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Simulation of The Backpropagation Method on Durability Value Using Starbit Asphalt Against Soaking Time

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Abstract: Starbit is a kind of celestial object elastomeric polymer asphalt that has been given additives. The advantages Starbit Asphalt are that it has high resistance to temperature and deformation and has good adhesion and cohesion. The purpose of this research is to calculate the durability value and try to use simulation. The research methodology encompasses simulating the backpropagation method and performing an experimental investigation in a tightly controlled laboratory setting. involves conducting an experimental investigation in a controlled laboratory setting. The durability testing encompasses different periods of time, such as thirty minutes, twelve hours, forty-eight hours, sixty-two hours, and ninety-six hours. The test results yielded an optimum asphalt content of 6.19%, which will be utilized for the production of durability samples. The test findings indicate that the durability value satisfies the criteria set by the 2018 Bina Marga Specification revision 2, which requires a minimum of 90% durability. Therefore, the material meets the durability requirements and can be utilized. After testing, the backpropagation method is simulated with stability values. The simulation results with the backpropagation method obtained the durability value with a maximum error value of 0.16% and the smallest value of -0.0068% error. So it can be concluded that the backpropagation method is considered capable of predicting durability values with an error of less than 50%. To obtain maximum results in further research, it is recommended to use.

Keywords: *Starbit PG 70 Asphalt; Backpropagation; Durability*

1. Introduction

Starbit PG 70 asphalt only is an elastic materials polymer asphalt which includes additives that enhance its durability compared to conventional asphalt. The advantageous characteristics of stabit PG 70 asphalt encompass being able to endure extreme temperature and deformation, in addition to it's powerful bond and cohesion [1]. In road pavement, the pavement layer used is AC-WC. The AC-WC layer itself is the top layer which in direct contact with the vehicle load. One of the causes of damage and decreased strength in flexible pavement is asphalt aging and the effects caused by temperature. One thing that influences the performance of the mixture is the durability value [2].Durability relates to the ability of concrete asphalt to endure the effect of traffic loads, like the load of vehicles and the contact within the wheels and the asphalt pavement. It includes damages produced by being exposed to various environmental and climate factors, such as water, air, and changes in temperature [3]. Several studies found in testing that the use and production of asphalt will continue to increase, where modified asphalt itself is asphalt that has been given additional ingredients that can be used in the field and while trying to simulate the backpropagation method on the durability value, it is able to predict the durability value being

tested. in the laboratory [4]. This research also carried out Marshall tests and immersion tests which benchmarked previous research by taking as an example a durability value of 94.82%. The data utilized in this study is data from immersion tests. The outcomes used of each immersion involve determining the durability value through the execution of the Marshall test. Additionally, the remaining stability value or durability value can be acquired [5] [6] [7]. Basically, the training itself is in the backpropagation method of three stages. They are as follows: Data has been entered onto the network's input (feedforward); error is computed and retreated properly; biases and weights are modified (adjusted) [8].

In feedforward, each data input unit (Xi) receives one input unit which is supplied to the hidden unit (Zj). Each hidden unit afterwards tracks and determines a few stimulations for the hidden unit (Zj). After that, each of the output unit (Yk) likewise determines the process of activating it (Yk) in order to develop and generate a response to the input given by the network. In relation to the instruction process, each outcome unit evaluative its degree of activation (Yk) to calculate it obtained incorrect activity value. The factor δk is calculated from the error. The coefficient δk the mechanism is employe to transmit an errir from the output to the preceding screen. The coefficient δj for the hidden unit Zj is computed using the identical method. The coefficient δk is employed to modify the weights connecting the layer that is hidden and the input layer. Following determinan all parameters, the weights of all layers are adjusted concurrently. The weights Wjk (from the hidden unit Zj to the output unit Yk) is done based on the factor δk and the activation Zj of the hidden unit Zj. Simultaneously, the weights Vij (from input Xi to hidden Zj) get modified based on the activation of factor δj and output Xi. The backpropagation architecture comprises three layers: the input layer, hidden layer and output layer. There is no computational procedure taking place at the input layer, however the signal gets sent to the hidden layer from the layer that receives the input. The hidden and output layers perform, calculations using weights and biases. The resulting some of these layers is determined by applying a certain activation function. This backpropagation algorithm uses the multiple binary sigmoid activation function because the expected result is between 0 and 1, so the process does not take long. The test was carried out using a mixture of asbuton where this research used varying soaking times, the duration periods are specifically half an hour, one day, forty-eight hours, seventy-two hours, and ninety-six hours [3]. With a durability test of 94.82%, it meets the minimum requirements of General Specifications Version 2 of 2018, namely 90% so that the pre-mixed Asbuton AC-WC mixture after hours of soaking the test sample is quite resistant to the effects of temperature and water. According to Setyarini, NL flexible floor covering, the layer of covering mixture is largely determined by the weather. Durability value can be described by the Index of retained strength (IRS), which is a comparison of the percentage of stability value in standard half an hour immersion with the stability value in modified immersion. namely one day hours, forty-eight hours, seventy-two hours and 168 hours in this study with a temperature of 60°C. This research is different from previous research in that this research used Starbit PG70 Asphalt to look for durability values for soaking time variations of half hour, one day, forty- eight hours, seventy-two hours and ninety-six hours. on AC-WC layer pavement and try to simulate it to predict durability values using artificial neural networks.

