Table 10.

Regarding the result of traffic analysis, it was obtained that the percentage of Heavy Vehicles was very high, that was more than 50% of volume of light vehicles. Apparently, there was an "extremely high" traffic growth in 2011, especially for Heavy vehicles. The decision taken to the average 34% of traffic growth in that period can be assumed "sufficient".

Table 10.Traffic Growth from 2008 to 2011 for Pamanukan Direction

Total	Year	AADT (Vehicle/Day)			Annual Traffic Growth (%)
		Light Vehicle	Heavy Vehicle	Total Vehicle	
Subang –Pamanukan	2008	8,520	4,387	12,907	
Ciasem - Pamanukan	2009	11,441	5,477	16,918	31.08
Subang –Pamanukan	2010	8,299	5,053	13,352	-21.08
Ciasem - Pamanukan	2011	12,893	12,878	25,771	93.02
Average(2008 – 2011)					34.34

4.3 Axle Load Analysis

The Truck Factor for vehicle category 2, 3, 4, 5A, 5B, 6A and 7B (see Table 11) were obtained from WIM Survey at Pamanukan-Eretankulon section, while for vehicle category 6B, 7A and 7C were obtained from WIM Survey at Cirebon-Losari and Cikampek-Pamanukan sections. The summary of Truck Factor (TF) value for vehicle category 6B, 7A and 7C are shown in Table 12.

Table 11.The Average Truck Factor for Light vehicles

Vehicle Category	**Axle Type**	**Truck Factor Pamanukan Direction**	**Truck Factor Ciasem Direction**
2	1.1	0.0021	0.0061
3	1.1	0.0021	0.0061
4	1.1	0.0021	0.0061
5A	1.1	1.1070	1.7800
5B	1.2	3.7417	2.4396
6A	1.1	1.1070	1.7800
7B	1.2 + 2.2	10.3720	15.6257

Source: DGBM,2011

The cumulative ESAL value can be determined by multiplying the AADT value for one-year with the lane distribution factor and the average Truck Factor (TF) for each vehicle. The prediction of cumulative ESAL from 2011 to 2014 is calculated using the AASHTO 1993 equation. This value is important in order to obtain the remaining life (RL) and the overlay thickness of that section.

Table 12. The Average Truck Factor for Heavy vehicles

Vehicle Category	Pamanukan Direction		Ciasem Direction	
	Year 2009	Year 2010	Year 2009	Year 2010
6B	9.59	5.09	6.26	5.40
7A	13.28	16.32	12.60	21.56
7C-1	62.89	26.17	57.62	43.99
7C-2	57.28	42.20	53.59	41.07
7C-3	87.57	91.54	82.98	40.14

Source: DGBM, 2011

The actual Cumulative ESAL from 2008 to 2011 is shown in Table 13, while the prediction of Cumulative ESAL from 2011 to 2013 can be seen in Table 14.

Table 13.The Actual Cumulative ESAL from 2008 to 2011

Year	Pamanukan Direction		Ciasem Direction	
	Fast Lane	Slow Lane	Fast Lane	Slow Lane
2008	9,059,328	6,039,552	7,696,710	5,131,140
2009	12,170,301	8,113,534	8,414,813	5,609,876
2010	13,983,720	9,322,480	8,217,661	5,478,441
2011	18,785,729	12,523,819	8,984,369	5,989,579

Table 14.The Cumulative ESAL predicted from 2011 to 2014

Year	Pamanukan Direction		Ciasem Direction	
	Fast Lane	Slow Lane	Fast Lane	Slow Lane
2011	37,765,558	25,177,039	28,234,914	18,823,276
2012	50,734,251	33,822,834	30,869,232	20,579,488
2013	68,156,393	45,437,595	33,749,331	22,495,045
2014	91,561,298	61,040,866	36,898,144	24,589,324

4.4. Structural Analysis Using AASHTO 1993 Method

4.4.1 Calculation of actual cumulative ESAL

The actual cumulative ESAL for *Terminate* (W_T) condition will be computed by using the AASHTO 1993 equation. However, several requirements are also needed:

- The calculation will refer to the average deflection which was influenced by the value of relative strength (a_1) and layer thickness (D). Moreover, those two variables could affect the cumulative ESAL value because they create the different *Original Structural Number* (SN_O) value.
- The value of 2.5 which describes the critical condition for arterial road will be used as P_{1a} value in *Terminate* condition (W_T).
- The M_R value was compared between the M_R value obtained from test-pit calibration result in 2008 and the M_R value obtained from FWD's back-calculation result in 2011. In

this case, the M_R value from test-pit CBR calibration was chosen because its value was smaller than the other one.

