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## ROAD SURFACE ANALYSIS USING THE INTERNATIONAL ROUGHNESS INDEX AND PAVEMENT CONDITION INDEX (CASE STUDY: Gajah Mada Street, Tegal City)

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**ABSTRACT**

Road surface quality plays an important role in ensuring safety and comfort for users Gajah Mada Street in Tegal City was chosen as the study site because it functions as a main route with heavy traffic flow, and there are various physical damages on its surface. This study aimed to evaluate the condition of the road by applying the International Roughness Index (IRI) and Pavement Condition Index (PCI) approaches. Data collection was conducted through field surveys using a Hawkeye vehicle for IRI and a visual PCI inspection based on ASTM D6433-11 standards. The analysis results showed an average PCI value of 77, categorized as very good, while the IRI value was 6.23 m/km, indicating a fair condition. The difference between the two methods highlights the importance of a multi-method approach in road condition assessment. This study recommends regular and periodic road maintenance to sustain optimal road performance.

***Keyword:*** *IRI, PCI, Surface Road*

## 1. INTRODUCTION

Road safety has become an important issue over the years and has become a global problem[1]. Road safety is closely related to road infrastructure. Adequate and well-maintained infrastructure is an important factor in creating safe roads[2]. Roads are vital infrastructure designed and constructed to provide transportation routes for motor vehicles, pedestrians and cyclists. This infrastructure generally has a hard surface, such as asphalt and concrete, and includes various types such as highways, toll roads, rural roads, and urban roads. One example is Gajah Mada Street located in Tegal City, Central Java Province. Gajah Mada Street in Tegal City is one of the main roads that has an important role in supporting community mobility and economic activities, as a city with heavy traffic, the condition of this road greatly affects the smooth running of daily activities. Roads have a vital role in the social and economic life of the community. Road conditions will affect the community economy, where poor road conditions can hinder mobility between regions which results in obstruction of traffic and the smooth running of the community's economy[3]. In addition to economic aspects, bad roads can cause accidents that can cause losses in terms of injury, damage, and material losses[4]. Roads must have ideal conditions in order to provide comfort, security, and safety for road users.

However, the current condition of Gajah Mada Street shows a decline in the physical quality of the road. With the increasing volume of vehicles, including heavy vehicles, the road surface begins to show various forms of road damage, such as cracks, holes, and deformation. This damage not only disrupts the smooth running of community activities, but also has the potential to reduce the comfort and safety level of road users.

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These problems indicate the need for serious attention in efforts to maintain and manage road infrastructure. Based on these conditions, this research aims to thoroughly understand the various types of damage that occur on the surface of Gajah Mada Street. By using the International Roughness Index (IRI) method to measure road hardness and the Pavement Condition Index (PCI) to visually evaluate damage, this study aims to reveal the extent and condition of road damage from two different perspective. Afterwards, the results of the two methods will be compared to see to what extent they provide an accurate picture. The PCI method was developed in America by the U.S. Army Corp of Engineers for airport pavements, highways and parking lots[5]. The PCI method is often used as a pavement condition measurements method, as it is a quick method to compare the overall condition of a pavement according to its maintenance needs[6]. Data related to pavement condition using this method can describe the overall condition of the road[7]. By combining approaches through the International Roughness Index (IRI) and Pavement Condition Index (PCI) methods, this study is expected to provide a more accurate and comprehensive picture.

## 2. RESEARCH METHOD

The research location was Gajah Mada Street, Tegal City at stationing 0+000 – 1+200. This road was chosen because it has a fairly high traffic volume. The tools used in data collection are Hawkeye 2000, roll meter, walking measure, camera, and stationery.


