Priority of provincial road maintenance in Kabupaten Aceh Besar based on analytic hierarchy process method

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Abstract. Road damage that has occurred on several roads has caused enormous losses, especially for road users, such as long travel times, congestion, accidents, and others. It is necessary to pay attention to this so that there is no deterioration in road quality due to road surface damage so that it can affect safety, comfort, and smoothness of traffic. Therefore, researchers examined road surface conditions, which can affect the travel time of the vehicle. The purpose of this research is to identify the type and level of road damage and to determine road-handling priorities. The results of calculating the condition of each provincial road section in the Aceh Besar District using the PCI method are included in the very good, good, and moderate categories, so that the type of handling can be determined is routine maintenance. From the results of the analysis of respondents by using Analytic Hierarchy Process (AHP), said that the priority road-handling by using several criteria, namely: the first order is the type of treatment with a weight of 0.47, then the second is the condition of the road with a weight of 0.37, then the third-order is accessibility with a weight of 0.12, and the fourth place is a land use with a weight of 0.04. As for the alternative road-handling priority obtained a score’s greatest at road Keutapang Dua - Mata le with the acquisition of a score of 0.34, then alternate both at road Batas Kota Banda Aceh - Sp. Lam Ateuk 0.32, the third alternative on road Ir. M. Thaher 0.26, for the fourth alternative on road Sp. Lamreueng-Sp. Cot Iri 0.06, the fifth alternative on road Kota Jantho-Alue Glong 0.011, the sixth alternative on road Bts. Banda Aceh-Blang Bintang 0.010, and for the seventh alternative on road Krueng Raya - Batas Pidie with a score of 0.003. The first priority for road handling based on an assessment of road conditions using the PCI method is road Krueng Raya - Batas Pidie section.

1. Introduction
Good transportation is a major supporting factor for determining the advancement of the economic growth of a region or country. Transportation is the lifeblood of the economy. The availability of good road transportation will provide services for vehicles that transport goods and can pass quickly, safely and comfortably to their destination. In addition to the construction of new roads, supervision and maintenance of existing roads must be carried out continuously so that they do not suffer damage before the calculated plan age has been reached [1].

Generally the cause of damage to the road there are many reasons that a design life on the road that has been passed, a puddle of water on the surface of the road that cannot flow due to drainage is not good, the traffic load recurring loads (overloaded) which causes the shelf life shorter paths of planning. Improper planning, inadequate supervision and implementation that is not in accordance with
existing plans. Apart from that, minimal maintenance costs, delays in budget expenditures and inaccurate priorities for handling are also the causes [2].

Road maintenance should be carried out regularly or periodically to keep pavement performance in good condition and avoid premature damage. The main objective of road maintenance is to maintain the infrastructure that has been built so that it is always close to its original condition (steady condition, i.e. good and moderate) in order to be able to provide optimal services to support regional social and economic activities [3].

As the condition of provincial roads in the Aceh Besar District, from year to year, it is always faced with the quality of road services. In general, the provincial roads in the Aceh Besar District have almost reached good condition, but in certain segments there are still road conditions that experience damage due to the increase in traffic volume and the large load of vehicles crossing the road, resulting in road damage that can be damaged. Interfere with the activities of road users.

Based on these conditions, this study assesses the existing conditions of the Provincial roads in the Aceh Besar District and can determine road handling priorities based on the level of importance of the criteria by using the decision-making method. This is due to the large number of roads that must be handled, both for road improvement and maintenance, while road management funds are very limited, it is necessary to set road handling priorities so that the allocation and use of limited funds becomes effective and efficient. The research method used to determine the priority scale of determination is the AHP (Analytic Hierarchy Process) method. The method is obtained from a ranking of the assessments given by respondents who are competent in the field of road management.

2. Research methodology

The location of this research is in the Aceh Besar District, the map of the Aceh Besar District can be seen in the Figure 1 to be precise on the provincial road section in the Aceh Besar District.

