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Research paper

The choice of district road construction by the method of analytical hierarchy process and simple multi attribute rating technique

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Abstract

The choice of country road construction applying the method of Analytic Hierarchy Process and Simple Multi Attribute Rating Technique for the aim of the formulation and decision-making for the choice of road construction between flexible pavement and rigid pavement. The case study takes a road in the area of Poso, Center of Sulawesi, Indonesia. Data is taken by using a detailed questionnaire and distributed to respondents at random by 30 people. From the analysis of the obtained results are as follows as the selection of the path using the method of Analytic Hierarchy Process by weighting variables long-term durability and maintenance, the Simple Multi Attribute Rating Technique method by trading and cost benefit. Based on long-term durability, road construction should be resistant to weather is the first priority, and to resistant of traffic density and the road construction must be impervious to the ground shifting. Based on maintenance. The first priority is the path should be a period of excellent treatment and ease implemented of construction. Road construction to be used based on Analytic Hierarchy Process and Simple Multi Attribute Rating Technique is the flexible pavement. The weighting of the results seen from long-term durability and maintenance are obtained that the road asphalt has the highest weight value is 61.4% while the concrete path is 38.6%. The cost of the flexible pavement has a price of Rp. 365.788.000,-value benefit of/km is 61.40%, whereas for rigid path have a price amounting is Rp. 708.029.000,-value benefit of/km is 38.60%.

Keywords: *Durability; Maintanance; Analytic Hierarchy Process and Simple Multi Attribute Rating Technique.*

1. Introduction

Highways provision is from the government through several phases, which is as planning, procurement, implementation and maintenance. In process requires serious handling to be completed in accordance with cost, quality and time. At the stage of the procurement process to maintenance there is certainly a risk that occurs, therefore required risk management to overcome it. Based on data from the Central Bureau of Statistics (2015), road construction in Indonesia in 2015 has reached 523,974 km consisting of 301,385 asphalt roads and 222,589 km of non-asphalt roads. In the total 47,017 km of State Roads, provincial roads are 55,416 km and 421,541 km. In terms of road conditions, not all road lengths are in good condition, 42.20% of roads are in good condition, 23.31% of roads are in moderate condition, 19.78% of roads are lightly damaged and 14.71% of roads are nasty damaged. Based on data from BPS (2015) road conditions on district roads in Indonesia, 39% are in good condition, 22% are in moderate condition, 22% are lightly damaged, 17% are severely damaged. The condition of road damage is light and heavy enough almost 40%. Therefore, the government should be able to plan the construction of road pavement construction. In Planning of pavement construction infrastructure, whether for development, rehabilitation and improvement. Decision making in the selection of pavement construction is not enough only to consider the parameters of pavement construction planning such as road function, pavement performance, live of the plan, traffic that is the burden of road pavement, the nature of the land base, environmental conditions, and other factors. To determine the type of road construction to be used, Michael (1992) states the need to adapt the methods of pre-evaluation and selection of road projects against the specific conditions at hand. Wahyuni & Wiyata (2013) suggested using AHP (Analytic Hierarchy Process) method. In addition to using AHP there is another method that is SMART (Simple Multi Attribute Rating Technique). According to Kustiyaningsih (2015), SMART is a multi-attribute decision-making method. This multi-attribute decision-making technique is used to help stakeholders choose between alternatives. Each alternative consists of a set of attributes and each attribute has values, this value is averaged on a certain scale. Each attribute has a weight that describes how important it is compared to other attributes. Therefore, the authors are interested in researching the selection of road construction by using Analytic Hierarchy Process and Simple Multi Attribute Rating Technique. Theoretical review flexible pavement according to Suhendra (2014), pavement is a very important component in fulfilling the smooth movement of traffic. The road pavement currently used generally consists of three types, namely flexible pavement, rigid pavement, and composite pavement. Flexible Pavement is a pavement type that uses asphalt as a binder for pavement layers. The flexible pavement construction comprises layers placed on a solidified base soil. These layers serve as traffic load receptors and spread to the layer below them. The hot asphalt mix is a mixed combination of dense aggregates containing coarse, fine, and filler aggregates as main compositions and then added asphalt as a binder. The materials are then mixed and compressed in hot conditions at a

certain temperature to form a mixture that can be used as a pavement material on the road. Types of pavement using a hot asphalt mixture is a type of flexible pavement.

