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RESEARCH ARTICLE

# Analysis of the Effect of Vehicle Load on Road Layer Damage on Alluvial Bedrock Using PCI and ESAL Approaches: A Case Study of Air Molek–Taluk Kuantan Road, Riau Province, Indonesia

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**Abstract**

The Molek-Taluk Kuantan Air Road in Indragiri Hulu Regency, Riau, has suffered a lot of damage due to frequent crossings by heavily loaded vehicles. This study aims to find out how much the vehicle load affects the damage to the road, as well as see how soil conditions and the shape of the area contribute to the worsening of the damage. The assessment was carried out using the PCI (Pavement Condition Index) method to see the level of physical damage to the road, and the ESAL (Equivalent Single Axle Load) method to calculate the vehicle load. The observation results show that the number of vehicles passing by reaches more than 4,000 per day, with a high overload rate (Truck Factor = 3.93). In addition, the soil structure in this region consists of soft soils such as clay and peatlands, which are very susceptible to damage if constantly subjected to heavy loads. The area through which the road passes also has a slope that can cause erosion and soil shift. Overall, the average road condition was in the damaged category (PCI value = 37.4). The results of this study show the need to repair roads that take into account soil conditions, strengthening drainage, and limiting vehicle loads so that damage does not continue to recur.

**Keywords:** Road Damage, Vehicle Load, Soft Soil, Peatland, PCI, ESAL

## 1. Introduction

Roads are land transportation infrastructure that covers all parts of the road, including complementary buildings and their equipment intended for traffic, which are located on ground level, above ground level, above water level and below ground and/or water level, except for railways, truck roads and cable roads (Government Regulation Number 34 of 2006). Roads are also one of the land transportation infrastructures that are always passed by vehicle loads which result in the road experiencing physical damage and one of the factors that must be watched out for is vehicle overloading Overloading is a condition where vehicles carry one load more than the load limit set by vehicles and roads (Sukirman, 2010). The effects of overloading are a very serious problem. This is because it causes huge losses, especially for road users, such as lower driving safety, long driving time, traffic accidents, traffic jams and so on.

The Molek-Taluk Kuantan Water Road is one of the provincial roads that connects two districts, namely Indragiri upstream and Kuantan singingi districts (Fig 1). Which is this road is a cross-economic path for the community in carrying out activities and transactions continuouslyIn this problem, it is necessary to carry out an assessment with the appropriate and appropriate method, namely the Pavement Condition Index (PCI) method to evaluate the physical condition of the damaged road by conducting a visual survey in the field. It will give an idea of the extent of road damage such as cracks, potholes, obesity, etc. (ASTM D6433-11,2007). Meanwhile, to ascertain whether this road is damaged due to the influence of vehicle load, the Equivalent Single Axle Load (ESAL) method is carried out to calculate the load of vehicles passing on the road. This method converts different types of vehicle loads (e.g., trucks of various sizes) into a load equivalent to a single standard axis, 8ton (AASHTO, 1993). Combining the PCI and ESAL methods can provide a more complete picture of what is happening now (physical damage) and how the damage occurred (vehicle load) and will provide accurate recommendations for road repair and maintenance, as well as vehicle load management.

Furthermore, geological characteristics and slopes of the region such as the presence of alluvial sediments, peatlands and the level of slope or slope will also be included in the analysis. These factors are important because they can weaken the carrying capacity of the soil and exacerbate damage due to the dynamic load of the vehicle.

Based on the above conditions, a study will be conducted with the title Analysis of the Influence of Vehicle Load on Damage to the Molek-Taluk Kuantan Water Road Section to identify and further research what happened to the Molek-Kuantan Waterway

## 2. Morphology

The general morphology of the area and the Lala River region of Indragiri district shows a diverse landscape, reflecting the complex geological history and environmental processes that have shaped the landscape. The following description provides an overview of the morphological characteristics observed in the study area:

1. Alluvial plains: These are found along the banks of rivers with slight gradients ranging from 0 to 3%. As rivers flow downstream, they are increasingly

affected by tidal fluctuations, resulting in the formation of swampy floodplains or "swamp valleys". (Koesoemadinata, 1980; Barber et al., 2005).

2. Peatlands (Peatlands): Peatlands stand out in areas such as Rengat and Kuala Cenaku. These areas have varying depths of peat deposits, which can significantly affect the topography and hydrology of the area. (Kausarian et al., 2023a).

Around Sungai Lala Village, the area is mostly flat to sloping (slope < 7%), considering that this location is near river valleys and swamp areas (Fig 2). The surrounding low hills will have a slope of between 7–15 %, which is classified as somewhat steep. In Van Zuidam's terms, this means that the morphological character includes sloping and somewhat steep, with a stable soil surface and dominated by slow erosion processes as well as mild weathering (Van Zuidam, 1985). If there are hills or roads that pass through the up and down areas, there will be zones with steeper slopes (15–30%) which according to the classification are called steep In this area, the influence of erosion will be more pronounced and soil material is prone to movement. Although conditions > 30% (very steep) or more (steep/upright) are rare in rural areas, their presence, although sporadic, further strengthens the possibility of land mass shifts, especially when it is raining heavily or if drainage is poor.

