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PERFORMANCE EVALUATION OF LASTON AC-WC ASPHALT MIXING PLANT UNIT WITH NATURAL LATEX ON RESULTS OF DAKTALITY & MARSHALL TESTS

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Abstract

Natural latex is the output by rubber plants. The rubber plants are one of output plantation sector that we could found in Indonesia especially North Sumatera Province. A rubber is superior commodity for human needs which is used for the ingredients of asphalt mixture substitution. Latex is a colloidal solution consisting of various substances, natural latex could improve the quality of the asphalt mixture. We could find the rubbers in the market so much but it's extremely cheap. Renewable innovation is needed to utilized rubber resources by using it as an asphalt substitute material. The method used in testing the 2018 Bina Marga and ASSTHO methods. The use of natural latex as a substitute is pure latex, first testing for the manufacture of KAO values (optimum Asphalt content) by making test specimens mixed with asphalt content ranging from 3% and 6%. The optimum asphalt content was obtained and then tested by mixing latex with variations in the composition of the mixture starting at 0%, 3%, and 6%. The collision was carried out with a standard proctor with a collision of 2 x 75 until the test object was declared solid and then tested with a Marshall tool. The test results from determining the optimum asphalt content of 4% there are results of 845 kg, 5% asphalt content of 1015 kg, 6%, and 7%, and the stability values obtained are 1015kg and 850 kg respectively. this value still meets the specified standard while the ductility test value obtained >1000 mm also still meets. Meanwhile, at levels of 3% and 6%, the stability value was reduced and did not meet the standard. The results showed the addition of latex substitution with high latex content has qualify of ductility although the value of stability decreases.

Keywords: Stability, Ductility, Marshall Test, Natural Latex

Introduction

As a basis for road infrastructure, it is also able to drive the economy both regionally and nationally (Siswanto et al., 2016). Seeing the increasingly significant condition of economic mobility, the policy of adding new roads and improving road quality is urgently needed to respond to road capacity and the needs of road users which will encourage an increase in traffic quality (Saputra et al., 2022).

In highway construction requires a principal part, namely road pavement (Pu et al., 2021). The condition of the road pavement will affect traffic mobility (Gholikhani et al., 2020). Unsupportive road conditions (cracked, potholes, bumpy, etc.) will hamper traffic activities such as increased use of fuel, increased travel time, even damage to vehicles will push up production costs due to rising transportation costs. This condition will make the economy ups and downs and threatens to decrease the value of the national economy.

The combination of fine aggregate and aggregate resulting from the asphalt mixture refers to the Jopmix Formula (JMF) (Shane Underwood et al., 2021) which will produce a strong and sturdy road pavement layer (Diefenderfer et al., 2021). In principle, layers of road construction must be prepared with several layers that are intertwined (Oreto et al., 2021) and integrated to be able to support the load of the wheels of vehicles passing through it (Prastanto et al., 2018). Judging from the materials that make up the road pavement (Asele & Kuleno, 2019), it is divided into two, the first is rigid pavement and both flexible pavements (Nuridha, 2020).

In Indonesia, asphalt is generally used with a flexible pavement type (Ayuningtyas & Subagio, 2019; Mulyawan et al., 2020). Flexible pavement is made from a combination of asphalt aggregate with other aggregates (Scovia, 2022) which is stretched over high-quality granular materials (Sihombing et al., 2022).

Flexible pavement on roads is divided into three layers (Nguyen et al., 2022), first surface, second surface foundation, third subbase (Jasman et al., 2021). The surface layer or Surface Course is composed of a binder and a mixture of mineral aggregates placed as the top layer and above the foundation layer (Leweherilla et al., 2022). The top layer or base course is placed between the surface and the bottom foundation (Puspitasari et al., 2022). Meanwhile, the lower foundation or Sub Base Course is between the subgrade and the foundation layer (Manuputty et al., 2022).

Data shows that Indonesia is in second place in the category of the largest natural rubber producing country in the world (KEMENTAN, 2021). From 2014 to 2018 production was 3.37 million tonnes. The average contribution value of rubber commodities is 23.44 percent. The type of natural rubber with high quality resistance to cracking and high wear resistance is called Latex (Rahmawan, 2019). Latex is used as an additive substitution material (Buritatum et al., 2021; Tran et al., 2022) because it provides many benefits in construction such as increasing softening point (Poovaneshvaran et al., 2020), decreasing penetration and increasing flash point (Trisilvana et al., 2019). The addition of latex to the asphalt mixture makes asphalt more resistant to cracking (Lubis et al., 2022), excessive deflection, and is resistant to weather changes and deformation (Aminsyah & Syahid, 2019; Virgo et al., 2020).

