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Loris Capirossi Suis [a*], Dian Eksana Wibowo [b]

[a]Universitas Negeri Yogyakarta, Department of Civil Engineering, Faculty of Vocational, Indonesia
[b]Universitas Negeri Yogyakarta, Department of Civil Engineering and Planning Education, Faculty of Engineering, Indonesia
*Corresponding Author: loriscapirossi.2019@student.uny.ac.id

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Research paper

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[a]Universitas Negeri Yogyakarta, Department of Civil Engineering, Faculty of Vocational, Indonesia
[b]Universitas Negeri Yogyakarta, Department of Civil Engineering and Planning Education, Faculty of Engineering, Indonesia
*Corresponding Author: loriscapirossi.2019@student.uny.ac.id

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ABSTRACT

Purpose: The purpose of this study is to find the Optimum Asphalt Content in recycled asphalt, know the characteristics of marshall in recycled asphalt, and find out the flexibility and resistance in the use of recycled asphalt with the addition of crushed stone ash.

Methods/Design: The methods used in this study are experimental and qualitative. The research was conducted by utilizing asphalt waste (asphalt recycle) obtained from the results of road dredging on Jl. Wates, KM 12, Sedayu, Sleman, Yogyakarta.

Findings: Asphalt waste is substituted with asphalt pen 60/70 as a rejuvenating material and filler is added using crushed stone ash. The planned new asphalt mixture is with percentage variations of 2%, 2.5%, 3%, and 3.5%. Meanwhile, the ash content of crushed stone as a planned filler is 3%, 5%, and 7%. The optimum asphalt content (KAO) obtained on new asphalt for recycled asphalt mixture meets the specifications of the Hot Paved Mixture Layer Implementation Guidelines (2007) at 3% asphalt content, while for crushed stone ash as filler, the Optimum Asphalt Content (KAO) value is obtained at 5% crushed stone ash content. In the use of recycled asphalt for Lataston bending pavement with the addition of crushed rock ash to marshall parameters, Stability values of 1765.10 kg, Density 2.31 gr / cc, Flow 3.11 mm, and Marshall Qoutient 567.56 mm / kg were obtained

Practical implication: Utilization of asphalt recycling with the addition of ash Stone as a Lataston mixture for flexible pavement can improve the quality of flexible pavement by combining recycled asphalt and stone ash in the Lataston mixture. it can also contribute to improving road construction technology and practices, which can benefit the construction industry and society.

INTRODUCTION

Highway construction is very important to facilitate the smooth running of land transportation, therefore highway construction must be planned well in order to provide comfort and safety for vehicles passing on it. Roads are one of the land transportation infrastructures most widely used by people for daily activities, so the volume of land transportation traffic is higher compared to other modes of transportation such as water and air transportation. Therefore, road pavement must be designed to be able to bear the volume of vehicles passing on it. In general, road pavement construction can be divided into flexible pavement and rigid pavement (Nahak et al., 2019).

In general, flexible pavement uses an asphalt mixture as a binding material, which causes flexible pavement to have good flexibility and a layered structure. Therefore, in this pavement concept a double-layer elastic system (Multilayer Elastic System) is applied where materials used with higher quality are placed on the surface layer. Asphalt mixtures can also use natural aggregates which have a smooth surface but their binding properties are not very good (Tarigan, 2019). Aggregate characteristics are the main factor in determining the ability of road pavement to bear traffic loads and weather resistance (Faqih & Pramudiyanto, 2014). Road pavement construction that uses flexible pavement has several layer structures consisting of a surface layer (Surface Grade) which is spread on the base soil (Sub Grade), an upper foundation layer (Base course), and a lower foundation layer (Sub Base Grade) which each layer has a traffic load. The asphalt mixture in flexible pavement construction structures functions as a surface layer and uses granular material for the bottom layer (Arthono, 2022). Flexible pavement also has the function of distributing vehicle traffic loads which are distributed over each layer down to the subgrade (Maharani, 2018). Flexible pavement is used on roads with light to moderate traffic loads, for example on city roads, roads with utility infrastructure underneath, road shoulder pavement, or pavement that requires gradual construction (Sukirman, 2010). Road pavement construction can be divided into flexible pavement and rigid pavement (Nahak et al., 2019). Meanwhile, problems that usually occur in basic soil are deformation or differences in soil subsidence due to traffic loads, changes in water content, variations in soil type, and uneven compaction (Masriadi, 2018).

