International Journal of Civil Engineering (IJCE)
ISSN(P): 2278-9987; ISSN(E): 2278-9995
Vol. 6, Issue 3, Apr - May 2017; 1-12

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

DEVELOPMENT PRIORITY OF ROAD INFRASTRUCTURE THE ACEH POST TSUNAMI IN SIMEULUE DISTRICT

HAFNIDAR A. RANI

Research Scholar, Department of Civil Engineering, Faculty of Engineering,
University of Muhammadiyah Aceh, Bathoh, Lueng Bata, Banda Aceh City, Aceh, Indonesia

ABSTRACT

Road infrastructure is one of the strategic elements in supporting the development in addition in accelerating the activity; economic and facilitating inter regional of people mobilities. The improving of development activities require more adequate road networks. The ring roads in Simeulue District have the total length of 310 km spread in 5 (five) sub districts and divided into 7 (seven) road segments, they are (1) Sinabang - Nasreuhe, (2) Nasreuhe - Alafan, (3) Alafan - Seurafon, (4) Serafon - Lewak Hulu, (5) Lewak Hulu - Lhok Makmur - Sangiran, (6) Sinabang - Lugu Sibahak, (7) Lugu Sibahak - Sangiran. The road construction needs the appropriate decision making method in order to help the policy maker in determining the priority according to the needs and the benefits involving all stakeholders. Based on the research results using AHP Method, it is obtained the rank of the development priority of Simelue ring roads consecutively is (1) Lugu Sibahak - Sangiran, (2) Serafon - Lewak Hulu, (3) Lewak Hulu - Lhok Makmur - Sangiran, (4) Sinabang - Nasrehe, (5) Sinabang - Lugu Sibahak, (6) Alafan - Serafon, (7) Nasrehe – Alafan. The priority scale results can be compared that there are the differences of priority rank in Simeulues Ring Roads Development and Nasrehe Simeulue - Alafan and Lewak Hulu - Lhok Makmur – Sangiran Road segment become the main priority and the development will be implemented in 2015. AHP Method Analysis mentions that Nasrehe – Alafan road segment is in 7 rank and Lewak Hulu - Lhok Makmur – Sangiran is in 3 rank in the development.

KEYWORDS: Development Priority, Road Infrastructure, Post Tsunami, AHP Method

INTRODUCTION

The Growth and development of the city or region implicated to the population needs improvement, in addition to the increasing number of the population also has a major contribution to the population needs improvement. By the increasing of population needs, it will also increase travel demands human and goods/equipments movement activity improvements within an area or cily, in which this movement activity absolute requires inadequate transportation infrastructure and facilities both in quality and quantity. Transportation infrastructure development including road infrastructure and facilities, railway network infrastructure and facilities, river transportation, sea transpotation and and air transportation, all are aimed to meet the community needs with all of human and goods/equipments movement activities that accompany them.

Road is one means of traffic facilities that has important role in the success of a sustainable economic development program. Simeulue District area is one tsunami affected areas in 2004 as well as other areas in the Aceh Province. Area developments post tsunami are not spread evenly in every are, this problem raises some obstacles encountered in the road construction such as in Simeulue District. Wide areas that have to be handled, and community

centers scattered, the distribution of population and economic resources which are not spread evenly and community low income cause that it is required effective policy and planning in the road construction in that area. Besides that the other constrain which is very influential for the road construction in Simeuleue Dictrict is the limitation budget for road construction, so it must be specify in determining the right road construction priorities in decision making so that it is on the appropriate target in accordance with the needs and the benefits received.

For the road construction, it is required a right decision making method in order to help policy makers in determining the right priorities according to the needs and benefits involving all stakeholders. One of the decision making methods can be used is Analytical Hierarchy Process (AHP). This study purpose is to determine the road construction priority ranking in Simeulue District and to compare the results of the between Bina Marga (Highway Institution) and AHP method.