One of the efforts to increase the price of national rubber includes the use of natural latex as a substitute for asphalt mixture (Hermandi & Ronny, 2015). which has now passed the competency test from the public works service and has been widely applied to road construction, especially in the area of the island of Java. From the test results carried out turned out to be satisfactory results.

Various types of asphalt reinforcement mixtures that can be used include natural latex substitutes as a modification (Remišová & Holý, 2017). This method aims to increase the stability of the asphalt, increase the strength or power of the asphalt and maintain the condition of the asphalt from being brittle or broken when in low temperature (Dalimunthe, 2015).

Previous research (Tambunan, 2021) added rubber to asphalt mixtures to increase the quality of the stability and MQ values which were increasing. Research done by Hermadi et al. (2021) in the dry rubber category of 4.2 percent of asphalt, mixed aggregate prices are 22 to 25 percent cheaper compared to other aggregates and produces high quality rubber asphalt. Research done by Ridha et al. (2022) the stability value of the asphalt mixture was obtained to increase by 9.98 percent with rubber input of 7.9 percent compared to the stability values of other asphalt without rubber aggregates. Research done by Hamdi et al. (2021) shows that the use of latex material of 4 percent in the six percent asphalt category produces a stability of 1237.6 kg. Calculations show a Flow value of 4.36 mm, a VIM value of 15.90 percent and an MQ of 321.5 kg/mm. The proportion of aggregate produced in this study fulfilled the test as a substitute for asphalt concrete in the wearing course.

Research Methodology

Collection of natural latex materials taken directly from rubber plantations in Kisaran, Asahan Regency. The asphalt used is the type of asphalt mixing plant sourced from the Belawan asphalt plant. as well as the use of fine aggregate and coarse aggregate taken from the District of Patumbak, Deli Serdang Regency in North Sumatra Province and then tested in the laboratory.

Several tests were carried out referring to the ASSTHO and Bina Marga test methods including gradation sieving, specific gravity testing, aggregate absorption testing, aggregate adhesion testing on asphalt, testing with the Los Angeles machine, stability testing with the Marshall test tool (AASHTO, 2019).

Mixed Planning Method

The method of mixing fine aggregate and coarse aggregate, making a jop-mix formula for adding natural latex content with a composition variation of 3% and 6%, the aggregate used is aggregate that has passed the test (Marga, 2020).

Marshall Test Method

All aggregates used must meet the technical requirements by AASTHO. The aggregate and mixture of asphalt and natural latex are mixed and heated on top of the container and compacted with a 2x 75 impact compactor and then tested with a Marshall tool. This test aims to determine the stability value of each test object (Nento et al., 2022). The purpose of this test is to obtain asphalt mixture results according to the rules in the planning criteria (SNI 06-2489, 2016). The type of marshal used to measure asphalt melting or flow is 22.2 kN (500 lb.f). The shape of the sample is a cylinder with a diameter of approximately four inches (10.16 cm) and a height (h) of 2.5 inches (6.35 cm) with a total of 12 test objects (AASHTO, 2019).

Results and Discussion

Research Aggregate Testing

The test results for each coarse aggregate, fine aggregate and coarse aggregate, with preparation test, fine and coarse aggregate absorption test, ductility test, sieve variation sieving analysis, specific gravity check and Marshall test have been carried out in accordance with procedures referring to the method AASTHO and Bina Marga.

The test results obtained from the results of the gradation of the mixture according to the analysis of the aggregate sieve and examination of the specific gravity and absorption of the aggregate will be analyze.