1.1. Costs

Cost in an implementation of the work certainly requires a fee. According to Hardianto (2015), the costs are all the places that need to be done for a production process, expressed in units of money according to the prevailing market price, neither of which has happened nor will happen. Financing is critical in an execution of the work, but there should be control of financing so that the budget has been set accordingly. According to Hardianto (2015), cost control is the final step in the management of project cost with the dress so that its costs and expenses in accordance with the established planning. Range of types of costs of implementing the work there are the direct costs and indirect costs.

1.2. Durability

According to Sukirman (2010), durability of asphalt concrete is the ability to receive traffic load as the weight of the vehicle and the friction between the wheels and the road surface, as well as hold the wear and tear due to the influence of weather and climate, like air, water, or temperature change. Sukirman (2010), describes that lifespan street plan is the number of years from the time the road opened to vehicle traffic until the necessary improvements that are structural (until the required overlay coating roughness). During the age of the plan the maintenance of road roughness remains to be done, such as a nonstructural layer serves as a lining worn. Age of plans for a new road roughness generally is taken by 20 years and for the improvement of the road by 10 years. Age plans greater than 20 years is no longer economically viable due to the development of traffic is too large and difficult to obtain sufficient precision (extra thick lining of the roughness causing the initial cost is quite high).

1.3. Maintenance (road maintenance)

Government regulations PU No. 13 (2011), stating that road maintenance is an activity handling the road, in the form of prevention, care and repair as needed to maintain the condition of the road in order to keep functioning optimally serving traffic so that the assigned plan age can be achieved.

According to Susandi (2016), maintenance can be classified based on the goals and program

a) Based on Objective

Based on the purpose of the maintenance can be divided into two, namely:

1) Prevention Maintenance is intended to reduce the rate deterioration in the way and prevent the onset of more severe damage. As well as maintaining the level of safety, comfort, tightness surface and continuity flow of traffic. Maintenance was carried out regularly on the damages that are light with broad deployment levels. In general the damage in the form of functional damage or structural damage such as cracked non smoother, wear out, obesity and other surface defects. Maintenance work is done on the surface layers without adding strength. Additional coats of the surfaces is considered not to have or add structural value way.
2) Repair or correction is performed to restore the power of the way, the level of safety, comfort and smoothness of traffic. These improvements aim to let any part of the road hard layer capable of running their structural function hold the burden of working her as planned, as well as restoring the section layers that suffered damage in order to be capable of such originally. This maintenance action performed on the roughness of the liner part suffered heavy damage. Damage can occur in the surface layers, layers of foundation, even to the ground base. The damage that require maintenance it is structural damage that requires repairs to add their structural capabilities. Repairs generally covers a limited area/local level in accordance with the conditions of the field. This fix is implemented on the site and extent of the damage that as hole, among others vanish, grooves and cracks together and other structural damage the hard layer. Repair of structural damage that occurs in layers of hard with the level of widespread deployment (the entire road surface) is not included in the category of maintenance again but is rehabilitation actions that can be done with reconstruction or with the method of recycling.

b) Based on the program

Based on the maintenance program can be clarified in two categories namely:

1) Routine maintenance is done constantly or continuously covering all maintenance and repair work done as treatment path. This work is done to control nuisance or damage layers and side streets such as cutting grass, cleaning the sediment and dirt drainage channel, clamp hole and so on. Activities undertaken included a small activity, because of the local nature where there is damage to the road.
2) Periodic maintenance is periodic or actions that have been planned at the time of the construction of new roads. Usually the granting of surface layers to maintain the quality of the surface layers of hard particularly flatness, skid resistance, as well as prevent damage to the further structure.

1.4. Analytical hierarchy process (AHP)

Yang at all (2016) Analytic Hierarchy Process to explain that (AHP) is a common method used to determine the criteria. AHP could measure the qualitative factors and assign weighting indexes. & Hadi Utomo (2011) stated that the Analytical Hierarchy Process (AHP) is a method developed by Prof. Thomas L. Saaty and published in 1980 can solve complex problems, for which the criteria and alternatives are taken pretty much. Also the complexity is caused by the structure of the issue unclear. AHP method is a technique of makers of decisions that incorporate double good criteria that is real and not real, quantitative as well as qualitative ones that take into account also the existence of conflict or differences of opinion. The application of AHP has expanded and not just used in engineering, management, and business. AHP also began to be known by analysts generally give support to the Government in determining its policies.

