

COMPARATIVE ANALYSIS OF THE QUALITY AND COST OF ROAD PATCHING USING *COLD PAVING HOT MIX ASBUTON* (CPHMA) WITH PENETRATION LAYER USING PERTAMINA'S EX ASPHALT

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Abstract

Road damage in the form of holes in flexible pavement can reduce the level of road service and endanger road users. Handling road damage requires effective maintenance methods, good pavement quality, and efficient implementation costs. This study aims to compare the quality and cost of road paving work using the *Cold Paving Hot Mix Asbuton* (CPHMA) method and the Macadam Penetration Layer (Lapen) method on the Bandar-Tulis Road Section, Batang Regency. The research method used is a quantitative method with data collection through field observation, laboratory testing using the Marshall method, and cost analysis based on Work Unit Price Analysis (AHSP). The quality parameters analyzed included Marshall stability values, *flow values*, and *Marshall Quotient* (MQ), while cost aspects were analyzed based on the need for labor, materials, and equipment for every 1 m³ of work.

The results of the study showed that the CPHMA method had better pavement quality than the Macadam Penetration Layer method. The *Marshall Quotient* (MQ) value in the CPHMA method ranges from 63,114–126,562 kg/mm, which indicates the blend's ability to resist deformation and traffic loads better. In terms of implementation, the CPHMA method is more practical and efficient because it uses ready-to-use mixtures so that the work time is faster and the use of equipment is less. Based on the cost analysis, the unit price of the CPHMA method is IDR 6,616,846.56/m³, while the Macadam Penetration Layer method is IDR 2,903,370.78/m³. The cost difference between the two methods is Rp3,713,475.78/m³ or around 56.12%, so that the Macadam Penetration Layer method is more economical than the CPHMA method. Thus, the CPHMA method is superior in terms of quality and efficiency of work implementation, while the Macadam Penetration Layer method is superior in terms of cost. The selection of road patching methods needs to consider the condition of road damage, the need for traffic services, and the availability of the road maintenance budget.

Keywords: Cold Paving Hot Mix Asbuton (CPHMA) Method, Macadam Penetration Layer, Marshall Stability

INTRODUCTION

Indonesia is experiencing rapid growth in the industrial sector. In this case, roads as one of the transportation infrastructure play an important role. As stated in the Law of the Republic of Indonesia Number 38 of 2004, roads not only support economic activities, but also become a vital element in social, cultural, environmental, political, and national security life, all for the welfare of the wider community. One of the districts that showed progress in Central Java was Batang Regency. The number of factories, office buildings and industrial estates that have been established has an impact on the increase in traffic activities in Batang Regency, especially traffic activities on land routes. (Ismiwati & Fitriyanti, 2023).

Through the PUPR Office, the Batang Regency Government continues to take various actions to overcome a series of road problems on the road section under its authority. One of the efforts made is the existence of routine maintenance activities on the road section to maintain road conditions and maintain the value of road stability conditions. Road maintenance actions are needed to maintain road conditions and maintain the value of road stability conditions. Road maintenance measures are necessary to ensure good operating conditions throughout the planning period, in addition to the fact that the maintenance and repair of damaged roads requires a large cost, it is very important to carefully evaluate the extent of road damage as well as determine the most suitable type of repair. (Hermastuti & Amudi, 2024). For routine maintenance of road sections with flexible pavement, there are many methods used to overcome road damage that is still on a small scale, especially for potholes in road conditions. Two methods that are often used for road *patching* activities on bending pavements in Batang Regency are pothole road patching using the Pertamina method and pothole road patching with the *Cold Paving Hot Mix Asbuton* (CPHMA) method or cold spread asbuton hot asphalt mixture. These two methods are used for the same purpose, namely to patch or repair roads with potholes, but both have differences in terms of the method of carrying out the work, the materials used, the quality of the work results, and the cost of the application of the work carried out. Based on these conditions, the author feels the need to study further through a study entitled. "Comparative Analysis of the Quality and Cost of Road Patching Using Cold Paving Hot Mix Asbuton (CPHMA) with Penetration Layer Using Pertamina Ex Asphalt (Case Study on the Bandar-Tulis Road Section, Batang Regency)".

