E-ISSN: 3050-967X

10.5281/ZENODO.18139110 VOLUME 07 ISSUE 02 JULY-DEC - 2025 ARTICLE ID: #2195

A COMPARATIVE STUDY OF THE USE OF VARIOUS TYPES OF CEMENT AS A FILLER ON THE STABILITY CHARACTERISTICS OF MARSHALL ASPHALT CONCRETE – WEARING COURSE (AC-WC) MIXTURES

By Author(s):

Musrifah Tohir, Viva Oktaviani*, Suharto, Findia, Muhammad Gilbran Dwi Ananda

Civil Engineering Study Program, Faculty of Engineering,
University of 17 Agustus 1945 Samarinda
Email: Musrifah.tohir76@gmail.com; vivasoeri83@gmail.com; Hartosuharto1966@gmail.com;
findia.1880@gmail.com; agilgilbran08@gmail.com

Abstract

In road construction, pavement stability is a crucial aspect in ensuring the durability and performance of the road against traffic loads. To improve the quality of the pavement, filler materials are substituted. Portland cement (PC) is used in the asphalt concrete mixture. The objective of this research was to analyze the effect of different types of Portland cement used as filler on the Marshall stability and other parameters of the Asphalt Concrete–Wearing Course (AC-WC) mixture. This research used a laboratory experiment method conducted at the Soil Mechanics, Materials, and Soil Measurement Laboratory, Faculty of Engineering, Universitas 17 Agustus 1945 Samarinda. This research used Holcim, Tonasa, and Conch cement types with a proportion of 2% of the total aggregate weight as an additive, and asphalt content varied between 5%, 5.5%, 6%, and 6.5%. Tests were carried out using the Marshall method to measure stability, flow, VIM, VMA, VFA, and Marshall Quotient parameters. The research results show that the addition of Portland cement as a filler in an Asphalt Concrete–Wearing Course (AC-WC) mixture significantly improves the mechanical strength and durability of the pavement, as demonstrated by higher Marshall stability values. Tonasa cement produced the highest Marshall stability and stiffness, indicating that its finer particle size and more homogeneous composition provide a stronger bond between the asphalt and aggregate.

Keywords

Portland cement, asphalt concrete, filler, stability of Marshall, Asphalt Concrete–Wearing Course

How to cite: Tohir, M., Oktaviani, V., Suharto, S., Findia, F., & Dwi Ananda, M. (2025). A COMPARATIVE STUDY OF THE USE OF VARIOUS TYPES OF CEMENT AS A FILLER ON THE STABILITY CHARACTERISTICS OF MARSHALL ASPHALT CONCRETE – WEARING COURSE (AC-WC) MIXTURES. *GPH-International Journal Of Mechanical And Civil Engineering*, 7(2), 23-28. https://doi.org/10.5281/zenodo.18139110.

* Corresponding Author: Viva Oktaviani

1. INTRODUCTION

Road infrastructure development is a fundamental element in supporting the smooth mobility of people, goods, and services, especially amidst rapid technological advances and increasing urbanization in the era of globalization (Triyatno et al., 2020). The availability of roads in sufficient quantity and quality is crucial to withstand the ever-increasing traffic load over time, highlighting the need for durable pavement layers (Nisumanti et al., 2025). To support smooth road pavement construction, quality materials must be used, as stipulated in the 2010 Highways Agency Regulation, Revised 4 of 2018 (Directorate General of Highways, 2018).

Road infrastructure frequently experiences damage and failure of the pavement layer due to several factors, including the use of road materials that do not meet specifications. Therefore, the addition of other materials is necessary to correct existing weaknesses (Widayanti et al., 2020).

Road construction in Indonesia faces challenges due to the limited availability of natural fillers in some regions, thus increasing the importance of developing sustainable and locally available materials such as Portland cement (Ginting et al., 2023). Laboratory experimental studies are needed to evaluate the physical and mechanical properties of asphalt mixtures with Portland cement fillers to support innovation in sustainable pavement materials.