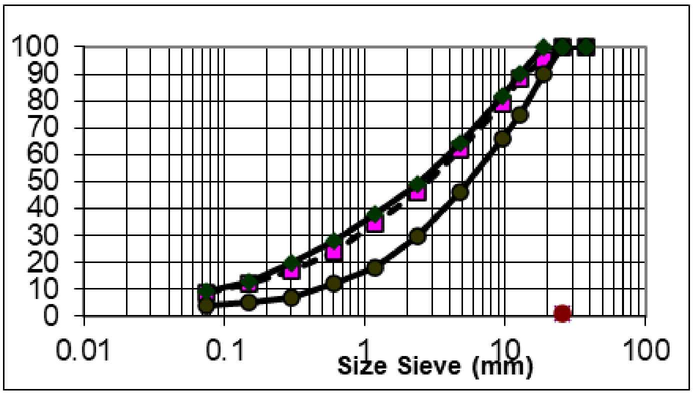

Figure 1. Aggregate gradation curve

From the curve it can be shown that the composition of the aggregate gradation mixture with a combination of several types of coarse, fine aggregate and rock ash filler is quite good.

Coarse Aggregate and Determination of Aggregate Specific Gravity

Table 1. Aggregate specific gravity determination test results

Checking Type	Value
Oven dry (BK)	5000 grams
Saturated surface dry (BJ)	5053.4 grams
Weight in water (BA)	3151.7 grams
Density (BK/ BJ-BA)	2.63
SSD specific gravity (BJ/BJBA)	2.67
Apparent specific gravity (BK/BK-BA)	2.705
Absorption (BJ-BK/BK X100)	1.067 %

Fine Aggregate Test

Table 2. Fine aggregate test with density

Checking type	Value
Saturated surface dry (SSD)	500 gr
Oven dry (BK)	430 gr
Pycnometer weight and water temperature 25^{0}C (B)	500 gr
Pycnometer weight + test object (SSD) + water (BT)	810 gr
Density	2.27
Saturated surface dry weight	2.61
Apparent specific gravity	3.42
Absorption	14.43

Asphalt Checking

Density value = 1,027. The result of penetration value showed in the table.

Table 3. Penetration observation

Penetration observation of asphalt	
Observation sampel 1	101.20
Observation sampel 2	105.0
Observation sampel 3	99.60
Average	**100.60**

The asphalt ductility test determines the value of the elasticity of asphalt measured starting from the longest sparse with the second category the mold is filled with hard bitumen which is pulled (without breaking) with a temperature of 25oC and a speed of 50 mm/minute (SNI 06-2456-1991, 2020). In this study the ductility inspection test was aimed at determining the meltability of asphalt with rubber substitution.

In this test, asphalt has been mixed with natural latex with a mixture that has been determined by carrying out this inspection, by reading on the ductility meter, it is obtained that the length of the asphalt is pulled until it breaks. It can be seen in this test, the test results obtained that the melting properties of asphalt meet the optimum asphalt content and meet the specifications of 5.50 percent.

Test Object 1

Asphalt Optimum = 5.50% x 1,200
= 66.0 grams
Latex level 3% = 3% x 66.0
= 1.98 grams
Asphalt weight = 66.0 grams – 2,736
= 63.264 grams

The amount of addition of natural latex = 1.98 grams mixed and stirred then by melting.

Test Object 2

Asphalt Optimum = 5.75% x 1,200
= 69 grams
Latex level 6% = 6% x 69.0
= 4.14 grams

Based on research conducted with a ductility testing machine, it was found that the Test Object value was greater than 1020 mm.

Job Mix Formula

The first step taken before entering the manufacture of test objects is to first make a job mix formula. Job Mix Formula is a base formula that is suitable and linear with the requirements in the manufacture of mixtures or aggregates (Abdurrohim and Setyawan 2017). The purpose of the jop-mix formula is to determine the amount and composition of each aggregate required according to the desired asphalt content formation in planning its stability value. In this test the mold used is the AASTHO specification with the following dimensions:

1. Diameter: 10.1 cm
2. Height: 7.5 cm
3. Total test objects: 1200 gr
4. Asphalt level: 5%, 5.5%, 6%, 6.5%, 7%

Asphalt Level 5%
CA = 159.6 grams
MA = 399 grams
FA = 444.6 grams
Sand = 114 grams
Filler = 22.8 grams
1140 grams
Asphalt Level 5.5%
CA = 158.76 grams
MA = 396.9 grams
FA = 442.26 grams
Sand = 113.4 grams
Filler = 22.68 grams
1134 grams
Asphalt Level 6%
CA = 157.92 grams
MA = 394.8 grams
FA = 439.92grams
Sand = 112.8 grams
Filler = 22.56 grams
1128 grams
Asphalt Level 6.5%
CA = 157.08 grams
MA = 392.70 grams
FA = 437.58 grams
Sand = 112.20 grams
Filler = 22.44 grams

