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Decision Support System Model Determines the Type of Road Construction in Indonesia

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Abstract. The road functions as an infrastructure of traffic movement and its performance can be assessed. It has mattered in performance, including durability, economic value, planned life, comfort, and flexibility. The roads can be damaged and require repairs to maintain performance. Handling road damage in Indonesia is still found to be a mismatch between planning and implementation. This research was conducted to assist decision-makers in determining the type of road construction in accordance with technical and non-technical factors. Factors used to assess eligibility in the selection of road improvements is the type of concrete construction or asphalt construction. This study intends to develop a decision support system to determine the type of road construction. The model was developed using Analytical Hierarchy Process method. The factors used in the model are the availability of resources, road surface comfort, weather resistance, ground movement, traffic conditions, and maintenance period. The results showing the technical factors have the highest weight resistance to weather (0.491), and non-technical factors are the availability of resources (0.667).

1. Introduction

The road is land transportation media that serve as a link between one region and another. Road conditions need to be maintained to provide comfort to the community. Roads are part of the national transportation system. Roads play an important role in supporting economic, social, cultural, environmental, political, defence and security. Handling damaged road infrastructure is arranged based on the scale of needs. In reality, there are discrepancies with the needs and plans which have been determined.

One of the factors causing discrepancies in the handling of damaged roads that policy makers are too dominant in determining project management. The policy is not based on objective considerations such as urgency and needs. As a result, many projects that should use a particular system or on a certain scale of priority can change to another system or other priority.

Decision making is a process of finding the best choice of all viable alternatives. Decision-making process is inseparable from the support of several factors, such as human resources and decision-making procedures. These factors are the components in a system. These conditions lead to the decision support system (DSS) [1]. In Asidik et al. [2], Decision Support System (DSS) is a system intended to support managerial decision-makers in semistructured and structured decision situations. DSS can provides various benefits and advantages, namely: DSS expands the decision-makers' ability in processing data/information for the users, DSS helps decision-makers to solve various problems, especially those very complex and unstructured problems, DSS can generate solutions more quickly, and the results are reliable, although a DSS, may not be able to solve problems faced by the decision-makers, but the DSS can become a stimulant for decision-makers in comprehending the problems occur because it is able to present various alternative solutions.

Based on these problems, it is necessary to develop a decision support system using scientific methods to help policymakers in deciding the handling of road projects. The scientific approach is carried out to reduce the element of subjectivity while increasing the objectivity of policymakers. Bernardo et al. [3] state that the scientific approach in the form of decision support systems helps decision-makers express information of different preferences interactively.

The scientific method that is commonly used is the analytic hierarchy process (AHP). AHP method is widely used in the field of decision making and management [4]. This study aims to apply the AHP in a decision system for the purposes of formulating and making decisions about the handling of road projects in government circles in Indonesia.

This study also aims to implement the AHP method in a model of decision support systems to help policymakers to make decisions objectively. Thus, the complexity and discrepancies in determining road construction can be reduced. The AHP method itself provides a way or pattern that every decision taken is based on tested criteria such as cost comparisons, durability of construction and in terms of qualitative assessments in the form of a comparison of comfort levels, environmental impacts, social impacts, availability of materials and equipment at the location, and methods and its implementation technology.

2. Hierarchy of decision-making

The hierarchy of the decision-making process with a hierarchy as shown in Fig. 1, decision makers use the same criteria without considering the score of each criterion [4].

