SSRG International Journal of Economics and Management Studies
ISSN: 2393 – 9125 /https://doi.org/10.14445/23939125/IJEMS-V7I10P101

Volume 7 Issue 10, 1-7, October 2020
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Review Article

Analysis of the Implementation of Train Journey Emergency Response on Disaster-Prone Railway Line (Semarang Tawang - Alastua)

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Received Date: 22 August 2020
Revised Date: 27 September 2020
Accepted Date: 07 October 2020

Abstract *- Semarang Tawang* **-** *Alastua Railway Line is an area prone to disasters, especially subsidence, floods, landslides and robs. To overcome this, DAOP 4 anticipates by raising rails, constructing water reservoirs, and repairing drains. To determine alternatives in case of a trail travel emergency, it requires some simple and quick strategy. From the research, it was found that strategies for handling emergency conditions using the Analytical Hierarchy Process (AHP) method with a Saaty scale of 1 to 9 processed using Microsoft excel software, i.e., Evacuating Passengers to a Safer Location (0.323031303)>Reporting Incidents to the Control Center (0.225652305)>Requesting a helper train or transferring passengers to another mode of transportation (0.101579347)> Stopping another train at the station before the location of the emergency (0.099737045).*

Keywords **--** *Analytical Hierarchy Process, Railway Line, Emergency, Alternative Selection*

I. INTRODUCTION

(Bappeda Semarang Kota, 2017) Topographically, the city of Semarang consists of coastal areas, lowlands and hills. The coastal area is an area in the north bordering the Java Sea. The average annual rainfall is 2,790 mm, and temperature ranges from 23ºc to 34ºc. Semarang is a downstream area which becomes a runoff area of the river and causes flooding during the rainy season. Flood is an annual natural disaster that occurs in Semarang City. Flood risk cannot be completely avoided and must be managed. Besides troubling road users and local residents, floods can also disrupt train travel. Semarang Tawang Station is one of the stations in the northern part of Semarang City. The station which is located at an altitude of +2 meters is the largest station owned by PT Kereta Api Indonesia in the operational area (DAOP) 4 as well as the largest station in the city of Semarang and northern central Java. Semarang Station has never been spared from the floods that occur almost every year. Semarang Tawang Station has located ± 2 km from the north coast of Semarang, which makes Semarang Tawang Station prone to tidal flooding. Public facilities and railway operational facilities are also affected by the flood that train operations and passenger services are severely disrupted. Furthermore, the railway line between Tawang Station and Alastua Station are also prone to flooding because several fish ponds on the side of the route can submerge the route during the high rainy season. There is a need for regulations or alternatives that can handle the situation when natural disasters interfere with train travel.

The Aim Of This Research Is A) Analyzing The Implementation Of Standard Operational Procedures On Railway Emergency Response Systems In Disaster Prone Areas B) Analyzing Strategies That Can Be Applied By PT Kereta Api Indonesia In Handling Emergency Conditions Of Natural Disasters

II. LITERATURE REVIEW

A. Analytical Hierarchy Process (AHP) Method

Tadeusz (2011) Analytical Hierarchy Process (AHP) is a multicriteria decision making by solving the problem through its parts, arranging the parts in a hierarchy starting from the objectives of a relevant criterion, sub-criteria, and alternatives, giving value to subjective considerations about each variable and synthesizing various considerations to assign the highest priority.

B. Hierarchical Structure Arrangement

If a decision-making problem is to be resolved using the AHP method, the problem needs to be modelled as three general hierarchies, i.e. objectives, criteria (including sub-criteria below), and alternatives.