Source: Google Earth (2025)

**Figure 1.** Research Location

This study utilized two categories of data, namely primary and secondary data. Primary data includes information on the level of unevenness of the road surface measured using the IRI method, road damage data based on the PCI approach, and traffic volume. Meanwhile, secondary data is in the form of road maps at the location of the study object. Data collection was conducted in May 2025. Road conditions were assessed objective through roughness assessment and subjectively through pavement condition assesment[8]. To collect IRI data, a special car called a Hawkeye 2000 is used, which is designed to accurately measure road surfaces roughness. Hawkeye 2000 cars are used to identify accident blackspot, measure road geometric elements, measure the International Roughness Index (IRI), and unevenness on a road section in order to improve road service levels[9]. Meanwhile, PCI data collection uses visual field surveys based on the ASTM D6433-11 method by identifying the type of road damage along with the severity and extent of damage to the damaged area[10]. The calculation process is carried out through a visual survey, which aims to evaluate the condition of the pavement structure based on the characteristics and intensity of damage observed in the field[11]. Traffic volume data is obtained through traffic counting.

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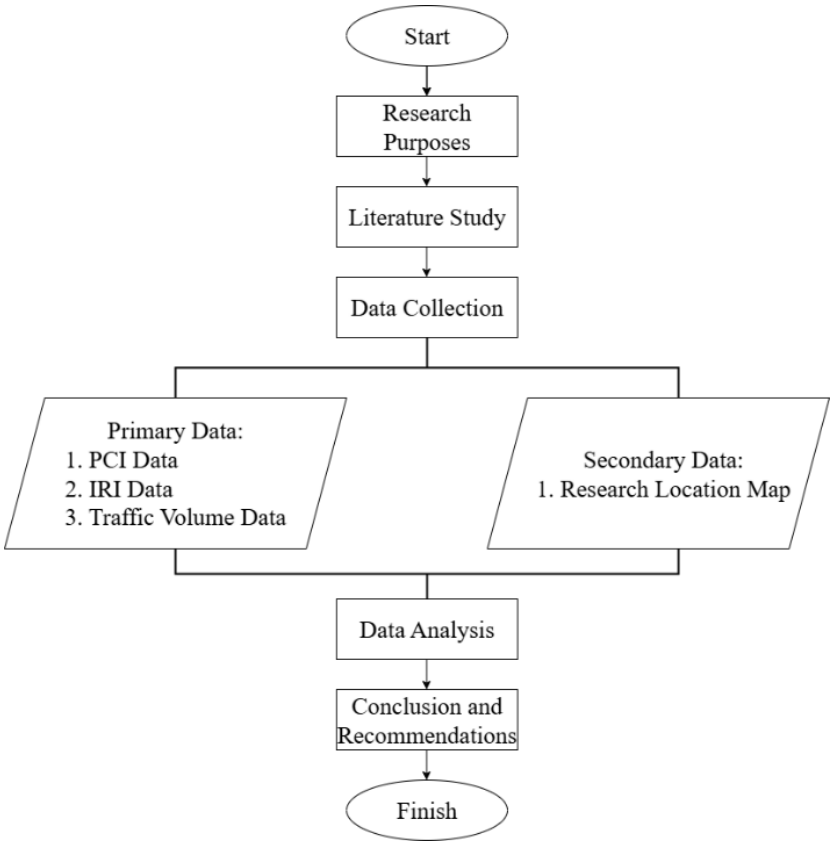
Source: Documentation (2025)

**Figure 2.** Hawkeye 2000

Data analysis was conducted using the ASTM D6433-11 Pavement Condition Index method. The method is used to determine the condition of pavement damage. There are several staged of the analysis. The stages carried out are identifying road damage, calculating the distress density value, deduct value, allowable number of deduct, total deduct value, corrected deduct value, and calculating the PCI value. The PCI value has a range of 0 to 100, where a value of 0 indicates that the road surface is in a damaged condition and 100 indicates that the road surface is in good and excellent condition[12]. PCI values of 0-10 include failed conditions, PCI values of 11-25 include very poor conditions, PCI values of 26-40 include poor conditions, PCI values of 41-55 include fair conditions, PCI values of 56-70 include good conditions, PCI values of 71-85 include very good, and PCI values of 86-100 include excelent conditions.[13]. While analyzing road unevenness using the IRI (*International Roughness Index*).




Source: Analysis Results 2025

**Figure 3.** Research Flow Chart

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## 3. ANALYSIS RESULTS AND DISCUSSION

The research was conducted on Gajah Mada Street Tegal city, where on this road section there are several types of damage. The types of damage found on Gajah Mada Street are Linear Cracking, Spalling Joint, Patching Small, Patching Large, Spalling Corner, Punchout, Lane/shoulder Drop Off, and Divided Slabs. The road is divided into 12 segments from stationing 0+000 – 1+200.