This research also utilizes the Matlab application to help solve problems in trying to simulate the results of durability data which will be used in predicting durability values using the backpropagation method simulation [9] [10].

2. Method

At the beginning of the testing phase, data was collected from several previous studies and also obtained data from manufacturers where Starbit modified asphalt was used. And using local materials used for this research as well as testing the Marshall test and also the immersion test by varying the soaking time at the same temperature. This research is not only in laboratory testing

but also uses a backpropagation method simulation where the tool used is Matlab [11]. The total data obtained from the results of this test is 8 data. Data analysis methods This research uses 2 (two) methods, namely testing in the laboratory and modeling using ANN Backpropagation using the Matlab program.

2.1 Approximation Equation

After the data was obtained, analysis of the Marshall test and immersion test was carried out using an approximation derive formula based on the outcome of the Marshall test and immersion test, employing diverse methodologies.

This research collected 7 equation data which are often used for testing the Marshall test and also the immersion test. The form of the formula used in this research is :

$$\textit{Index of Retained Strength} = \frac{S2}{S1} \text{x } 100$$

This research uses the following specifications Aggregate testing SNI 1969 : 2016, SNI 2417 : 2008, asphalt testing SNI 06-2434:2011, SNI 2432:2011. Mixture Planning with several components This mixture consists of coarse aggregate, fine aggregate and bitumen which will be checked before use. It establishes the characteristics of the material being examined, regardless of whether the required material is mentioned or not. Upon finishing the examinations of both rock and asphalt.

2.2 Algoritma Backpropagation

The backpropagation method is one of the methods used in the simulation process to create artificial neural networks. According to Andriyani, S. and Sihombing, N., (2018), there are basics, training using the backpropagation procedure consists of the following 3 steps:

1. Data is inputted into the network through the feedforward process (feedforward)
2. Computation and monitoring based on the specific fault at hand
3. Modify the weights and bias

The backpropagation algorithm employed in training artificial neural networks with a single hidden layer (with a binary sigmoid activation function) is outline as follows:

X^'=(0.8(x-a))/(b-a)+0.1

Step 1: If the termination requirements are not met, steps 2-8 are executed
Step 2: Execute steps 3-8 for every set of training data utilized. Phase I: Propagate forward
Step 3: Each unit is required to receive the signal and transmit it to the unit directly above it in a cover manner
Step 4: Compute the values of all concealed first output data z_j (j=1,2 ,p).
Step 5: Compute the collective network outputs as a single output y_k (k=1,2 ,m).
Step 6: Compute the error factor the error factor δ of the output unit based on the error in each output unit y_k(k=1,2. ,m)
δ_k is the error unit used when changing the weight of the underlying layer (step 7). Calculate the weight change term wkj (which will later be used to change the weight w_kj) at the acceleration rate α.
Step 7. Compute the hidden unit error factor δ based on the error of each hidden unit z_j (j =0,1, ,p).
Step 8: Compute the total weight change from the change in line weight in hidden units:

3. Result and Discussion

Before making samples, a material test is first carried out which aims to ascertain the properties and details of the material utilized. First, a property test is carried out, namely checking coarse,

fine aggregate, sand equivalent, and asphalt specific gravity. The materials used are crushed stone which comes from the base area, and fine aggregate which comes from 13 Koto Kampar. The results from several tests obtained results from the specific gravity of the aggregate, water absorption by the aggregate, and wear on the Los Angeles machine which met the specification requirements. In the asphalt test, the asphalt specific gravity result was 1.022%, which satisfies the specified standards. Below is a tabulated report detailing the findings of the asphalt inspection.