![Figure 1. Map of the research location](image-url)
connecting roads used for various accesses to locations both to government centers, education centers, shopping centers and tourist attractions. These roads can be seen in Table 1.

| No. | Road Section Name                                      | Road Length (Km) |
|-----|--------------------------------------------------------|------------------|
| 1   | Road of Batas Kota Banda Aceh - Simpang Lam Ateuk      | 4.99             |
| 2   | Road of Ir. M. Thaher                                 | 3.32             |
| 3   | Road of Keutapang Dua - Mata Ie                       | 3.17             |
| 4   | Road of Simpang Lamreueng – Simpang Cot Iri           | 4.42             |
| 5   | Road of Batas Banda Aceh – Blang Bintang              | 7.99             |
| 6   | Road of Kota Jantho - Alue Glong                      | 7.04             |
| 7   | Road of Krueng Raya – Batas Pidie                      | 33.44            |

In this study, the method used is the Pavement Condition Index (PCI) method to obtain road conditions to be handled in order to obtain the type of handling that will be carried out. Road conditions are obtained from the results of the Road Condition Survey on the road sections under review. After obtaining the results of road conditions and handling, then determining the type of road handling based on 4 (four) criteria using the Analytic Hierarchy Process (AHP) method. For data processing, the Microsoft Excel program is used for the Road Condition Survey data and data from distributed questionnaires. The steps for determining the value of conditions and types of handling can be described as follows:

a. The value of damage in the Road Condition Survey form that has been obtained is then carried out by calculating the Pavement Condition Index (PCI) for the road segment for each road damage with the help of the Microsoft Excel program where the assessment of the pavement condition is carried out according to the following formula:

\[ \text{Density} = \frac{\text{Ad}}{\text{As}} \times 100\% \]  

b. Deduct Value of each sample unit, enter the density percentage on the graph of each type of damage, then draw a vertical line to cut the severity of the damage (low, medium, high). Then a horizontal line is drawn and the deducts value (DV) is obtained.

c. Total Deduct Value (TDV) is the total amount of the reduction value of each sample unit or the total value of the individual deduct value of each type of damage and the level of damage that exists in a segment unit.

d. Corrected Deduct Value is obtained from the curve of the relationship between the TDV value and the CDV value by selecting the curve according to the number of individual deduct values that have a value greater than 2. The graph shows the relationship between the corrected deduct value (CDV) and the total deduct value (TDV).

e. The PCI value of each sample unit is calculated using the following formula:

\[ \text{PCI (s)} = 100 - \text{CDV} \]  
\[ \text{PCI} = \frac{\sum \text{PCI(s)}}{N} \]

As for solving the problems faced by using the AHP method, the following steps are necessary:

(a) Defining the problem and determining the desired solution;
(b) Creating a hierarchical structure starting with a general objective, followed by the criteria and alternatives;
(c) Create a pairwise comparison matrix that describes the relative contribution or influence of each element to each goal and criterion level above it. Comparisons are made by assessing the importance of an element with other elements;
(d) Perform pairwise comparisons to obtain a total judgment of \( n(n-1)/2 \), with the number of elements being compared;
(e) Calculating the eigenvalues and testing the consistency, otherwise the data collection must be repeated;

\[
\text{Wi} = n \sqrt{\text{Number of Rows}} \quad (4)
\]

\[
\text{Vector Eigen } (X_i) = \frac{W_i}{\sum W_i} \quad (5)
\]

In the pairwise comparison assessment, there is often inconsistency in the references provided by the decision-maker. [4] has proven that the consistency index of matrices of order \( n \) can be obtained by formulas:

\[
C.I = \frac{\lambda \text{ maksimum} - n}{n-1} \quad (6)
\]

\[
C.R = \frac{C.I}{RI} \quad (7)
\]

If the CI is zero, it means that the matrix is consistent. The inconsistency limit is measured using a random generator value (RI), as summarized in Table 2.

| n  | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 |
|----|----|----|----|----|----|----|----|----|----|----|
| RI | 0  | 0  | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.58 |

The value of the Consistent Ratio (CR) is smaller than 0.1, which means that it is smaller than 10%, then the value is in accordance with the consistency requirements, which must be less than 0.1 or 10%.

(f) Determine road handling priorities based on the value of alternative performance.

3. Results and discussion

Assessment of road conditions can be done by looking at the damage to the road surface. This assessment is carried out by calculating the percentage of damage along the road sections under review on provincial roads in the Aceh Besar District. The damage that is mined is crack, potholes, depression, edge cracking, and corrugation. The road conditions for each road segment can be seen in Table 3.