This study is limited to the decision making model arrangement using AHP methods with benefit and cost ratio techniques and in the road construction prioritization. From the phases conducted, it is obtained 7 (seven) road sections that are selected as the development priorities, they are (1) Sinabang - Nasreuhe; (2) Nasreuhe - Alafan; (3) Alafan - Seurafon; (4) Serafon - Lewak Hulu; (5) Lewak Hulu - Lhok Makmur - Sangiran; (6) Sinabang - Lugu Sibahak; and (7) Lugu Sibahak - Sangiran.

LITERATURE STUDY

Road Definition

According to Indonesia Law Number 22 of 2009, the road is a whole road sections, including the supplementary constructutions that are intended for public traffic, which is located under the ground level, above the ground level, under the water surface, and above the water surface, except railway and cable way. The road has a role to support the development in all development unit areas, in order to reach the development level inter areas. Road is one unity of road network system which binding and connecting the development center with other areas

Road Status

Based on The Law Number 38 of 2004 about the road, the road network system is a unity of the road sections that interconnecting and binding the growth centers and other areas which are located in their services influence in a hierarchical relation. Road based on its status is divided into its responsible authority of, they are:

- The National road is an arterial and collector road in the primary road network system connecting the province capital and national strategic road, also toll roads. The national road is the road that become the center government responsible
- The Province Road is an arterial and collector road in the primary road network system connecting the province capital and the district capital and province strategic road. The province road is the road that become the province government responsible.
- The District Road is a local road in the primary road network system connecting the district capital and the local activity center, inter local activity center and public road in the secondary road network system in the district area and and distric strategic road. The district road is the road that become the district government responsible.

- The Urban Road is public road in in the secondary road network system connecting the service center in the town, connecting the service center and plot, connecting inter plot, and also connecting the housing areas in the town.
- The Rural Road is public road connecting the areas and/or inter house in the village, and also village road

Road Priority Scale Determination based on Decree Letter Number.77 of Highways General Directorate, 1990

Methods from Highway General Directorate is district road planning guidelines issued by the Highways General Directorate as a reference in determining district road handling priority ranking (Highways General Directorate, 1990). In the annual program preparation, it is described some road handling priority ranking criterias (Decree Letter Number. 77, 1990 in module 6: task 5, pp. 5E-1 to 5E-2), namely:

- Main criteria used for the priority selection is benefits/feasibility (NPV)/km, by giving first priority to the project which has the highest of NPV/Km.
- Project evaluation code is also givento the projects with the range of NPV / Km for the choosing instruction

Priority Scale Determination using Analytical Hierarchy Process (AHP)

Suryadi and Ramdhani (2002) stated that the basic of decision making process is choosing an alternative. The main equipment of AHP is a functional hierarchy with the main input of human perception. By hierarchy, a complex and unstructured problems can be solved into groups. Then the groups are arranged into a hierarchy.

According Suyasa (2007), the matter to be concerned in the decision making thing is data collection period, in which the data is expected to be more approaching to the true value. The customer interest degree can be carried out by the pairwise comparison approach. For every criteria and alternatives, we have to perform pairwise comparisons which are comparing every other element in every hierarchy level in pairs so that the element interest level value can be achieved in the qualitative opinion. To quantify the qualitative opinion is used rating scale so that it will be obtained a qualitative opinion value.

Analytical Hierarchy Process (AHP) Model in Benefits and Cost Analysis

Permadi (1992) stated that, the calculation of the benefit and cost analysis recently is performed by the financial analysis method which emphasizes the discount rate and the present value. If the difference between the present value of benefits and costs are calculated separately and the value is more than zero, then the project is feasible to conduct. Likewise, if the ratio of benefits and costs relies on purely financial assessment, it has big weakness which is not accounted the qualitative elements that affect the reality.

Benefits are positive or favorable things to one party while the costs are negative or unfavorable things to one party. Therefore, for optimal problem solving, it is required to be made two separate hierarchies in which one hierarchy is special to discuss the benefits of an action and other hierarchy will discuss costs arising from that action.