1122 grams

Asphalt Level 7%

CA = 156.24 grams
MA = 390.6 grams
FA = 435.24 grams
Sand = 111.6 grams
Filler = 22.32 grams
1116 grams

By obtaining the results of the job-mix formula planning, then the test sample is made. stability testing with Marshall test with 5 different variations of asphalt content. Taken 3 test samples at each bitumen content. From the test, the optimum bitumen content was obtained at 5.7% which can be seen in Figure 2 stability. The following is the result of a job mix design with an optimum asphalt content of 5.7%.

Natural Latex Content 3%

Asphalt Optimum = 68.4 grams
Latex 4% = 2.736 grams
Asphalt weight = 68.4 grams – 2.736
= 65.664 grams
CA = 171.9 grams
MA = 378.18 grams
FA = 412.56 grams
Sand = 137.52 grams
Filler = 45.84 grams
1131.6 grams

Natural Latex Content 6%

Asphalt Optimum = 68.4 grams
Latex 6% = 4.104 grams
Asphalt weight = 64.296 grams
CA = 171.9 grams
MA = 376.2 grams
FA = 410.4 grams
Sand = 136.8 grams
Filler = 45.6 grams
1131.6 grams

Marshall Test

Stability

Table 4 attaches the results of the stability inspection of the test object referring to the asphalt content determination as the binder object. The inspection aims to obtain the optimum bitumen content that has not utilized the natural latex content. Mixing with natural latex is carried out after obtaining the optimum content referring to the planned concentration.

Table 4. Stability

% Asphalt	**Latex Ingredients**			
	0%	**0%**	**0%**	**Average**
5.00	898	798	835	843
5.50	1090	920	1019	1010
6.00	1026	993	1090	1036
6.50	1043	982	1019	1015
7.00	834	872	769	825

The stability value is generated by examining Marshall stability and the stability value of the 3 test object materials with attached bitumen content and the average stability value of the test material. The results of the stability check are shown in the following graph.

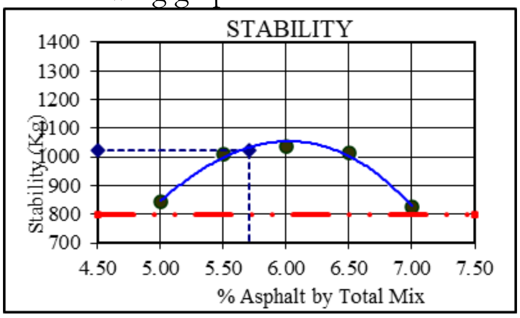

Figure 2. Stability curve

Based on the examination of the optimum bitumen content value obtained at 5.70%. The next step is to check the optimum bitumen content with 3% and 6% latex content. Formation of specimens with interpolation of natural latex ingredients of 0%, 3% and 6% was continued after obtaining optimum bitumen content. Here are the results of the inspection.

Table 5. Stability with natural latex

% Asphalt	**Ingredients Latex**	
	3%	**6%**
5.7	641	641
5.7	650	638
5.7	675	675
Average	**656**	**651**

From the test, there was a decrease in the average stability value of mixing using natural latex. The stability value decreases in direct proportion to the increase in natural latex content.

Flow

Table below attaches the melting values obtained through the use of asphalt content of 5% to 7% non natural latex.

Table 6. Flow

% Asphalt	Ingredients Latex			
	0%	0%	0%	Average
5.00	2.60	2.20	2.30	2.37
5.50	3.10	3.10	3.20	3.13
6.00	3.60	3.50	3.60	3.57
6.50	4.10	4.00	4.20	4.10
7.00	5.50	4.80	4.50	4.77

From the test, there was a decrease in the average stability value of mixing using natural latex. The stability value decreases in direct proportion to the increase in natural latex content. Through testing, a comparative graph of melting values obtained from the average melting test of test objects with Asphalt content is obtained as shown in Figure 3 below.