Flexible pavement has several mixtures, one of which is Thin Layer Asphalt Concrete (Lataston) which is known as Hot Rolled Sheet-Wearing Course (HRS-WC). Lataston is a type of surface layer that consists of two components, namely the wear layer (Lataston layer aus/HRS-WC) and the intermediate surface layer (Lataston layer between surfaces/HRS-Binder). The material used by Lataston is aggregate with a lame gradation dominated by sand and a high asphalt content, spread out and then compacted in a hot condition at a certain temperature (Badan Standardisasi Nasional Binamarga, 2007). To improve the quality of Lataston pavement, one method used is by adding materials and additives at the Asphalt Mixing Plant (AMP) which is called modified asphalt (Yusrizal, 2019). The part of flexible pavement construction that is located below the surface layer is the top foundation layer structure. The upper foundation layer functions to place the surface layer, support vehicle loads, and distribute vehicle loads to the structural layers below (Rumiati, 1993). Meanwhile, the lower foundation layer functions to distribute the load from vehicle wheels to the layer beneath it or to the subgrade layer (Afriansyah, 2023). The asphalt mixture in flexible pavement construction structures functions as a surface layer and uses granular material for the bottom layer (Arthono, 2022). The asbuton aggregate mixture layer has a minimum thickness of 40 mm with the largest size of aggregate grains being 19 mm (Asidin, 2022).

The addition of additional layers for continuous road improvements can cause asphalt and materials to decrease, therefore it is necessary to reprocess old pavement materials that are no longer used by adding filler, mixtures and new asphalt so that they meet construction requirements. This method of reprocessing unused asphalt (asphalt waste) is also called the recycling method. Sustainable reprocessing of asphalt waste can contribute to the creation of environmentally friendly construction services. Asphalt pavement waste can be reused as a very useful resource. The asphalt recycling process can be carried out using two methods, namely processing at the mixing site (In Plant) and processing directly in the field or (In Place). Processing at the mixing plant is the result of raking used asphalt which is taken to the mixing plant so that its properties can be improved, thickness adjusted, and the type of road recycling selected for use. Meanwhile, processing in the field is the process of raking, compacting and forming directly on the spot (Latjemma, 2022).

In making the HRS-WC mixture, aggregate is a very important part. Aggregates are divided into two categories, namely natural aggregates and artificial aggregates. Over time, the availability of natural aggregates has decreased due to increasing infrastructure development in Indonesia, as a result, natural materials that are used continuously can damage the environment. Therefore, an alternative is needed as a substitute for natural aggregate by utilizing residual waste from the stone crushing industrial process (Mahbubi, 2019). Stone ash is a type of fine aggregate that successfully passes through a sieve with a diameter of 4.75 mm and remains on a sieve with a size of 0.075 mm, so that stone ash can be used as a building construction mixture. Stone ash can be used as a filler to replace sand in asphalt mixtures (Handayani, 2019). Inspection of asphalt materials is carried out to ensure that one of the stability factors for pavement construction is met, as well as other aspects related to implementation in the field (Nugroho, 2019). Reclaimed Asphalt Pavement (RAP) itself was historically caused by the petroleum crisis in the 1970s and the increase in material prices (Frank et al., 2016). Due to the increasing price of materials for road pavement and awareness of damage to the environment, researchers have encouraged researchers to find pavement construction technologies that are more environmentally friendly and economical in terms of costs (Rathore et al., 2019).

The main objective of this research is to find the benefits of asphalt recycling by adding crushed stone ash as a Lataston mixture for flexible pavement. This data is very useful in saving flexible pavement construction costs, helps reduce the environmental impact of road construction, improves the quality of flexible pavement by incorporating recycled asphalt and rock ash in Lataston mixes, and contributes to improving road construction technology and practices, which can benefit the construction industry and Society.

METHODS

This research uses experimental and qualitative methods. Asphalt waste was substituted with new 60/70 penetration asphalt as a rejuvenating agent and filler was added using crushed stone ash. The object of this research is flexible pavement for Thin Layer Asphalt Concrete (LATASTON) mixtures. The planned mixture of new asphalt and recycled asphalt is with percentage variations of 2%, 2.5%, 3% and 3.5%. Meanwhile, the planned crushed stone ash content as filler is 3%, 5% and 7%. This research is expected to optimize asphalt waste and crushed stone ash waste for reprocessing and increase the stability of the Lataston mixture.