C. Pairwise Comparison Matrix

Pairwise comparison matrix is used to produce relative weights between criteria and alternatives. One criterion will be compared with other criteria in terms of how important it is to the achievement of the objectives above.

$$wi = \frac{\text{Comparison Matrix}}{\text{Number of Corresponding Column Matrix}} \quad (1)$$

Annot :
Wi : weighting value

D. Eigen calculations

In making decisions, it is important to determine the consistency because low consistency considerations are undesirable. This particular step is executed as follows; multiplying each value in the first column by the relative priority of the first element, the value in the second column with the relative priority of the second element and so on, adding up each row, the result of the sum of the rows divided by the corresponding relative priority element. Add the quotient above by the number of elements; the result is called (λmax).

$$\lambda = \text{rata} - \text{rata matrik normalisasi}$$

$$\lambda max = \sum_{i=1}^{n} \left(\frac{s12}{wi}\right) / n$$

Calculate Consistency Indeks

$$C1 = \frac{(\lambda max - n)}{(n-1)}$$

Annot :
λmax :*eigen value maximum*
n : matriks amount

E. Calculating the consistency ratio (CR)

CR value ≤ 10% for standard data consistency is acceptable, and if it exceeds 10%, the data is inconsistent. The formula used is:

$$CR = \frac{C1}{R1} \quad (5)$$

Annot :
CR : Consistency Ratio
RI : Random Consistency Index

F. Making Priority Ranking

The priority value arrangement is based on the highest value from the calculation results.

N	1	2	3	4	5	6	7	8	9	10
R1	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

III. RESEARCH METHODS

A. Methods Of Collecting Data

In writing this thesis, several data collection methods were used for both primary data and secondary data to obtain data completely and accurately. Primary data collection includes interview methods and direct field observations. Interviews were conducted to find out what had been done in handling the situation with the related operational officer as the subject. Observations are made to determine which infrastructure is affected by natural disturbances. The literature study method was also used to find references related to floods that occurred in Semarang, especially the Semarang Tawang-Alastua railway line. Complementary data is needed to assist research, including those obtained through data collection from companies.

B. Data Processing Methods

The method used to process the data is the Analytical Hierarchy Process (AHP). AHP is a method for solving complex, unstructured situations into several components in a hierarchical arrangement that gives subjective values about the relative importance of variables and determines which variables have the highest priority in order to influence the outcome of the situation.

C. Data Analysis Method

The data collected is analyzed using Microsoft Excel software program to make it easier to calculate the informative results; performing calculations ranging from pairwise comparisons of matrices to finally getting alternative results to deal with train journey emergencies.

IV. RESULTS AND DISCUSSION

A. Emergency Response SOP Analysis of PT. KAI

PT KAI holds standard operational procedures to handle emergency conditions of train travel as outlined in the PT KAI Directors Regulation concerning Standard Operational Procedures for Emergency Response Procedures for Train Journey Operational Disruptions caused by natural disturbances. In this regulation, natural disturbances are part of the Non-Railway Accident (NKKA) which can cause operational disruptions, the chaos in train travel, including floods, earthquakes, erosion, and landslides. Emergency response procedures for natural disturbances are regulated as follows:

1. Reporting Action
2. Security Measures
3. Safeguard Measures and Authority Responsibilities

In this regulation there are several shortcomings; there is the inexistence of standard operating procedure for emergency response during natural disaster which regulates journey of other trains that are disrupted due to the flood, including its passengers, as well as regarding passenger evacuation procedures. In addition, the regulation does not include tasks distribution of each employee in case of an emergency. The actions taken in dealing with an emergency are limited to initiation and improvisation from the employees due to lack of regulations.

B. Analysis of Disaster Prone Areas

From the data obtained, it has been reported which areas are prone to disasters in DAOP 4 Semarang. The difference in disaster risk is influenced by several factors, i.e. the elevation /sea level of the station/crossing, soil structure, and other natural conditions. Disasters that may occur in DAOP 4 Semarang include:

a) Landslides
b) Subsidence
c) Flood

The Semarang Tawang - Alastua railway line is prone to subsidence and also flooding. Along its railway line, there are several large ponds that are no more than 5 meters from the rail. This condition is very dangerous if it rains with high intensity and for a long time. Efforts have been made to elevate the track and to avoid it being submerged or affected by flooding like the previous years. However, elevating the railway doesn't mean that previous events won't repeat themselves because rainfall cannot be forecasted.