Tabel 1. Results of asphalt specific gravity inspection

Item	Specification	Hasil pengujian	keterangan
Specific gravity	>1,0	1,022	Fulfil
Penetration	-	48,7	Fulfil
Softening point	-	49,5°C	Fulfil

In the aggregate gradation test, the aggregates are grouped into coarse, fine and filler aggregates which will be used in mixing it's visible in the graphic image provided

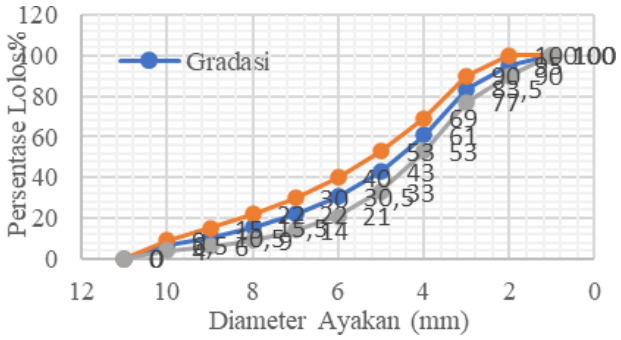

Fig 1. Aggregate gradation graph

The result of the test for the ideal asphalt content value can theoretically be determined using the following formula:

Pb = 0.035×(%CA)+0.045(%FA)+0.18(%FF)+K
Pb = 0.035 ×(57.66)+0.045(36.36)+0.18(5.98)+1
Pb = 2.018+1.636+1.0+1
Pb = 5.65% = 6%

From the results of ideal asphalt content calculations theoretically, the ideal asphalt content planned in the laboratory is 6% and one percent above with a range of 0.5 percent. The percentage of asphalt planned in the laboratory is 5%, 5.5%, 6%, 6.5%, 7%, 7.5% of the mixture weight. The Marshall testing carried out aims to obtain the values that exist in the Marshall. The results obtained include density, VMA, VFWA, VITM, stability, flow and MQ. From Marshall testing carried out using 6 variations of asphalt content, the optimum asphalt content was achieved at 6.19%. The OAC value is used to make samples to obtain durability values by utilizing Starbit asphalt with a variable immersion test. As for determining the ideal asphalt content value, the reference utilized to ascertain the ideal asphalt content for the mixture is Laston, specially the 2018 Bina Marga Specification Revision 2. The number was derived after analyzing the data acquired from the Marshall test. The optimal asphalt content value achieved was 6.19%. When establishing the ideal asphalt content, it is necessary to satisfy five specific criteria: VITM, VMA,

VFWA, stability and flow parameters. These five points must adhere to the standards provided in their respective provisions.

The technique used to get OAC values from the variables above is the Narrow Range technique and using interpolation to get the middle value of the VITM and Flow limits.

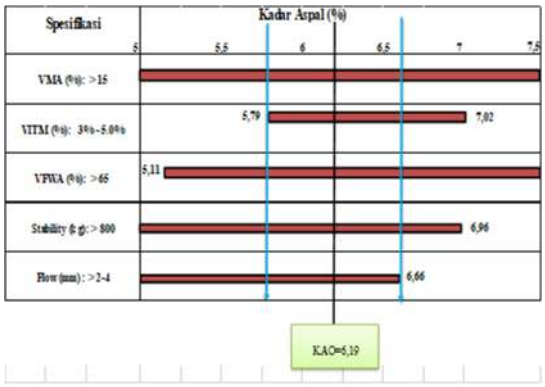

Fig 2. Optimum Asphalt Content graph

The results of the immersion test in the immersion test are several series of tests by immersing the sample or test object in a water bath. In its implementation, the immersion test is the same as the Marshall examination, but what makes the difference between the two is the immersion time of the test object in the water bath. Where in the Marshall test the time required for immersion is 30 minutes, while for this immersion test a variety of immersion times of half an hour, one day, forty-eight hours, seventy- two hours, and ninety-six hours are used. Using a fixed temperature of ±60°C. The test object used was starbit asphalt by varying the soaking time from half an hour, one day, forty-eight hours, seventy-two hours, and ninety-six hours. The total aggregate used is 1200 grams or the same as 36 grams. The results of the immersion test after being examined in the laboratory.