To analyze the results of Marshall testing, researchers used qualitative methods. Marshall testing aims to obtain stability values against static melting of recycled hot asphalt mixtures. The addition of new asphalt to asphalt waste functions as a rejuvenating agent, and the addition of crushed stone ash aims to ensure that the recycled hot asphalt mixture meets predetermined standard specifications. The results of the marshall test are expected to meet the requirements for thin layer asphalt concrete (Lataston) flexible pavement. The results of this research refer to the Specifications of the National Highways Standardization Agency (2007) concerning Guidelines for the Implementation of Hot Mixed Asphalt Layers.

The research location was carried out at the Road Construction Laboratory, Department of Civil Engineering and Planning Education, Faculty of Engineering, Yogyakarta State University. This test is carried out in stages starting from asphalt penetration testing and marshall testing. This testing was carried out from June 2023-September 2023. Testing was carried out in accordance with K3 standards to obtain the expected results.

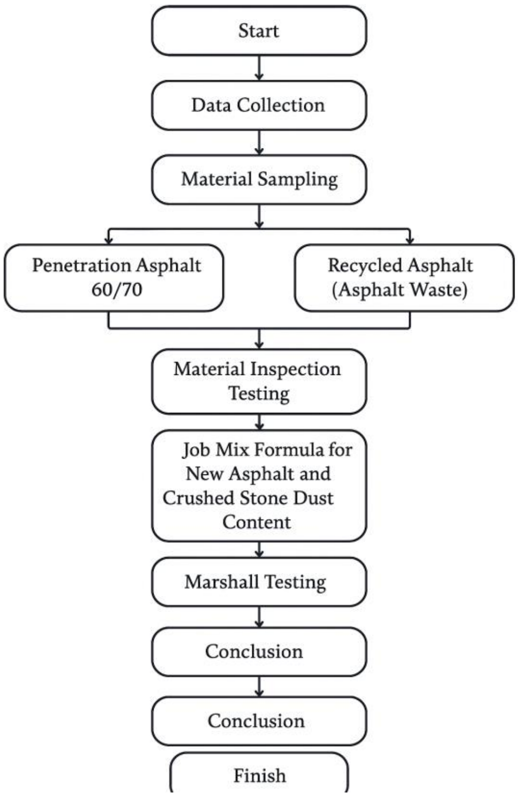

Figure 1. Flow Chart Research

The research was carried out by utilizing asphalt waste (asphalt recycling) obtained from road dredging on Jl. Wates, KM 12, Sedayu, Sleman, Yogyakarta. The results of dredging unused asphalt are then processed at the Road Construction Laboratory, Department of Civil Engineering and Planning Education, Faculty of Engineering, Yogyakarta State University. The used asphalt is then broken into smaller chunks to make the mixing process easier with new asphalt and crushed stone ash as a rejuvenator and filler for the Lataston pavement mixture. The used asphalt processing process used has limitations, where the aggregate in the used asphalt cannot be filtered to separate the aggregate and old asphalt attached to the pavement mixture.

Figure 2. Asphalt Waste from Dredging

FINDINGS

In this study, used asphalt (recycled asphalt) was used as a result of dredging the old pavement on Jl. Wates, KM 12, Sedayu, Sleman, Yogyakarta, as a research object to reprocess used asphalt that is no longer used so that it can be reused for flexible thin layer asphalt concrete (Lataston) pavement.

A. Asphalt Inspection Test Results

The quality of the ingredients in the asphalt concrete mixture can be determined by testing asphalt penetration, softening point, flash point, ductility, viscosity and specific gravity. The aim of the asphalt test is to indicate the asphalt's ability to withstand loads and temperature changes, as well as predicting the long-term performance of the road or asphalt surface. The results of the asphalt inspection test can be seen in Table 1.

Table 1. Results of Asphalt Inspection Testing

Test Type	Spec	Results	Requirements
Penetration, 25˚C; 100 gr; 5 seconds; 0.1mm	60-79	64,77 mm	OK
Softening point,˚C	48-58	51. 5˚C	OK
Flash point,˚C	Min 200	306˚C	OK
Ductility 25˚C, cm	Min 100	150 cm+	OK
Specific gravity	Min 1	1.044 gr/cc	OK

From the results of the material inspection tests above, it shows that the asphalt used meets the standard requirements set out in the Hot Mix Asphalt Coating Implementation Guide.