The formulation of the problem in this study is:

1. How is the cost incurred for 1 m³ of work volume compared between road patching using *the Cold Paving Hot Mix Asbuton* (CPHMA) method and the Penetration Layer of ex Pertamina asphalt?
2. What is the level of efficiency between the method of implementing pothole road patching work using *the Cold Paving Hot Mix Asbuton* (CPHMA) method and the pothole road patching using the Penetration Layer method from ex Pertamina asphalt?

LITERATURE REVIEW

Road Pavement and Road Maintenance

Road pavement is a structure designed to distribute vehicle loads to the ground so that it is able to provide safe and comfortable traffic services. As the age of road services increases and the volume of vehicles increases, the pavement will experience a decrease in conditions characterized by cracks, deformations, and holes on the road surface. Therefore, road maintenance activities are needed to maintain the level of road services so that they remain optimal. According to the General Specification of Bina Marga 2018 Revision 2, road maintenance is carried out to maintain the

condition of the pavement so that the damage does not develop into heavy damage that requires greater handling costs. Handling potholes (patching) is one of the most common routine maintenance methods on flexible pavement.

Cold Paving Hot Mix Asbuton (CPHMA)

Cold Paving Hot Mix Asbuton (CPHMA) is an Asbuton-based asphalted mixture that is produced through a hot mixing process but can be spread in cold conditions in the field. This material was developed as a practical alternative to asphalt mixtures for road maintenance and rehabilitation work because it has flexibility of use and ease of mobilization. The Implementation Guidelines for Cold Spread Hot Mix Asbuton explains that CPHMA is used for road improvement and maintenance work with simpler implementation procedures than conventional hot paved mixtures.

Research by Tipawael et al. (2024) shows that CPHMA mixtures have good Marshall characteristics and are able to improve the stability of the mixture, especially with the addition of rock ash as a filler. In addition, Hamkah (2023) stated that the use of Portland cement additives in CPHMA mixtures can improve the Marshall characteristics of the mixture and improve the quality of the pavement. However, the use of CPHMA has a relatively higher material cost than conventional methods because it uses ready-to-use mixtures and special materials based on Asbuton.

Lapis penetrasi macadam (Lapen)

Macadam Penetration Layer (Lapen) is a pavement layer consisting of staple aggregate, locking aggregate, and covering aggregate bonded using penetration asphalt. This method is widely used on roads with low to moderate traffic volumes because its implementation is relatively simple and construction costs are more economical. According to the General Specification of Bina Marga 2018 Revision 2, the Lapen's work is carried out in layers by spraying hot asphalt on each aggregate arrangement so as to produce a fairly good bond between aggregates. The advantages of this method are the ease of obtaining materials and lower implementation costs, but the quality of the work is greatly influenced by the control of asphalt temperature, aggregate gradation, and compaction processes in the field.

Marshall Testing

Marshall testing is a laboratory testing method used to determine the characteristics of paved mixtures based on stability and fatigue (flow) parameters. Stability indicates the ability of the mixture to withstand deformation due to traffic loading, while flow values indicate the level of flexibility of the mixture before it is damaged. Research by Laras (2022) shows that the length of CPHMA mixture has an effect on the Marshall stability value produced. In addition, the evaluation of local materials in CPHMA mixtures shows that Marshall stability is an important parameter in determining the deformation resistance of pavement mixtures.

The comparison between stability and flow values is known as the Marshall Quotient (MQ), which is used to indicate the stiffness level of a paved mixture. The higher the MQ value, the more stable the mixture is to permanent deformation.

RESEARCH METHODS

Research Location

The location of the research is on the Jalan Bandar-Tulis Km.4 + 100 – Km.5 + 900 section. The Bandar-Tulis Road section is one of a total of 139 road sections that are included in the status of district roads based on the Decree of the Regent of Batang Number 050/243/2016 concerning the Determination of the Status of Regency Road Sections. Administratively, the Km.4+100 – Km.5+900 Bandar-Tulis Road Section is located in Wonosegoro Village, Bandar District, Batang Regency, Central Java Province.