The types of damage on lanve 1 of Gajah Mada Street are shown in the following table.

**Table 1.** Types of Damage on Lane 1 Gajah Mada Street

| Sta | Type of Damage |
|---|---|
| 0+000 – 0+100 | Linear Cracking |
| | Spalling Joint |
| 0+100 – 0+200 | Linear Cracking |
| | Patching Small |
| | Spalling Joint |
| 0+200 – 0+300 | Linear Cracking |
| | Spalling Corner |
| | Patching Small |
| 0+300 – 0+400 | Patching Large |
| 0+400 – 0+500 | Linear Cracking |
| | Divided Slabs |
| | Patching Large |
| 0+500 – 0+600 | Patching Large |
| 0+600 – 0+700 | - |
| 0+700 – 0+800 | Linear Cracking |
| | Spalling Joint |
| | Divided Slabs |
| 0+800 – 0+900 | Linear Cracking |
| 0+900 – 1+000 | Patching Large |
| 1+000 – 1+100 | - |
| 1+100 – 1+200 | Divided Slabs |

Source: Analysis Results, 2025.

The table shows the type and number of damages in lane 1 of Gajah Mada at each stationing. There are 39 damages along lane 1 with the most damage type being Linear Cracking spread across 16 points.

The types of damage on lane 2 of Gajah Mada Street are shown in the following table.

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**Table 2.** Type of Damage on Lane 2 of Gajah Mada Street

| Sta | Type of Damage |
|---|---|
| 0+000 – 0+100 | Linear Cracking |
| | Punchout |
| 0+100 – 0+200 | Linear Cracking |
| | Patching Small |
| | Patching Large |
| 0+200 – 0+300 | Linear Cracking |
| | Divided Slabs |
| | Patching Small |
| 0+300 – 0+400 | Linear Cracking |
| | Patching Large |
| | Divided Slabs |
| 0+400 – 0+500 | Linear Cracking |
| | Patching Large |
| 0+500 – 0+600 | Linear Cracking |
| | Patching Large |
| | Lane/Shoulder Drop Off |
| 0+600 – 0+700 | Linear Cracking |
| | Divided Slabs |
| | Patching Large |
| | Patching Small |
| 0+700 – 0+800 | Linear Cracking |
| | Spalling Joint |
| | Patching Large |
| | Patching Small |
| | Lane/Shoulder Drop Off |
| 0+800 – 0+900 | Patching Small |
| 0+900 – 1+000 | Linear Cracking |
| | Patching Small |
| | Patching Large |
| | Spalling Joint |
| 1+000 – 1+100 | Patching Large |
| 1+100 – 1+200 | Linear Cracking |

Source: Analysis Results, 2025

The table shows the type and amount of damage in lane 2 of Gajah Mada Street at each stationing. The most common type of damage is Linear Cracking which is spread across 52 points. The data was analyzed using the PCI and IRI methods.

The results of the data analysis obtained using the PCI method are presented in the table below.

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**Table 3.** PCI Value of Gajah Mada Street

| Sta | PCI Value | Description |
|---|---|---|
| 0+000 – 0+100 | 72 | Very Good |
| 0+100 – 0+200 | 79 | Very Good |
| 0+200 – 0+300 | 64 | Good |
| 0+300 – 0+400 | 64 | Good |
| 0+400 – 0+500 | 55 | Medium |
| 0+500 – 0+600 | 75 | Very Good |
| 0+600 – 0+700 | 81 | Very Good |
| 0+700 – 0+800 | 74 | Very Good |
| 0+800 – 0+900 | 93 | Excelent |
| 0+900 – 1+000 | 92 | Excelent |
| 1+000 – 1+100 | 94 | Excelent |
| 1+100 – 1+200 | 80 | Very Good |
| **Average PCI Value** | **77** | **Very Good** |

Source: Analysis Results, 2025

Road conditions are divided into several categories according to the PCI method. PCI value of 0-10 include Failed condition, PCI value of 11-25 include Very Poor condition, PCI Value of 26-40 include Poor condition, PCI Value of 41-55 include Fair condition, PCI Value of 56-70 include Good condition, PCI Value of 71-85 include Very Good condition, and PCI Value of 86-100 include excelent condition.[14]. The table shows the value of pavement condition in very good condition with a score of 77. Stationing with the lowest PCI value is stationing 0+400 – 0+500 with a value of 55, with a medium category. While the highest PCI value at stationing 1+000 – 1+100 with a value of 94, with a excelent category.