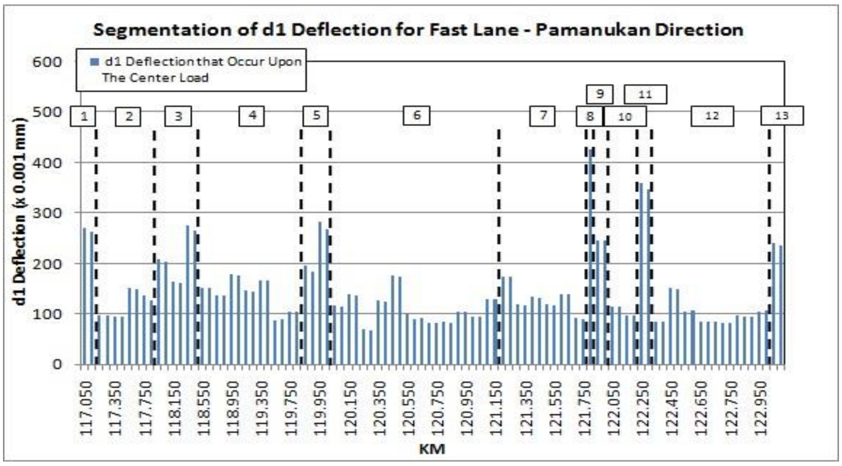


Figure 9. Segmentation of d_1 Deflection for Pamanukan Direction- Fast Lane

The next calculation will refer to the average deflection from the segmentation of FWD deflection data. For example, the segmentation for Pamanukan direction (fast lane) is shown in Figure 9, while the actual cumulative ESAL for W_T condition is presented in Table 15.

Table 15.Actual Cumulative ESAL for Pamanukan Direction- Fast Lane

Segment	KM	Distance (km)	W_T (ESAL)
1	117.000 – 117.150	0.150	2,260,973
2	117.150 – 117.750	0.600	5,855,831
3	117.750 – 118.350	0.600	1,962,919
4	118.350 – 119.750	1.400	4,495,933
5	119.750 – 119.950	0.200	1,699,116
6	119.950 – 121.200	1.250	6,644,294
7	121.200 – 121.750	0.550	1,922,706
8	121.750 – 121.850	0.100	420,141
9	121.850 – 121.950	0.100	1,068,779
10	121.950 – 122.150	0.200	3,858,894
11	122.150 – 122.250	0.100	420,141
12	122.250 – 122.950	0.700	3,367,152
13	122.950 – 123.000	0.050	1,068,779

4.4.2 Deflection analysis

Referring to Subagio et al. (2011) and the AASHTO-93 method (1993) as shown in Figure 10, the value of deflection d_1 reflects the main condition of pavement layer from surface course to subgrade layer. Therefore, the segmentation of deflection data will be carried out by considering the deflection d_1 visually. The level of uniformity is highly considered during the segmentation process, because it can cause an *over design* calculation for overlay thickness. The uniformity for each segment shall be less than 30 percent, which indicates that the uniformity is good enough.