1.5. SMART (simple multi attribute rating technique)

SMART method is a SMART decision making multi attribute. This multi attribute decision making techniques used to assist stakeholders in selecting among several alternatives. Each alternative consists of a set of attributes, and each attribute has a value, this value is an average with a certain scale. Each attribute has a weight that illustrates how important it is compared to other attributes (Bidara, 2008).

With SMART attribute weighting is done in two steps:

a) Sort of interest a worst level of attributes to the best level.
b) Make a comparison of the ratio of the interest of each attribute with another attribute below.

SMART is more widely used because of its simplicity in responding to the needs of decision makers and how to analyze responses. The analysis involved is transparent so that this method provides a high understanding of the problem and is acceptable to the decision maker. Weighting at SMART uses a scale between 0 and 1, thus facilitating the calculation and comparison of values in each alternative.

2. Method

1) Description population

According to Arikunto (2010) defined population that is overall population is the subject of research. So is the population are individuals who have the same properties although the percentage of similarity it slightly, or in other words the whole of the individuals who will serve as the object of research .The population examined in this community are writing Poso as 30 people.

2) Sample

Arikunto (2010:174) gives the definition that "a sample is representative of the population partially or researched". Method of withdrawal of samples in this research is to use the method of withdrawal of samples Sampling of saturated or the census where all the population being sampled. The number of samples to be taken in performing the study was 30 people.

3) Research methods in this study

The authors used a quantitative research method. Quantitative research method is a method of research that focuses on the symptoms that had certain characteristics in human life which is named as a variable. In the quantitative approach, the nature of the relationships among the variables are analyzed using the theory of objective (Darmawan, 2013).

3. Data analysis techniques

a) Analytical Hierarchy Process method of AHP (AHP)

Proposed in this research aims to provide an assessment to the immeasurable measurable factors and sub factors that influence the decision of the selection of the type of road construction (Cement Concrete Road or Hot Mix).The selection of a methodology based on the characteristics problems and consideration of the advantages and drawbacks of the other methodologies. Researchers assess the importance of each criteria according to value pair criteria comparison. Final results of the AHP is a ranking or weighting of priorities from each of the alternatives a decision. The research in this study focus on the formulation of a model-based AHP to assess the type of road construction between Cement Concrete Road or the Hot Mix has good reasoning based on cost, long-term durability and maintenance. However the concept of development and the structure of the model that will be developed will be put in place for the selection of the type of road construction to another if desired. Fundamentally, there are three steps in the model of AHP: build hierarchy, judgments, and synthesis of priorities.

b) Establishment of the Hierarchy

In this section introduced a conceptual approach to the assessment of the appropriateness of the type of road construction by using the model of AHP. In the model proposed in this study, there are at least 3 levels of hierarchy is as follows:

1) Level I: Objectives of the decision to be taken is placed at the top of the hierarchy. In this case the intended target is "the selection of road construction in Poso."
2) Level II: On the second level, the proposed assessment criteria of cost, long-term durability and maintenance.
3) Level III: On the third level of proposed alternative types of road construction that can be applied on a road in poso, namely Cement Concrete Road and Hot Mix.

c) Assessment or Scaling

Assessment or scaling is done according to the level of significance of each criterion or element in the AHP structure. The level of significance of each criterion is divided into two types: the level of significance between the criteria and the level of significance between the criteria and the alternatives. The level of significance between criteria can be determined on the basis of the researcher's consideration (subjective) or by expert judgment (survey). While the significance level between the criteria and the alternative is obtained from the results of the primary survey using interview or questionnaire method with selected respondents. The results of this assessment are further scaled to convert from qualitative to quantitative assessment.

d) Weighted Calculation Process

The weighting procedure is established by using a search model of the eigenvalues of a matrix for each criterion level. Eigenvalues are obtained by normalizing the matrix. The description of how the matrix normalization to obtain eigenvalues is further explained. At least in this study there are 9 pieces of matrix pair pairwise comparison). From each matrix will result in weighting at each level. The weight of each level will be the input for the next level until the final weighting is obtained.

e) Consistency Index Calculation (CI) and Consistency Ratio (CR)

The consistency index is calculated using the following formula:

$$\mathrm{CI} = \frac{\mathrm{E_{max}} - \mathrm{n}}{\mathrm{n}-1}$$

Note:
Emax = the maximum eigenvalues of the eigenvectors
n = number of matrix orders
By using the CI value, then it can be calculated the value of consistency ratio, as follows:

$$CR = \frac{CI}{RI}$$

4. Results and discussion

The results of the assessment of the next question are recorded in tabular form. In the table input based on the results of the questionnaire that has been distributed.
To scale the answer the negative number to indicate the selected factor is the left, while the positive number to indicate the selected factor is the right.

