



## **CONDITION ASSESMENT STUDY OF ROAD DEFECTS IN MERSING DISTRICT ROAD IN JOHOR**

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### **Abstract**

This study covers road distress that is further discussed as flexible pavement distress. Road condition is crucial for safety and is also used to forecast maintenance schedules. The objectives of this study are focused on determining the road defects and identifying the conditions of the road defects in Mersing district. The method used in this study was based on observations made on the road referring to ASTM D6433 and Technical Manual, Pavement Maintenance Management which according to the Public Work Department (PWD) standard. This research concentrates on two selected roads in the Mersing district which are (i) Tanjung Resang Road and (ii) Tanjung Resang - Penyabong Road. For data collection, mixed methods such as observations (picture) and calculation of Pavement Condition Index (PCI) is used. The findings indicated that the road condition in these two Mersing roads requires more regular maintenance. The results show that the lowest priority roads require better maintenance planning and consistent implementation, as well as re-planning of maintenance structure. Overall, this study contributes novel insights into the relationship between deteriorating road conditions and the increasing demand for maintenance. The result can benefit planning of road upgrading as well as bigger scope in infrastructure of urban planning. Future research could investigate this problem successfully by expanding their data into more districts and the number of roads.

**Keywords:** Road, Pavement, Road Maintenance

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## **INTRODUCTION**

Malaysia has a diverse and developed road network covering paved, unpaved, national and leading regional roads and local roads. The types of road pavement in Malaysia are flexible road pavement and rigid pavement which are constructed throughout Malaysia. Road capacity refers to the ability of a road to operate, and it largely depends on pavement surface conditions.

Roads are one of the transportation infrastructures that is classified as public goods. According to Ismail et al. (2021), in Malaysia, the road network has more than 100,000 km and is categorised into three main classes namely federal roads, state roads and toll highways. Susanna et al. (2017), emphasize that the lack of awareness regarding the state of road conditions prevents road maintenance agencies from adequately identifying the fund necessary for correct maintenance on time. Mersing District was chosen because it is a main federal road in Johor. As coastal roads, it is important to ensure the road is in good condition especially for drivers. Therefore, the objectives of this paper are to (i) determine the road defects in Mersing district and (ii) to identify the conditions of the road defects in Mersing district.

## **LITERATURE REVIEW**

### **Road Conditions are Reflection of their Maintenance**

Planning road maintenance activities require information on the road conditions (Setianingsih et al., 2017). This statement is supported by Arianto et al. (2018), who state that to carry out road repair activities on time, a plan based on correct pavement condition data is required. Recently, Hamsan et al. (2018) reported in previous literature through road roughness measurement which looked at rutting, texture depth and crack visibility to assess the road in Petaling, Malaysia. Road condition was assessed by taking into consideration the roughness of the road, total crack area, average crack width, number of potholes, and depth of vehicle rutting (Arianto et al., 2018).

Siswanto et al. (2018) in Indonesia assessed road defects and found eighteen types of road distress. The distress or defect types include potholes, cracking, bumps, bleeding, depression and rutting. Although the primary type of road defects is similar in these studies, the differences were determined by the tools or software used to determine the road condition. Thus, Dolla and Laishram (2022) discover that concepts such as road funding and distribution of funds, road planning, design and development, maintenance services and administration, road operations, and road safety are predominantly limited to high-volume of roads in most of the research. These criteria have a lot of impacts on road flooding.

### ***Causal Factors of Road Damage***

Road damage or defects are frequent and common problems in most countries. Many roadways are damaged or already starting to deteriorate (Angreni et al., 2018). Pavement distress is an apparent defect on the road surface, which shows that pavement structural degradation symptoms are present (Mubarak, 2014). Sarie et al. (2015) indicates that road damage is divided into two categories which are structural damage and functional damage. Surbakti and Doan (2018) explained both damages.

Several studies have stressed that overloading vehicles are significant factors in road deterioration (Hatmoko et al. 2019; Ismail et al. 2021; Selamat et al. 2019). It was pointed out by Selamat et al. (2019) that the meaning of vehicle overload is the traffic load that has considerably surpassed the specified bearing capability of the proposed road structure. Many researchers also described the effects of overloading vehicles on the road, such as it could suffer from massive early pavement degradation (Hatmoko et al. 2019; Selamat et al. 2019).

Environmental conditions also play a critical factor in determining the state of health of a road and predict the road's future condition (Kulkarni & Miller, 2003). When there is an inoperative drainage channel, water can readily infiltrate through the pavement and inevitably causes road damage in the future (Hatmoko et al., 2019).