Provincial road in the district of Aceh Besar is more than 50% have a category of good condition, from the results of field observations, roads in good condition is a road Batas Banda Aceh - Simpang Lam Ateuk with PCI value 66, Road Ir. M. Thaher with a PCI score of 66, Road Keutapang Dua - Mata le with a PCI value of 58, Road Simpang Lamreung - Simpang Cot Iri with a PCI value of 67, and Road Kota Jantho - Alue Glong with a PCI score of 68. However, there are still road conditions with the medium category which is on the Krueng Raya - Batas Pidie road section with a PCI value of 67. The road of Banda Aceh - Blang Bintang is in very good condition with a PCI value of 75.
Table 3. PCI values

| No. | Road Section Name                  | PCI Value | Road Condition |
|-----|------------------------------------|-----------|----------------|
| 1   | Road of Batas Kota Banda Aceh - Simpang Lam Ateuk | 66        | Good           |
| 2   | Road of Ir. M. Thaher              | 66        | Good           |
| 3   | Road of Keutapang Dua - Mata Ie    | 58        | Good           |
| 4   | Road of Simpang Lamreueng – Simpang Cot Iri | 67        | Good           |
| 5   | Road of Batas Banda Aceh – Blang Bintang | 75        | Very good      |
| 6   | Road of Kota Jantho - Alue Glong   | 68        | Good           |
| 7   | Road of Krueng Raya – Batas Pidie  | 53        | Fair           |

In the Analytic Hierarchy Process (AHP) method, it begins with distributing questionnaires to several respondents, in this case it has been carried out to 8 respondents. The data collected from these respondents are primary data from questionnaires. The number of questionnaires distributed to 8 selected respondents. The questionnaire data were collected from 8 respondents who were directly involved in the maintenance of provincial roads in the Aceh Besar District.

The largest sample, 67% has a Masters in Engineering education, it causes a reliable mindset and understanding of the work. The distribution of questionnaires as many as 8 copies were carried out by giving directly to respondents. The figures given to the respondents' perceptions are a scale of comparison of each of the criteria and alternative factors.

Answers to the assessment on the "criteria", from the results of interviews with respondents by conducting questions in the questionnaire in determining the level of importance of the criteria, answers were obtained based on the scale / rating range given on the questionnaire sheet. The answers to each respondent's perceptions of the "criteria" are tabulated as shown in Table 4.

Table 4. Recapitulation of respondents answers to "criteria"

| Respondents | RESPONDENT PERCEPTION | A: B | A:C | A: D | B: C | B: D | CD |
|-------------|-----------------------|------|-----|------|------|------|----|
| R1          |                       | 2    | 3   | 3    | 2    | 4    | 3  |
| R2          |                       | 3    | 2   | 4    | 3    | 2    | 3  |
| R3          |                       | 2    | 2   | 4    | 3    | 2    | 2  |
| R4          |                       | 2    | 4   | 3    | 2    | 3    |    |
| R5          |                       | 2    | 3   | 2    | 3    | 3    | 2  |
| R6          |                       | 3    | 3   | 3    | 3    | 5    | 2  |
| R7          |                       | 3    | 3   | 2    | 3    | 2    | 3  |
| R8          |                       | 2    | 2   | 3    | 2    | 3    |    |

There are several criteria that influence the decision-making policy on road maintenance assessments. As for the criteria factors that influence the basis for selecting road maintenance are road condition, type of handling, accessibility and land zone. Weight of Assessment Criteria of each criterion were analyzed using the Analytic Hierarchy Process (AHP) method with the following steps:

- Step 1 Calculation of the initial matrix for the assessment "criteria"

Beginning with analyzing the data in Table 4, it is analyzed by inverse calculation according to the pairwise comparison matrix. The data is as complete as it is shown in Table 5.
Table 5. Pairwise comparison

| Respondents | RESPONDENT PERCEPTION |
|-------------|-----------------------|
|             | A: B                  | A: C | A: D | B: C | B: D | CD |
| R1          | 2.00                  | 2.00 | 2.00 | 0.50 | 4.00 | 3.00 |
| R2          | 3.00                  | 0.25 | 3.00 | 3.00 | 2.00 | 3.00 |
| R3          | 2.00                  | 2.00 | 0.25 | 4.00 | 0.50 | 0.50 |
| R4          | 2.00                  | 2.00 | 0.33 | 2.00 | 0.50 | 3.00 |
| R5          | 0.50                  | 2.00 | 0.20 | 3.00 | 3.00 | 2.00 |
| R6          | 3.00                  | 0.25 | 0.25 | 3.00 | 5.00 | 0.50 |
| R7          | 2.00                  | 0.33 | 2.00 | 0.33 | 2.00 | 0.33 |
| R8          | 0.50                  | 0.33 | 0.33 | 2.00 | 2.00 | 3.00 |
| Σ R         | 15.00                 | 9.17 | 8.37 | 17.83 | 19.00 | 15.33 |
| R / 8       | 1.88                  | 1.15 | 1.05 | 2.23 | 2.38 | 1.92 |