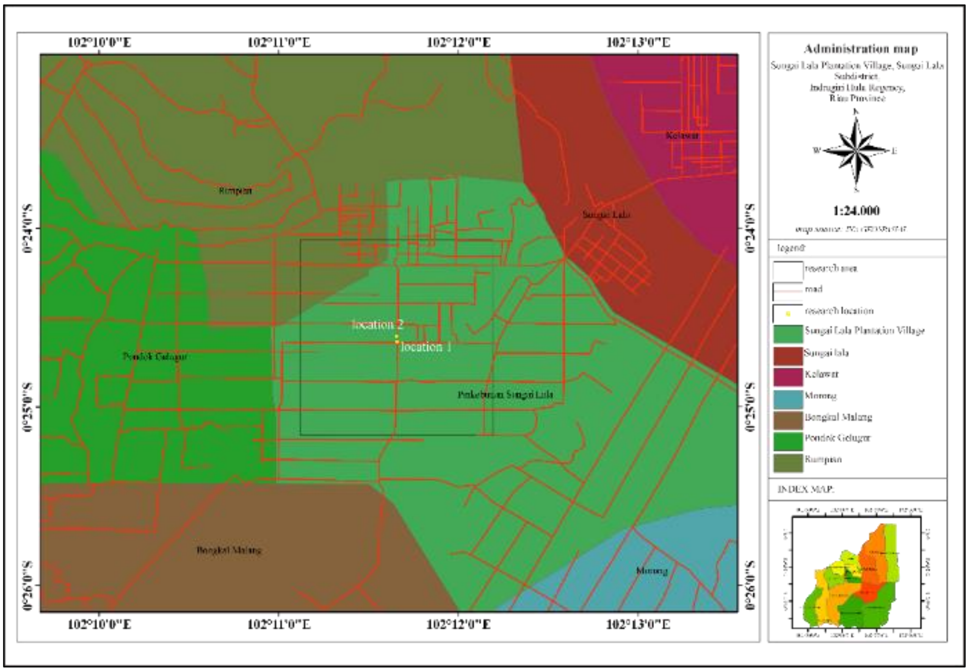


Fig 1. Administration Map of the Study Area

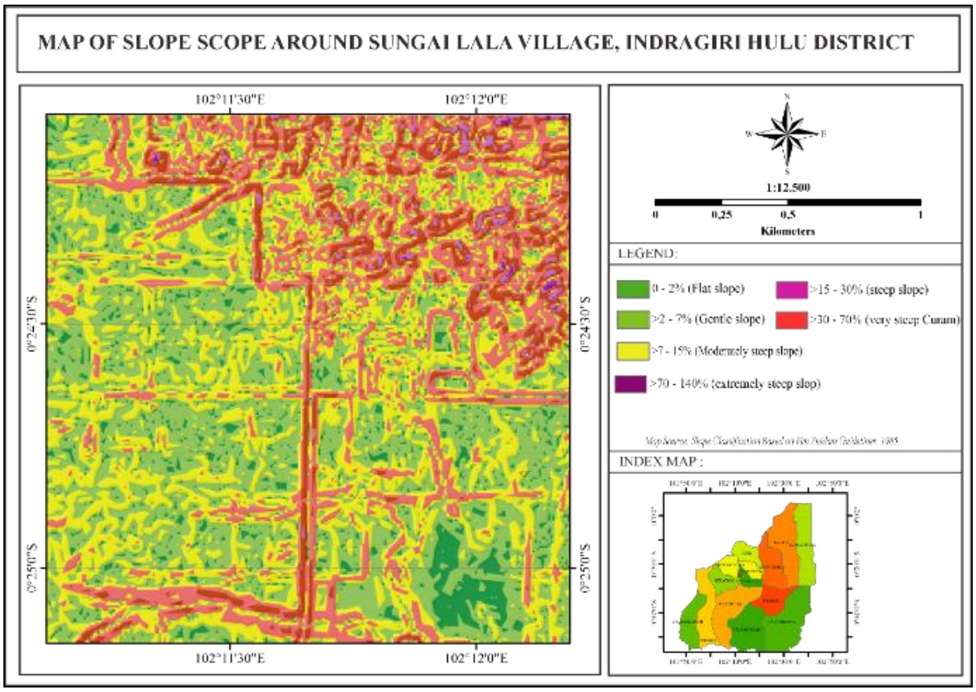


Fig 2. Slope Map of Study Area

With the majority of surfaces falling into the category of flat to slightly steep (< 15%), the Molek–Taluk Kuantan Air Road route is generally relatively safe from the risk of large land shocks. However, in the segments that pass through hills with a slope of 7–15%, the effects of rapid erosion and rutting due to vehicle load will be higher especially when a combination of peat soft soil and vehicle overloading occurs (Kausarian et al., 2023; AASHTO, 1993; Huang, 2004). Therefore, road construction planning and maintenance should take into account this grade of slope. Stabilization of cliffs and optimization of drainage systems is highly recommended to prevent local erosion and ensure the reliability of the road is maintained in the long term.