### ***Pavement Condition Assessment***

Road pavements require non-stop repair and maintenance to prevent damage caused by repeated traffic loads and the environment. This means pavement maintenance management requires the relevant authority to carry out a pavement condition evaluation at regular intervals (Ismail et al., 2021). The data is used to regulate the functional and structural condition of the road. The data is also used to detect areas of poor condition pavements, which are then followed by pavement treatment to be applied at the most appropriate time (Hamsan et al., 2018).

#### ***Pavement Condition Index (PCI)***

This rating system is referred to as Pavement Condition Index (PCI). This method is known as the Pavement Condition Index (PCI). PCI is typically determined to annually evaluate changes in the road network system (Karim et al., 2016). The pavement condition rating is calculated using six steps that follow (ASTM D6433-11 2011). First, separate pavement sections in manageable sizes or into sample units. Second, identify pavement distress, severity and extent for which they developed guidelines on how to carry out pavement distress evaluation. Third, deduct values were assigned for each distress type, severity and extent level. Fourth, the total number of deducting values are added. Fifth, the corrected deduct value is determined based on the total deduct values of the road that have

been observed. Sixth, the pavement condition rating is determined on a scale from 0-100.

#### ***Road Maintenance Prioritization***

Four classes of prioritization methods are (i) simple subjective ranking, (ii) ranking based on parameters with scoring or weighting, (iii) ranking based on parameters with economic analysis and (iv) optimization (Karim 2014)

Another factor to consider when giving priority to road maintenance is the traffic flow. Another study conducted in one Indonesian district discovered that the authorities in the district place road conditions as the priority, followed by traffic volume, economic factor, and land use (Siswanto et al., 2019).

Previous literature has shown that current road conditions are crucial to determine the safety and assessment for future maintenance management. In this study, Mersing Road was selected as a case study due to its heavy traffic.

### **RESEARCH METHODOLOGY**

For this research, it has been decided that there will be five roads that will be assessed. The sampling used to select the study population is a convenient method of sampling for this research. The study sample then reduced to two roads as a subsample from a larger cohort of Mersing district roads. The interviewee for the fidelity of observation was also chosen based on convenient sampling. Two types of roads were assessed, and convenient sampling was chosen to select the study population. The study sample of two roads was a subsample from a larger cohort of Mersing district roads. The interviewee for the fidelity of observation was also chosen based on convenient sampling. Edgar and Manz (2017) note that convenient sampling refers to a method in which samples are obtained conveniently as they are accessible at a place or on the web.

After the road sample was determined, two road samples were divided into sample units. The number of sample units inspected was established and randomly picked. The road sample that was observed for this study has a total length of 3 km. This 3km length of the two roads sample was divided into few units. The sample unit for flexible pavement area is about 450 – 650 m<sup>2</sup> (Karim, 2014). During a Pavement Condition Index inspection, road damage is assessed through visual observation supervised by a site engineer and is vet through based on standard evaluation rules and procedures. The inspection follows specific guidelines to ensure consistency and accuracy in identifying pavement defects. Type of road distress is based on common rules used during road damage inspection, by identifying the defects, namely longitudinal cracks, transverse cracks, alligator cracking, potholes, rutting, depression, edge cracking and patching deterioration

$$\text{Density} = \frac{\text{Distress amount in m2}}{\text{Sample unit area in m2}} \times 100$$

**Figure 1:** Sample Unit Formula (Source: Karim, 2014)

Where:

n = number of sample units to be inspected

N = total number of sample units (length of sample unit/length of the sample)

$\sigma$  = standard deviation in PCI (10 for flexible pavement)

e = allowable error in determining the genuine PCI (allowance of 5 for error)

After recording all the defects found, each of the defects was recorded according to the severity of the defect that occurs, which is whether they are high, medium or low. The guide to determine the severity is stated in the Headquarters Department of the Army (1982) and Public Works Department (2017). Then, the roads were measured using the PCI method of calculation (ASTM D6433-11 2011; Karim et al. 2016; Mubarak 2014; Sholichin & Utomo 2018). After recording all of these, each of the density of the road defects was documented in percentage following the formula below. Each of the density of the road defects was documented in a percentage based on the formula in figure 2, that is all the defects that are calculated in square meters (m2).

$$\text{Density} = \frac{\text{Distress amount in m2}}{\text{Sample unit area in m2}} \times 100$$

**Figure 2:** Formula of Density in m2 (Source: Karim et al. 2016)

Meanwhile, the following formula for density in Figure 3 is for defects calculated in linear meters (m) such as bumps, edge cracking, joint reflection cracking, edge drop-off, longitudinal crack, and transverse cracks (Karim et al. 2016).

$$\text{Density} = \frac{\text{Number of potholes}}{\text{Sample unit area in m2}} \times 100$$

**Figure 3:** Formula of Density in m (Source: Karim et al. 2016)

After calculating the density (%), the deduct value will be decided. The deduct value will be decided by looking at the graphs of deducting values curve based on the Headquarters Department of the Army (1982). Each defect of the road has a different deduct value curve graph.