Tabel 2. Results of Immersion Test

Asphalt Content	Time	Condition	Durability	Result
6,19	30 minutes	90%	100	Fulfil
	24 hour		94,14	Fulfil
	48 hour		93,82	Fulfil
	72 hour		81,80	Not
	96 hour		81,66	Not

The results of this inspection show that the starbit asphalt test object meets the specification requirements within 48 hours with a durability value of 93.82% and meets the 2018 Bina Marga specifications, revision 2, where durability is >90%. Similar research that has been carried out in looking at durability values only looks at the value from treatments carried out in the laboratory with various variation in soaking time, but in this research, after the results in the laboratory were obtained, a simulation of the durability values was carried out using the backpropagation method.

Backpropagation method simulation The input data used for the simulation is data from laboratory examination results. The simulation used is an artificial neural network which is carried out to obtain data on the durability value of Starbit asphalt. Based on the results of previous research, laboratory test results showed that the durability value decreased along with the length of immersion and the flow value. The results obtained are based on results in the laboratory and have not been simulated, and this research, the durability value been simulation to strength about durability based on soaking time variation [12]

The data is normalized in intervals because the information used is positive. Also, the function of

the given function is binary sigmoid. then data transformation is applied, carried out at a smaller time interval, namely (0.1:0.8) and the Matlab modeling results:

Tabel 3. Transformation results data arrangement patterns

Time	X1	X2	X3	Target
30 minutes	0,24	-0,57	-0,32	4,87
24 hours	0,80	0,08	1,73	4,53
48 hours	0,10	0,87	0,23	4,53
72 hours	0,90	0,71	0,95	4,58
96 hours	0,47	0,66	1,05	4,58

The input Matlab data modeling is the durability value of the effectiveness of the backpropagation method in predicting and analyzing the durability value of the Starbit asphalt mixture. Examples of calculations for data transformation can be seen in the calculations below:

Variabel 30 minute
X1=(0,8×(1283,01-1321,25)/(1099,72-1321,25)+0,1=0,24
X2=(0,8×(1505,57-1321,25)/(1099,72-1321,25)+0,1=-0,57
X3=(0,8×(1436,43-1321,25)/(1099,72-1321,25)+0,1= -0,32
Y=(0,8×(100-1321,25)/(1099,72-1321,25)+0,1=4,51

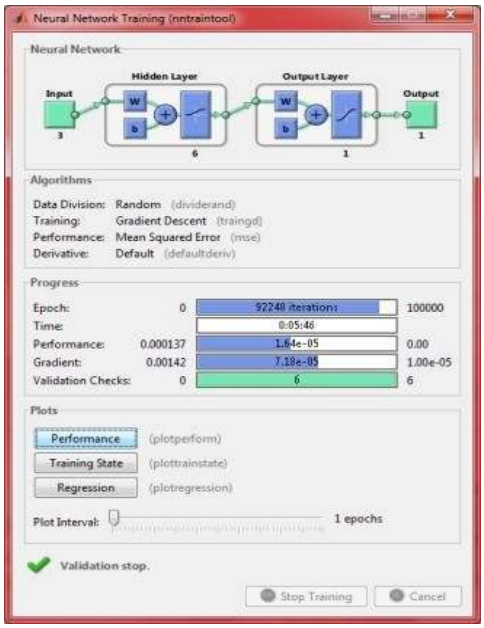

Fig 3. Training ANN process

The following are the results of data training used in simulations using Matlab

Tabel 4. Training JST data

Time	Znet	*Z*	Y ANN	Y data	error
30 minutes	0,06	*0,5*	4,7	4,87	0,143
24 hours	1,62	*0,8*	4,5	4,53	-0,00
48 hours	0,36	*0,5*	4,6	4,53	0.164
72 hours	5,05	*0,9*	4,5	4,58	0,000
96 hours	3,03	*0,9*	4,5	4,58	0,001