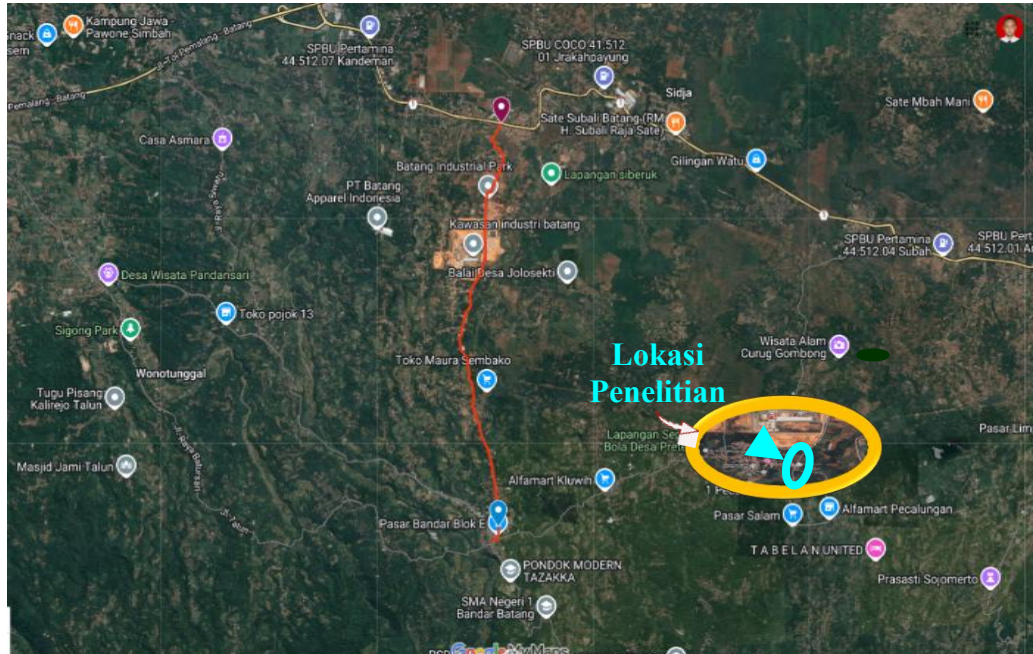


Figure 1 Map of Kota-Tulis Road Km.4+100 – Km.5+900
(Source: Google Maps, 2025)

Types of Research

This study uses a quantitative approach, which means that the method relies on numerical data to analyze, predict, and control certain phenomena (Leo, 2013).

Research Variables

According to Sugiyono (2013), research variables include everything that the researcher decides to study in order to obtain data and then draw conclusions. This study uses two types of variables, namely independent variables and independent *variables*.

Independent variables are factors that affect bound variables with impacts that can be positive or negative. In this study, the free variables include the basic unit price for materials, labor, and equipment rental, the value of the coefficient of materials, labor, and equipment rental, and the patching method used, namely CPHMA and Pertamina's Ex. Asphalt Makadam Penetration Layer.

Dependent variable

A bound variable is a variable whose value or outcome depends on another variable. where the value can change. The bound variable is often also called the response variable denoted by Y. The bound variables in this study are the cost, quality of the method of carrying out the work and the quality of paving work on the Batang Regency Road Section.