Then the Corrected Deduct Value (CDV) was determined. Firstly, the maximum allowable number of deducting values were established. The

calculation is as follows:  $m = 1 + (9/98) (100 - HDV)$ , HDV is the highest deduct value (Mubaraki 2014). After obtaining the maximum allowable number of deducts, the deduct value was arranged in descending order. Then, the deduct value was added based on the maximum allowable number (Mubaraki 2014). The total deduct value (TDV) of each road then is adjusted to obtain the CDV. This CDV was obtained by plotting the value of TDV in Corrected Deduct Value curves stated in Appendix I (ASTM D6433-11 2011; Headquarters Department of the Army 1982). The deduct value that more than 5 (q) needed to be concluded first (Headquarters Department of the Army 1982; Mubaraki 2014; Sholichin & Utomo 2018). This  $q$  is the curve used to plot the Corrected Deduct Value curves. Lastly, the PCI was computed by  $100 - CDV$ . This PCI value was categorized based on the value obtained. The road condition was based on the PCI rating shown in Figure 4.

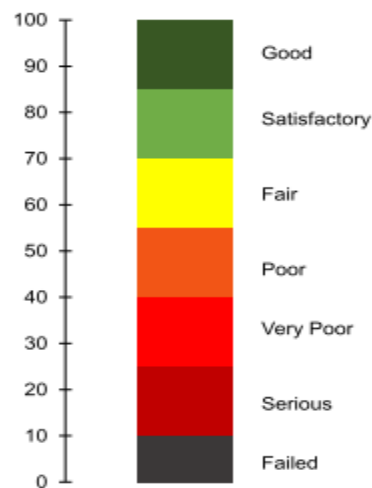


**Figure 4:** PCI Rating (Source: ASTM D6433-11 2011)

The Pavement Condition Index (PCI) was used with the volume of the traffic flow to identify the pavement road maintenance priority based on the result of the PCI index. The result of the Pavement Condition Index provides a ranking on each of the roads observed. The Pavement Condition Index (PCI) is a standard method used to assess the physical condition of a road pavement. It helps engineers and local authorities determine how damaged or well-maintained a road is. A higher PCI value indicates that the road is in better condition and requires less maintenance, while a lower PCI value shows that the road is deteriorating and may need urgent repair or rehabilitation.

## ANALYSIS AND DISCUSSION

### Type of Road Defects in Mersing Districts

This research analysed the defects that appeared on two roads, namely (i) Tanjung Resang (TR) and (ii) Tanjung Resang-Penyabong (TRP), the two roads went through visual observation for each 1.5km of the road. The sample units are separated into the pavement feature. For flexible pavement, a sample unit of around 450 m<sup>2</sup> - 650 m<sup>2</sup> is used.

### Type of Road Distress in Tanjung Resang (TR) Road

The sampling size for the road has been appropriately selected, considering the width of the road. Since the width of the road is 7.10 m, then it has been decided that the length of the sample size is 70.00m. Thus, making the sample size of Tanjung Resang Road to be 70.00m x 7.10m, which is 497 m<sup>2</sup>. The number of samples calculation is shown at Figure 5 below.

|                                                                              |                              |
|------------------------------------------------------------------------------|------------------------------|
| <p>ROAD : Tanjung Resang Road</p> <p>Length : 70 m</p> <p>Width : 7.10 m</p> | $N = \frac{1500}{70}$ $= 21$ |
|------------------------------------------------------------------------------|------------------------------|

$$n = \frac{N\sigma^2}{\frac{s^2}{4}(N-1) + \sigma^2}$$

$$= \frac{21(10^2)}{\frac{5^2}{4}(21-1) + 10^2}$$

$$= \frac{2100}{6.25(20) + 100}$$

$$= \frac{2100}{225}$$

$$= 9$$

**Figure 5:** Calculation of Tanjung Resang road Sampling Unit (Mubaraki 2014)

There were three types of defects found on the TRR. The defects found are obtained from four samples which are (i) patching, (ii) alligator cracking, (iii) polished aggregate and (iv) longitudinal Cracking.