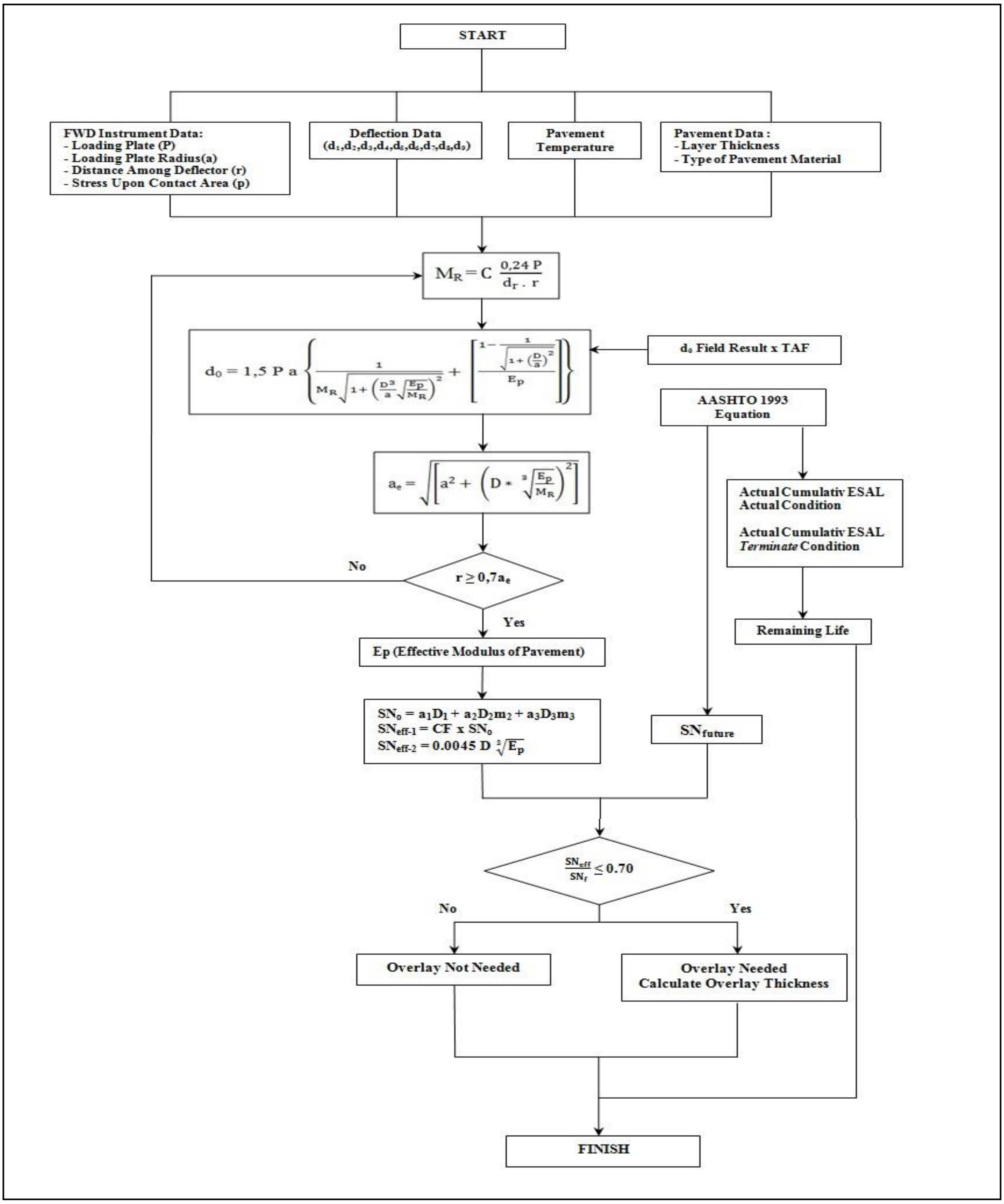


Figure 10. Flow Chart of Structural Analysis Using the AASHTO 1993 Method

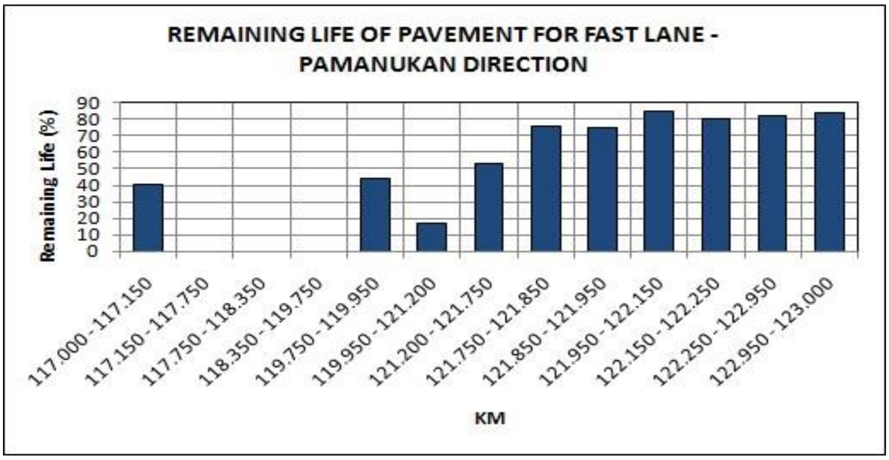


Figure 11. Remaining Life of Pavement for Pamanukan Direction- Fast Lane

The Remaining Life (RL) of pavement structure is shown in Figure 11 and Figure 12. There are two types of Remaining Life, which is based on the *Actual* condition (W_A) and *Terminate* condition (W_T). The difference between their calculations resides in the P_1 (terminal condition) value. The *Terminate* condition used the value of 2.5, while the *Actual* condition used the PSI value obtained from functional analysis.

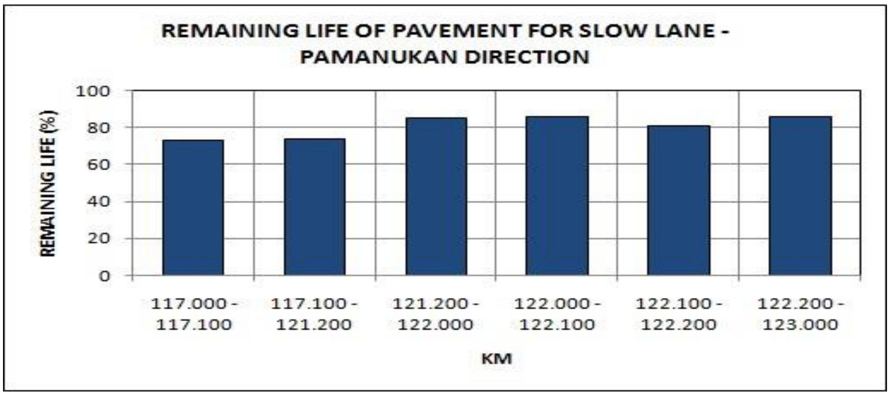


Figure 12. Remaining Life of Pavement for Pamanukan Direction- Slow Lane