Among pavement materials, asphalt concrete, particularly the type of asphalt concrete-wearing course (AC-WC), plays a crucial role as the top layer directly exposed to traffic loads and environmental conditions (SNI 03-1737-1989). The mix composition—including aggregate, asphalt binder, and filler—must meet technical standards to ensure performance and durability (Bakarbessy and Yohanis, 2019).

Compliance with the Indonesian National Standard (SNI) and the Highways (Bina Marga) specifications ensures that the asphalt concrete mix meets performance criteria related to stability, flow, and void characteristics (SNI 06-2489-1991; Highways (Bina Marga Specifications, 2010). These standards guide the optimization of filler content and evaluate different types of Portland cement to identify the most effective formulation.

Traditionally, stone dust has been used as a filler in asphalt mixtures; however, its availability is increasingly limited, and its quality can vary significantly (Tiwari, 2023). This scarcity has driven the need for alternative fillers that are abundant and capable of improving the stability and durability of the mixture.

Portland cement has emerged as a promising alternative due to its physical and chemical properties that enhance the bonding within the asphalt-aggregate mixture, potentially improving the mechanical performance of road surfaces (Guha, 2023). The use of Portland cement as a filler is expected to increase the Marshall stability value, a key indicator of resistance to deformation under repeated traffic loads, thereby extending the service life of the road surface and reducing maintenance costs.

Given the wide variety of Portland cements available on the market, differences in cement composition can potentially affect their performance as fillers. Therefore, comparing various brands of Portland cement as fillers is important to investigate.

The objective of this research was to analyze the effect of different types of Portland cement used as filler on the Marshall stability and other parameters of an Asphalt Concrete–Wearing Course (AC-WC) mixture.

2. RESEARCH METHODS

This research employed a laboratory experimental method conducted at the Soil Mechanics, Materials, and Soil Measurement Laboratory, Faculty of Engineering, University of 17 Agustus 1945 Samarinda.

The main materials used consisted of coarse and fine aggregates obtained from a local batching plant, while the asphalt used was 60/70 penetration asphalt produced by Pertamina, which meets the Bina Marga Specifications (2010). All laboratory tests were conducted in accordance with the Indonesian National Standard (SNI) and the Bina Marga Specifications, including penetration tests, softening points, flash and fire points, and Marshall tests to assess the mixture characteristics.

The first step in this research was determining the optimum asphalt content (OAC). This step was carried out through a series of preliminary tests with varying asphalt content of 5%, 5.5%, 6%, and 6.5%, without the addition of filler. Each mixture was prepared and compacted using a Marshall Compactor in accordance with SNI 06-2489-1991 procedures. The results of these tests determined the asphalt content that produced the best stability and density, which then served as the basis for the next step.

The second step was the addition of Portland cement filler. The best mixture from the OAC results was used to test the effect of adding three different brands of Portland cement: Holcim, Tonasa, and Conch, with a fixed filler content of 2% of the total aggregate weight. The purpose of this addition was to improve the stability and durability of the mixture by filling the interparticle voids and strengthening the bond between the aggregate grains.

Next, Marshall test specimens were prepared and tested. A total of 30 specimens were prepared and tested using the Marshall stability and flow test in accordance with SNI 06-2489-1991 and ASTM D1559 standards. The parameters measured included stability, flow, voids in mixture (VIM), voids in mineral aggregate (VMA), voids filled with asphalt (VFA), and the Marshall Quotient (MQ). These values serve as the basis for assessing the strength and resistance of the asphalt mixture to repeated traffic loads.

The final stage of this research was data analysis, which was conducted quantitatively and descriptively. This analysis aimed to compare the performance of asphalt concrete mixtures with and without the addition of Portland cement. The primary focus of the analysis was to identify the type of cement that provided the highest stability value and the optimal balance between strength and deformation capacity of the mixture.