Picture Path Condition When Inundated by Flood

C. Analysis of Interviews with Related Station Heads

This interview was conducted to determine the extent to which the station prepares for a natural disaster. The target of this interview is the station head or related officers. There is no special team to handle emergencies at each station. A special team for handling emergencies is very important considering that the Semarang Tawang-Alastua railway line is prone to flooding. Simulation debriefing has been provided, but provisioning is not carried out on a scheduled basis. It should be that at least once a year, all employees are provided with a complete simulation and cover several emergencies. From the results of the interview, it was concluded that a simulation was needed when there was an emergency of a natural disaster because the two stations were located closest to the flood-prone location and the railway line was also right next to the fish ponds so that the existing operational facilities were mainly in prone areas.

D. Determining Alternative Emergency Response

PT KAI arranges procedures regarding trains emergency response in case of natural disturbances. In this study, the authors used an alternative emergency response system that has been implemented in the metro rail system in China, which aims to address optimal emergency response situations. The method used is the Analytical Hierarchy Process (AHP) to determine the required emergency response alternatives according to the opinion of the officer or experts in the field.

Hierarchy Chart

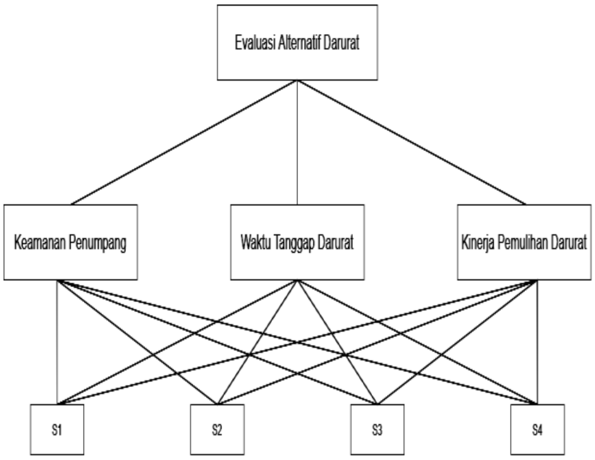

Table 1. Alternative Emergency Response

S1	Report the Incident to the Control Center
S2	Evacuate Passengers to a Safer Place
S3	Requesting a Rescue Train or Transferring Passengers to Another Mode of Transportation
S4	Stops Other Trains at Stations Before Disturbance Occurs

Table 2. Calculation Results of Expert Criteria 1

MATRIX OF COMPARISON CRITERIA (EXPERT 1)									
Criteria	K1	K2	K3	Normalization			Amount	Eigen	Rank
K1	1	3	5	0.652	0.692	0.555	1.900	0.633	1
K2	0.3333	1	3	0.217	0.230	0.333	0.781	0.260	2
K3	0.2	0.3333	1	0.130	0.076	0.111	0.318	0.106	3
Amount	1.5333	4.3333	9				3	1	

Matriks normalisasi K11 $= \frac{\text{Matriks Perbandingan}}{\text{Jumlah Matrik Kolom Bersesuaian}} = \frac{1}{1.5333}$ = 0.652

Matriks normalisasi K12 $= \frac{\text{Matriks Perbandingan}}{\text{Jumlah Matrik Kolom Bersesuaian}} = \frac{3}{4.3333}$ = 0.692

Matriks normalisasi K11 $= \frac{\text{Matriks Perbandingan}}{\text{Jumlah Matrik Kolom Bersesuaian}} = \frac{5}{9}$ = 0.55

Eigenvector = Rata-rata dari matriks normalisasi = $\frac{(0{,}652+0{,}692+0{,}555)}{3}$ = 0.633