Plate a

Plate b

Plate c

**Figure 6:** Patching on Tanjung Resang Road

Figure 6 indicates that there are patches on the Tanjung Resang Road samples of plate a, plate b and plate c, respectively. The patches on the road have the quantity of 0.40 m<sup>2</sup>, 1.15 m<sup>2</sup> and 2.88 m<sup>2</sup>.

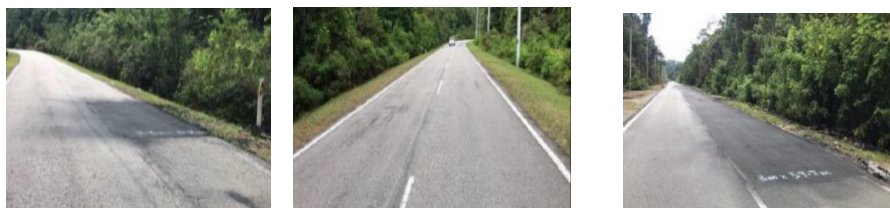


plate a

plate b

plate c

**Figure 7:** Polished Aggregate on Tanjung Resang Road

Figure 7 shows that polished aggregate was discovered on the Tanjung Resang road samples a, b and c. The portions on the road have the area of 1.15 m<sup>2</sup>, 1.30 m<sup>2</sup> and 1.20m<sup>2</sup>



plate a

plate b

**Figure 8:** Alligator Cracking on Tanjung Resang Road

Figure 8 shows that the surface area of alligator cracking is measured in meter square. Alligator cracking was identified in TRR samples. 1.15 m<sup>2</sup> are the sizes for both road segments that encountered alligator cracking.



Plate a

**Figure 9:** Longitudinal Cracking on Tanjung Resang Road

Based on Figure 9, longitudinal cracking was found in Tanjung Resang Road samples 9. The length of cracking is 0.11 m.

**PCI Calculation for Road Distress in Tanjung Resang (TR) Road**

**Table 1:** Tanjung Resang Road Distress Quantity and Density (DQD)

ROAD : Tanjung Resang Road

Area of sample : 497 m<sup>2</sup>

| Sample | Distress Type | Distress Severity | Distress Quantity (m <sup>2</sup> /m /nr.) | Density (%) |
|--------|---------------|-------------------|--------------------------------------------|-------------|
| 1      | 6             | L                 | 0.40                                       | 0.08        |
| 2      |               | M                 | 1.15                                       | 0.23        |
| 3      |               | H                 | 2.88                                       | 0.58        |
| 4      | 1             | M                 | 1.15                                       | 0.23        |
| 5      |               | M                 | 1.15                                       | 0.23        |
| 6      | 13            | -                 | 1.15                                       | 0.23        |
| 7      |               |                   | 1.30                                       | 0.26        |
| 8      |               |                   | 0.40                                       | 0.08        |
| 9      | 14            | H                 | 0.11                                       | 0.02        |

(Source: Researcher's Findings)

The quantity is measured after the severity of each road defect has been determined. The density of the distress will be calculated using the measured quantity. The researcher divides the length of the defects by the area of the sample to get the density percentage.

Table 1 shows the density percentage for patching in TR roads are 0.08%, 0.23%, and 0.58% for road samples 1, 2 and 3. Furthermore, 0.23% is the density percentage for both sample 4 and 5 of alligator cracking. The third road defect is polished aggregate, which is 0.23% for sample 6, 0.26% for sample 7 and 0.08% for sample 8. The last road distress is longitudinal cracking with a density of 0.02%.

**Table 2:** Tanjung Resang Road Deduct Value (DV)

ROAD : Tanjung Resang Road      Area of sample : 497 m2  
 Maximum Allowable Number of Deducts: 9

| Sample | Distress Type | Distress Severity | Distress Quantity (m2 /m /nr.) | Density (%) | Deduct Value | 9 allowable number of deducts |
|--------|---------------|-------------------|--------------------------------|-------------|--------------|-------------------------------|
| 1      | 6             | L                 | 0.40                           | 0.08        | 0            | 14                            |
| 2      |               | M                 | 1.15                           | 0.23        | 3            | 10                            |
| 3      |               | H                 | 2.88                           | 0.58        | 14           | 10                            |
| 4      | 1             | M                 | 1.15                           | 0.23        | 10           | 4                             |
| 5      |               | M                 | 1.15                           | 0.23        | 10           | 3                             |
| 6      | 13            | -                 | 1.15                           | 0.23        | 0            | 0                             |
| 7      |               |                   | 1.30                           | 0.26        | 0            | 0                             |
| 8      |               |                   | 0.40                           | 0.08        | 0            | 0                             |
| 9      | 14            | H                 | 0.11                           | 0.02        | 4            | 0                             |