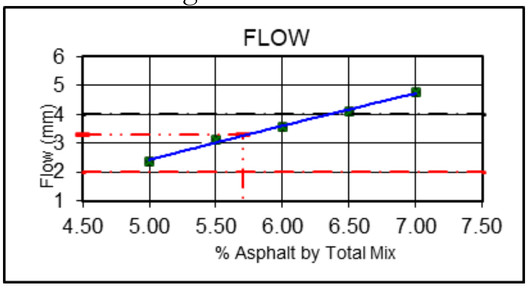

Figure 3. Flow curve

The melt test graph illustrates the correlation of Asphalt content directly proportional to melting. The graph shows that the higher the percentage of Asphalt, the melting also increases. It can be concluded that all percentage categories are within the specification of 2 to 6 mm melt.

The following table shows the melting values obtained by utilizing the optimum Asphalt content of 5.70%.

Table 7. The flow with natural latex

% Asphalt	Ingredients Latex	
	4 %	6 %
5.70	2.70	2.75
5.70	2.55	2.55
5.70	2.45	2.50
Average	**2.57**	**2.60**

From the test table 7 it is concluded that based on the average value, the melting value has increased in line with the addition of the value of natural latex content.

Determination of Air Cavities in Void in Mixtured (VIM) Mixture

Table below shows the results of the analysis of the effect of Mixed Modified Asphalt (VIM) using variations of Asphalt without latex mixture on air voids in the mixture.

Table 8. Void in mixture

% Asphalt	Ingredients Latex
	0%
5.0	6.03
5.5	4.92
6.0	3.97
6.5	3.25
7.0	3.22

According to the VIM value, a comparison graph of the cavity value with variations in the Asphalt content of the mixture is obtained as follows.

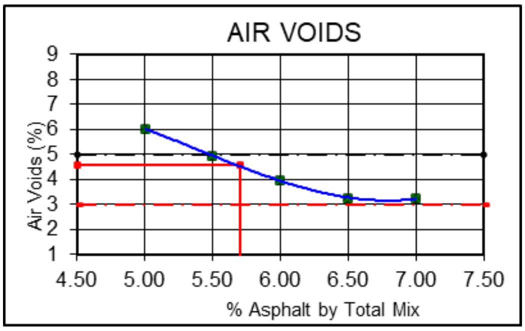

Figure 4. VIM curve

The test graph above shows the correlation between Asphalt content and voids in the mixture of the mixture. The correlation shows an inverse relationship between the percentage of Asphalt and voids in the mix. The higher the Asphalt percentage value, the lower the cavity content in the mixture.

The following table shows the VIM value with the optimal asphalt content category of 5.70%.

Table 9. Natural latex for VTM

% Asphalt	**Ingredients Latex**	
	3%	**6%**
5.7	5.41	4.99

The test results provide information on the VIM value. The relationship obtained is inversely proportional. The higher the natural latex content, the lower the VIM value.

VMA (Void in the Mineral Aggregate)

The following table displays the results of the aggregate analysis (VMA) with variations of the standard mix against the mix voids.

Table 10. Void in mineral aggregate

% Asphalt	**Ingredients Latex**
	0%
5.0	15.49
5.5	15.55
6.0	15.76
6.5	16.17
7.0	17.19

Referring to the results of testing the aggregate sample on the average void value in the mixture, the aggregate comparison graph with variations in Asphalt content to the cavity value in the mixture is obtained as follows.

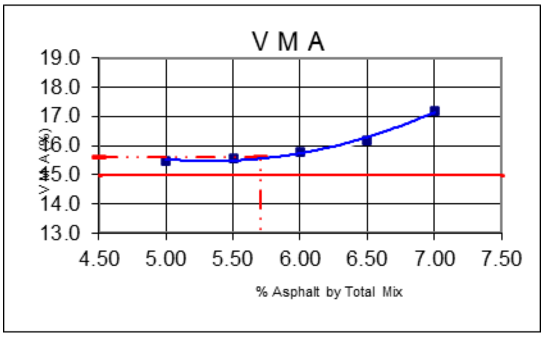

Figure 5. VMA curve

The graph displays a direct proportional relationship between the level of Asphalt and voids in the mix. The higher the Asphalt percentage value will increase the number of voids in the mixture.

The following table displays the VMA values in the mixture with the optimum utilization of Latex Asphalt level category.