Source: Documentation, 2025

**Figure 4.** Linear Cracking Damage

Source: Documentation, 2025

**Figure 5.** Patching Damage

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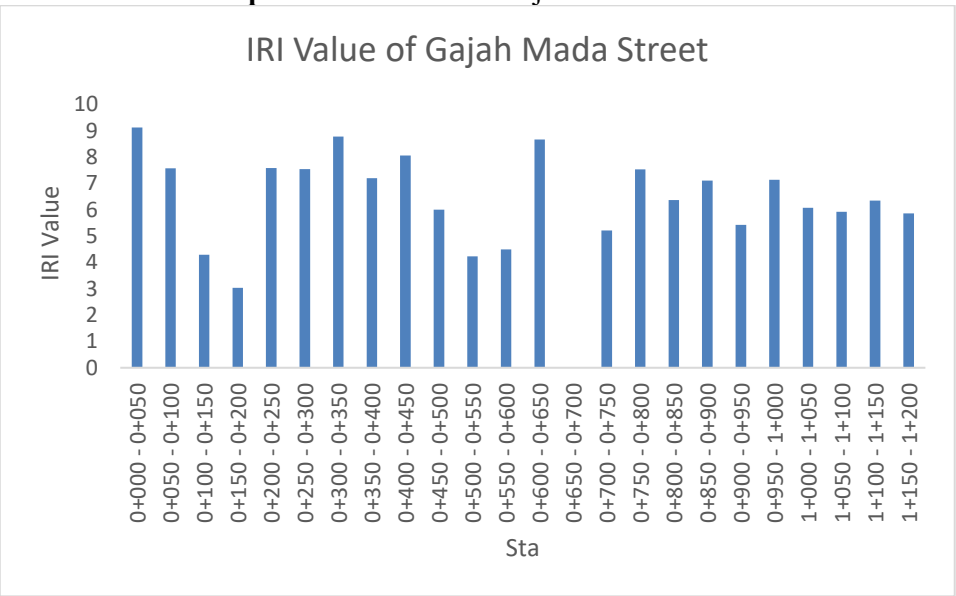
The results of data analysis obtained using the IRI method are presented through the following table.

**Graphic 1.** IRI Value Of Gajah Mada Street




Source: Analysis Results, 2025

Road surface conditions based on The International Roughness Index (IRI) values are classified info four categories. If the IRI value is less than or equal to 4 m/km, the road is in good condition. Values between 4,1 and 8 m/km indicate fair condition. A road is categorized as bad if the IRI value is in the range of 8,1 to 12 m/km, while an IRI value exceeding 12 m/km indicates a poor condition[15]. From the table above, the IRI value on Gajah Mada Street is 6.23 m/km which is included in the fair category. The result of the research on Gajah Mada Street in Tegal City showed that the average PCI value was 77, with a very good category. Meanwhile, the average *International Roughness Index* (IRI) value was 6.23 m/km, which was categorized as fair condition. On the other hand, the traffic volume on this road is relatively high, amounting to 7,160 55 smp/hour in lane 1 and 5,919,55 smp/hour in lane 2, with the dominance of two-wheeled vehicles. The Gajah Mada road pavement uses rigid pavement. Rigid pavement is a pavement structure formed form a concrete mixture, consisting of cement, sand, and coarse aggregates suchs a crushed stone, which can be reinforced with steel reinforcement or not, depending on design needs. In general, this pavement consist of subgrade, subbase, and Portland cement concrete slab with or without reinforcement.[16]. Concrete pavement was chosen because the road is traversed by vehicles with large loads and high traffic volumes[17]. This type of pavement has advantages over flexible pavement because rigid pavement can distribute the load over a large area of the subgrade[17]. In addition, rigid pavement are more resistant to heavy loads and have a longer road life than flexible pavement[18].