The purpose of determining the severity and density percentage is to find a DV for each of the road distress. Each distress has a different distress DV curve. For patching, based on Table 2, the DV for low severity with the density of 0.08% is 0. Medium severity patching with 0.23% density has a deduct value of 3. Then, high severity patching with 0.58% density has the deduct value of 14. Next, both alligators cracking with medium severity in TR road density 0.23% have the deduct value of 14. Then, the polished aggregate deducts value curve (Appendix A) recorded the deduct value of 0 for the density of 0.23%, 0.26%, and 0.08%. Lastly, the low severity longitudinal cracking with the density of 0.02% gains the deduct value of 4.

Consequently, to obtain the PCI, the DV must first be established on the maximum allowable number of deducts, to sum up, the Total Deduct Value. The formula for the maximum number of deductions that can be taken is as follows:

$$[m = 1 + (9/98) (100-HDV)], \text{ where } HDV \text{ is the greatest deduct value}$$

Thus, Tanjung Resang Road,  $m = 1 + (9/98) (100-14) = 9$  maximum allowable number of deducts. The number of deducted values should be reduced to the value of m. If the number of deducting values is less than the value of m, all of the deduct values should be used. Following the value of m, the deduct values should be listed in descending order, as shown in Table 2.

**Table 3:** Tanjung Resang PCI Calculation

| ROAD : Tanjung Resang Road   |               |                   |                                |             | Area of sample : 497 m2 |                               |                                 |   |
|------------------------------|---------------|-------------------|--------------------------------|-------------|-------------------------|-------------------------------|---------------------------------|---|
|                              |               |                   |                                |             | Maximum Allowable       |                               |                                 |   |
|                              |               |                   |                                |             | Number of Deducts: 9    |                               |                                 |   |
| Sample                       | Distress Type | Distress Severity | Distress Quantity (m2 /m /nr.) | Density (%) | Deduct Value            | 9 allowable number of deducts | q (deduct value greater than 5) |   |
| 1                            | 6             | L                 | 0.40                           | 0.08        | 0                       | 14                            | 3                               |   |
| 2                            |               | M                 | 1.15                           | 0.23        | 3                       | 10                            |                                 |   |
| 3                            |               | H                 | 2.88                           | 0.58        | 14                      | 10                            |                                 |   |
| 4                            | 1             | M                 | 1.15                           | 0.23        | 10                      | 4                             |                                 |   |
| 5                            |               | M                 | 1.15                           | 0.23        | 10                      | 3                             |                                 |   |
| 6                            |               |                   | 1.15                           | 0.23        | 0                       | 0                             |                                 |   |
| 7                            | 13            | -                 | 1.30                           | 0.26        | 0                       | 0                             |                                 |   |
| 8                            |               |                   | 0.40                           | 0.08        | 0                       | 0                             |                                 |   |
| 9                            |               |                   | H                              | 0.11        | 0.02                    | 4                             |                                 | 0 |
| TOTAL DEDUCT VALUE (TDV)     |               |                   |                                |             | 41                      |                               |                                 |   |
| CORRECTED DEDUCT VALUE (CDV) |               |                   |                                |             | 25                      |                               |                                 |   |
| PCI (100 - CDV)              |               |                   |                                |             | 75.00                   |                               |                                 |   |

To obtain the PCI rating of the road condition, the corrected deduct value must be attained first. To acquire this corrected deduct value, at first,  $q$  needs to be determined.  $Q$  is the deduct value of which is greater than 5. For Tanjung Resang, the  $q$  is three, as seen in Table 3, and this will serve as the curve to plot to find the corrected deduct value. By looking for the proper adjustment, the researcher could ascertain the corrected deduct value from  $q$  and total deduct value. The total deducted value is 41 making the corrected deduct value to be 25. PCI is calculated by  $100 - \text{Corrected Deduct Value}$ . The PCI for Tanjung Resang is  $100 - 25 = 75$  road condition.