According to Verstappen (1983), the geomorphological structure in such areas is generally considered stable, provided it is not disturbed by human activities or extreme weather changes. Lowland areas and gently sloping terrains (with slopes less than 15%) tend to experience slow surface erosion and weathering processes. However, when road infrastructure traverses hilly regions with slopes reaching 15–30%, the potential for surface runoff and erosion increases significantly. Although extreme slopes (>30%) are rarely encountered, they still pose a high landslide risk, especially if drainage systems are poorly designed or during periods of heavy rainfall. Bell (2004) also emphasizes that the bearing capacity of peatland soils must be given special attention, as they are prone to deformation under excessive vehicle loads. Therefore, road development projects—such as the Molek–Taluk Kuantan route—should incorporate slope reinforcement, adequate water drainage planning, and soil stabilization techniques to ensure long-term road reliability (Verstappen, 1983; Bell, 2004; Bowles, 1997).

## 3. Geological and Research Background

The regional geology of the study area is located in the density formation (Qtke) of the Central Sumatra Basin. This formation consists of fine-medium grained quartz sandstone, tufan clay, tufa, local clay sand tufan-pebble pebs, reddish-gray and local cross with a thickness of 50m-75m. (Koesoemadinata, 1980; Barber et al., 2005).

Formations in the surrounding area, namely the Kasai (Qrt) formation, including the sub-basin of Jambi and South Sumatra, this formation consists of tufan sandstone and lower layer rhyolitic tephra, sandstone, conglomerate, polymic and tufsand as well as gravel lenses (rudite), sandstone and tuff clay containing plant residues and some fragments of wood were observed. The regional geological map can be seen in Fig 3.

When roads are built on top of these Qtke formations, the sub-framing layer becomes susceptible to deformation or deformation due to the nature of the soft soil, especially under heavy vehicle loads and under suboptimal drainage conditions. (Kausarian et al., 2023; Gaillot et al., 2023)

The geological setting of the study area, situated within the Central Sumatra Basin, reflects a sedimentary sequence that is prone to structural instability when subjected to load and moisture changes. Similar lithological units, as described by Van Bemmelen (1949), consist of interbedded sandstones, tuffaceous clay, and weathered pyroclastic deposits, which are often associated with variable mechanical behavior and poor subgrade strength. In road construction over such materials, the presence of volcanic ash and tuff layers can induce expansion and shrinkage due to moisture variations, increasing the risk of cracking, rutting, and pavement deformation (Mitchell & Soga, 2005). When clay-rich horizons or loosely bonded tuff layers are exposed to dynamic traffic loads, particularly without efficient drainage systems, structural failure of the pavement system becomes more likely. To address these geotechnical concerns, this study integrates both primary and secondary data, including field observations of road conditions, subgrade material characteristics, traffic load assessments, and supporting topographic and geological information. Data processing incorporates the Pavement Condition Index (PCI) for alignment and surface integrity evaluation, as well as the Equivalent Single Axle Load (ESAL) approach to assess the cumulative impact of vehicular stress on the road structure (FHWA, 2011; Das, 2010; Terzaghi et al., 1996).

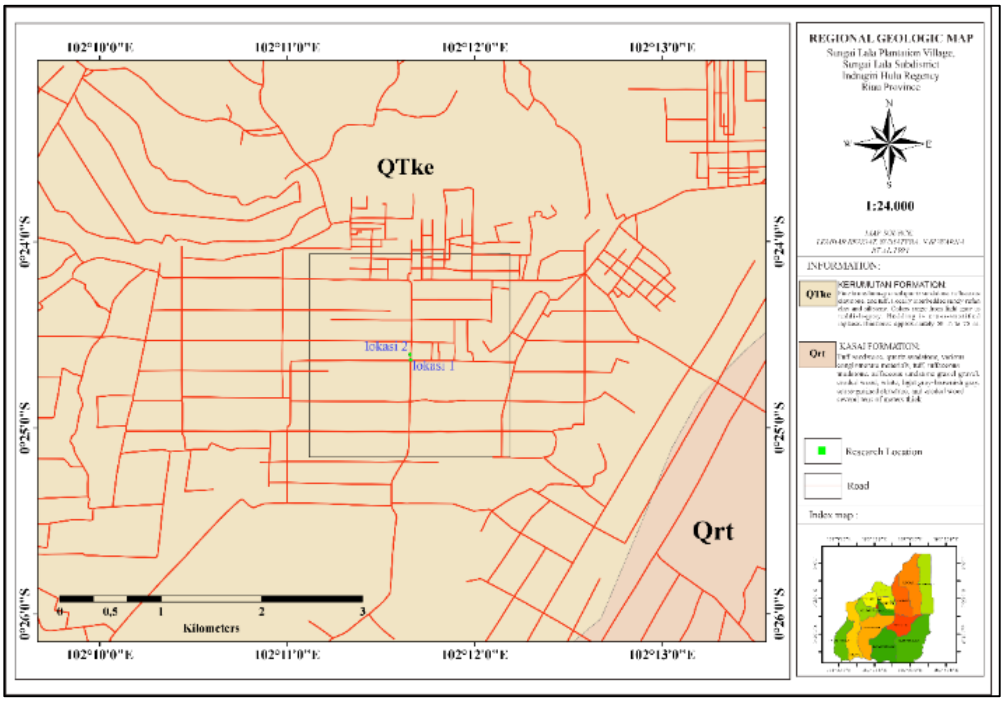


Fig 3. Regional Geological Map of the Lala River

The presence of clay minerals and the texture of tuff in this formation can cause problems of structural deterioration and physical properties of the road due to the process of swelling-shrinkage and erosion.if there is an expanding clay mineral or the nature of tuff contains loose clastic, then the road faces the risk of soil vulnerability, rutting or even soil shift, especially during rain or vehicles that pass with different loads.therefore in this study tests are carried out with primary data and secondary