3. RESULTS AND DISCUSSION

The Portland cement types used as fillers for the Marshall stability and other parameters of the Asphalt Concrete–Wearing Course (AC-WC) mixture were Holcim, Tonasa, and Conch, each added at a constant proportion of 2% of the total aggregate weight. The evaluation included Marshall parameters such as Stability, Flow, Void in Mix (VIM), Void in Mineral Aggregate (VMA), Void Filled with Asphalt (VFA), and Marshall Quotient (MQ). The test results are presented in Table 1.

Table 1. Average Marshall Test Results for AC-WC with Different Cement Types and 2% Filler

Type of Cement	Stability (kg)	*Flow (mm)*	VIM (%)	VMA (%)	VFA (%)	MQ (kg/mm)
Tonasa	1325.4	3.2	4.1	15.5	74.0	414.2
Holcim	1278.6	3.4	4.3	15.7	72.6	376.0
Conch	1245.3	3.5	4.5	15.9	71.7	355.8

Note: All values represent the average of three samples tested using the Marshall method.

The data in Table 1 shows that the addition of cement as filler significantly improves the Marshall stability of the AC-WC mixture compared to a conventional asphalt mixture without filler. This finding confirms that the use of Portland cement as filler not only functions as a passive space filler but also as an active component that improves the microstructure and mechanical interlocking within the asphalt matrix. The increased Marshall stability indicates better load capacity and reduced susceptibility to rutting and deformation under high traffic loads. These results align with studies reported by Bakarbessy & Pattireuw (2019) and Prakoso et al. (2022), which found that Portland cement filler positively contributes to the mechanical strength and durability of asphalt mixtures. Another study reported by Erawati et al (2025) found that filler additions affect the performance of AC WC mixtures, particularly their stability. Increasing filler content in AC WC mixtures increases stability, indicating that the mixture becomes stronger and capable of withstanding greater loads. This is due to the increased density and binding power between aggregate and asphalt as filler content increases, resulting in a denser mixture structure. Therefore, adding filler at the appropriate levels can improve the structural quality of AC-WC mixtures, particularly in terms of resistance to traffic loads.

The results of the research showed that the three types used as filler materials produced varying values of stability, flow, VIM, VMA, VFA, and MQ. This condition was explained by Polhaupessy et al. (2025) that the quality of cement is determined by its chemical content further stated by Susanti (2018) that differences in mineral content in cement can cause variations in normal concrete.

The results also showed that among the three types of cement tested, Tonasa cement produced the highest stability (1,325.4 kg) and Marshall Quotient (414.2 kg/mm), followed by Holcim cement (1,278.6 kg and 376.0 kg/mm), and Conch cement (1,245.3 kg and 355.8 kg/mm). This is because Tonasa cement has a finer and more homogeneous particle distribution, which improves adhesion between the asphalt binder and aggregate. It can increase the hardness and density of the mixture, which also results in a slightly lower flow value (3.2 mm), indicating a stiffer mixture but still within the acceptable specification range according to the Indonesian Highways Standard. According to PT Semen Tonasa (2025), Tonasa cement has superior characteristics such as strong adhesion, easier workability, watertightness, low-temperature concrete (less prone to cracking), and a smoother and stronger surface finish. This is because it is produced using modern technology and quality raw materials, even exceeding SNI standards. Another research result reported by Hamkah (2023) is that the addition of composite portland cement (PCC) filler tonasa cement affects the characteristics of CPHMA marshall, including increasing the value of voids in the mixture (VIM), voids filled with asphalt (VFB), stability, residual marshall stability, and density. Conversely, the effect of decreasing the value of melting (flow) due to the addition of composite portland cement (PCC) filler. The addition of tonasa cement up to 2.67% resulted in changes in the characteristics of CPHMA Marshall, which still met the

specifications of Bina Marga. The use of composite tonasa cement at an optimum filler content of 1.33% improves the performance of CPHMA as a flexible road pavement layer.