λ max = $\sum$ Jumlah kolom normalisasi x eigenvector = (1.5333 x 0.633) + (4.3333 x 0.260) + (9 x 0.106) = 3.055361493

C1 = ((λmax-n))/((n-1))
= (3.055361493 – 3) / (3 – 1)
= 0.027680747

$CR = \frac{C1}{R1} = \frac{0.027680747}{0.58}$ = 0.04772540

In the same way, these calculations can be done to find the calculation results of the other criteria matrix. The calculation results of the expert criteria 1 matrix above show that Passenger Safety (K1)> Emergency Response Time (K2)> Emergency Recovery Performance (K3) as observed from the ranking of the eigenvector value.

Table 3. Calculation Results of Expert Criteria 2

MATRIX OF COMPARISON CRITERIA (EXPERT 2)									
Criteria	K1	K2	K3	Normalization			Amount	Eigen	rank
K1	1	3	5	0.652	0.6	0.714	1.966	0.655	1
K2	0.333333333	1	1	0.217	0.2	0.142	0.560	0.186	2
K3	0.2	1	1	0.130	0.2	0.142	0.473	0.157	3
Amount	1.533333333	5	7				3	1	

Table 4. Calculation Results of Expert Criteria 3

MATRIX OF COMPARISON CRITERIA (EXPERT 3)									
Criteria	K1	K2	K3	Normalization			Amount	Eigen	rank
K1	1	3	5	0.652	0.692	0.555	1.900	0.633	1
K2	0.333333333	1	3	0.217	0.230	0.333	0.781	0.260	2
K3	0.2	0.333333333	1	0.130	0.076	0.111	0.318	0.106	3
Amount	1.533333333	5	7				3	1	

Table 5. Consistency Test

Consistency Test	**Expert**		
	1	2	3
λ MAX	3.055361493	3.043174603	3.055361493
CI	0.027680747	0.021587302	0.027680747
CR	0.04772540	0.037219485	0.047725425

After making pairwise comparisons, the weighted criteria (eigenvector) is calculated by calculating the average value of the normalized matrix. From the three respondents, the three weight matrix criteria were produced, namely:

Table 6. Average Criteria Weights

Passenger safety(K1)	**0.640726**
Emergency response time (K2)	0.235915
Emergency recovery performance (K3)	0.123359

The results of the eigenvector are obtained from the average of each criterion eigenvector of the three respondents. The resulting priority decisions can be said to be consistent if they have a consistency ratio of not more than 0.1 or 10%. From these calculations, it is found that the comparison matrix is a consistent result. From these results, the ranking shows that passenger safety is more important than emergency response time, passenger safety is also more important than recovery performance and emergency response time is more important than recovery performance.

Table 7. Alternative Calculations Based on Expert Passenger Safety

Alternate	**S1**	**S2**	**S3**	**S4**	**Normalization**				**Amount**	**Eigen**	**Rank**
S1	1	1	3	5	0.39473	0.41666	0.32142	0.3571428	1.4899749	0.3724937	2
S2	1	1	5	5	0.39473	0.41666	0.53571	0.3571428	1.7042606	0.4260651	1
S3	0.33333	0.2	1	3	0.13157	0.08333	0.10714	0.2142857	0.5363408	0.1340852	4
S4	0.2	0.2	0.33333	1	0.07894	0.08333	0.03571	0.0714285	0.2694235	0.067355	3
Amount	2.53333	2.4	9.33333	14					4	1	

Matriks normalisasi S11 $= \dfrac{\text{Matriks Perbandingan}}{\text{Jumlah Matrik Kolom Bersesuaian}} = \dfrac{1}{2.53333} = 0.39473$

Matriks normalisasi S12 $= \dfrac{\text{Matriks Perbandingan}}{\text{Jumlah Matrik Kolom Bersesuaian}} = \dfrac{1}{2.4} = 0.41666$