Information:
∑ R = the cumulative number of assessment comparison scales
R / 8 = Average comparison of ratings

Table 6. Initial "Criteria" Matrix

| Criteria | A   | B   | C   | D   |
|----------|-----|-----|-----|-----|
| A        | 1.00| 1.88| 1.15| 1.05|
| B        | 0.53| 1.00| 2.23| 2.38|
| C        | 0.87| 0.45| 1.00| 1.92|
| D        | 0.96| 0.42| 0.52| 1.00|
| Σ        | 3.36| 3.74| 4.90| 6.34|

• Step 2. Calculation of the Eigenvectors.

Table 7. Value Eigenvectors for determining the scale of the "Criteria"

| Criteria | A   | B   | C   | D   | total | Wi | E-Vector |
|----------|-----|-----|-----|-----|-------|----|----------|
| A        | 1.00| 1.88| 1.15| 1.05| 2.25  | 0.56| 0.37     |
| B        | 0.53| 1.00| 2.23| 2.38| 2.82  | 0.71| 0.47     |
| C        | 0.87| 0.45| 1.00| 1.92| 0.75  | 0.19| 0.12     |
| D        | 0.96| 0.42| 0.52| 1.00| 0.21  | 0.05| 0.04     |
| Σ        | 3.36| 3.74| 4.90| 6.34| 6.03  | 1.51| 1.00     |

• Step 3. Calculation of the “Criteria” Maximum Eigenvalues is obtained from the Initial Matrix from Table 6, which is multiplied by the E-Vector of each matrix indicated by Table 7, and then the product is added. This is shown in Table 8 below.

Table 8. "Criteria" Maximum Eigen Vector Matrix

| Criteria | A   | B   | C   | D   | E-Vector |
|----------|-----|-----|-----|-----|----------|
| A        | 1.00| 1.88| 1.15| 1.05| 0.37     | 1.89|
| B        | 0.53| 1.00| 2.23| 2.38| 0.47     | 1.60|
| C        | 0.87| 0.45| 1.00| 1.92| 0.12     | 0.53|
| D        | 0.96| 0.42| 0.52| 1.00| 0.04     | 0.12|
| Σ        | 3.36| 3.74| 4.90| 6.34| 4.13     |
• Step 4. Control of the Consistency Index (CI)
  
  \[
  \text{Consistency Index (CI)} = \frac{(4.13 - 4)}{(4-1)} = 0.038
  \]
  
  \[
  \text{Consistency Ratio (CR)} = \frac{0.043}{0.9} = 0.048 < 0.1 \text{ (consistent)}
  \]

• Step 5. Weighting Criteria. The weight of the element is obtained from the \textit{E-Vector value} which is expressed as a percentage as shown in Table 9.

| Criteria                  | Weight |
|---------------------------|--------|
| Road Condition            | 0.37   |
| Type of Handling          | 0.47   |
| Accessibility             | 0.12   |
| Land Zone                 | 0.04   |
| Total                     | 1.00   |

From Table 9 above, it can be seen that the respondent's assessment of several criteria shows that the criteria for road conditions have an influence on the level of importance namely with a weight of 0.37 (37%) then followed by the type of handling factor with a weight of 0.47 (47%), the accessibility factor with a weight of 0.12 (12%), and finally the land zone factor with a weight of 0.04 (4%).

The selected alternative is obtained by multiplying the total criterion weight with an alternative assessment or scoring. Table 10 displays a summary of the results:

| Criteria                  | Weight | x1    | x2    | x3    | x4    | x5    | x6    | x7    |
|---------------------------|--------|-------|-------|-------|-------|-------|-------|-------|
| Road Condition            | 0.373  | 0.119 | 0.097 | 0.125 | 0.023 | 0.004 | 0.004 | 0.001 |
| Type of Handling          | 0.468  | 0.149 | 0.122 | 0.157 | 0.029 | 0.005 | 0.005 | 0.002 |
| Accessibility             | 0.124  | 0.040 | 0.033 | 0.042 | 0.008 | 0.001 | 0.001 | 0.000 |
| Land Zone                 | 0.035  | 0.011 | 0.009 | 0.012 | 0.002 | 0.000 | 0.000 | 0.000 |
| Total                     | 0.319  | 0.261 | 0.335 | 0.061 | 0.010 | 0.011 | 0.003 |