B. Marshall Test With the Addition of New Asphalt

In this Marshall test, new asphalt was added to the recycled asphalt mixture. Marshall testing for the addition of new asphalt to recycled asphalt is limited to the parameters Stability, Density, flow and Marshall Qountient. Based on the results of Marshall testing to determine the optimum asphalt content as a rejuvenating agent in recycled asphalt, the following results were obtained from the planned parameters

1) Stability

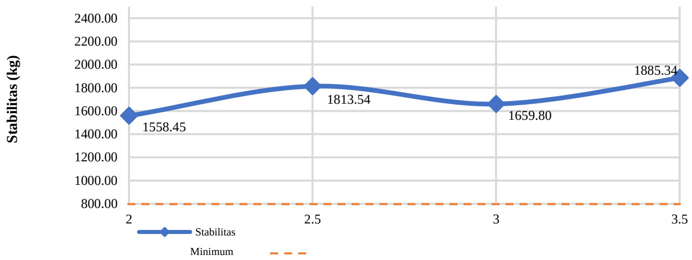

Figure 3. Stability Value Graph

Table 2. Stability Values from Marshall Testing

Asphalt Content (%)	Stability (kg)
2	1558.45
2	1558.45
2.5	1813.54
3	1659.80
3.5	1885.34

From Figure 3 and Table 2, the stability values from the marshall test results in this study have met the standard specifications required in the Hot Mix Asphalt Layer Implementation Guide (2007), for Lataston hot mix asphalt, namely a minimum of 800 kg.

2) Density

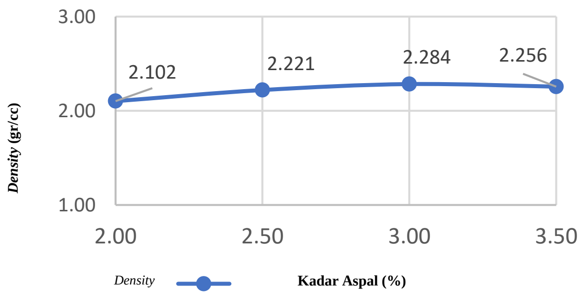

Figure 4. Density Value Graph

Table 3. Density Values from Marshall Testing

Asphalt Content (%)	**Density (gr/cc)**
2	2.102
2.5	2.221
3	2.284
3.5	2.256

From Figure 4 and Table 3 it can be seen that the density value from the Marshall test results in this study continues to increase up to an asphalt content of 3%, and slightly decreases at an asphalt content of 3.5%. Asphalt plays a very important role as a binding agent which causes the mixture to become denser.

3) Flow

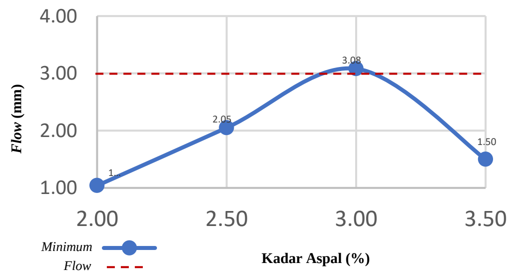

Figure 5. Flow Value Graph

Table 4. Density Flow from Marshall Testing

Asphalt Content (%)	**Flow (mm)**
2	1.04
2.5	2.05
3	3.08
3.5	1.50

From Figure 5 and Table 4, at an asphalt content of 3%, the flow value meets the standard specifications required in the Hot Mix Asphalt Layer Implementation Guide (2007) for Lataston hot asphalt mixes, namely a minimum of 3 (mm).