Matriks normalisasi S13 $= \dfrac{\text{Matriks Perbandingan}}{\text{Jumlah Matrik Kolom Bersesuaian}} = \dfrac{3}{9.33333} = 0.32142$

Matriks normalisasi S14 $= \dfrac{\text{Matriks Perbandingan}}{\text{Jumlah Matrik Kolom Bersesuaian}} = \dfrac{5}{14} = 0.3571428$

Eigenvector = Rata-rata dari matriks normalisasi $= \dfrac{(0.39473 + 0.41666 + 0.32142 + 0.3571428)}{4} = 0.3724937$

λ max = $\sum$ Jumlah kolom normalisasi x eigenvector

= (2.53333x 0.3724937)+(2.4x 0.4260651)+(9.33333x 0.1340852) +(14x 0.067355)

= 4.160651629

C1 = ((λmax-n))/((n-1))

= (4.160651629– 4) / (4 – 1)

= 0.053550543

$$CR = \frac{C1}{R1} = \frac{0.053550543}{0.90} = 0.059501$$

In the same way, these calculations can be done to find the results of other alternative matrix calculations. The calculation results of the alternative expert 1 matrix above show that evacuating passengers to a safer place (S2)> Reporting the incident to the Control Center (S1)> Stopping other trains at stations before the location of the disturbance (S4)> Requesting a helper train or moving passengers to another mode of transportation (S3) as seen from the ranking of eigenvector values.

Table 8. Alternative Calculations Based on Expert Passenger Safety 2

Alternate	**S1**	**S2**	**S3**	**S4**	**Normalization**				**Amount**	**Eigen**	**Rank**
S1	1	0.33333	1	3	0.1875	0.17857	0.16666	0.3	0.832738	0.208184	2
S2	3	1	3	5	0.5625	0.53571	0.5	0.5	2.098214	0.524553	1
S3	1	0.33333	1	1	0.1875	0.17857	0.16666	0.1	0.632738	0.158184	3
S4	0.33333	0.2	1	1	0.0625	0.10714	0.16666	0.1	0.436309	0.109077	4
Amount	5.33333	1.86666	6	10					4	1	

Table 9. Alternative Calculations Based on Expert Passenger Safety 3

Alternatif	**S1**	**S2**	**S3**	**S4**	**Normalization**				**Amount**	**Eigen**	**Rank**
S1	1	0.33333	3	3	0.2142	0.1842	0.25	0.375	1.023496	0.255874	2
S2	3	1	7	3	0.6428	0.5526	0.5833	0.375	2.153822	0.538455	1
S3	0.33333	0.14285	1	1	0.0714	0.0789	0.0833	0.125	0.358709	0.089677	4
S4	0.33333	0.33333	1	1	0.0714	0.1842	0.0833	0.125	0.463972	0.115993	3
Amount	4.66666	1.80952	12	8					4	1	

Tabel 10. Consistency test

Consistency Test	Expert		
	1	2	3
ƛ MAX	4.160651629	4.129365079	4.172499702
CI	0.053550543	0.043121693	0.057499901
CR	0.059501	0.047912992	0.063888778

Tabel 11. Alternative Calculations Based on Emergency Response Time Expert 1

Alternate	S1	S2	S3	S4	Normalization				Amount	Eigen	Rank
S1	1	0.33333	3	0.33333	0.13636	0.125	0.3	0.125	1.023496	0.17159	3
S2	3	1	3	1	0.40909	0.375	0.3	0.375	2.153822	0.36477	1
S3	0.33333	0.33333	1	0.33333	0.04545	0.125	0.1	0.125	0.358709	0.09886	4
S4	3	1	3	1	0.40909	0.375	0.3	0.375	0.463972	0.36477	2
Amount	7.33333	2.66666	10	2.6666					4	1	

