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# ANALYSIS OF ROAD DAMAGE LEVEL BASED ON THE *INDEKS KONDISI PERKERASAN* METHOD ON THE MOJOKERTO-JOMBANG ROAD SECTION

**Indri Lestari[1], Nain Dhaniarti Raharjo [2], Moch.Sholeh[2]**
Mahasiswa Manajemen Rekayasa Konstruksi[1] , Dosen Jurusan Teknik Sipil[2] , Dosen Jurusan Teknik Sipil[3]
Email: Indrilestari056@gmail.com[1], nainraharjo@polinema.ac.id[2], moch.sholeh@polinema.co.id[3]

**ABSTRACT**

Mojokerto-Jombang Road section is a national road that connects the main use areas in Mojokerto and has a high vehicle intensity. This damage to the road caused the decrease in quality and disturb in comfort of road users. Therefore this study aims to analyze the level of damage, provide handling, and find out the Cost Budget Plan needed for handling the damage. The calculation method used *Indeks Kondisi Perkerasan* Method (IKP). The primary data in this study is visual damage condition survey, while the secondary data are average daily traffic data, road technical data, CBR data, and PUPR 2022 unit prices. The results of the study are road damage Patching by approximately 41,8%, Edge Cracking around 4,3%, Potholes by approximately 8,9%, Aligator Cracking around 33,7%, Block Alligator by approximately 4,6%, Bleeding around 0,6%, Longitudinal Cracking by approximately 5,2%, Polished Aggregate around 0,5%, and Rutting by approximately 0,3% with a pavement surface condition value a 19,4% Good, 14,2% Satisfactory, 20,1% Fair, 17,2% Poor, 11,9% Very Poor, 14,9% Serious, and 2,2% Failed. On the other hand, the types of handling in this study obtained Routine Maintenance 19%, Periodic Maintenance 14%, Rehabilitation 19%, and Reconstruction/ Recycling 47%. The budget estimate plan for all repair works is about Rp. 63,562,961,000,-.

**Keywords :** IKP Method; Road Damage; Budget Estimate Plan.

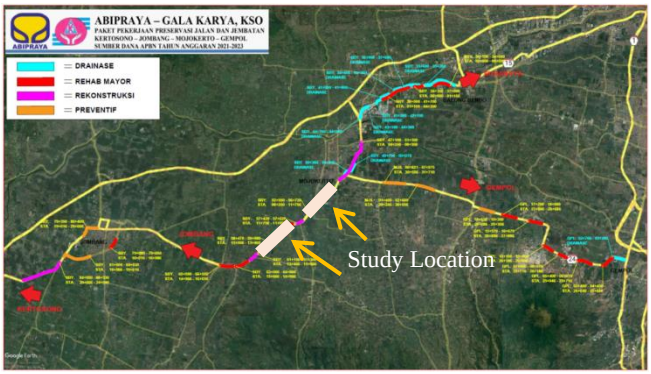
***ABSTRAK***

*Ruas Jalan Mojokerto–Jombang merupakan jalan nasional yang menghubungkan berbagi wilayah utama di Mojokerto dan memiliki intensitas kendaraan yang tinggi. Banyaknya kerusakan pada sepanjang ruas jalan tersebut mengakibatkan terjadinya penurunan kualitas dan mengganggu kenyamanan para pengguna jalan. Penelitian ini bertujuan untuk menganalisis tingkat kerusakan, memberikan alternatif penanganan, serta mengetahui Rencana Anggaran Biaya yang dibutuhkan pada penanganan tersebut. Metode perhitungan yang diapakai merupakan Metode Indeks Kondisi Perkerasan (IKP). Data primer yang dibutuhkan dalam penelitian ini yaitu survei kondisi kerusakan secara visual, sedangkan data sekunder yang dibutuhkan yaitu data lalu lintas harian rata-rata, data teknis jalan, data CBR, dan Harga satuan pekerjaan PUPR 2022. Hasil dari analisis didapatkan kerusakan jalan Tambalan sebesar 41,8%, Retak Tepi sebesar 4,3%, Lubang sebesar 8,9%, Retak Buaya sebesar 33,7%, Retak Blok sebesar 4,6%, Bleeding sebesar 0,6%, Retak Memanjang sebesar 5,2%, Pengausan Agregat sebesar 0,5%, dan Alur Sebesar 0,3% dengan nilai kondisi permukaan perkerasan 19,4% Sangat Baik, 14,2% Baik, 20,1% Sedang, 17,2% Jelek, 11,9% Parah, 14,9% Sangat Parah, dan 2,2% hancur. Jenis penanganan pada penilitian ini didapatkan Pemeliharaan Rutin 19%, Pemeliharaan Berkala 14%, Peningkatan Struktural 19%, dan Rekonstruksi/Daur Ulang 47%. RAB yang dibutuhkan untuk seluruh pekerjaan perbaikan sebesar Rp. 63.562.961.000,-.*