Table 11. Natural latex for VMA

% Asphalt	**Ingredients Latex**	
	3%	**6%**
5.7	15.29	14.93

In the analysis of the Asphalt mixture without Latex, it shows a directly proportional relationship to the VMA value. However, in the case of mixed Asphalt using Latex, it is inversely proportional. The use of Latex, the higher the Latex level causes a decrease in the VMA value.

VFA (Void Filled Asphalt)

The results of the analysis of cavity filled Asphalt (VFA) with standard mixture variations can be seen in the following table:

Table 12. Void filled asphalt

% Asphalt	**Ingredients Latex**
	0%
5.0	61.07
5.5	68.34
6.0	74.80
6.5	79.94
7.0	81.25

A graph of the comparison of the cavity value of the Asphalt mixture to the mixture is obtained from the test results for each sample of the average cavity of the Asphalt mixture as follows.

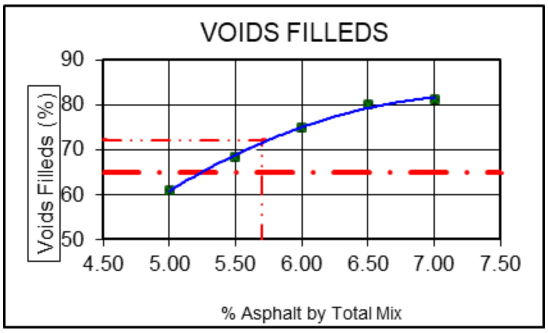

Figure 6. VFA curve

The test results show that there is a direct relationship between Asphalt levels and Asphalt voids. The higher the percent Asphalt content will increase the number of cavities filled with Asphalt.

The VFA analysis with the use of natural Latex in mixtures with optimal levels of Asphalt is as follows.

Table 13. Natural latex for VPA

% Asphalt	Ingredients Latex	
	3%	6%
5.70	67.40	63.79

Table test results above, the higher the natural latex content, the lower the VFA value.

Marshall Quotient (MQ)

The following table displays the results of the MQ analysis of the variation of mixed ingredients (modified asphalt).

Table 14. Marshall test

% Asphalt	Ingredients Latex
	0%
5.0	356
5.5	322
6.0	291
6.5	247
7.0	173

Testing the average MQ for each sample is figured on a comparison graph of the MQ test values using Asphalt content for the total mixture as follows:

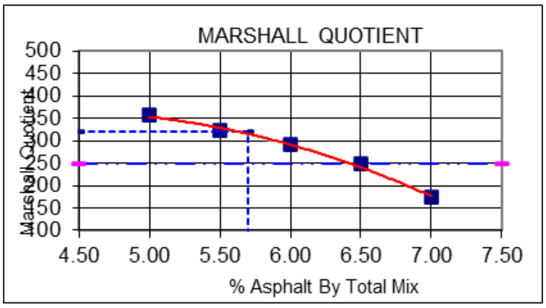

Figure 7. MQ curve

From Figure 7 above it can be concluded that the relationship between Asphalt levels and MQ is that more and more Asphalt mixtures cause an increase in the MQ value. Under optimum conditions, the MQ value decreases.

The following table displays the MQ values for mixtures utilizing natural latex in the optimal content category of Asphalt.

Table 15. MQ used natural latex

% Asphalt	Ingredients Latex	
	3%	6%
5.70	255	251

Tests show that the higher the use of Latex content in the mixture, the lower the MQ value.

Conclusion

From the results of the tests performed, the ductility was > 1000 mm. The KAO value in the stability category is very good (800 kg). The 5% Asphalt category obtained an average stability value of 845 kg. Asphalt category 5.5% worth 1010 kg. Asphalt category 6% worth 1036 kg. Asphalt category 6.5% worth 1015 kg. Asphalt category 7% worth 825 kg. Stability values using natural Latex category 4 and 6% decreased. The average stability value of adding 4% Latex is 656 kg with a Latex content of 5.7%. the average value of the stability of the addition of Latex 6% is 651 kg. the overall research results meet the 2018 Bina Marga standard specifications.

The test results obtained values of flow, VMA, VIMA, VFA, MQ with good ductility category but the use of Latex in Asphalt mixture is not good. This is due to the stability value obtained does not meet the minimum specifications (< 800 kg) from the 2018 Bina Marga division VI revision III.

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