4) Marshall Qoutjent

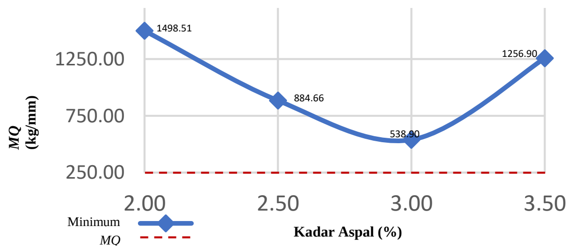

Figure 6. Marshall Qountient Value Graph

Table 5. MQ Values from Marshall Testing

Asphalt Content (%)	***Marshall Quontient*** **(kg/mm)**
2	1498.51
2.5	884.66
3	538.90
3.5	1256.90

Figure 6 and Table 5 show that the marshall quotient quality in this study is in accordance with the requirements described in the Hot Mix Asphalt Layer Implementation Guide (2007) for Lataston hot mix asphalt, namely a minimum of 250 (kg/mm).

The best Optimum Asphalt Content (KAO) value is 3% asphalt content because it meets the Marshall criteria for Stability, Density, Flow and Marshall Qoutient. After obtaining KAO from the new asphalt content, testing of the asphalt trial mix will be continued with the addition of crushed stone ash as a filler. KAO from marshall testing with the addition of new asphalt to recycled asphalt can be seen in Figure 7 below:

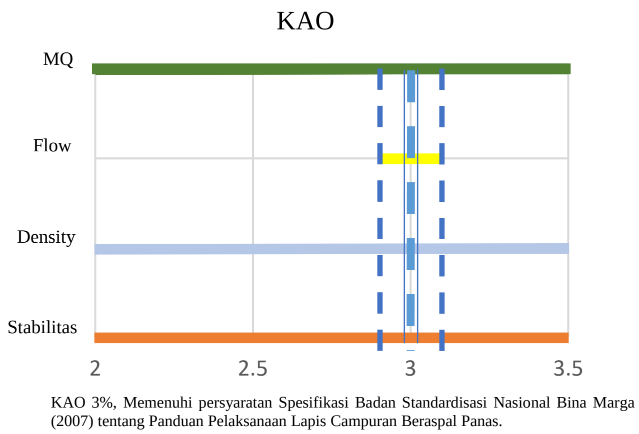

Figure 7. KAO Chart for New Asphalt Mixtures

C. Marshall Test with Addition of Crushed Stone Ash

In this research, crushed stone ash was also added which functions as a filler to fill empty cavities so that it can increase the flexibility and durability of the pavement. Testing was carried out using the Marshall method, Marshall parameters were limited to Stability, Density, Flow and Marshall Qoutient. Mixing recycled asphalt is carried out by adding 3% new asphalt and crushed stone ash to create a mix design.

1) Stability

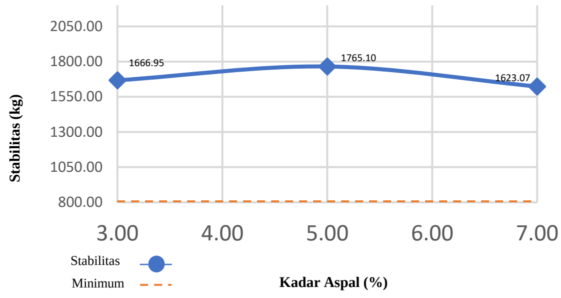

Figure 8. Stability Value Graph

Table 6. Stability Values from Marshall Testing

Asphalt Content (%)	Stability (kg)
3	1666.95
5	1765.10
7	1623.07

From Figure 8 and Table 6, the highest stability value is at a crushed stone ash content of 5% and decreases at a level of 7%. The stability value is in accordance with what is required in the Hot Mix Asphalt Layer Implementation Guide (2007) for Lataston hot asphalt mix, namely a minimum of 800 kg.

2) Density

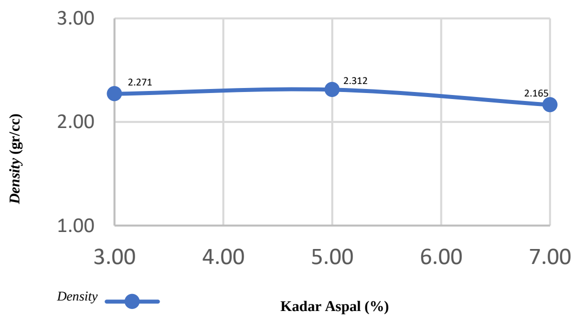

Figure 9. Density Value Graph

Table 7. Density Values from Marshall Testing

Asphalt Content (%)	Density (kg)
3	2.27
5	2.31
7	2.17

From Figure 9 and Table 7 it can be seen that the density value increased at a crushed stone ash asphalt content of 5% and fell again to the lowest value at a crushed stone ash content of 7%. The density value meets the standard specifications required in the Hot Mix Asphalt Layer Implementation Guide (2007) for Lataston hot mix asphalt