Table 1: The Results of the Questionnaire Can Be Seen Below

RESULTS OF A ROAD USER'S QUESTIONNAIRE WITH ANALYTICAL HIERARCHY PROCESS (AHP) METHOD																					
Respondens for	Durability & Maintenance Effect															Effect of Durability on Asphalt Pavement (JA) and Rigid Pavement (JB)			Effect of Mantenage on Asphalt Pavement (JA) and Rigid Pavement (JB)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	1	2	3
1	-3	-3	-3	1	1	1	-3	-3	-3	1	-3	1	-3	1	-3	1	1	1	-3	-3	-3
2	1	-5	-3	1	1	1	-5	-3	1	1	-3	1	1	1	1	3	-3	3	1	-3	-3
3	1	1	1	1	1	1	1	-3	-3	-3	-3	-3	-3	-3	1	1	1	3	-3	-3	-3
4	1	1	1	-3	-3	1	-3	-3	-3	-3	1	1	1	-3	-3	1	1	1	-3	-3	-3
5	1	1	3	1	1	1	1	-3	1	1	-3	-3	1	1	-3	3	1	3	1	-3	-3
6	1	3	3	1	-3	1	3	1	1	3	-3	1	-3	-3	-3	3	1	1	-3	-5	-7
7	1	3	1	1	1	3	1	-3	1	3	-3	1	1	-5	1	5	3	5	-5	-3	-7
8	1	1	1	1	1	5	3	-5	-3	1	-5	-7	1	-3	1	5	1	3	-5	-7	-7
9	3	3	3	-3	3	3	-3	-3	1	-3	-3	-3	-3	-3	-3	-3	1	3	-3	-3	-3
10	1	1	3	-3	3	3	-3	-3	-3	-3	-3	3	-3	-3	1	1	1	3	-3	-3	-3
11	-3	3	1	1	1	1	-3	-7	-3	-5	-3	-3	-3	-3	-3	3	-3	1	-7	-7	-7
12	-3	3	5	1	1	3	-5	-5	-3	-3	-3	3	-5	-5	-3	-7	-5	3	-7	-3	-9
13	-5	-5	3	1	3	7	-5	-5	-3	3	-3	3	1	-3	3	-5	1	-5	-5	-5	-9
14	-3	5	5	-3	7	3	-3	-3	3	-3	-3	3	-5	-5	1	-9	1	-9	-9	-5	-5
15	1	5	3	1	-9	5	-3	-3	3	3	-5	1	3	-3	3	-9	-3	5	-9	-5	-9
16	7	3	-7	-7	-3	5	5	-3	3	1	-9	-3	5	-3	5	-9	1	3	-7	-3	-7
17	1	3	1	1	-3	7	9	-7	-3	3	-5	-5	5	-3	3	-5	-3	3	-9	-5	-5
18	-3	-3	5	1	-5	-7	3	3	-3	7	5	1	-3	3	-5	-5	-3	3	-5	-5	-9
19	1	-3	-5	-7	-3	7	9	-3	3	5	-3	3	5	-3	3	3	-3	5	-9	-7	-5
20	5	-3	-7	-5	1	7	3	-3	3	-3	-7	1	3	-3	5	-5	1	-3	-9	-3	-7
21	1	3	1	-3	3	5	-3	-3	-7	-5	-3	3	-3	-3	1	1	-3	1	-7	-7	-9
22	-3	-3	1	-7	1	7	-3	-5	3	3	-5	3	1	-3	3	-5	-3	3	-9	-5	-7
23	-3	-3	3	-5	1	7	3	-7	3	3	-5	3	3	-3	3	3	1	5	3	-7	-9
24	-3	3	5	-5	-3	3	3	-5	-3	5	1	3	-3	-3	-5	3	1	5	-5	-7	-7
25	5	3	1	-7	-5	3	5	-3	3	3	-7	-3	3	-5	-3	-9	1	-9	-9	-5	-9
26	3	-3	-5	1	3	3	-5	-3	-3	-5	-3	1	-3	1	5	3	1	3	-5	-3	-5
27	-3	3	5	-7	-3	3	1	-5	1	5	1	3	3	-3	-3	5	3	5	-3	-3	-3
28	-3	1	1	-3	1	1	-5	-7	-7	1	-5	-3	-3	-7	-5	3	3	3	-3	-7	-7
29	1	3	3	1	3	3	-3	-5	-3	-7	-7	-7	-7	-3	-3	7	5	5	-7	-7	-9
30	3	3	-3	-9	-7	3	3	-3	-3	3	-7	-3	5	-5	-3	3	3	3	-7	-7	-7