***Kata kunci** : Metode IKP; Kerusakan Jalan; Rencana Anggaran Biaya*

## 1. INTRODUCTION

The Mojokerto-Jombang Road section is a national road which is a road that connects the main areas in Mojokerto and has a high vehicle intensity such as heavy vehicles. The condition on the Mojokerto-Jombang Road section has some damage that is classified as light, moderate to severe. The impact of damage to the road surface is that it can interfere with the comfort of road users and endanger the safety of road users (accidents). In connection with the above, it is necessary to have an analysis or study to know for sure about the type and condition of pavement on the road section to better provide a measurable assessment of the condition of the pavement. From the results of the study, it will be known the level and type of dominant damage that occurs, as well as alternative road damage handling can be done based on the results of the assessment of damage conditions on road sections and the costs needed for handling.




## 2. METHOD

### A. Road Condition Method

Pavement condition surveys are carried out visually to obtain data on road damage (volume and severity) and aim to prepare road maintenance program plans.

### B. *Indeks Kondisi Perkerasan* (IKP) Method

*Indeks Kondisi Perkersan* (IKP) is one of the indicators for the assessment of road pavement conditions. IKP has a range of values ranging from 0 to 100%, with a value of 0 indicating the worst pavement condition that may occur and a value of 100% indicating the best pavement condition that may be achieved [1].

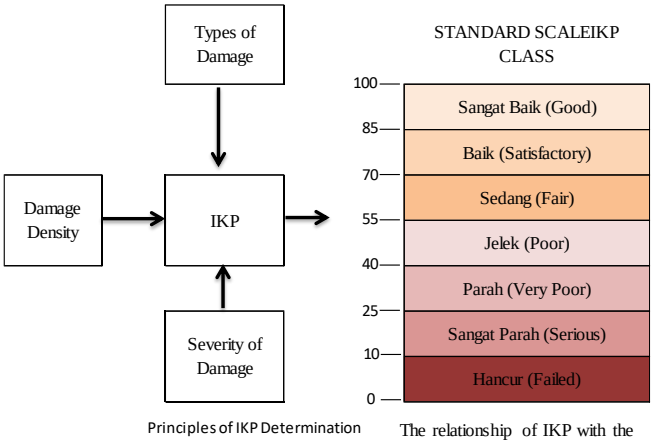



**Figure 1** Recommended *Indeks Kondisi Perkerasan* Class Scale and Colors

*Source: Pd-01-2016-B*

IKP is useful for showing the level of pavement surface condition. The IKP shows the measure of pavement condition at the time of the survey, based on the observed damage to the pavement surface, which also indicates the structural cohesiveness and functional condition of the pavement (unevenness and roughness). IKP is an objective and rational basis for determining the necessary maintenance and repair programs and the order of handling priorities.

**Table 1** Use of IKP to Determine the Type of Handling

| IKP | Types of Maintenance |
|---|---|
| ≥ 85 | Routine Maintenance |
| 70 - 85 | Periodic Maintenance |
| 55 - 70 | Structural Improvement or Road Rehabilitation |
| < 55 | Reconstruction or Recycling |

*Source: Pd-01-2016-B*

### C. Reconstruction Method

One of the treatments that can be done for the type of reconstruction damage is an increase in structural strength in the form of pavement resurfacing or structural overlay [2].

1. Traffic Growth factors (i)
   Traffic growth over the life of the plan can be calculated by the Cumulative Growth Factor as follows:
   $$R = \frac{(1+0{,}01i)^{UR}-1}{0{,}01\,i} \quad (1)$$
2. Traffic on the Plan Lane
   To get traffic on the plan lane (w18) can use the formula below:
   $$W18 = DD \times DL \times \hat{w}18 \quad (2)$$
3. Load Equivalent Factor
   Traffic loads are converted into standard weights (ESA5) using a Vehicle Damage Factor[3].
4. Resilient Modulus ($M_R$)

MR of basic soil can also be estimated from CBR standards and soil index test results or values[4]. The correlation of the resilient modulus with the CBR value can use the following formula:

MR (psi) = 1.500 x CBR (3)

5. Reability

The reliability planning factor takes into account possible variations in traffic estimates and performance forecasts and therefore provides the level of reliability (R) at which the pavement section will survive during the planned time interval[4].