AHP method is widely used in the DSS model [5], [6]. The decision making process using the AHP method is generally built on three principles [7]:

a. Principles of hierarchy

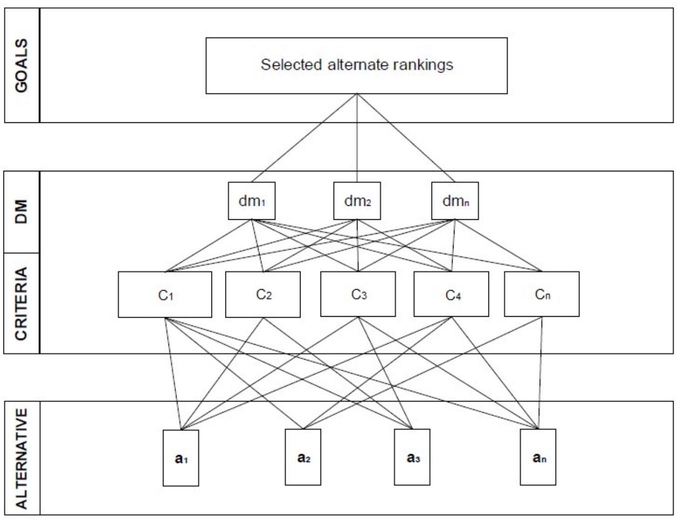

Figure 1. Structure of AHP hierarchy

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b. Principles of priority setting

Determination of priorities is done by comparing one element with another element into a matrix. This is called pairwise comparison. Comparisons like this are characteristic of the AHP method, which is to compare between a pair of objects [8]. The AHP comparison scale is in Table 1.

Table 1. Pairwise Comparison Scale

Level	Definition	Description
1	Equally of important	Both elements have the same influences
3	Rather more important one over the other	Experience and judgment favor one element more than the partner
5	Quite important	Experience and decisions showing preference for one activity more than anothers
7	Very important	Experience and decisions showing a strong fondness for one activity more than another
9	Absolute more important	One absolute element is preferred over its partner, at the highest level of confidence
2,4,6,8	The middle value between two adjacent values	When compromise is needed

The results of the elements that have been compared, then poured into a matrix. The matrix will undergo a normalization process using eigenvector. The iteration process lasts until the difference in the eigenvalues between the iterations reaches relatively small values. The matrix normalization process aims to find the order of priority. Application of the eigenvector method implemented by: (a) squares pairwise matrices by matrix multiplication operations, (b) add up each row, (c) normalize the matrix, (d) perform iterations of steps 1 to 3, until the difference in eigenvalues between the two iterations is relatively small.

c. Principle of Consistency

The use of AHP is measured by the amount of consistency ratio (CR). CR is the result of a comparison between consistency index (CI) and radom index (RI). If the CR result is <= 0.10 then the degree of consistency is optimal. Preferably, if the CR is> 0.10 then there is inconsistency in determining the comparison, which allows the solution resulting from the AHP method to be meaningless [9], [10]. The Consistency Ratio is obtained by the following steps [10], [11].

1. Calculate λ max

$$\lambda\text{max} = \sum_{i=1} \left\{ \left[\sum_{j=1}^{n} a_{ij} \right] \text{x } w_i \right\} \quad (1)$$

2) Calculate the consistency index *(CI)*

$$CI = \frac{\lambda\text{max} - n}{n - 1} \quad (2)$$

In equation (2), *CI* is consistency index and n is the number of criteria.

3) Calculate the Consistency Ratio *(CR):*

$$CR = \frac{CI}{IR} \quad (3)$$

In equation (1), a is a matrix, and w is a matrix of eigenvalues in row format. Otherwise, In equation (2), *CI* is consistency index and n is the number of criteria, and in equation (3), CI is a Consistency Index, and IR is a Random Consistency Index. Then, the Random Consistency Index is in Table 2.

Table 2. Random Consistency Index

n	1	2	3	4	5	6	7	8	9	10
R1	0,00	0,00	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

3. Result, Analysis and Discussion

The weighting of technical factors in Table 3 indicate that the technical factors considered to be the most dominant to measure the feasibility between asphalt and concrete roads are the power factor to weather with a weight of 0.491. The second factor is resistance to ground movement with a weight of 0.347, and the third factor is resistance to traffic changes (0.162).