Table 12. Alternative Calculations Based on Emergency Response Time Expert 2

Alternate	S1	S2	S3	S4	Normalization				Amount	Eigen	Rank
S1	1	1	1	5	0.3125	0.39473	0.125	0.5	1.33223	0.33305	2
S2	1	1	5	3	0.3125	0.39473	0.625	0.3	1.63223	0.40805	1
S3	1	0.2	1	1	0.3125	0.07894	0.125	0.1	0.61644	0.15411	3
S4	0.2	0.3333	1	1	0.0625	0.13157	0.125	0.1	0.41907	0.10476	4
Amount	3.2	2.5333	8	10					4	1	

Table 13. Alternative Calculations Based on Emergency Response Time Expert 3

Alternate	S1	S2	S3	S4	Normalization				Amount	Eigen	Rank
S1	1	3	3	5	0.53571	0.4090	0.6428	0.4166	2.00432	0.50108	1
S2	0.33333	1	0.33333	3	0.17857	0.1363	0.0714	0.25	0.63636	0.15909	3
S3	0.33333	3	1	3	0.17857	0.4090	0.2142	0.25	1.05194	0.26298	2
S4	0.2	0.33333	0.33333	1	0.10714	0.0454	0.0714	0.0833	0.30735	0.07683	4
Amount	1.8666	7.3333	4.6666	12					4	1	

Tabel 14. Consistency test

Consistency Test	Expert		
	1	2	3
ƛ MAX	4.192424242	4.380131579	4.251370851
CI	0.064141414	0.126710526	0.083790284
CR	0.071268238	0.014078947	0.093100315

Table 15. Alternative Calculations Based on Expert Emergency Recovery Performance 1

Alternate	S1	S2	S3	S4	Normalization				Amount	Eigen	Rank
S1	1	1	1	5	0.31818	0.39473	0.125	0.5	1.33791	0.33447	2
S2	1	1	5	3	0.31818	0.39473	0.625	0.3	1.63791	0.409479	1
S3	1	0.2	1	3	0.31818	0.07894	0.125	0.1	0.62212	0.155532	3
S4	0.1428	0.3333	1	1	0.04545	0.13157	0.125	0.1	0.40203	0.10050	4
Amount	3.1428	2.5333	8	10					4	1	

Table 16. Alternative Calculations Based on Expert Emergency Recovery Performance 2

Alternate	S1	S2	S3	S4	Normalization				Amount	Eigen	Rank
S1	1	3	5	1	0.39473	0.6206	0.4166	0.2307	1.6628	0.4157	1
S2	0.3333	1	3	2	0.13157	0.2068	0.25	0.4615	1.0500	0.2625	2
S3	0.2	0.3333	1	0.3333	0.07894	0.0689	0.0833	0.0769	0.3081	0.0770	4
S4	1	0.5	3	1	0.39473	0.1034	0.25	0.2307	0.9789	0.2447	3
Amount	2.5333	4.8333	12	4.3333					4	1	

Table 17. Alternative Calculations Based on Expert Emergency Recovery Performance 3

Alternate	S1	S2	S3	S4	Normalization				Amount	Eigen	Rank
S1	1	1	3	1	0.3	0.375	0.25	0.1923	1.1173	0.2793	2
S2	1	1	3	3	0.3	0.375	0.25	0.5769	1.5019	0.3754	1
S3	0.3333	0.3333	1	0.2	0.1	0.125	0.0833	0.0384	0.3467	0.0866	4
S4	1	0.3333	5	1	0.3	0.125	0.4166	0.1923	1.0339	0.2584	3
Amount	3.3333	2.6666	12	5.2					4	1	

Table 18. Consistency test

Consistency Test	Expert		
	1	2	3
ƛ MAX	4.337912395	4.306954818	4.316923077
CI	0.112637465	0.102318273	0.105641026
CR	0.012535556	0.011368697	0.011737891