The analysis in this research is that starbit asphalt was carried out in the Highway Laboratory, Faculty of Engineering, Lancang Kuning University and Pekanbaru College of Technology. In its implementation, several stages are carried out. The first stage is a literature study which will be used in carrying out the research. Then proceed with testing of aggregate properties which include specific gravity of coarse aggregate, fine aggregate, sand equivalent, water absorption in aggregate, specific gravity of asphalt, penetration and softening point. Based on wear testing using a Los Angeles machine carried out in the laboratory, a result of 16% was obtained. It can be concluded that the wear test meets the criteria as stated in the 2018 Bina Marga Specifications revision 2, namely a maximum of 40%.

The aggregate density test carried out resulted in a result of 2.703. In accordance with the 2018 Bina Marga Specifications revision 2 for aggregate specific gravity, namely ≥2.5, so it can be concluded that the test results obtained meet the classification according to these requirements. In the water absorption test by the aggregate carried out in the laboratory, the result was 1.626. From the testresults, it was concluded that the aggregate adhesion test on asphalt met the 2018 Bina MargaSpecifications revision 2, namely <3. Based on the inspection results, the specific gravity of the fine aggregate produced was 2.662. From the inspection results, it was concluded that the aggregate adhesion test to asphalt was in accordance with the 2018 version 2 version of the Bina Margaspecifications, namely. minimum ≥2.5. Based on the results of the sand equivalent examination carriedout, a result of 94.1% was obtained. From the results of the inspection, it was concluded that the aggregate adhesion test on asphalt met the 2018 Bina Marga Specifications revision 2, namely Min.
>50.

Based on the results of water absorption tests carried out by aggregates, a result of 1.626 was obtained. From the test results, it was concluded that the asphalt adhesion test to aggregate met the requirements of the 2018 Bina Marga Specifications variation 2, namely <3. In determining the optimum asphalt content, 6 variations of asphalt content are used, namely 5.0%, 5.5%, 6.0%, 6.5%, 7.0% and 7.5%. This value was obtained from the results of the theoretically planned asphalt content and obtained a result of 6.0%. The next test looks for the optimum asphalt content using Marshall characteristic testing using several parameters. The parameters used are stability, flow, VMA, voids filled with asphalt (VFWA), voids filled with mixed materials (VITM), density and Marshall quotient (MQ). The asphalt used in the AC-WC layer is starbit PG70 asphalt. The OAC value is generated from the middle value of the maximum and minimum values from the Marshall characteristic test results. After carrying out the Marshall test, the optimal asphalt content value was equal to 6% [13]. The asphalt content produced from the Marshall will be used in making the AC-WC mixture. The reference parameter for durability values in this research is the immersion test. This test was carried out with variations in the time used for 4 days, where the time variations were half an hour, one day, forty-eight hours, seventy-two hours, and ninety-six hours. At standard water bath temperature 60^{o}C. This immersion test has followed the durability criteria, namely that it must be rational, the residual stability value obtained at 48 hours of immersion is 93.82%. So a simulation model was created from the durability value data using durability value data using laboratory test data. After carrying out the backpropagation method simulation, the predicted value of durability results was obtained with a maximum error of 0.16% and a minimum error of -0.0068%. The results of this simulation show that the results from using the Matlab application with manual calculations are not too far from the data obtained from the data obtained from manual calculations, the maximum error value is 0.011% and the smallest is 0.00035%. The backpropagation method is considered capable of predicting durability values because the error for predictions is less than 50%. This is because the input data entered is very small.

4. Conclusion

From the conclusions obtained from the Marshall test, the optimum asphalt content was 6.19% and the durability value obtained was 93.82%, which met the 2018 Bina Marga specifications, revision 2, of >90%. Simulating with the Backpropagation method can be used to predict the results of the durability value with a maximum value of 0.16% and the smallest error -0.0068%. In this research, there is a pattern of distribution of input data resulting from searching for durability values. The amount of information is small, so the resulting accuracy is less detailed.

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