Hierarchy of benefits and costs can be shaped in accordance with the users' will, but must be guide to the principle that there should be hierarchies level which explains benefits and cost aspects separately. The local and global priorities calculation is exactly same with the AHP model in general where the end result of each hierarchy is a global priority weight of alternative-alternatives contained in the last level.

From the global priorities calculation, each element on the last level of each hierarchy will get two global priority vectors, in which one of the benefits hierarchy and cost hierarchy.

Pairwise Comparison Matrix

Suryadi and Ramdhani (2002) argued that the pairwise comparisons scale is based on the AHP fundamental values by weighting of value from 1 as important to 9 as very important. From the pairwise comparison matrix arrangement is produced a number of priorities which is the relative effects of elements numbers in the above level. Eigen vector calculation is calculated by multiplying the elements in each row and multiplying by n root, where n is the element. Then we perform normalization to unify the columns number which is obtained. By dividing each value by the total value, the decision maker can determine not only ranking priority in every calculation step but also the priority amount. Criteria were compared based on the opinions of every decision maker and then is determined the priorities.

Element Weight Calculation

According to Suryadi and Ramdhani (2002), the element weight calculation is done by using a matrix. In operating system sub topic there are operating elements 'n', they are operating elements such as A_1, A_2, A_3, ...A_n, then the comparison results of these elements in pairs will form a comparison matrix.

Pairwise comparisons start from the highest hierarchy level, where a criterion used as the comparison basis. A_n x n matrix is a reciprocity matrix. It is assumed there are elements, they are W_1, W_2, ... W_n in which will be assessed in comparison. Pairwise comparisons Value (judgment) between (W_i, W_j) can be presented as the matrix.

$$\frac{W_i}{W_j} = a(i,j) : i.j = 1,2,3,...n \quad \textbf{(1)}$$

Where, W = *Eigen Vektor*

W_i/W_j value with i, j = 1, 2, ..., n is explored from the participants, people who are competent in the analyzed issues. When the matrix is multiplied by the column vector W = (W_1, W_2, W_3....W_n), it will be achieved the relation such as:

$$AW = nW \quad \textbf{(2)}$$

Where, n = Matrix Size

W = *Eigen Vector*

If Matrix A is known and W value wants to be achieved, it can be solved through the below formula:

$$[A-nI]\ W = 0 \quad \textbf{(3)}$$

Where, n = Matrix Size;

I = Identity Matrix;

W = *Eigen Vector.*

The Equation 3 can produce a solution which is not zero if (if and only if) n is an eigen value of A and W is its Eigen Vector. After matrix Eigen Value of A comparison is obtained, such as λ_1, λ_2, ..., λ_n and based on Matrix A that is

uniqueness, ie a_{ii} = 1 with i = 1,2, ..., n, so: $\sum_{i=1}^{n} \lambda 1 = n$

Here all of eigen value is zero, unless that is not zero, ie the maximum eigen value. Then, if the assessment is done consistently, it will be obtained the maximum eigen value of A which value is n. To get W, it can be done by substituting the maximum eigen value price in the equation: AW = λ_{maks} W, then the equation 3 can be changed to:

$$[A - \lambda_{maks} I] W = 0 \quad \textbf{(4)}$$

Where, W = Eigen Vector;

I = Identity Matrix;

λ_{maks} = Maximum Eigen Vector value.