#### ***Type of Road Distress in Tanjung Resang-Penyabong Road (TRP)***

TRP road was the second road to be assessed. The length of the sample size has been determined to be 70.00m and the road width is 7.50 m. Hence, the TRP road sample size is  $70.00\text{m} \times 7.50\text{m}$ , with a total area of 525 m2. The number of samples in calculation is shown below:

$$\begin{aligned}
 &\text{ROAD : Tanjung Resang - Penyabong Road} \\
 &\text{Length : 70 m} \quad N = \frac{1500}{70} \\
 &\text{Width : 7.50 m} \\
 &n = \frac{N\sigma^2}{\frac{s^2}{4}(N-1) + \sigma^2} = 21 \\
 &= \frac{21(10^2)}{\frac{5^2}{4}(21-1) + 10^2} \\
 &= \frac{2100}{6.25(20) + 100} \\
 &= \frac{2100}{225} \\
 &= 9
 \end{aligned}$$

**Figure 10:** Calculation of TRP road Sampling Unit (Mubaraki 2014)

From the calculation above (Figure 10), there are 9 sections of the road that were observed for this route. TRP road had four different categories of defects namely, (i) Polished aggregate, (ii) patching, (iii) longitudinal cracking and (iv) raveling. Pore were the defects discovered in TRP road in all nine samples examined.



plate a



Plate b



Plate c

**Figure 11:** Polished Aggregate on TRP Road (Source: Researcher's Observation)

The observation for the TRP road found some road defects, which are patches, as shown in Figure 11. The sizes of the road segments are both 5.25 m<sup>2</sup> and 3.53 m<sup>2</sup>



**Figure 12:** Patches on TRP Road (Source: Researcher's Observation)

The visual observation made from TRP road discovered that there are two patches on the road segments Figure 12. The area of the patch's defects found are 2.63 m<sup>2</sup> and 1.50 m<sup>2</sup> the last defect found on Tanjung Resang – Penyabong road are categorized as raveling. Figure 15 shows road segment nine which has a raveling at 1.76m<sup>2</sup>

#### PCI Calculation for Road Distress in Tanjung Resang – Penyabong Road

**Table 4:** Tanjung Resang - Penyabong Road Distress Severity

| Sample | Distress Type | Distress Severity |
|--------|---------------|-------------------|
| 1      | 13            | -                 |
| 2      |               |                   |
| 3      |               |                   |
| 4      |               |                   |
| 5      | 6             | L                 |
| 6      |               | H                 |
| 7      |               | H                 |
| 8      | 14            | L                 |
| 9      | 17            | L                 |

(Source: Researcher's Findings)

Based on Table 4, it can be found that the defects that occur are those of number 13 (polished aggregate), 6 (patching), 14 (longitudinal cracking) and 17 (ravelling) for TRP road. Next, the patching for TRP roads is low and high severity. The low severity shows that the patch in sample 5 is in good working order and delivers satisfactory results. Lastly, the TRP road has a high degree of distress severity recorded and this is when the patches must be replaced.

It has been observed that the TRP road has longitudinal cracking on the road surface.

The last distress recorded is raveling with low severity for sample 9 on TRP road. Low severity shows the aggregate or binder has only begun to deteriorate.

**Table 5:** TRP Road Distress Quantity and Density (Source: Researcher's Findings)

ROAD : Tanjung Resang - Penyabong Road Area of sample : 525 m2

| Sample | Distress Type | Distress Severity | Distress Quantity (m2 /m /nr.) | Density (%) |
|--------|---------------|-------------------|--------------------------------|-------------|
| 1      | 13            | -                 | 5.25                           | 1.00        |
| 2      |               |                   | 5.25                           | 1.00        |
| 3      |               |                   | 3.53                           | 0.67        |
| 4      |               |                   | 3.53                           | 0.67        |
| 5      | 6             | L                 | 2.63                           | 0.50        |
| 6      |               | H                 | 1.50                           | 0.29        |
| 7      |               | H                 | 1.50                           | 0.29        |
| 8      | 14            | L                 | 0.47                           | 0.09        |
| 9      | 17            | L                 | 1.76                           | 0.34        |

From Table 5, the density percentage for polished aggregate in TRP road is 1.00%, 1.00% and 0.67% for road samples 1, 2 and 3. Furthermore, 0.50% is the density percentage for sample 4, and 0.29% is the density percentage for both sample 6 and 7 for patching. Next is the density percentage for longitudinal cracking, which is 0.09% for sample 8. The last road distress is raveling with the density of 0.34%.