The data in this study contains primary data and secondary data, the primary data in the study includes road inventory data, road damage data, traffic volume data, and secondary data damage documentation, which includes administrative maps of the research area, regional geological maps as well as slope maps and LALIN traffic data

Data analysis includes alignment analysis using the PCI method, Traffic volume analysis and vehicle load analysis using the ESAL method (ASTM, 2007; AASHTO, 1993; Huang, 2004).

## 4. Results and Analysis

### 4.1 Average Daily Traffic Analysis (LHR)

In the assessment of the condition of the Molek – Taluk Kuantan Water Section, LHR data was obtained from direct observation in the field. Observations were carried out for 7 consecutive days starting from Monday 27 January 2025, Tuesday 28 January 2025, Wednesday 29 January 2025, Thursday 30 January 2025, Friday 31 January 2025, Saturday 1 February 2025, and Sunday 2 February. Data from field surveys. The total number of vehicle volumes will be used in the priority scale to determine the value of road conditions. The following are the results of average daily traffic data obtained from the survey results during direct observation at the location for 7 days on the Molek-Taluk Kuantan water road (Table 1).

The survey on the Air molek – Taluk Kuantan road was carried out by dividing 2 LHR survey teams, namely LHR west-east, and LHR east-west.

Table 1. 7-day survey results

| Vehicle Type | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday | LHR Kenny |
|---|---|---|---|---|---|---|---|---|
| Light Vehicles | | | | | | | | |
| 1. Bicycle / Motorcycle / e-Scooter / 3 Wheel | 1121 | 1356 | 1465 | 1203 | 906 | 807 | 691 | 1078 |
| 2. Sedan, Jeep | 1079 | 1269 | 1489 | 1231 | 1124 | 911 | 712 | 1116 |
| 3. Attention, Pickup, Micro Pickup | 900 | 812 | 881 | 766 | 676 | 721 | 512 | 752 |
| 4. Truck, Delivery Cars | 703 | 687 | 788 | 755 | 652 | 545 | 432 | 651 |
| Number of Light Vehicles | | | | | | | | 3,602 Vehicle/day |
| Heavy Vehicles | | | | | | | | |
| 5a. Small Bus | 168 | 194 | 161 | 161 | 168 | 156 | 98 | 158 |
| 5b. Big Bus | 30 | 33 | 31 | 22 | 29 | 16 | 24 | 26 |
| 6a. 2-Axle Truck (4 Wheels) | 54 | 98 | 32 | 33 | 30 | 29 | 26 | 43 |
| 6b. 2-Axle Truck (6 Wheels) | 154 | 246 | 161 | 132 | 143 | 113 | 100 | 150 |
| 7a. 3-Axis Truck | 190 | 154 | 242 | 221 | 233 | 212 | 187 | 209 |
| 7b. Truck Coupled | 24 | 16 | 11 | 11 | 13 | 12 | 11 | 14 |
| 7c. Semi Trailer Truck | 13 | 14 | 27 | 25 | 22 | 11 | 9 | 17 |
| Number of Heavy Vehicles | | | | | | | | 626 Vehicle/day |
| Non-Motors | | | | | | | | |
| 8. Unmotorized Vehicles | 14 | 17 | 11 | 13 | 16 | 9 | 3 | 12 |
| Number of Non-Motorized Vehicles | | | | | | | | 83 Vehicle /day |
| Total LHR Number | | | | | | | | 4,306 Vehicle/day |

Table 2. Traffic volume in 1 week

| Date | Vehicle Volume |
|---|---|
| 27 January 2025 | 5362 |
| January 28, 2025 | 4907 |
| 29 January 2025 | 4687 |
| January 30, 2025 | 4342 |
| January 31, 2025 | 4321 |
| 01 February 2025 | 3644 |
| 02 February 2025 | 2907 |
| Total Number of LHRs | 30.170 |
| Average | 4,310 Vehicle/day |
| Number of Vehicles 1 hour | 179 Vehicle/hour |

### 4.2 Vehicle axial load equivalent figures

(VDF) is a comparison of the damaged power by the axial load of a vehicle to the damaged power by the standard axial load (table 3).

Based on the table above, the total results of traffic surveys on the Air molek – Taluk Kuantan road in a week from east–west and west–east are 30,170 kend/week, divided by 7 days which are 4,310 unit/day, and 179 unit/hour (Table 2).