Concrete pavements are generally designed to withstand heave loads and high traffic volumes as they have sufficient stiffness to spread the load directly to the subgrade. However, the continuous high intensity of traffic can still cause a decrease in driving comfort, which is reflected in the increasing IRI values. Another indicator is the condition of the road surface, which is both structurally and functionally damaged[19]. The high volume of traffic generally leads to a decrease in the quality of the road surface, which is reflected in the increasing IRI values, although the PCI values still indicate that the visual condition of the pavement is relatively good. This also indicates that the visual damage is not yet severe, despite the high traffic load. The road is likely still in good structural condition or has undergone regular maintenance, thus preventing a drastic decrease in PCI. Locations with low PCI (stationing 0+400 – 0+500) may be prone to heavier traffic loads or more frequent large vehicle movements.

The same is true for the IRI values, where there are several stations that fall into the lightly damaged category. The high intensity of traffic, especially from large vehicles, triggers deformation of the road surface such as the formation of rutting or waves even though visually there is no significant damage.

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The difference between PCI and IRI values indicates that road surface unevenness (IRI) is more sensitive to the effects of high traffic loads than visual surface deterioration (PCI). Some road segment, suchs as at stationing 0-000 – 0+100 and stationing 0+400 – 0+500, show high IRI values (>8 m/km) although the PCI values in these segment are still classified as good to fair. This indicates that the road is still visually good, but is beginning to experience comfort issues due to vibration or unevenness, which are not immediately apparent from visual inspection. It also shows that although there is not much severe visual damage, the road surface has undergone deformations that can impair driving comfort.

The high IRI values in some segments may be caused by small deformations, uneven concrete joints, or patches that have begun to bump, which are common characteristics of early deterioration of concrete pavement under high traffic loads. The amount of pressure from daily traffic, including heavy vehicles, is one of the main factors for these deformation. Increased traffic loads lead to an increase in IRI values, resulting in a reduction in the planned life of the road and increased road maintenance costs.[20]. Road damage due to excessive load on the road can occur because the growth of vehicles is higher than the growth of the road[21]. High traffic volumes accelerate surface deterioration in the form of roughness (IRI) before visual damage (PCI) becomes severe. This reinforces that concrete pavements, although structurally sound, still need to be monitored regularly especially in the context of high traffic volumes. Therefore, the recommended treatment is routine/periodic road maintenance, so that their function in serving user need can be optimally maintained[22]. Additionally, recommended technical measures include light grinding (profiling) to reduce unevenness and local patching in areas of minor damage. Overlaying is not necessary at this stage because no major structural damage was found. Routine and periodic maintenance remains the primary step in maintaining road performance and long-term service life. Routine and periodic road maintenance activities aim to ensure user safety and comfort and maintain the structural durability of the road until it reaches its planned life and supports mobility[23]. In addition, maintenance is also carried out so that road infrastructure is still able to accommodate the growth in traffic volumes during the planned service period.

## 4. CONCLUSION

Based on the results of the data analysis, it can be concluded that Gajah Mada Street experienced various types of damage to the pavement layer. The damages found were Linear Cracking, Punchout, Spalling Corner, Patching Small, Pathcing Large, and Divided Slab. The analysis that has been carried out obtained the results of the PCI value on Gajah Mada Street is 77, this figure indicates that the condition where the pavement is in very good condition, while the results of the IRI value is 6.23m/km, where the road condition is included in the fair condition. This value can be used as an important reference for planning repairs or handling existing damage to the road. A comprehensive understanding of road conditions allows relevant authorities to formulate appropriate actions to sustainably maintain the quality of road infrastructure. As a recommendation, it is suggested that routine or periodic road maintenance be carried out. Recommended technical measures include light grinding (profiling) to reduce unevenness and local patching in areas of minor damage. Scheduled maintenance plays an important role in preventing further damage and ensuring that Gajah Mada Street is always in a proper condition to serve the mobility needs of the community.

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