**Table 2** Recommended Reliability Levels for Various Road Classifications

| Road Classification | Recommended levels of reliability | |
|---|---|---|
| | Urban | Intercity |
| Highway | 85 - 99.9 | 85 - 99.9 |
| Artery | 80 -99 | 75 - 95 |
| Collectors | 80 - 95 | 75 - 95 |
| Local | 50 - 80 | 50 - 80 |

Source : *Ditjend Bina Marga, 2002*

6. Drainage Coefficient (m)

To see the general definition of drainage quality, please see the table below:

**Table 3** Definition of Drainage Quality

| Drainage quality | Water is lost in |
|---|---|
| Good | 2 hours |
| Satisfactory | 1 day |
| Fair | 1 week |
| Poor | 1 month |
| Very Poor | Water will not flow |

*Source : Ditjend Bina Marga, 2002*

7. Surface Index (IP)

This surface index expresses the value of unevenness and pavement strength related to the level of service for passing traffic[4].

Some IP values and their meanings are as follows:

IP = 2,5 : states the road surface is still quite stable and good;

IP = 2,0 : declares the lowest level of service for roads that are still stable;

IP = 1,5 : declares the lowest possible level of service (uninterrupted path);

IP = 1,0 : states that the road surface is in a state of heavy damage so that it greatly disrupts vehicle traffic.

8. Relative Strength Coefficient (a)

The value of the relative strength coefficient can be seen using a graph according to the type of pavement layer used on each surface layer[4].

9. Pavement Thickness Index (ITP)

To determine the ITP value can be calculated using trial and error with the formula below:

$$\text{Log10w18} = ZR\ x\ S0 + 9.36\ x\ log10\ (ITP + 1\ ) - 0.20 + \frac{\log 10\left[\frac{\Delta IP}{Ip0-IPf}\right]}{0.40+\frac{1094}{(ITP+1)^{5\cdot1}}^{9}} + 2.32\ x\ log10(MR) - 8.07 \quad (4)$$

10. Structural Number (SN)

To determine the SN value can be used using trial and error with the formula below:

$$\text{Log10w18} = \text{ZR x S0} + 9.36 \text{ x log10 (SN} + 1\text{ )} - 0.20 + \frac{\log 10\left[\frac{\Delta PSI}{4,2-1,5}\right]}{0.40+\frac{1094}{(SN+1)^{5\cdot1}}^{9}} + 2.32 \text{ x log10(MR)} - 8.07 \quad (5)$$

11. Road Foundation Design

The road foundation design depends on the local base soil CBR value[3].

12. Pavement Types

The choice of pavement type will vary based on traffic volume, plant life, and road foundation condition. Pavement planning must consider the lowest cost over the life of the plan, limitations, and practicality of implementation[3].

13. Flexible Pavement Design

The design of flxible pavement with a paved mixture is a mechanical characteristic of the material and mechanistic analysis of pavement structure[3].

14. Material Modulud Characteristics

The characteristics of the modulus of bounded materials and basic soils used in MDP 2017.

**D. Overlay Method**

Overlay is an additional layer of work carried out as an effort to improve the condition of non-structural surfaces on pavement [4].

1. Lalu Lintas Harian Rata-Rata (LHR)

Average daily traffic (LHR) is obtained through surveys directly by grouping vehicles based on vehicle load type by vehicle unit/day[3].

2. Load Equivalent Number (E)

The load equivalent number (E) of each axle load group (each type of vehicle) is determined as below:

E STRT = ((Axis Load (Ton))/5.4)⁴ (6)

E STRG =(( Axis Load (Ton))/8.16)⁴ (7)

E SDRG =( (Axis Load (Ton))/13.76 (8)

E STrRG =( (Axis Load (Ton))/18.45)⁴ (9)

3. Modulus Resilien ($M_R$)

$M_R$ of basic soil can also be estimated from CBR standards and soil index test results or values[4]. The correlation of the resilient modulus with the CBR value can use the following formula:

MR (psi) = 1.500 x CBR (10)

4. Reability (R)

The reliability planning factor takes into account possible variations in traffic estimates and performance forecasts and therefore provides the level of reliability (R) at which the pavement section will survive during the planned time interval.