**Table 6:** TRP Road Deduct Value (Source: Researcher's Findings)

ROAD : Tanjung Resang - Penyabong Road Area of sample : 525 m2  
 Maximum Allowable 9  
 Number of Deducts:

| Sample | Distress Type | Distress Severity | Distress Quantity (m2 /m /nr.) | Density (%) | Deduct Value | 9 allowable number of deducts |
|--------|---------------|-------------------|--------------------------------|-------------|--------------|-------------------------------|
| 1      | 13            | -                 | 5.25                           | 1.00        | 0            | 10                            |
| 2      |               |                   | 5.25                           | 1.00        | 0            | 10                            |
| 3      |               |                   | 3.53                           | 0.67        | 0            | 1                             |
| 4      |               |                   | 3.53                           | 0.67        | 0            | 1                             |
| 5      | 6             | L                 | 2.63                           | 0.50        | 1            | 0                             |
| 6      |               | H                 | 1.50                           | 0.29        | 10           | 0                             |
| 7      |               | H                 | 1.50                           | 0.29        | 10           | 0                             |
| 8      | 14            | L                 | 0.47                           | 0.09        | 0            | 0                             |
| 9      | 17            | L                 | 1.76                           | 0.34        | 1            | 0                             |

The polished aggregate deducts value curve recorded the deduct value of 0 for the density of 1.00% and 0.67%, respectively. Table 6 found that for patching based on Appendix C, the deduct value for low severity with the density of 0.50% is 1. High severity patching with 0.29% density, as seen in Table 6, has the deduct value of 10. After that, the low severity longitudinal cracking with the density of 0.09% gains the deduct value of 0 by using Appendix D. The fourth one is raveling with low severity in TRP road density 0.34% has the deduct value of 1 using Appendix B to plot the value. TRP road maximum allowable number of deducts is  $m = 1 + (9/98) (100-10) = 9$ . Following the value of  $m$ , the deduct values were listed in descending order, as shown in Table 6.

**Table 7: TRP PCI Calculation (Source: Researcher's Findings)**

ROAD : Tanjung Resang - Penyabong Road      Area of sample : 525 m<sup>2</sup>  
 Maximum Allowable Number of Deducts: 9

| Sample                       | Distress Type | Distress Severity | Distress Quantity (m <sup>2</sup> /m /nr.) | Density (%) | Deduct Value | 9 allowable number of deducts | q (deduct value greater than 5) |
|------------------------------|---------------|-------------------|--------------------------------------------|-------------|--------------|-------------------------------|---------------------------------|
| 1                            | 13            | -                 | 5.25                                       | 1.00        | 0            | 10                            | 2                               |
| 2                            |               |                   | 5.25                                       | 1.00        | 0            | 10                            |                                 |
| 3                            |               |                   | 3.53                                       | 0.67        | 0            | 1                             |                                 |
| 4                            |               |                   | 3.53                                       | 0.67        | 0            | 1                             |                                 |
| 5                            | 6             | L                 | 2.63                                       | 0.50        | 1            | 0                             |                                 |
| 6                            |               | H                 | 1.50                                       | 0.29        | 10           | 0                             |                                 |
| 7                            |               | H                 | 1.50                                       | 0.29        | 10           | 0                             |                                 |
| 8                            | 14            | L                 | 0.47                                       | 0.09        | 0            | 0                             |                                 |
| 9                            | 17            | L                 | 1.76                                       | 0.34        | 1            | 0                             |                                 |
| TOTAL DEDUCT VALUE (TDV)     |               |                   |                                            |             |              | 22                            |                                 |
| CORRECTED DEDUCT VALUE (CDV) |               |                   |                                            |             |              | 17                            |                                 |
| PCI (100 - CDV)              |               |                   |                                            |             |              | 83.00                         |                                 |

Table 7 shows that TRP  $q$  is 2. The TDV is ascertained using the curve  $q = 2$  in Appendix A. The total deducted value calculated is 22 making the corrected deduct value to be 17. PCI for TRP is  $100 - 17 = 83$  road conditions.

#### ***The Road Defects Identification in Mersing District***

To determine the road maintenance prioritization, traffic load and PCI value are needed. The traffic flow is obtained by visual observation done for a week on each road for 6 hours. However, the traffic level may be affected since this study was conducted during COVID-19, and this contributed to fewer vehicles than the average traffic level.