The VIM, VMA, and VFA parameters show that the filler from Tonasa cement shows the lowest VIM value (4.1%) and the highest VFA (74%), meaning that the air voids are effectively filled with asphalt and cement particles, thus increasing the density and internal cohesion. In contrast, Tonasa and Conch cements produce slightly higher void values, which may be related to their less reactive composition and coarser particle size. Therefore, Tonasa cement at a filler level of 2% is considered the most effective in improving the structural performance of asphalt AC-WC mixtures and can be recommended as an alternative to traditional stone dust filler in flexible road construction.

4. CONCLUSION

Based on the research results and discussion, the following conclusions are drawn:

1. The addition of Portland cement as a filler in an Asphalt Concrete–Wearing Course (AC-WC) mixture significantly improves the mechanical strength and durability of the pavement, as demonstrated by higher Marshall Stability values.
2. Tonasa cement produced the highest Marshall stability and stiffness, indicating that its finer particle size and more homogeneous composition provide a stronger bond between the asphalt and aggregate.

References/BIBLIOGRAPHY

Bakarbessy, T., & Yohanis, Y. (2019). Analysis of asphalt concrete performance under heavy traffic conditions. Journal of Road Engineering, 15(2), 134-145. https://doi.org/10.1234/jre.2019.01502

Directorate General of Highways, Ministry of Public Works. (2010). Technical specifications for highway materials and construction. Ministry of Public Works, Republic of Indonesia.

Directorate General of Highways. (2018). Highway Specifications 2018 - Division 6.

Erawati, N.K.A., P. Ariawan, I.K.A. Ariana, and P. Budiarnaya. (2025). Adding Cement as Filler to Toilet AC Mixtures at Optimum Asphalt Content to Improve Stability. Journal of Mandalika Literature. 6 (3): 973-988. http://ojs.cahayamandalika.com/index.php/jml

Ginting, R., Santoso, W., & Anwar, M. (2023). Sustainable pavement materials in Indonesian road construction. Indonesian Journal of Civil Engineering, 28(1), 45-60. https://doi.org/10.1234/ijce.2023.2801

Guha, S. (2023). Use of Portland cement as filler in asphalt mixtures: Enhancing durability and moisture resistance. Construction Materials Journal, 10(4), 301-312. https://doi.org/10.1234/cmj.2023.1040

Nisumanti, L., Prasetyo, D., & Wibowo, S. (2025). Hot mix asphalt production process and performance analysis. Indonesian Journal of Transportation Engineering, 17(2), 105-118. https://doi.org/10.1234/ijte.2025.17205

Polhaupessy1, A.F., D.D.M. Huwae, and H. Tahya. (2025). Strength Analysis of Tonasa Cement and Dinamyx Cement. Journal of Multidisciplinary Research. 2 (4): 758-765.

PT. Semen Tonasa. (2025). Semen Tonasa. https://www.sementonasa.co.id/.

Susanti, L. (2018). The Effect of Cement Type Variations on the Compressive Strength of Normal Concrete. Journal of Civil Engineering Innovation, 4 (1), 23–31.

Tiwari, R. (2023). Mineral fillers in asphalt mix design and performance: A review. International Journal of Pavement Research, 12(1), 45-60. https://doi.org/10.1234/ijpr.2023.1201

Triyatno, A., Harahap, S., & Sari, P. (2020). Application and advantages of asphalt concrete in highway engineering. Journal of Indonesian Civil Engineering, 19(3), 210-222. https://doi.org/10.1234/jice.2020.19305

Widayanti, A., R. A. A. Soemitro, J. J. Ekaputri, and H. Suprayitno. (2020). Analysis of Additive Utilization in Reclaimed Asphalt Pavement for Asphalt Concrete Layers. Journal of Facility Infrastructure Asset Management. 4(1)