To achieved the zero value, it is required to set:

$$A - \lambda_{maks} I = 0 \quad \textbf{(5)}$$

Consistency Calculation in AHP Method

According to Suryadi and Ramdhani (2002), there will be some deviations from this relation on the real situation, so that the matrix is not consistently perfect. This can happen because it is not consistent in one's preference; the matrix consistency sample is shown in Figure 1.

$$A = \begin{vmatrix} & i & i & k \\ i & 1 & 4 & 2 \\ j & ¼ & 1 & ½ \\ k & ½ & 2 & 1 \end{vmatrix}$$

Figure 1: Matrix Consistency (Suryadi and Ramdhani, 2002)

Matrix A is consistent because :

Aij x ajk = aik ---- = 4 x ½ = 2

Aik x akj = aij ---- = 2 x 2 = 4

Ajk x aki = aji ---- = ½ x ½ = ¼

Random matrix is with a scale from 1 to 9 and its opposite as Random Index (RI). Random Index (RI) for each matrix order is shown in Table 1.

Table 1: The Relation between Matrix Size and Index Random Value

Matrix Order	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	1,49

Source: Suryadi and Ramdhani (2002)

Based on calculations using 500 samples, if the numerical decision taken randomly from a scale of 1/9, 1/8,.., 1, 2, ..., 9 will receive a consistency average to the matrix with different sizes. Comparison between CI and RI for a matrix is defined as Consistency Ratio (CR). For comparison matrix AHP model can be accepted if the consistent ratio value is not more than 10% or equal to 0.1

$$CR = \frac{CI}{RI} \leq 0,1 \text{ (OK)} \quad (7)$$

Where, CR = Consistency Ratio;

CI = Consistency Index;

RI = Random Index.

RESEARCH METHODOLOGY

Data Collection

Data collection Method is done by distributing questionnaires involving several stakeholders who are competent in the road handling in Simeulue District. To facilitate respondents in answering, the questionnaire is compiled in the scale interval of 1 to 9 based on the pair's preferences and by circling one of the numbers on the interval of the assessment provided, in which each scale shows criteria indicator interest level compared to the surrounding criteria indicator.

Data Processing and Analysis using AHP

This study uses benefit – cost ratio analysis techniques, so in this study is formed 2 (two) hierarchy models. The first hierarchy is a hierarchy related to the benefits (benefit) of the coad section in accordance with the criteria used and the second hierarchy is a hierarchy related to the cost. There are 4 (four) sub-criteria of benefit criteria used to establish ring road development priorities in Simeulue District, they are:

- Area Potency Development (PPW);
- Traffic Smoothness (KLL);
- Area Transportation Development (PTW);
- Travel Time Reduction (PWT);

For the cost criteria, there are 3 (three) sub criteria used to establish ring road development priorities in Simeulue District, they are:

- Investment Cost (BI);
- Operational and Maintenance Cost (BOP);
- Environmental Handling Cost (BPL).

Data analysis phases in this study are below:

- Data preparation is primary and secondary data collection, then analyzed in order to determine the criteria and sub criteria of the hierarchy model with the objective (focus) is 'ring road handling priority determination in Simeulue District' that is useful to know the data series to be assessed. This phase is Decomposition Process Phase;
- Getting an assessment score of the chosen roas sections for the criteria and sub criteria carried out by distributing questionnaires to the experts in inquiry. The inquiry is a written response from the expert to the listed questions (questionnaire) that has been distributed. Questionnaires were distributed to 27 (twenty seven) experts respondents by sending directly for one time only, then it is collected 23 (twenty three) questionnaires;

- Creating a pairwise comparison matrix for all criterias and sub criterias with the numbers that have been obtained from the respondents' data. In the pairwise comparison matrix process is assessed on the relative importance of two elements at a certain level in relation to the level above. This is the Comparative Judgment Process Phase;
- Conducting the synthesis process, in which every pairwise comparison matrix for every level is looked for the Eigen Vector to obtain local priority and finally obtained Synthesis of Priority Process;
- Consistency test is the result of every local priority in every criteria and sub-criteria tested in the following methods:
  - Multiplying the pairwise comparison matrix by preferences vector (local priority) for every criteria and sub-criteria in order to obtain a column matrix;
  - Calculating λ max that is the result of column matrix division by column matrix of local priority for every criteria and sub-criteria then summed and found the averaged;
  - Calculating the Consistency Index *(CI)*;
  - Calculating *Consistency Ratio* (CR), CR value may not be more than 10%, if necessary, the matrix must be revised. This is Logical Consistency Process Phase .
- Grouping the priorities of the seven roads sections related to the every criteria and sub criteria which have the highest priority. Then it is summed each of the seven road sections to obtain the whole priority ranking from the road sections.