Table 19. Rank Result

Alternate	∑ Eigen	Mean	Rank	Alternate
S1	0.902609	0.30087	2	Report the Incident to the Control Center
S2	1.292125	0.430708	1	Evacuate Passengers to Safer Places
S3	0.406317	0.135439	3	Requesting a helper train or transferring passengers to other modes of transportation
S4	0.398948	0.132983	4	Stopping another train at the station before the location of the disturbance

After going through the hierarchical chart compilation stages, pairwise comparisons using the Saaty scale, calculating the alternative weight of the criteria, and calculating the consistency of the ratio, the next step which is the end of the AHP method is alternative ranking. Based on the above ranking, the appropriate alternative for an emergency response to train travel in disaster-prone areas according to the research is:

1. Evacuate passengers to a safer place
2. Report the incident to the control centre
3. Requesting a helper train or transferring passengers to another mode of transportation
4. Stop other trains at stations before the location of the disturbance

V. CONCLUSION

From the results of the analysis previously discussed, it can be concluded that:

1. Based on the results of the analysis through interviews it is concluded that the implementation of the SOP for Emergency Response for Railway Travel refers to the official regulation number 23 which includes reporting measures, security measures and responsibility for authority. In addition, DAOP 4 Semarang also anticipates the same disturbance by improving existing infrastructure, for example by building a water storage pool in front of the Semarang Tawang station, raising rails, and improving waterways more effectively.

2. The results of the calculation using the AHP method to determine the emergency handling strategy on the railroad track, it is concluded that, Evacuate Passengers to a Safer Place> Report Incidents to the Control Center> Request Rescue Trains or Transfer Passengers to Other Transportation Modes> Stop Other Trains at the station Before the location of the disturbance.

REFERENCES

[1] (Persero), P. K. (2017). Peraturan Dinas 23 (PD 23). Bandung.

[2] Agusta, Y. (2020, July 23). method A. Taken back from Analytical Hierarchy Process (AHP): https://yudiagusta.wordpress.com/2014/02/23/analytical-hierarchy-process-ahp/#:~:text=Analytical%20Hierarchy%20Process%20(AHP)%20adalah,menjadi%20kriteria%2C%20dan%20alternative%20pilihan.

[3] Sentot Patria. W. S, Ahmadi, Okol S Suharyo, Arica Dwi Susanto, "Performance Assessment of PT. X Automotive Companies Using Performance Prism and Analytical Hierarchy Process (AHP)" SSRG International Journal of Economics and Management Studies 5.8 (2018):24-31

[4] Kota, B. S. (2020, July 24). "Bencana Kota Semarang ". Taken back from http://bappeda.semarangkota.go.id/v2/

[5] Oleo, U. H. (2019). "Paper Writing instructions for the Symposium on inter-College Transportation Studies Forum. Kendari".

[6] Tadeusz. (2020, Juli 22). Analytical Hierarchy Process (AHP). Taken back from https://idtesis.com/pembahasan-lengkap-teori-analytical-hierarchy-process-ahp-menurut-para-ahli-dan-contoh-tesis-analytical-hierarchy-process-ahp/

[7] Zhao, B. (2016). "Applying Hybrid Decision-Making Method Based on Fuzzy AHP-WOWA Operator for Emergency Alternative Evaluation of Unattended Train Operation Metro System." Beijing: Hindawi Publishing Corporation.

[8] Hari Boedi, Willy Artha Wirawan, Fadli Rozaq, Dadang Sanjaya Atmaja. (, 2020). "The Effect Of Quenching Media On Surface Treatment Process On The Rel UIC R42 (Union Internationale Des Chemins De Fer-42) Endurance". International Journal of Advanced Science and Technology, 29(6s), 1329 – 1336

[9] W.A. Wirawan et al., "The Effect Of Material Exposure Variations On Energy Absorption Capability And pattern Of Deformation Material Of Crash Box Of Three Segments". Journal of Physics: Conference Series 1273 (1), 012081, 2019. doi:10.1088/1742-6596/1273/1/012081.