By analyzing the criteria for the implementation of routine road maintenance using the Analytic Hierarchy Process (AHP) method, there are weights that indicate the ranking order of the criteria given by 8 respondents. The following is a weighting order of criteria which can be seen in Table 11 below.

| Criteria                  | Weight | Weights |
|---------------------------|--------|---------|
| Road Condition            | 0.37   | 2       |
| Type of Handling          | 0.47   | 1       |
| Accessibility             | 0.12   | 3       |
| Land Zone                 | 0.04   | 4       |

Table 11 shows that the criteria considered for the implementation of routine road maintenance are based on 8 respondents. These respondents are respondents who are directly involved in handling routine road maintenance. From the results of the analysis using the Analytic Hierarchy Process (AHP) method, it is known that the order that is considered in the selection of priority road handling is the 1st order is the type of handling with a weight of 0.47, then the second is the road conditions with a weight of 0.37, then the sequence third is accessibility with a weight of 0.12, and fourth is land zone with a weight of 0.04.
The results of the weighting of the criteria using AHP on 4 (four) criteria are carried out to determine the priority of road handling based on the results of a survey of respondents' perceptions showing that the type of handling criteria has the most influence in making road handling decisions. This is based on the calculation results shown in Figure 2, which shows that the handling specific gravity value has the greatest weight.

Based on the calculation results in Table 1, the results of the assessment of the alternative options analyzed using AHP can be explained as follows on road of Keutapang Dua - Mata Ie the weight gain is 0.34, then on road Batas Kota Banda Aceh - Sp. Lam Ateuk obtained a weight of 0.32, then road of Ir. M. Thaher 0.26, on road of Sp. Lamreueng-Sp. Cot Iri 0.06, road of Kota Jantho-Alue Glong 0.011, road of Batas Banda Aceh - Blang Bintang 0.010, and for road of Krueng Raya - Batas Pidie with a weight gain of 0.003. The results of the calculation of the assessment based on the respondents' perceptions indicate that the priority for handling of roads with the greatest weight value is on the road Keutapang Dua - Mata Ie. From the results of alternative analysis using the Analytic Hierarchy Process (AHP) method in selecting road handling priorities, as shown in Table 12.

Based on the results of the above analysis using the Analytic Hierarchy Process (AHP) method, it shows that of the 8 respondents who presented the opinion that the priority of road handling with this type of routine maintenance is better done especially on road Keutapang Dua - Mata Ie. This is because the respondent's choice of weight is the largest choosing road Keutapang Dua - Mata Ie with a weight of 0.34. Figure 3 shows that road of Keutapang Dua - Mata Ie has the highest weight compared to other provincial roads in Aceh Besar District.
Figure 3. Alternative weight sequence

4. Conclusion
On provincial road in the district of Aceh Besar based on observations by the method of Pavement Condition Index (PCI), the obtained results for all the roads under review is more than 50% have a good condition, but there are roads with category Area on the Krueng Raya - Batas Pidie road. The road of Batas Banda Aceh - Blang Bintang is in very good condition. Types of handling for provincial roads in Aceh Besar District are at the level of routine maintenance where the PCI values of each observed road segment are in the very good, good and moderate categories with PCI values ranging from 51 - 75. The results of the analysis of 8 respondents using the Analytic Hierarchy Process (AHP) method show that for the greatest weight of the criterion assessment, namely the type of handling with a weight of 0.47, then road conditions with a weight of 0.37, followed by accessibility of 0.12, and land zone of 0.04. Whereas for the alternative priority of road handling the highest weight was obtained on road Keutapang Dua - Mata Ie with a weight of 0.34, then the second alternative was on road Batas Banda Aceh -Sp. Lam Ateuk 0.32, the third alternative on road Ir. M. Thaher 0.26, for the fourth alternative on road Sp. Lamreueng-Sp. Cot Iri 0.06, the fifth alternative on road Kota Jantho - Alue Glong 0.011, the sixth alternative on road Batas Banda Aceh - Blang Bintang 0.010, and for the seventh alternative on road Krueng Raya - Batas Pidie with a weight gain of 0.003.

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