**Table 4** Recommended Reliability Levels for Various Road Classifications

| Road Classification | Recommended levels of reliability | |
|---|---|---|
| | Urban | Intercity |
| Highway | 85 - 99.9 | 85 - 99.9 |
| Artery | 80 -99 | 75 - 95 |
| Collectors | 80 - 95 | 75 - 95 |
| Local | 50 - 80 | 50 - 80 |

*Source : Ditjend Bina Marga, 2002*

5. Traffic on the Plan Lane
   To get traffic on the planned lane (w18) can use the formula below:
   $W18 = DD \times DL \times \hat{w}18$ (11)
6. Surfavce Index (IP)
   This surface index expresses the value of unevenness and pavement strength related to the level of service for passing traffic[4].
   Some IP values and their meanings are as follows:
   IP = 2,5 : states the road surface is still quite stable and good;
   IP = 2,0 : declares the lowest level of service for roads that are still stable;
   IP = 1,5 : declares the lowest possible level of service (uninterrupted path);
   IP = 1,0 : states that the road surface is in a state of heavy damage so that it greatly disrupts vehicle traffic.
7. Relative Strength Coefficient (a) of Each Type of Damage
   For overlay calculations, the strength of existing pavement structures is measured using the FWD tool.
8. Thick Layer of Old Road
   In bending pavement structures usually consist of: subbase course, base course, and surface course. Data on the thickness of the old mesh layer can be obtained from the Local Public Works Department.
9. Pavement Thickness Index Needs (ITP Necessary)
   To determine the ITP value can be calculated using trial and error with the formula below:
   $$\text{Log10w18} = ZR \times S0 + 9.36 \times \log10\,(ITP + 1) - 0.20 + \frac{\log 10\left[\frac{\Delta IP}{Ip0 - IPf}\right]}{0.40 + \frac{1094}{(ITP+1)^{5.19}}} + 2.32 \times \log10(MR) - 8.07$$ (12)
10. Pavement Thickness Index (ITP Exists)
    The ITP there is obtained by multiplying each layer thickness of the old path by the relative coefficient of strength (a). ITP calculation there can be calculated by the formula below:
    $ITP\ ada = a1D1 + a2D2 + a3D3$ (13)
11. Overlay (D)
    $\Delta ITP = ITP\ perlu - ITP\ ada/eksisting$ (14)
    $\Delta ITP = D \times a$ (15)

### E. Budget Estimate Plan (BEP)

Budget estimate plan is the result of detailed cost estimation at the planning stage (detail engineering design)[5].

## 3. RESULT AND DISCUSSION

The Mojokerto-Jombang road section has type 4/2D and the lane width varies from 7 m to 8.10 m with the division of each segment being 100 m.

**Table 5** Example of IKP Damage Analysis

| TYPE &; SEVERITY OF DAMAGE | QUANTITY | | | | TOTAL | DENSITY % | DEDUCTION VALUE |
|---|---|---|---|---|---|---|---|
| 1 S | 4,5 x 1,2 | | | | 5.4 | 0.7 | 17.5 |
| 1 T | 27 x 1 | 2,4 x 1,2 | 20 x 0,8 | 7,5 x 0,92 | 52.8 | 7.0 | 58 |
| 3 T | 8,2 x 1,2 | | | | 9.8 | 1.3 | 8.3 |
| 11 T | 4 x 1,5 | 2,5 x 1 | 1,5 x 0,8 | 1,7 x 0,5 | 10.6 | 1.4 | 24.5 |

*Source: Analysis Results*

The following is a recapitulation of the results of road damage analysis using the IKP method according to road damage criteria and a recapitulation of the type of handling carried out.