Research Workflow

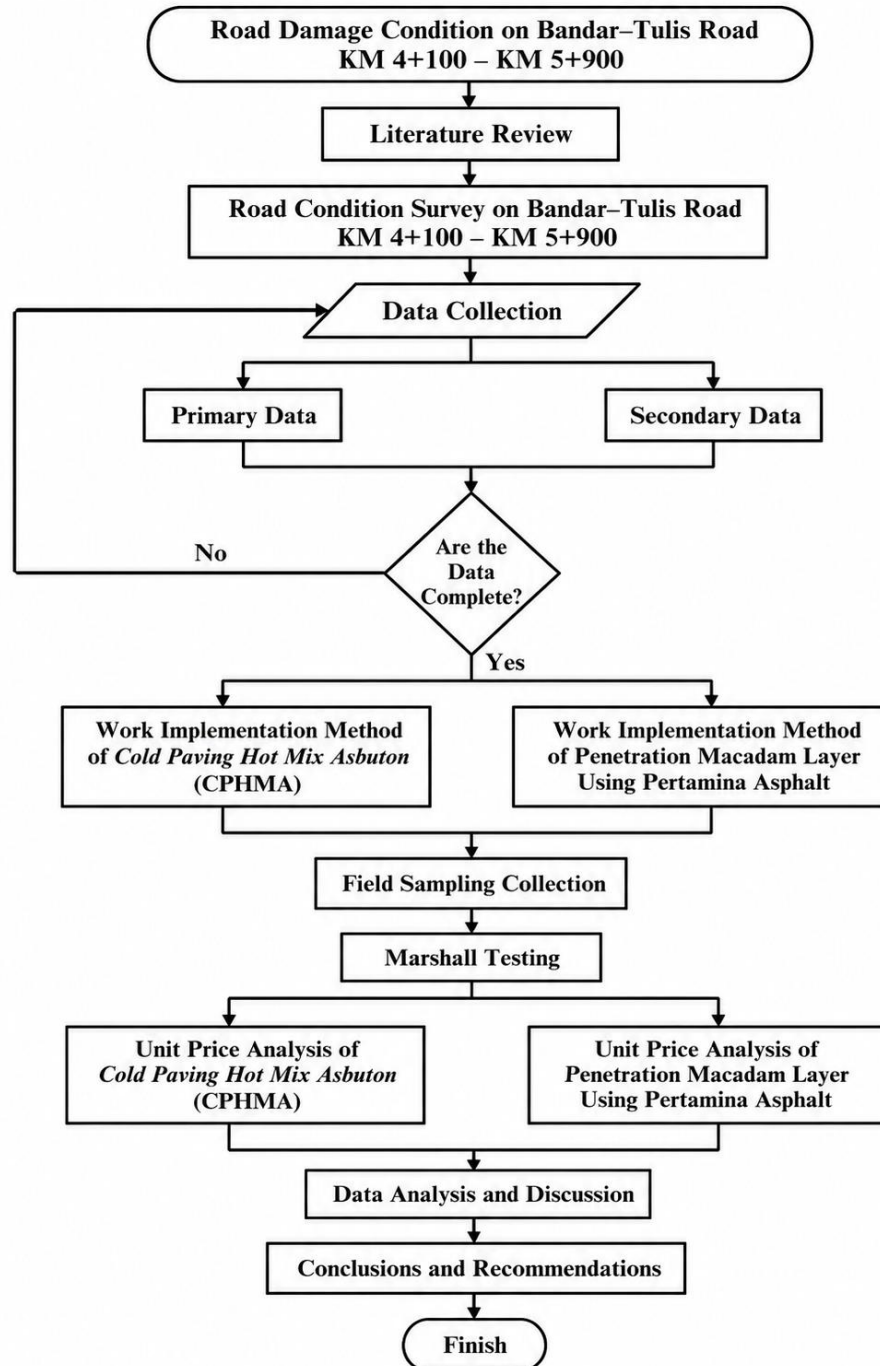


Figure 2. Research flowchart

Number		Field Name	Day	LHR Vehicle		Total 2-way LHR
Squirtting	Sections			North Direction	Southbound	
UPTD Area.		Cities				
III	88	City – Write	Monday, 19 May 2025	4095,2	3790,8	7886
III	88	City – Write	Wednesday, August 6, 2025	4140,8	3835,6	7976,4
III	88	City – Write	Friday, August 1, 2025	3868,8	3863,2	7732

RESULTS AND DISCUSSION

Analysis of Observation Results and Implementation

Table 1. Recapitulation of Traffic Calculation of Bandar Road – Tulis Km. 4+100 – Km. 5+900

(Source: Researcher, 2025)

Based on the LHR calculation data for the Bandar-Tulis Road Section Km.4 + 100 – 5 + 900 above, the highest traffic volume was recorded on Wednesday, August 6, 2025 which was 7976.4 smp/day. Based on Table 2.1 regarding Traffic Classes for Maintenance Works, the traffic volume of 7976.4 smp/day is categorized in traffic class 6.

Testing Cold Paving Hot Mix Asbuton

The results of the CPHMA Paved Mix Density, Stability and Fatigue Test are calculated with the formula $MQ = \frac{MS}{MF}$

Marshall Quotient (MQ) value at 35 minutes:

Test Specimen 1

$$MQ \text{ Test Specimen 1} = \frac{MS \text{ Benda uji 1}}{MF \text{ Benda uji 1}}$$

$$MQ \text{ Test Specimen 1} = \frac{552,3}{5,2}$$

$$= 106,211$$

Test Specimen 2

$$MQ \text{ Test Specimen 2} = \frac{MS \text{ Benda Uji 2}}{MF \text{ Benda Uji 2}}$$

$$MQ \text{ Test Specimen 2} = \frac{662,8}{5,5}$$

$$= 120,509$$

Test Piece 3

$$MQ \text{ Test Specimen 3} = \frac{MS \text{ Benda Uji 3}}{MF \text{ Benda Uji 3}}$$

$$MQ \text{ Test Specimen 3} = \frac{607,5}{4,8}$$

$$= 126,562$$

Marshall Quotient (MQ) values at 24 hours:

Test Piece 4

$$\text{Test Object MQ 4} = \frac{\text{MS Benda Uji 4}}{\text{MF Benda Uji 4}}$$

$$\text{MQ Test Object 4} = \frac{469,5}{6,2} = 75,725$$

Test Specimen 5

$$\text{MQ Test Object 5} = \frac{\text{MS Benda Uji 5}}{\text{MF Benda Uji 5}}$$

$$\text{MQ Test Specimen 5} = \frac{497,1}{5,5} = 90,381$$

Test specimen 6

$$\text{MQ Test Piece 6} = \frac{\text{MS Benda Uji 6}}{\text{MF Benda Uji 6}}$$

$$\text{MQ Test Piece 6} = \frac{441,8}{7,0} = 63,114$$

Macadam Penetration Layer Testing

Asphalt Pen Testing 60/70

One of the materials used for the Macadam Penetration Layer work in the study consisted of an asphalt pen. 60/70. Based on the tests that have been carried out on asphalt with a penetration rate of 60/70, the data as listed in Table 2 are obtained.

Table 2. Asphalt Inspection Results Pen. 60/70

No.	Examination description	Method	Results	Units	Specification
1.	Penetration 25°C, 100 gr, 5 sec	SNI 2456 – 2011	68	0,1 mm	60 – 70
2.	Specific Gravity 25°C	SNI 2441 – 2011	1,039	gr/ml	≥ 1,0
	Asphalt viscosity with Brookfield tools				
1.	Asphalt temperature in the mixing viscosity range (200-500) cSt	SNI 06-6441-2000	139 - 159	°C	145 – 155
2.	Asphalt temperature in the compaction viscosity range (1000-2000) cSt	SNI 06-6441-2000	108 – 124	°C	125 – 145
3.	Marshall sample mixing asphalt temperature (170±20) cSt		160	°C	155±1
4.	Temperature of Marshall sample compaction asphalt (280±30) cSt	SNI 06-6441-2000	150	°C	145±1

(Source: Central Java Province Highway and Highway Testing and Equipment Center, 2025)

Table 3. Results of Testing the Physical Properties of Macadam Penetrating Layer Aggregates

No	Examination Description	Method	Results	Specification	Serenity
A.	Tree Aggregate - 2 1/2" Broken Stone				
1.	Dry Specific Gravity (Bulk)	SNI 1969 -2016	2,65		
2.	Absorption	SNI 1969 -2016	1,53 %		
3.	Flat, oval or flat and oval granules	SNI 8287 : 2016	1,36 %	Max 15 %	Meet
4.	Keausan Agregat	SNI 2417 – 2008	15,25 %	Max 40 %	Meet
B.	Locking Aggregate - 1" Broken Stone				
1.	Dry Specific Gravity (Bulk)	SNI 1969 -2016	2,65		
2.	Absorption	SNI 1969 -2016	2,19 %		
3.	Flat, oval or flat and oval granules	SNI 8287 : 2016	14,91 %	Max 15 %	Meet
4.	Keausan Agregat	SNI 2417 – 2008	16,55 %	Max 40 %	Meet
C.	Aggregate Cover - 1/2" Broken Stone				
1.	Dry Specific Gravity (Bulk)	SNI 1969 -2016	2,67		
2.	Absorption	SNI 1969 -2016	2,28 %		
3.	Flat, oval or flat and oval granules	SNI 8287 : 2016	9,92 %	Max 15 %	Meet
4.	Keausan Agregat	SNI 2417 – 2008	25,12 %	Max 40 %	Meet

(Source: Central Java Province Highway and Manufacturing Testing and Equipment Center, 2025)

Based on the data listed in Table 4, all aggregate materials used in the Macadam Penetration Layer work method have met the standards required in the 2018 General Specification Revision 2 for Road and Bridge Construction Works, especially in Section 6.7. and SNI 6751-2016 specification, then aggregate can be used as a constituent material for Macadam Penetration Layer. In this study, based on the results of the testing of the constituent materials above, the composition of the estimated quantity of aggregate and asphalt for the preparation of Macadam Penetration Layer work using a layer thickness of 5 – 8 cm which refers to the amount of use of aggregate and asphalt pen 60/70 based on the 2018 General Specifications for Road and Bridge Construction Work Revision 2.