4.1. Weighting effect of durability and maintenance

Table 2: The Calculation Results Can Be Seen in the Following Table

Respondens	VARIABLE FOR CHOICE OF ROAD						ROAD	
	Clime (C)	Soil friction (PT)	Traffic density (KLL)	Steady road (JM)	Siplicity to implement (KPP)	Care of duration (JWP)	Aspalt pavement (JA)	Rigid pavement (JB)
1	0,350	0,194	0,158	0,101	0,970	0,101	0,555	0,445
2	0,318	0,216	0,094	0,116	0,100	0,156	0,554	0,446
3	0,191	0,225	0,231	0,132	0,109	0,113	0,525	0,475
4	0,255	0,201	0,206	0,160	0,089	0,089	0,564	0,436
5	0,187	0,195	0,245	0,152	0,114	0,108	0,455	0,545
6	0,096	0,129	0,356	0,218	0,105	0,096	0,576	0,424
7	0,145	0,154	0,284	0,199	0,072	0,145	0,453	0,547
8	0,249	0,320	0,168	0,095	0,052	0,117	0,468	0,532
9	0,135	0,241	0,351	0,082	0,057	0,135	0,513	0,487
10	0,240	0,213	0,260	0,082	0,057	0,149	0,506	0,494
11	0,287	0,207	0,303	0,068	0,063	0,072	0,668	0,332
12	0,253	0,099	0,403	0,063	0,049	0,132	0,813	0,187
13	0,429	0,070	0,113	0,097	0,050	0,241	0,810	0,190
14	0,140	0,097	0,361	0,060	0,048	0,293	0,815	0,185
15	0,910	0,073	0,231	0,434	0,036	0,134	0,869	0,131
16	0,770	0,366	0,049	0,317	0,03	0,161	0,658	0,342
17	0,162	0,179	0,124	0,385	0,054	0,097	0,76	0,240
18	0,158	0,043	0,128	0,314	0,314	0,043	0,75	0,240
19	0,093	0,113	0,043	0,473	0,05	0,226	0,764	0,236
20	0,094	0,367	0,057	0,19	0,034	0,258	0,678	0,322
21	0,186	0,255	0,372	0,094	0,064	0,03	0,599	0,401
22	0,259	0,095	0,104	0,186	0,032	0,324	0,781	0,219
23	0,183	0,083	0,110	0,290	0,033	0,300	0,458	0,542
24	0,164	0,048	0,385	0,255	0,053	0,094	0,464	0,536
25	0,060	0,214	0,185	0,414	0,033	0,093	0,767	0,233
26	0,260	0,332	0,076	0,051	0,071	0,21	0,511	0,489
27	0,174	0,049	0,257	0,349	0,048	0,123	0,488	0,512
28	0,371	0,166	0,268	0,097	0,041	0,057	0,761	0,239
29	0,182	0,274	0,368	0,041	0,048	0,087	0,281	0,719
30	0,098	0,231	0,144	0,439	0,03	0,057	0,555	0,445
MEAN (1-30)	0,247	0,182	0,214	0,198	0,097	0,141	0,614	0,386
	1	4	2	3	6	5	1	2

From table 2 it can be seen that included in durability is weather resistance, resistance to ground shifts, resistance to traffic density. While included in the maintenance is a steady road, ease of development implementation and maintenance period.
After calculated the weight, then searched average weight of each variable for easy to understand as in the picture below,

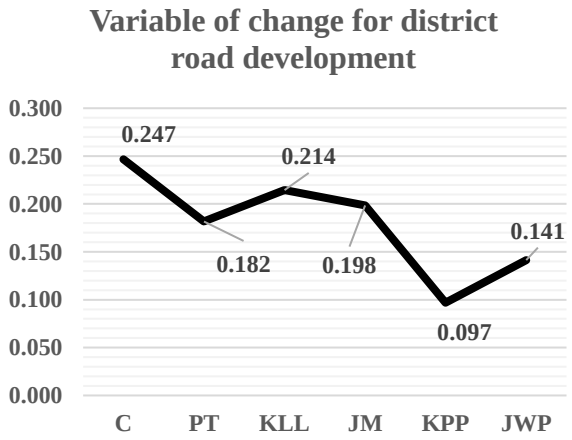

Fig. 1: Graphs the Change Variable of Weighting County Road Construction.