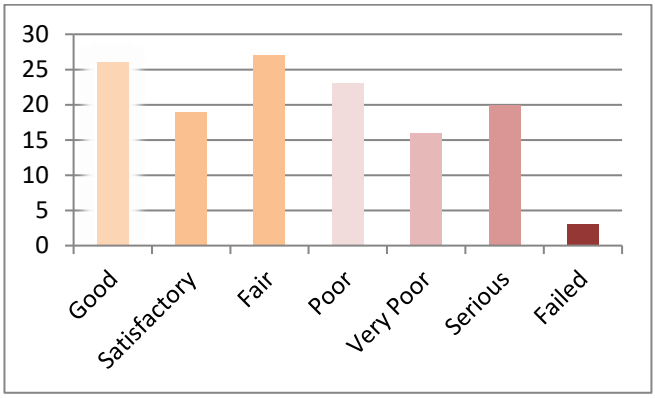



**Figure 2** Road Damage Criteria Recapitulation Chart
*Source: Analysis Results*

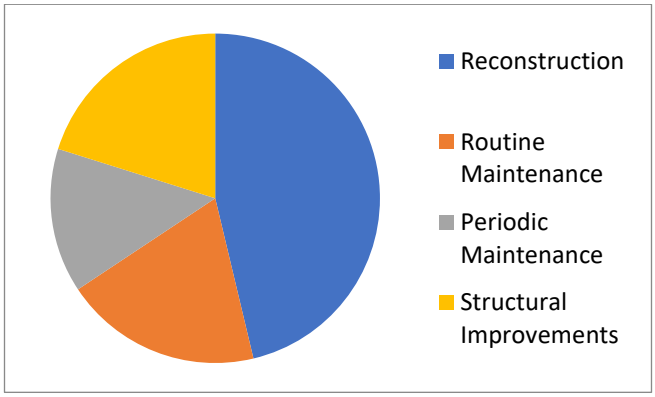



**Figure 3** Types of Damage Handling
*Source: Analysis Results*

In the results of the analysis of the shape and level of road damage according to the calculation of road conditions, namely: 19,4% Good, 14,2% Satisfactory, 20,1% Fair, 17,2% Poor, 11,9% Very Poor, 14,9% Serious, and 2,2% Failed. Then the road will be treated in the form of overlays (added layer thickness) with a percentage of Routine Maintenance 19%, Periodic Maintenance 14%, Structural Improvement 19%, and Reconstruction/Recycling 47%.

**Reconstruction Method**

1. Traffic Growth factors (i)
   R = $2022 - 2024 = \frac{(1+0.01(4.80\%))^2-1}{0.01(4.8\%)} = 2$
   $R\ 2025 - 2044 = \frac{(1+0.01(4.8\%))^{18}-1}{0.01\ (4.8\%)} = 18.074$
2. Traffic on the Plan Lane
   W18 = 0.5 x 80% x 204710688.361
   = 81884275.344
   Wt = w18 x $\frac{(1+4.8\%)^{20}-1}{4.8\%}$ = 2651051168
3. Load Equivalent Factor
   The total result of calculating the load equipment factor is 204,710,688.4
4. Resilient Modulus ($M_R$)
   MR = 1500 x 2.58%
   = 3870 Psi
5. Reability
   The reliability value is 85% so that the ZR value is -1.037. The standard deviation value (S0) is 0.45.
6. Drainage Coefficient (m)
   - Top Foundation Layer AC Base m2 = 0.8
   - Granular Bottom Foundation Layer m3 = 0.13
7. Surface Index (IP)
   Initial Service Capability Index (p0) = 4
   Final Service Capability Index (pt) = 2
   Service Loss Index (ΔPSI)
   ΔPSI = Ip0 – Ipt
   = 2
8. Relative Strength Coefficient (a)
   - ACWC + ACBC a1 = 0.38
   - Top Foundation Layer AC Base a2 = 0.24
   - Granular Bottom Foundation Layer a3 = 0.14
9. Pavement Thickness Index (ITP)
   ITP with a age plan of 20 years at 7.20 (by trial and error using formula 4).
10. Structural Number (SN)
    SN with a age plan of 20 years at 7.36 (by trial and error using formula 5).
11. Road Foundation Design
    In accordance to the Manual Desain Perkerasan Jalan (REVISI Juni 2017) for a CBR value of 2.58% a basic soil improvement of 350 cm is required.
12. Pavement Types
    For the type of pavement referring to the Manual Desain Perkerasan Jalan (REVISI Juni 2017) obtained ≥ a 100 mm AC pavement structure with a grained foundation layer (ESA to the power of 5) because the CESA5 value is 204.710.688,361
13. Flexible Pavement Design
    In accordance referring to the Manual Desain Perkerasan Jalan (REVISI Juni 2017) with a CESA5 value of 204,710,688,361 pavement is obtained as follows:
    - ACWC + ACBC d1 = 100 mm
    - Top Foundation Layer AC Base d2 = 245 mm
    - Granular Bottom Foundation Layer d3 = 300 mm
14. Material Modulud Characteristics
    - ACWC + ACBC
      Eac = 333586.80 Psi
    - Top Foundation Layer AC Base
      Ebs = 232060.38 Psi
    - Granular Bottom Foundation Layer
      Esb = 21756 Psi