**Table 8:** Each Road Traffic Level

| No | Name of Road                    | Rank | Traffic Level (vehicles/day) |
|----|---------------------------------|------|------------------------------|
| 1  | Tanjung Resang road             | 1    | 10                           |
| 2  | Tanjung Resang – Penyabong road | 2    | 48                           |

**Table 9:** PCI calculation

| No | Name of Road                    | PCI | Condition Category | Traffic Level (Vehicles) | Rank of Maintenances for traffic |
|----|---------------------------------|-----|--------------------|--------------------------|----------------------------------|
| 1  | Tanjung Resang road             | 75  | Satisfactory       | 10                       | 2                                |
| 2  | Tanjung Resang – Penyabong road | 83  | Excellent          | 48                       | 1                                |

Tables above (Table 8 and Table 9) represent the PCI calculation. For TR road is PCI 75 and for TRP road is 83 for the rank. As for the condition, TR road is satisfactory and TRP road is in excellent condition. As for Table 9, traffic level TR road is 10 and TRP road is 48. Lastly, for rank for maintenance for traffic, TR road is 2 and TRP road is 1. The roads observed in this study are two roads chosen within the Mersing district. The two roads are TR road and TRP road. Each road has its road defects that occur on the sample observed. For the first road, which is Tanjung Resang, it was discovered that the distress occurred are (i)patching, (ii) alligator cracking, (iii) polished aggregate and (iv)longitudinal cracking. For the second road, TRP road had three different categories of defects identified namely (ii)patching, (iii)longitudinal cracking and (iv)raveling.

**Table 10:** Road Condition categories and PCI value

| No | Name of Road                    | PCI | Condition Category |
|----|---------------------------------|-----|--------------------|
| 1  | Tanjung Resang road             | 75  | Satisfactory       |
| 2  | Tanjung Resang – Penyabong road | 83  | Excellent          |

From Table 10, the road condition categories and PCI value. TR road has the highest PCI value, 83, making the road categories fall into the excellent road condition category.

To conclude, the most road defects that occur in all of two roads are polished aggregate. Among other frequent defects found are patching and cracking, which are most likely due to the road having become a frequent road to travel for heavy vehicle load since all the roads above are old roads in the district.

The significance of the findings was that road maintenance management differs based on the amount of load that vehicles traveled. Early detection by evaluating the road condition and optimizing the maintenance planning schedule are necessary to ensure the efficiency of road performance. Consistency of road maintenance can minimize road damage and reduce accidents due to deteriorating roads. There is a need to identify road locations where road accidents occur frequently before proceeding to clarify underlying issues and develop preventive measures (Bashayar Alhajri, *et.all*, (2024)

**Table 11:** PCI and maintenance priority

| No | Name of Road                    | PCI | Condition Category | Traffic Level (Vehicles) | Rank of Maintenances for traffic | Priority |
|----|---------------------------------|-----|--------------------|--------------------------|----------------------------------|----------|
| 1  | Tanjung Resang road             | 75  | Satisfactory       | 10                       | 6                                | 3        |
| 2  | Tanjung Resang – Penyabong road | 83  | Excellent          | 48                       | 6                                | 2        |

From Table 11, the road that obtains the most priority is Endau – Penyabong road because the road still maintains a satisfactory road condition even when there is a lot of traffic. This means the maintenance program for this road must be maintained and done regularly to avoid more road deterioration.

The second priority goes to Tanjung Resang – Penyabong road with excellent road condition even when the rank of maintenance for traffic flow is only 6. Tanjung Resang road is inevitably the third priority as the rank of maintenance for traffic flow is only six. The traffic level is minimal, causing the road conditions to be satisfactory. The maintenance program must be maintained for both of this road; however, maybe prioritization can be given to other roads with severe or deplorable road conditions.

Dominant pavement defects are commonly influenced by factors such as traffic loading, inadequate drainage systems, poor patching quality, pavement ageing, and environmental conditions, all of which contribute to the deterioration of road performance and service. To address the inherent limitations of conventional pavement maintenance evaluation, which often struggles with fuzzy boundary values and disparate evaluation indices, advanced approaches are emerging that integrate image processing with Multi-Criteria Decision Making. (Cavalli et al., 2023)

## CONCLUSION

The level of maintenance and repairing technology found in this case study were currently satisfactory, but there is still room for improvement. This research states

that insufficient funding is the cause of ineffective road maintenance and this causes the road to continue to deteriorate. The road maintenance company should always inspect and be on the alert when it comes to monitoring the road condition. Moreover, such an approach will ensure that there is no wastage of funding allocated for road maintenance.

The findings show that the accuracy of the method used, namely Pavement Condition Index (PCI) and International Roughness Index (IRI) is reliable to determine the type of defects. Therefore, detailed data on road conditions can be used for effective maintenance planning. Future research can be more accurate and thorough if the road condition analysis is done with more advanced technology, such as using Falling Weight Deflectometer (FWD). This method can measure the structural strength of the road structure and can result in better findings for the road condition. Axle Load Test can also measure the damages done to the road surface caused by vehicles. HDM-4 also can be carried out to forecast the budget for road maintenance.

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Received: 5<sup>th</sup> December 2025. Accepted: 6<sup>th</sup> February 2026