### 4.3 Standard-Axle Load (ESAL) equivalent analysis

Vehicles that have axle, wheel, and variable configurations in the total load they carry are commonly known as Equivalent Single Axle loads (ESAL). Equivalent Single Axle load (ESAL) serves to express a number that indicates the number of standard axial trajectories that can cause the same damage for a single vehicle trajectory. The ESAL analysis can be seen in Table 4 below.

Table 3. vehicle axle load equivalent figures

| GOAL | Tipe Vehicle | Total vehicle weight (tons) | Load configuration vehicle axle (Tons) | | |
|---|---|---|---|---|---|
| | | | Front | back | |
| | | | | 1 | 2 |
| a | b | c | d | e | f |
| 1 | Light vehicles | 2 | STRT<br>50%<br>1 | STRT<br>50%<br>1 | |
| 5a | Small buses | 7,5 | STRT<br>34%<br>2,55 | STRG<br>66%<br>4,95 | |
| 5b | Big buses | 13 | STRT<br>34%<br>4,42 | STRG<br>66%<br>8,58 | |
| 6a | Light Goods Truck | 12,28 | STRT<br>34%<br>4,18 | STRG<br>66%<br>8,10 | |
| 6b | Medium goods truck | 21,58 | STRT<br>34%<br>7,34 | STRG<br>66%<br>14,24 | |
| 7a | Truck 3as | 35,2 | STRT<br>25%<br>8,80 | STdRG<br>75%<br>26,4 | |
| 7b | Truck 4axes | 42,6 | STRT<br>18%<br>7,67 | STRG<br>28%<br>11,93 | STdRG<br>54%<br>23 |
| 7c | Truck coupled trailer | 40,03 | STRT<br>13%<br>5,20 | STRG<br>40%<br>16,01 | STdRG<br>47%<br>18,81 |

*Source : Field survey results*

Table 4. ESAL equivalent analysis results for each vehicle

| Goal | Vehicle type | SINGLE | | | Jlh ESA Front Back | LHR Vehicle | Total ESA per day |
|---|---|---|---|---|---|---|---|
| | | Front | Back | | | | |
| | | | 1 | 2 | | | |
| a | b | c | d | e | f | g | h = f x g |
| 1 | Light vehicles | STRT<br>0,0011<br>8 | STRT<br>0,0011<br>8 | | 0,00235 | 1078 | 2,544 |
| 5a | Small Bus | STRT<br>0,04973 | STRG<br>0,13541 | | 0,18514 | 158 | 29,252 |
| 5b | Big Bus | STRT<br>0,44886 | STRG<br>1,22233 | | 1,67119 | 26 | 43,45 |
| 6a | Light Goods Truck | STRT<br>0,35903 | STRG<br>0,9709 | | 1,32994 | 43 | 57,187 |
| 6b | Medium Goods Truck | STRT<br>3,41357 | STRG<br>9,2743 | | 12,68783 | 150 | 1903,174 |
| 7a | 3-axle truck 1.22 | STRT<br>7,0527 | STdRG<br>13,55 | | 20,60279 | 205 | 4223,571 |
| 7b | 4-axle truck | STRT<br>4,07011 | STRG<br>4,5688 | STdRG<br>7,8062 | 8,6389 | 14 | 120,944 |
| 7c | Trailer Trailer | STRT<br>0,85988 | STRG<br>14,8185 | STrRG<br>1,08036 | 15,6784 | 17 | 266,532 |
| | | Number of ESALS Per Day | | | | 1691 | 6646,654 |

### 4.4 Truck Factor (TF)

Truck factor is the main factor causing deformation or road damage so that it becomes overloading. A road section is overloaded if the value of truck factor (TF) > 1. To find out the value of the truck factor of the Molek-Taluk Kuantan water road section which has a study of the road section along ± 2 Km and analyzed by collecting ESAL data for each type of vehicle and LHR of heavy and light vehicles. Calculation of looking for value (TF) using the following equation formula

$$TF = \frac{TOTAL\ ESAL}{N}$$

$$TF = \frac{6646{,}654}{1691} = 3.93 > 1$$

Based on the results of the analysis, Truck Factor obtained a result of 3.93 > 1 which indicates that there has been overload on the Molek-Taluk Kuantan Air Road Section, especially in Sungai Lala village. The road section is not able to accept the load of the vehicle axis that crosses the road, therefore the road section has suffered heavy damage**.**

### 4.5 Pavement Condition Analysis

In determining the condition of the 2 km deep dende road section, it is necessary to have a road sketch starting from STA 0+000 to STA 2+000 as can be seen in the figure below