RESULTS AND DISCUSSIONS

Benefit – Cost Criteria Analysis

Score or benefit criteria factors scale based on questionnaires distribution results starting from score 1 (as important as the benefits) to score 9 (very important benefits), it is obtained results from 23 (twenty three) respondents whose answers shown below.

Table 2: Benefit Criteria Weight

No.	Benefit Criteria	Score	Maximum Weight
1	Area Development Potency (PPW)	5	65 %
2	Traffic Smoothness (KLL)	6	61 %
3	Area Transportation Development (PTW)	8	70 %
4	Travel Time Reduction (PWT)	7	74 %
	Total	**26**	

Table 3: Cost Criteria Weight

No.	Benefit Criteria	Score	Maximum Weight
1	Investment Cost (BI)	8	70 %
2	Operational and Maintenance Cost (BOP)	5	65 %
3	Environmental Handling Cost (BPL)	4	57 %
Total		**17**	

Simeulue Ring Road Construction Benefit

The results show that the benefits that will be received by the community and the government if it is implemented the ring road construction in Simeulue is moderate to high (scores 6 and 7). Respondents' respons in benefit criteria can be observed in Table 4 below.

Table 4: Respondent Assessment Score Average to Road Benefit Criteria (Respondents = 23)

No.	Benefit	Criteria			
		PPW	KLL	PTW	PWT
1	Sinabang - Nasreuhe	6,57	6,57	6,57	6,22
2	Nasrehe- Alafan	6,65	6,70	6,65	6,39
3	Alafan - Serafon	6,13	6,13	6,09	5,83
4	Serafon - LewakHulu	6,22	6,26	6,30	6,04
5	LewakHulu - LhokMakmur - Sangiran	6,74	6,78	6,78	6,48
6	Sinabang - LuguSibahak	6,91	6,91	6,87	6,57
7	LuguSibahak - Sangiran	6,35	6,39	6,48	6,13
Average		**6,51**	**6,53**	**6,53**	**6.24**

Simeulue Ring Road Construction Cost

Investment Costs criteria (BI) according to the average respondents' interest level is 6.51 or in other words the respondents considered that the investment cost (BI) has the most important of benefit compared to other criterias. While the Environmental Controlling Cost (BPL) is the lowest important of benefit compared to the Investment Cost criteria (BI) and Operational and Maintenance Costs (BOP). Respondents' respons regarding cost criteria shown in Table 5 below.

Table 5: Cost Criteria Assessment Score Average to Every Road Section (Respondents = 23)

No.	Cost	Criteria		
		BI	BOP	BPL
1	Sinabang - Nasreuhe	6.52	6.00	5.22
2	Nasrehe- Alafan	6.70	6.17	5.26
3	Alafan - Serafon	6.17	5.52	4.78
4	Serafon - LewakHulu	6.26	5.74	4.91
5	LewakHulu - LhokMakmur - Sangiran	6.74	6.26	5.35
6	Sinabang - LuguSibahak	6.83	6.35	5.48
7	LuguSibahak - Sangiran	6.35	5.87	5.13

Simeulue Ring Road Construction Priority Scale

After being evaluated the benefit by using AHP Mown in Table 6 below.

Table 6: Benefit Criteria Score

No.	Benefit Criteria	Score
1	Area Development Potency (PPW)	0.0460
2	Traffic Smoothness (KLL)	0.1036
3	Area Transportation Development (PTW)	0.6367
4	Travel TimeReduction (PWT)	0.2137

From the assessment above shown that the highest score is Area Transportation Development (PTW) which score is 63.67%, it means that by being implemented Simeulue ring road construction will be significant benefits to the mobility/movement of goods/equipment and people from the sourrounding area of the roads.