3) Flow

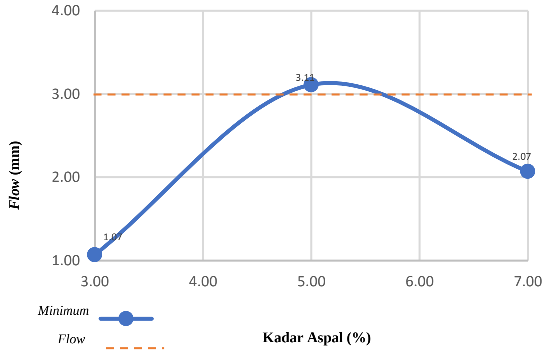

Figure 10. Flow Value Graph

Table 8. Flow Values from Marshall Testing

Asphalt Content (%)	Flow (mm)
3	1.07
5	3.11
7	2.07

From Figure 10 and Table 8, the flow value in the marshall test with the addition of crushed stone ash obtained the best value at a crushed stone ash content of 5%, and meets the standard specifications required in the Hot Mix Asphalt Layer Implementation Guide (2007) for Lataston hot asphalt mixes, namely minimum 3.0 mm.

4) Marshall Qoutjent

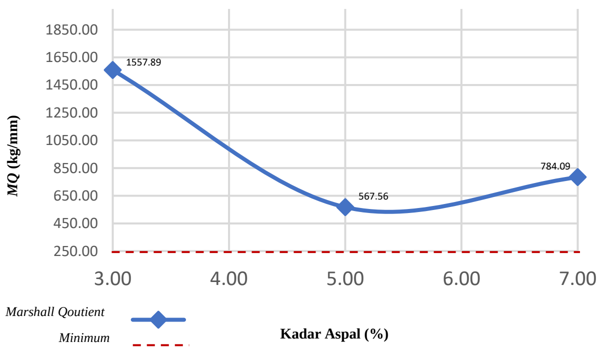

Figure 11. Marshall Qountjent Value Graph

Table 9. MQ Values from Marshall Testing

Asphalt Content (%)	*Marshall Quontient* (kg/mm)
3	1557.89
5	567.5
7	784.09

From Figure 11 and Table 9, the highest marshall qoutient value is at a crushed stone ash content of 3% and the lowest is at a crushed stone ash content of 5%. The marshall qoutient value in this study is in accordance with the specifications required in the Hot Mix Asphalt Layer Implementation Guide (2007) for Lataston hot mix asphalt, namely a minimum of 250 (kg/mm).

From the Marshall test results on the addition of new asphalt with a content of 3% and the addition of crushed stone ash to recycled asphalt, the Optimum Asphalt Content value for crushed stone ash was obtained at a crushed stone ash content of 5%. Marshall test results meet the Hot Mix Asphalt Layer Implementation Guide Specifications (2007) for Lataston hot asphalt mixes. KAO values and examination of Marshall test results on the addition of 3% new asphalt with crushed stone ash can be seen in Figure 12 below:

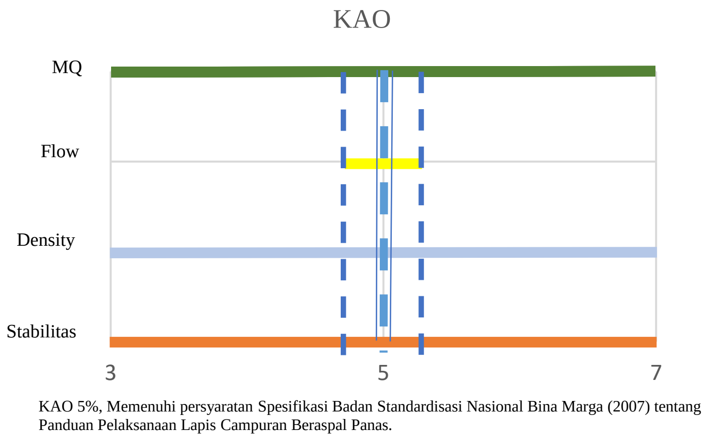

Figure 12. KAO Chart for Crushed Stone Ash Mixture

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