**Bina Marga 2002 Method**

1. Load Equivalent Number (E) and Traffic on the Plan Lane

**Table 6** Load Equivalent Number (E) and Traffic on the Plan Lane

| Vehicle Type | Average Daily Traffic | E | ŵ18 |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| 2 | 14,403 | 0.0024 | 33.9 |
| 5B | 986 | 0.3839 | 378.5 |
| 6A | 344 | 0.2775 | 95.5 |
| 6B | 5,300 | 6.4192 | 34021.5 |
| 7A1 | 1,524 | 5.2422 | 7989.1 |
| 7C1 | 989 | 15.5362 | 15365.3 |
| 7B1 | 684 | 4.8776 | 3336.3 |
| Total | | | 61220.1 |

*Source: Analysis Results*

2. W 18 Value
   The result of calculating the cumulative standard axle load value for 10 years is 343291,450 ESAL.
3. Reability and Standard Deviation ($Z_R$)

The reliability value is 85% so that the ZR value is -1.037. The standard deviation value (S0) is 0.45.

4. Serviceability
   Initial Service Capability Index ($p_0$) = 4
   Final Service Capability Index (pt) = 2
   Service Loss Index (ΔPSI)
   ΔPSI = Ip0 – Ipt
   = 2
5. Resilient Modulus (MR)
   MR = 1500 x 2,58%
   = 3870 Psi
6. ITP Calculation Necessary
   ITP Necessary with a plan life of 10 years at 3.44 (by trial and error using formula 12).
7. Calculating of existing ITP
   - Asphalt 20 cm D1 = 0,08 x 7.874 = 0.630 inch
   - LPA 30 cm D2 = 0,1 x 11.811 = 1.181 inch

   ITP existing = 0.630+1.181 = 1.811 inch
8. Thick Pavement Overlay
   ΔITP = ITP necessary – ITP existing
   = 3.44 – 1.811
   = 1.629 inch
   ΔITP = D x a
   ΔITP = 1.629 x 0.40
   D = 4.072 inch
   = 10.344 cm = 10 cm

   From the calculation above, the overlay thickness is 10 cm for a plan life of 10 years using LASTON MS 744.

**Budget Estimate Plan (BEP)**

**Table 7** Budget Estimate Plan (BEP)

| RAB RECAPITULATION | | |
|---|---|---|
| NO | JOB DESCRIPTION | PRICE AMOUNT |
| 1 | General | 15170000 |
| 2 | Earthworks | 4236367975 |
| 3 | Grained Pavement Works | 6789186668 |
| 4 | Asphalt Works | 46711058396 |
| (A) Total Price Amount | | 57,751,783,038.78 |
| (B) Value Added Tax (PPN 10%) | | 5,775,178,303.88 |
| (C) Total Amount of Work Price (A) + (B) | | 63,526,961,342.66 |
| (D) Rounded | | 63,526,961,000.00 |

*Source: Analysis Results*

## 4. CONCLUSSION

1. The types of surface damage that occurred on the Mojokerto-Jombang Road Section were Patching by 41,8%, Edge Cracking by 4,3%, Potholes by 8,9%, Aligator Cracking by 33,7%, Block Alligator by 4,6%, Bleeding by 0,6%, Longitudinal Cracking by 5,2%, Polished Aggregate by 0,5%, and Rutting by 0,3%.
2. Of the total road length reviewed amounting to 13.4 km, the value of pavement conditions on the surface of the Mojokerto-Jombang Road Section was 19,4% Good, 14,2% Satisfactory, 20,1% Fair, 17,2% Poor, 11,9% Very Poor, 14,9% Serious, and 2,2% Failed.
3. The form of handling on the Mojokerto-Jombang Road Section obtained types of handling forms, namely Routine Maintenance 19%, Periodic Maintenance 14%, Rehabilitation 19%, and Reconstruction/Recycling 47%.
4. The total cost incurred for all handling work on the Mojokerto-Jombang Road Section with a road length of 13.4 km with an average road width of 7m is Rp. Rp. 63,562,961,000 ( Sixty three billion five hundred twenty-six million nine hundred sixty one thousand rupiah).

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