Simeulue Ring Road Construction Priority Scale from the Scale Criteria

Assessment scores are presented in Table 7 shows that the highest score is Investment Cost of (BI) that is 78.42%, meaning that the investment cost in road construction work consisted of physic construction, land acquisition and others are very dominant. While the Environmental Controlling cost (BPL) is the lowest cost criterion value, it is 7.47% meaning the respondents judge that the Investment Cost (BI) and Operational and Maintenance Costs (BOP) is more important of the interests compared to Environmental Handling Cost (BPL).

Table 7: Cost Criteria Score

No.	Cost Criteria	Score
1	Investment Cost (BI)	0.7842
2	Operational and Maintenance Cost (BOP)	0.1411
3	Environmental Handling Cost (BPL)	0.0747

Total Benefit and Cost Criterias Priority Scales

Assessment scores are presented in Table 7 shows that the highest benefit criteria score is Sinabang - Lugu Sibahak Road Section that is 32.64%. Based on benefit criteria shows that Sinabang - Lugu Sibahak Road Section has the highest priority to be handled compared to other road sections. Meanwhile the lowest cost criteria assessment score is Alafan – Serafon Road Section that is 2.74%. It means that based on cost criteria shows that Alafan – Serafon Road Section has first priority compared to other road sections.

Table 8: Total Benefit and Cost Criterias Priority Scales of Each Road Section

No.	Road	Criteria Score	
		Benefit	Cost
1	Sinabang - Nasreuhe	0.1214	0.1164
2	Nasrehe- Alafan	0.1658	0.2243
3	Alafan - Serafon	0.0254	0.0274
4	Serafon - LewakHulu	0.0443	0.0364
5	LewakHulu - LhokMakmur - Sangiran	0.2365	0.2159
6	Sinabang - LuguSibahak	0.3264	0.3246
7	LuguSibahak - Sangiran	0.0802	0.0549

Road Contrustion Priority Criteria based on Benefit – Cost Ratio Criteria

In Table 9 shows that based on benefit - cost ratio, there are are 5 (five) road sections that have the benefit – cost ratio value is more that one (B/C>), thay are Lugu Sibahak - Sangiran, Serafon – Lewak Hulu, Lewak Hulu – Lhok Makmur - Sangiran , Sinabang - Nasreuhe, Sinabang – Lugu Sibahak Ring Road Sections. While there are two (2) other road sections, Alafan - Seurafon, Nasreuhe – Alafan, that have benefit – cost ratio value is lower that one (B/C<1).

Table 9: Construction Priority of Simeulue-Aceh Ring Roads

No.	Road Construction Priority Choosing	Benefit-Cost Ratio(B/C)	Priority Ranking	
			AHP	Bina Marga
1	Lugu Sibahak - Sangiran	1.4614	1	-
2	Serafon – Lewak Hulu	1.2169	2	-
3	Lewak Hulu – Lhok Makmur - Sangiran	1.0951	3	2
4	Sinabang - Nasrehe	1.0425	4	-
5	Sinabang – Lugu Sibahak	1.0057	5	-
6	Alafan - Serafon	0.9272	6	-
7	Nasrehe - Alafan	0.7390	7	1

DISCUSSIONS

Based on the analysis using Analytical Hierarchy Process (AHP), the construction priority in the rank are (1) Lugu Sibahak - Sangiran, (2) Serafon - Lewak Hulu, (3) Lewak Hulu - Lhok Makmur - Sangiran, (4) Sinabang - Nasrehe, (5) Sinabang – Lugu Sibahak, (6) Alafan - Serafon, (7) Nasrehe - Alafan. From the analysis mention that the priority scale determination of priorities can be compared, there are priority rank differences in some Simeulue Road Sectios such as Nasrehe - Alafan and Lewak Hulu - Lhok Makmur - Sangiran become the most priority to be carried out construction in 2015 Budgeting in accordance with Aceh Highways Institution.