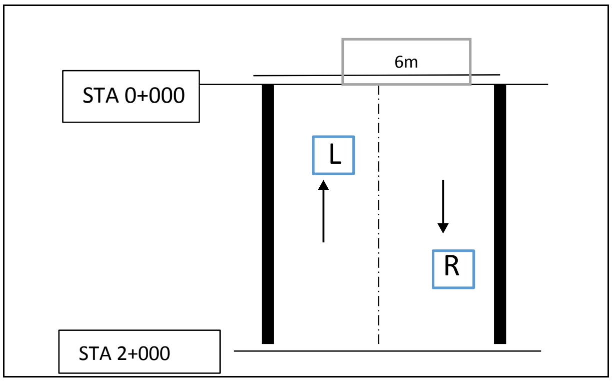


Fig 4. Top view sketch

### 4.6 Results of Road Damage Analysis Using the PCI Method

1. PCI Calculation Results Take Examples of STA 1+100 With STA 1+200

FORMULIR SURVEY KONDISI PERKERASAN JALAN

AIRFIELD ASPHALT PAVEMENT CONDITION INDEX SURVEY DATA FOR SAMPLE

UNIT : Sample 1

| | | |
|---|---|---|
| 1. Retak Kulit Buaya | 7. Lubang | 13. Bahu Jalan Turun |
| 2. kegemukan | 8. Alur | 14. Retak Memanjang/Retak Melintang |
| 3. Retak Blok | 9. Sungkur | 15. Retak Slip |
| 4. Keriting | 10. Tambalan | 16. Pengembangan |
| 5. Amblas | 11. Agregat Licin | 17. Pelepasan Butir |
| 6. Retak Pinggir | 12. Retak Sambungan | 18. Pengausan |

| Distress severity | Kualitas Kerusakan | Quality(Luasan) | | | | | | | | | | | | | | | Total | Density | Deduct Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a | b | c | | | | | | | | | | | | | | | d=total c | d/Lu*100 | f=Grafik |
| 18 | H | 120 | | | | | | | | | | | | | | | 120 | 20.00 | 5 |
| 10 | M | 4 | 3.2 | | | | | | | | | | | | | | 7.2 | 1.2 | 10 |
| 10 | L | 0.4 | 0.5 | | | | | | | | | | | | | | 0.9 | 0.15 | 1 |
| 7 | M | 0.47 | 0.18 | 0.1 | | | | | | | | | | | | | 0.75 | 0.125 | 38 |
| | | | | | | | | | | | | | | | | | 0 | 0 | |
| | | | | | | | | | | | | | | | | | 0 | 0 | |
| | | | | | | | | | | | | | | | | | 0 | 0 | |
| | | | | | | | | | | | | | | | | | 0 | 0 | |
| | | | | | | | | | | | | | | | | | 0 | 0 | |
| | | | | | | | | | | | | | | | | | 0 | 0 | |

Fig 5. form survey pavement condition index (PCI)