Comparison of CPHMA Work Unit Price Analysis and Macadam Penetration Layer .

Table 4. Comparison of CPHMA Work Unit Price Analysis and Macadam Penetration Layer.

No.	CPHMA Job Unit Price Analyst		Macadam Penetration Layer Unit Price Analyst	
1	Total Labor Price	14.581, 71	Total Labor Price	22.675,33

No.	CPHMA Job Unit Price Analyst		Macadam Penetration Layer Unit Price Analyst	
2	Total Material Price	5.836,666,667	Total Material Price	2.484.719,35
3	Total Equipment Price	164.066, 67	Total Equipment Price	132.033,30
4	Total Prices of Energy, Materials and Equipment (A+B+C)	6.015.315,05	Total Prices of Energy, Materials and Equipment (A+B+C)	2.639.427,98
5	Overhead dan Profit 10,00 % X D	601.531, 51	Overhead dan Profit 10,00 % X D	263.942,80
6	D+E Working Unit Price	6.616.846,56	D+E Working Unit Price	2.903.370,78

(Source: Researcher, 2025)

From the results of the calculation of the Unit Price Analysis for routine maintenance of the CPHMA method and the Macadam Penetration Layer, the following results were obtained:

1. The estimated unit price of work per 1 m³ for routine road maintenance using the CPHMA method is Rp 6,616,846.56.
2. The estimated unit price of work per 1 m³ for routine road maintenance using the Macadam Penetration Layer method is Rp 2,903,370.78.

The difference in the price of the unit of work for routine road maintenance using the CPHMA method and the Macadam Penetration Layer is as follows:

IDR 6,616,846.56 – IDR 2,903,370.78 = IDR 3,713,475.78. The percentage difference between the unit price of routine maintenance work per 1 m³ using the CPHMA method and the Macadam Penetration Layer method is as follows:

$$\frac{\text{Rp } 3.713.475,78}{\text{Rp } 2.903.370,78} \times 100 = 127,90 \%$$

Based on the results of the research that has been carried out for routine maintenance on the Bandar – Tulis Road Km. 4 + 100 – 5 + 900 section, both using the CPHMA method and the Macadam Penetration Layer method, the researcher conducted a comparative analysis of the advantages and disadvantages of the CPHMA method and the Macadam Penetration Layer. The analysis of the advantages and disadvantages of the CPHMA method and the Macadam Penetration Layer is based on the limitations of the research that has been conducted, which can be summarized as in the following table.

Comparison of CPHMA Method and Macadam Penetration Layer Work

Table 5 Comparison of CPHMA Method and Macadam Penetration Layer Work

Preview	Cold Paving Hot Mix Asbuton	Lapis Penetrasi Macadam
Method	The work execution time is relatively faster. Relatively fewer types of tools are used. It does not require a location for asphalt frying activities. The materials used are more practical to be mobilized because they are already in the form of materials mixed in packaging.	The implementation of the work is carried out in each layer and is carried out in hot asphalt conditions. Requires a loose location for the asphalt frying process. The constituent materials are still in a condition that has not been mixed so that more places are needed for the <i>material dropping</i> process .
Cost	The cost of labor wages for 1 m3 of work is smaller. The cost of materials or materials for 1 m3 of work is larger. The cost of renting equipment for 1 m3 of work is greater. The overall cost of the unit price of work for 1 m3 is more expensive.	The cost of labor wages for 1 m3 of work is greater. The cost of materials or materials for 1 m3 of work is smaller. The cost of renting equipment for 1 m3 of work is smaller. The overall cost of the unit price of work for 1 m3 is cheaper.

(Source: Researcher, 2025)

CONCLUSION

1. Based on the results of the comparison of work costs per cubic meter between the *Cold Paving Hot Mix Asbuton* (CPHMA) method and the *Macadam Penetration Layer* method using asphalt produced by Pertamina, it is known that the work cost per cubic meter with the CPHMA method is relatively higher than the Penetration Layer method.
2. In terms of work implementation efficiency, the pothole road patching method using *Cold Paving Hot Mix Asbuton* (CPHMA) is more efficient than the Macadam Penetration Layer method from asphalt produced by Pertamina.
3. Based on the comparison of the quality of the work results between the two methods, the patching method using *Cold Paving Hot Mix Asbuton* (CPHMA) produces better quality. This is demonstrated through the testing of Marshall stability and fatigue (*flow*) values, which makes the quality of the work more technically measurable.

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