Table 3. Weight for technical factors

Number	Factors	Weight
1.	Weather resistance	0,491
2.	Resistance to ground movement	0,347
3.	Resistance to traffic changes	0,162

Table 4. Weighting for non-technical factors

Number	Factors	Weight
1.	Surface comfort of road	0,221
2.	Ease of development	0,123
3.	Duration of road maintenance	0,328
4.	Availability of resources and technology	0,328

In Table 4, showing that the most influential non-technical factors for assessing the feasibility of a road are the time period of maintenance and availability of resources (0.328). The maintenance period is related to the speed or duration of a construction that needs repair. On the other hand, the availability of resources is mainly related to the availability of funds. The another important factor to consider is the comfort problem of the road construction surface (0.221). This factor is important because it relates to the comfort of the user after the construction is completed. The comfort factor is also more favored than the ease factor in development (0.123).

After assessing, what the factors are most considered in assessing a roadworthiness, it is next important to assess how far these factors determine construction choices. Roadworthiness is assessed based on a combination of technical, non-technical and cost factors. The results of the assessment of each factor are traced based on the weighting of factor 1 to factor 8, as shown in Table 5.

Table 5. Weight for all factors

Number	Factors	Weight		Ratio
		Concrete	Asphalt	
1	Weather resistance	0,86	0,14	6 : 1
2	Resistance to ground movement	0,86	0,14	6 : 1
3	Resistance to traffic changes	0,83	0,17	5 : 1
4	Road surface comfort	0,17	0,83	1 : 5
5	Ease of development	0,17	0,83	1 : 5
6	Duration of road maintenance	0,85	0,15	5,5 : 1
7	Availability of resources	0,33	0,67	1 : 2
8.	Cost	0,33	0,67	1 : 2

Table 5 showing that in terms of weather resistance, concrete construction is 6 times superior to asphalt, in terms of resistance to soil movement, concrete is 6 times superior to asphalt. It is also known that in terms of resistance to traffic changes, concrete is 5 times superior to asphalt, and in terms of road surface comfort factor, asphalt is 5 times superior to concrete. Table 5 also informs us that in terms of ease of construction, asphalt is 5 times superior to concrete, but in terms of the maintenance period, concrete is 5.5 times superior to asphalt.

In another part, in terms of resource availability, asphalt is 2 times superior to concrete, while in terms of cost, asphalt is 2 times cheaper than concrete. The highest value indicates the best criteria that must be considered to produce the most quality road repairs [12]. However, as stated by Fitouri et al. [13] that the best choice in a decision depends on the level of effectiveness of the decision rules used.

Table 6. The final eigenvector vector grading the feasibility of asphalt and concrete roads

Number	Type of construction	Weight
1.	**Concrete**	0,580
2.	**Asphalt**	0,420

The final assessment is traced from the weighting as listed in Table 5. In Table 5, the overall concrete construction is better than asphalt construction. This is indicated by the eigenvalues of concrete construction (0.580) higher than the eigenvalues for asphalt construction (0.420).

3.1. Further works
This research can be continued by developing DSS into collaborative DSS by involving stakeholder participation, as was done by Trisnawarman and Rusdi [14]. Collaborative DSS is a GDSS model by involving active participation from participants or parties involved in decision making (DM). These comprise: government/project initiators, the general public/end-users, pressure groups such as the NGOs and mass media, and all other project affected people [15].

4. Conclusion
The technical factor that has the highest weight is the weather resistance factor (0.491). This indicates that the weather resistance factor is the most important technical factor to assess the feasibility of a road-based construction. Meanwhile, non-technical factors that have the highest weighting is the availability of resources (0.667). This indicates that the resource availability factor is the most non-technical factor considered in the selection of roadworthiness.

Based on eight assessors, concrete construction is superior to 4 factors, namely weather resistance, resistance to soil movement, resistance to traffic and maintenance period with an average level of excellence of 6 times compared to asphalt construction. In contrast, asphalt construction excels at road surface comfort factors, ease of construction implementation, availability of resources and technology and costs with an average level of excellence four times compared to concrete construction. The results of a comparative analysis involving all the factors reviewed revealed that the average concrete road was superior to the asphalt road. This is shown from the weighting results for concrete construction reaching 0.580, while the weight for asphalt construction is only 0.420.

5. References

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