CONCLUSIONS

Based Analytical Hierarchy Process (AHP), the most priority is the construction of roads Lugu Sibahak – Sangiran Road Section because this road section is very important for continuous traffic flow on Simeulue ring road network since Lugu Sibahak and surrounding areas are and also palm, clove, nut, cocoa, rubber, teak and Jabon plantation areas. Therefore, the traffic smoothness on Lugu Sibahak – Sangiran Road Section becomes very important in order to support commodities (goods) and people movements from and to Lugu Sibahak - Sangiran become smooth and comfortable.

Because the traffic smoothness in Simeulue is important to Simeulue District Area Development beside the budget limitation on the other hand, it is necessary to road infrastructure management institution of Aceh Province Government to consider AHP Method besides based on Highways General Directorate. The consideration is because AHP method can combine various aspects and criterias done by weighting based on the interest level so that the road construction priority ranking obtained can be more representative

REFERENCES

1. Anonymous. (1990). Petunjuk Teknis Perencanaan dan Penyusunan Program Jalan Kabupaten. Surat Keputusan No.77/KPTS/Db/1990. Dinas Pekerjaan Umum RI, Jakarta.
2. Anonymous. (1997). Manual Kapasitas Jalan Indonesia. Dinas Pekerjaan Umum RI, Jakarta.
3. Anonymous. (2004). Undang-undang No. 38 tahun 2004 tentang Jalan. Peraturan Presiden Republik Indonesia, Jakarta.
4. Anonymous. (2009). Undang-undang No. 22 tahun 2009 tentang Lalu Lintas dan Angkutan Jalan. Peraturan Presiden Republik Indonesia, Jakarta.
5. Anonymous. (2014). Daftar Usulan Rencana Kegiatan. PPTK Pembangunan Jalan dan Jembatan Wilayah XXI (Simeulue) Dinas Bina Marga Aceh, Banda Aceh.
6. Ayu, N.A.P. (2011). Penentuan Skala Prioritas Penanganan Jalan Kabupaten Di Kabupaten Bangli. Program Magister Teknik Sipil Universitas Udayana, Denpasar.
7. Fakrurrazi, T. (2010). Analisis Perbandingan Risiko Biaya Antara Kontrak Lumpsum Dengan Kontrak Unit Price Dengan Menggunakan Metode Analytical Hierarchy Prosess (AHP). Program Magister Teknik Sipil Universitas Syiah Kuala, Banda Aceh.

8. Mulyono, A. (2006). Teori Pengambilan Keputusan. Bumi Aksara, Jakarta.
9. Pamoto, T. (2004). Penentuan Prioritas Penanganan Jalan Antar Kota di Daerah Perkotaan Sumatera Utara. Program Pasca Sarjana Universitas Sumatera Utara, Medan.
10. Permadi, B. (1992). Analytical Hierarchy Prosess (AHP). Universitas Indonesia, Jakarta.
11. Sofyan, M.S, Ibnu, A.M & Firdasari. (2013). Penerapan Metode Analytical Hierarchy Prosess (AHP) dalam Penentuan Prioritas Penanganan Pemeliharaan Jalan Di Kota Banda Aceh. Jurnal Transportasi, Vol. 13, No. 2, 75-84.
12. Suryadi, K. & Ramdhani, M. A. (2002). Sistem Pendukung Keputusan, Suatu Wacana Struktural Idealisasi dan Implementasi Konsep Pengambilan Keputusan. Remaja Rosdakarya, Bandung.
13. Suyasa, D.G. (2007). Penentuan Skala Prioritas Penanganan Jalan Kabupaten Badung dengan Metode AHP. Program Magister Teknik Sipil Universitas Udayana, Denpasar.