2. Deduct Value

A. In STA 1+100 to STA 1+200 there is damage as follows:

Patch (Medium) = 7.2 $m^2$

Patch (Low) = 0.9 $m^2$

Aggregate wear = 120 m

Hole = 0.75 m

B. Density calculation

Density(%)=(Area or length of damage/Segment area) X 100

Patch (Medium) = 7.2 x $\frac{100}{600}$ = 1.2 %

Patch (Low)= 0.9 x $\frac{100}{600}$ = 0.15 %

Aggregate Wear = $\frac{120 \times 100}{600}$ = 20 %

Hole= $\frac{0.75 \times 100}{600}$ = 0.125 %

C. Deduct Value Graph

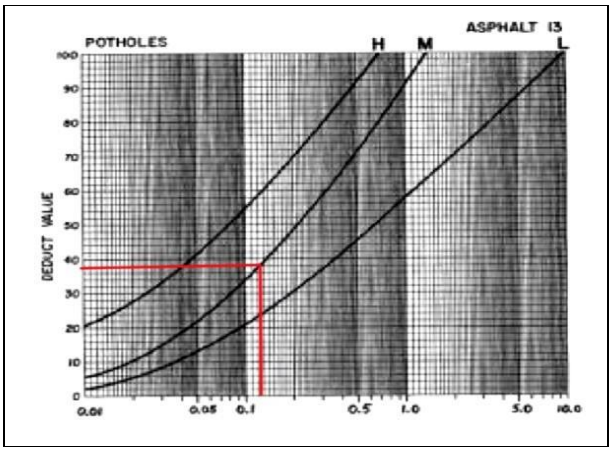


Fig 6. Graph of the deduction value of the STA 1+100 hole up to STA 1 +200

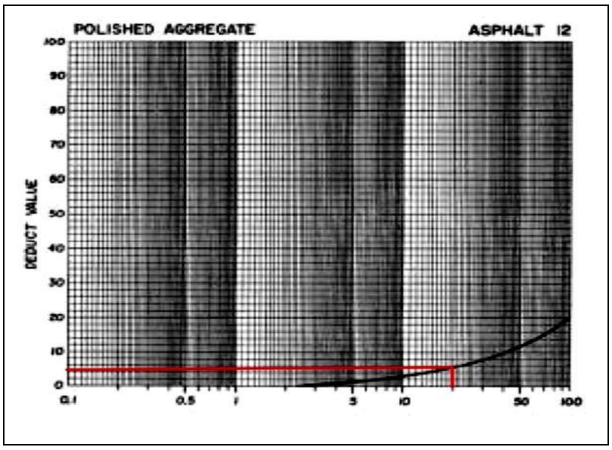


Fig 7. Graph of the deduct value of the STA hole 1+100 up to STA 1 +200

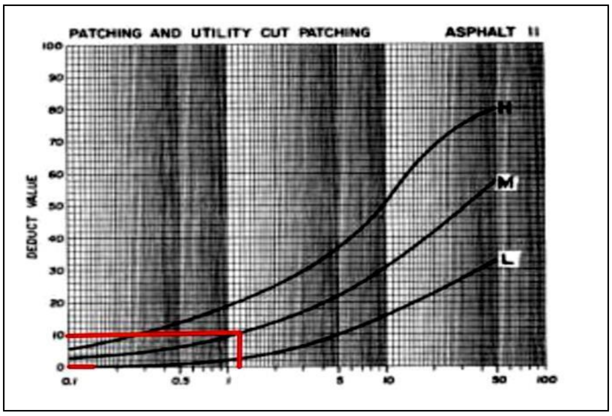


Fig 8. Graph of the deduct value of the STA 1+100 hole up to STA 1 +200

D. Maximum corrected reduction-value (CDV)

| STA | DEDUCT VALUE | | | | TOTAL | Q | CDV |
|---|---|---|---|---|---|---|---|
| 1 + 100 – 1 + 200 | 5 | 10 | 1 | 38 | 10 | 3 | 33 |

After that, it is continued by entering the results from the table into the following graph.

In the graph above, it can be seen that the corrected reduction value (CDV) at STA 1+100 to STA 1+200 is 33.

E. PCI Value Calculation

PCI value = 100 – CDV

Where:

PCI = Pavement Condition Value

CDV = Corrected Reduction Value

The PCI calculation on STA 1+100 to STA 1+200 is as follows: PCI = 100 – 33 = 67 (GOOD)With the results of the calculation, the value of the condition of the road pavement studied can be determined whether it is in very good, good, or very bad condition by looking at the parameters of the PCI method. The following are the results of the PCI calculation of all segments on the Air molek – Taluk Kuantan road section.

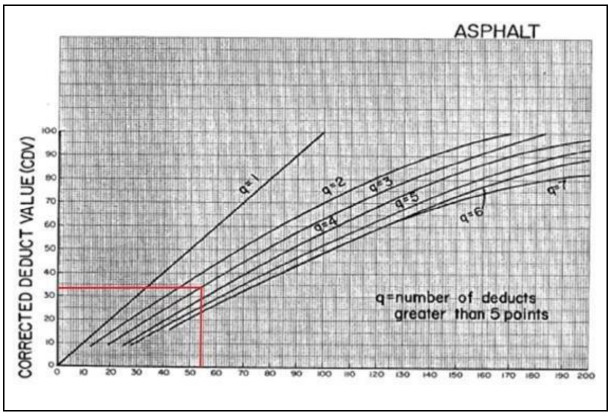


Fig 9. Graph Total deduct value (TDV) STA 1+100 up to STA 1 +200

Table 5. PCI Calculation Results for the Air Molek- Taluk road section

| STA | KIND DAMAGE | CLASS DAMAGE | SIZE (m/m2) | DENSITY (%) | DV | CDV | PCI |
|---|---|---|---|---|---|---|---|
| 0+000 – 0 + 100 | Amblas | High | 4.04 | 0.67 | 16 | | |
| | Hole | Medium | 0.66 | 0.11 | 35 | | |
| | | | | | 51 | 38 | 62 |
| 0+100 – 0 + 200 | Hole | Low | 8.32 | 1.39 | 65 | | |
| | Release Granules | High | 5.56 | 0.93 | 16 | | |
| | Amblas | High | 2.56 | 0.43 | 14 | | |
| | | | | | 95 | 60 | 40 |
| 0+200 – 0 + 300 | Hole | Low | 3.47 | 0.58 | 48 | | |
| | Release Granules | High | 6.9 | 1.15 | 17 | | |
| | Road Bridge Go Down | Low | 0.75 | 0.13 | 2 | | |
| | Wear | Medium | 3.2 | 0.53 | 1 | | |
| | | | | | 68 | 50 | 50 |
| 0+300 – 0 + 400 | Road Bridge Go Down | High | 13.14 | 2.19 | 11 | | |
| | Shoulder Down | Medium | 3.18 | 0.53 | 4 | | |
| | Hole | Low | 0.91 | 0.15 | 26 | | |
| | Hole | Medium | 0.35 | 0.06 | 25 | | |
| | Hole | High | 1.32 | 0.22 | 74 | | |
| | Patches | High | 6 | 1 | 19 | | |
| | Wear | Medium | 2.6 | 0.43 | 0 | | |
| | Release Grain | High | 12 | 2 | 20 | | |
| | Amblas | High | 4.15 | 0.69 | 16 | | |
| | | | | | 19<br>5 | 82 | 18 |
| 0+400 -0+500 | Hole | Low | 2 | 0.33 | 39 | | |
| | Hole | Medium | 2.3 | 0.38 | 64 | | |
| | Crack Elongated | High | 7 | 1.17 | 20 | | |
| | Patches | Medium | 7.3 | 1.22 | 15 | | |
| | Patches | Low | 0.8 | 0.13 | 0 | | |
| | Edge Crack | Medium | 8.3 | 1.38 | 9 | | |
| | Release Grain | High | 133.4 | 22.23 | 58 | | |
| | | | | | 20<br>5 | 85 | 15 |
| 0+500 -0+600 | Hole | Low | 1.06 | 0.18 | 29 | | |
| | Hole | Medium | 0.14 | 0.02 | 10 | | |
| | Wear | Medium | 5 | 0.83 | 0 | | |
| | Crack Suburbs | Medium | 5.3 | 0.88 | 8 | | |
| | | | | | 47 | 29 | 71 |
| 0+600 -0+700 | Crack Suburbs | Low | 0.65 | 0.11 | 1 | | |
| | Release Grain | Low | 3.76 | 0.63 | 2 | | |
| | Grain Release | High | 10.35 | 1.73 | 20 | | |
| | Hole | Medium | 0.28 | 0.05 | 22 | | |
| | Hole | Low | 1.91 | 0.32 | 39 | | |
| | Wear | Medium | 3.2 | 0.53 | 0 | | |
| | | | | | 84 | 53 | 47 |