Fig. 1 we can explain the weights on Durability, as follows:
a) Durability to Weather (C) has a weight of 24.7%
b) Durability to Land Movement (PT) has a weight of 18.2%
c) Durability to Traffic Density (KLL) has a weight of 21.4%

While the weight on maintenance is:
a) The steady road (JM) has a weight of 19.8%
b) Ease of Implementation of Development (KPP) has a weight of 9.7%

4.2. Weighting effect of durability and maintenance on flexible pavement and rigid pavement

Weighting is done to know the flexible pavement weight and rigid pavement compared to the influence of durability and maintenance. For more details can be seen in figure 2 below:

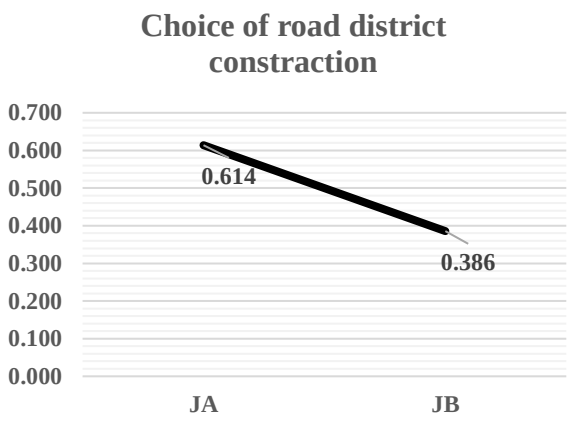

Fig. 2: Chart Weighting Macadam and Concrete Path.

Note:
JA; Flexible Pavement
JB: Rigid Pavement

The flexible pavement has the highest weight with the value of 61.4% while the weight for the rigid pavement is 38.6%. So, based on the durability and maintenance of roads should be built is the flexible pavement because it has a higher weight when compared with the rigid pavement.

4.3. Final assessment

In the final assessment stage the author uses SMART analysis to complete the calculation of the questionnaire results. Assessment is taken from the value of benefit (durability & maintenance) to trade with the cost value between flexible pavement and rigid pavement as in table 3 below,

Table 3: Benefit Aggregate

TRADING COST VS BENEFIT		
Choice of pavement	**COST (x1000)**	**BENEFIT AGGREGATE**
Aspalt pavement	**1500**	**61,4**
Rigid pavement	**2000**	**38,6**

In table 3 benefit aggregate obtained from the percentage flexible pavement weight and rigid pavement as for the cost obtained from the Cost Price Analysis (AHB) district Poso Year 2018. Then the results are made graphs to see the trading that occurred. The trading cost vs. benefit graph of asphalt pavement has a cheap price of Rp. 365,788,000, - with a high benefit value of 61.40 %, while for the rigid pavement has an expensive price of Rp. 708,029.000, - with low benefit value equal to 38,60 %. From the explanation can be concluded based on the comparison between trading cost with the benefit itself that, then the government of district Poso should build the flexible pavement.

5. Conclusion

From the results of the Study on the Selection of Regency Road Development Using Analytic Hierarchy Process (AHP) Method and Simple Multi Attribute Rating Technique (SMART), the following conclusions can be drawn:
a) The selection of road construction using the AHP method done by weighting the durability and maintenance variables. After getting each weights using SMART by comparing weights with cost (cost) and getting high weight and low price.
b) The criterion in the selection of road construction is
    1) Based on Durability
        a) Road construction must be Resistant to weather.

b) Road construction must be Resistant to traffic density.
c) Road construction should be Resistant to Ground Shifts.

2) Based on Maintenance
a) The first priority is the road must be steady.
b) The second priority is the maintenance period.
c) The last priority is the ease of development implementation.

c) Road construction that is used based on Analytical Hierarchy Process and Simple Multi Attribute Rating Technique is using asphalt pavement. The asphalt pavement has the highest weight with 61.4% value. While the weight for the concrete road is 38.6%. While the cost side of the flexible pavement has a cheap price of Rp. 365.788.000, - / Km with a high benefit value of 61.40%, while for the rigid pavement has an expensive price of Rp. 708.029.000, - / Km with a low benefit value of 38.60%.

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