Pavement structural capacity consists of SN_f (Future Structural Number), SN_o (Initial Structural Number) and SN_{eff} (Effective Structural Number). SN_f represents the Structural capacity based on traffic volume prediction in 2014, while SN_o is the Structural capacity based on the initial pavement condition in 2008, and SN_{eff} is the actual Structural capacity at the time of analysis in 2011.

The overlay thickness required (D_{ov}) is calculated based on the difference between SN_f and $SN_{eff\text{-}min}$ value and the result is divided by the layer coefficient of wearing course (AC-WC). The overlay thickness was calculated for each survey-point and its result was shown in Figure 13, while the Street Map obtained from that calculation is presented in Figure 14.

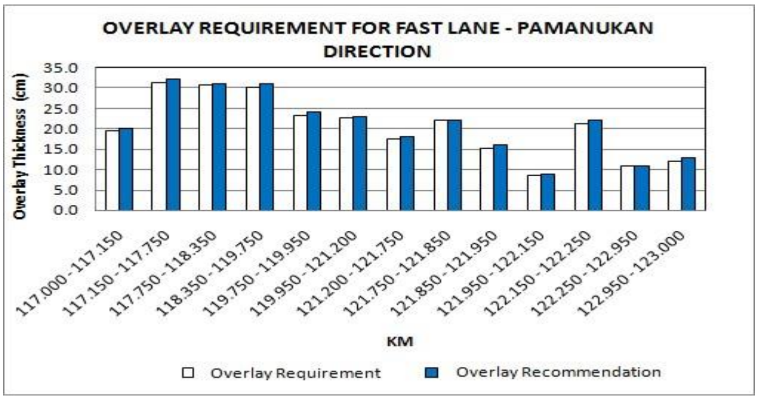


Figure13. Overlay Thickness for Pamanukan Direction- Fast Lane

Regarding the result of structural analysis, several important points can be shown:

- Some "zero" Remaining Life was obtained in the fast lane. This could be happened due to high value of AADT in 2011 (AADT > 10.000 vehicle/day), a high growth factor (34%) and an extremely high value of *Truck Factor*. Thus, it can be concluded that the intensity of traffic loading can impose a critical impact on the pavement structural capacity.
- The required overlay thickness at the point-survey with "zero" Remaining Life was about 25cm. It is really an "extreme" value and it needs to be overlaid by one or more additional surface layer. Another solution for this problem should be considered, for example, the implementation of reconstruction method.

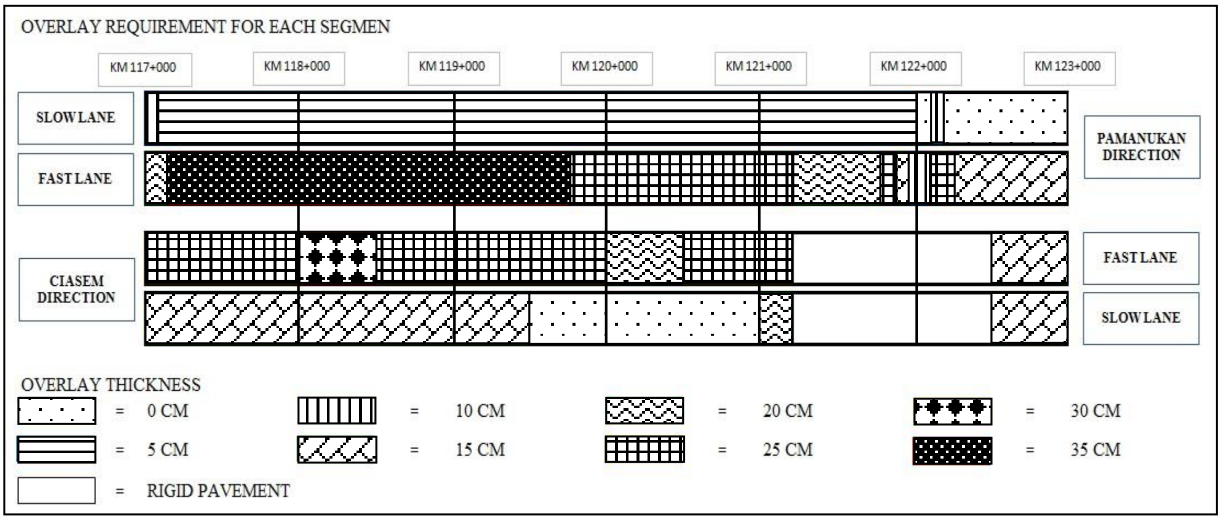


Figure14. Street Map of Overlay Thickness for Both Directions

5. CONCLUSIONS

Based on the result from this research, some conclusions could be taken:

1. The results of Functional Analysis using the PSI and the IRI-SDI criteria, based on the Bina Marga's method, do not recommend any "significant" treatment, because the pavement condition in those sections are "good" and "fair".

2. On the contrary, the results of Structural Analysis using FWD's deflection data and the AASHTO-93 method confirm that all of the pavement sections were in "fair to weak" conditions. Some survey-points in those sections have "zero" Remaining Life and those sections require a "very high" overlay thickness, i.e. more than 25 cm.
3. In general, the analysis of "very heavy" trafficked road, such as : the National road in North Java corridor (PANTURA), needs a very special method. The implementation of the Functional analysis (only) cannot show the "real" pavement condition in-situ. Alternatively, the Structural analysis offers the best and accurate solution.
4. In order to obtain a more accurate result in the Pavement Analysis for the PANTURA National road, another method could be recommended, such as : the use of EVERSERIES program (WSDOT,2005) which is based on the Mechanistic method, as presented in Subagio et al.(2011).

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