6. Pavement data recapitulation

From the results of the PCI calculation above, the value of pavement conditions obtained in all segments can be seen in the following table

Table 6. PCI Recap Results at STA 0+00 to 2+000

| NO | STA | SEGMEN AREA (m2) | CVD MAX | PCI | LEVEL |
|---|---|---|---|---|---|
| 1 | 0+000 S/D0+100 | 600 | 38 | 62 | GOOD |
| 2 | 0+100 S/D0+200 | 600 | 60 | 40 | POOR |
| 3 | 0+200 S/D0+300 | 600 | 50 | 50 | FAIR |
| 4 | 0+300 S/D0+400 | 600 | 82 | 18 | VERY POOR |
| 5 | 0+400 S/D0+500 | 600 | 85 | 15 | VERY POOR |
| 6 | 0+500 S/D0+600 | 600 | 29 | 71 | VERY POOR |
| 7 | 0+600 S/D0+700 | 600 | 53 | 47 | FAIR |
| 8 | 0+700 S/D0+800 | 600 | 100 | 0 | FAILED |
| 9 | 0+800 S/D0+900 | 600 | 69 | 31 | POOR |
| 10 | 0+900 S/D1+000 | 600<br>6000 | 96<br>662 | 4<br>338<br>33.8 | FAILED<br>POOR |
| 11 | 1+000 S/D1+100 | 600 | 10 | 90 | EXCELLENT |
| 12 | 1+100 S/D1+200 | 600 | 33 | 67 | GOOD |
| 13 | 1+200 S/D1+300 | 600 | 64 | 36 | POOR |
| 14 | 1+300 S/D1+400 | 600 | 60 | 40 | POOR |
| 15 | 1+400 S/D1+500 | 600 | 87 | 13 | VERY POOR |
| 16 | 1+500 S/D1+600 | 600 | 60 | 40 | POOR |
| 17 | 1+600 S/D1+700 | 600 | 75 | 25 | VERY POOR |
| 18 | 1+700 S/D1+800 | 600 | 87 | 13 | VERY POOR |
| 19 | 1+800 S/D1+900 | 600 | 17 | 83 | VERY POOR |
| 20 | 1+900 S/D2+000 | 600<br>6000 | 97<br>590 | 3<br>410<br>41 | FAILED<br>FAIR |
| | | | | ∑PCI =748 | |

From the results of the PCI recapitulation, an average score was obtained with the following calculations:

$$\text{PCIr} = \frac{\sum \text{PCI. s}}{N}$$

$\text{PCIr} = \frac{748}{20}$= *37.4 % POOR*

Therefore, it was concluded that the average pavement value on the Air Molek-Taluk Kuantan road section was Bad (POOR) and the lowest pavement value occurred at STA 0+700 to Sta 0+800 with a Failed (FAILED) classification.

## 5. Conclusion

Based on the results of all the discussions that have been described in this study, the following conclusions can be drawn:

1. Poor Average Road Conditions due to Combination of Load and Geology Based on the analysis of the Pavement Condition Index (PCI), the average road condition is classified as poor (PCI value = 37.4), with some segments experiencing very severe damage to the point of failure. This is not only due to the excessive load of heavy vehicles, but also to the geological characteristics of the region, especially due to the soft soil layer of the Grass Formation (Qtke) consisting of tufan clay and fine sandstone

2. Overloading Accelerates Damage to Labile Soil The value of Truck Factor (TF) = 3.93 (>1) indicates significant overloading. In the geological context, soils with volcanic clay and tuff content tend to be expansive and easily expand-shrinkage, so they are not able to withstand dynamic loads continuously. The combination of the physical properties of the soil and the heavy load accelerates the appearance of cracks, potholes, and road subsidence.

3. Lowland and Peat Geomorphology Increases Vulnerability This section of road passes through alluvial plains and peatlands with a slope of <7% to 15%. This geomorphological condition is very prone to subsidence and waterlogging, especially in areas with suboptimal drainage systems. Peatland itself has a low carrying capacity and high water storage capacity, so it is not ideal for carrying heavy vehicle loads.

4. High Risk of Deformation in Slope and Hill ZonesIn road segments located in areas with a slope of 7–15% (slope hills), the combination of geologically labile soil and surface slope causes the erosion and deformation process of the road to occur faster. This causes damage to the road surface structure such as wearing, repetitive patches, and elongated cracks

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