

FEASIBILITY STUDY OF MOUNTAIN MATERIAL AS CLASS B AGGREGATE FOUNDATION LAYER FOR HIGHWAY FLEXIBLE PAVEMENT

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Abstract: This study aims to examine the technical feasibility of the Wae Lengkas Quarry mountain material as a Class B Aggregate Foundation Layer for flexible road pavements. Material samples were taken from the quarry and then tested in the Civil Engineering Laboratory of the Catholic University of Indonesia St. Paulus Ruteng. The test results were compared with the 2018 General Specifications for Roads and Bridges which regulate the quality standards for road materials. The types of tests carried out are grain size distribution, wear, light density and Atterberg limits. From the results of the grain size test, the percentage of sand was 93%, clay 1.5% and salt 5.47%. Based on the percentage of the grain division, the Wae Lengkas Quarry material is included in the sand in the USDA (U.S. Department of Agriculture) triangle chart. The liquid limit (LL) value is 32%, the plastic limit (PL) is 26.74% and the plasticity index (PI) is 5.26% which is the difference between the liquid limit and the plastic limit. Based on the Atterberg limits value, the material is feasible because the B value < 35 and $PI < 10$. Specific gravity (Gs) 2.5 gr/cm³, maximum dry unit weight 1.62% at optimum water content 13.45% and abrasion value 46.28%. Based on the abrasion value, the material is not suitable as Class B Aggregate because it is $> 40\%$. This shows that the Wae Lengkas Quarry material cannot be used directly as Class B aggregate but must be mixed with gravel from other quarries that meet the abrasion value.

Keywords: *Mountain material, Laboratory Test, Class B Aggregate, feasibility.*

INTRODUCTION

Strong, stable and safe construction is the main target in road construction work to ensure that the right quality aspects are met. The realization of this depends on the available resources, one of

which is construction materials. Materials in the form of sand, logs, crushed stone, or gravel (sirtu) are absolutely the main resources in road work. Its availability in the natural environment is quite abundant, but not all of it can be used as construction material, considering the technical requirements that must be met in terms of quality.

Technically, roads are composed of several compacted layers, namely the surface layer, foundation layer and subgrade. The strength of the pavement structure does not only depend on the surface layer, but the base soil and subbase layers are the main supporting factors. The existence of the base soil and subbase is also a major concern from the design stage to the implementation stage. Subbase is designed to reduce the thickness of the upper foundation layer, surface layer and reduce the adverse impact of the base soil.

The road construction is an integral part of the planning, implementation, operation and maintenance stages. This series of stages is a mandatory matter for road organizers, including the exploitation of nature to meet construction material needs. The organizers in this case are the project owner, contractor, planning consultant and supervisory consultant. All scopes of work must be measurable and listed in the TOR (Terms of Reference) document so as not to deviate from the initial plan and reduce the risk of construction failure during implementation and building failure during operation (Gon et al., 2025).

The main material in road paving is aggregate because it fills the component by 90-95% by weight and 75-85% by volume (Hakzah et al., 2021). Therefore, the quality of the material must be considered from the initial exploration of nature to transportation, spreading and compaction in the field. In Indonesia, the quality requirements for road materials have been regulated in the 2018 General Specifications for Roads and Bridges. Where Class B Aggregate must meet requirements such as a maximum abrasion value of 40%, liquid limit (LL) of no more than 35, a maximum plasticity index value of 10, and a minimum immersion CBR of 60% (Ministry of PUPR, 2018).

In Manggarai Regency, East Nusa Tenggara Province, there are several sources of mining in the form of sand and stone for construction work, one of which is from the Wae Lengkas quarry.

The material from the quarry is generally used as a mixture of mortar or concrete for construction work. But it has not been optimally utilized as road paving material. This study aims to examine its feasibility so that it can be applied as a Class B Aggregate Foundation layer in flexible pavement work on highways.

METHOD

This research was conducted on local materials from Wae Lengkas, Manggarai Regency, East Nusa Tenggara Province. There are a series of stages in this research, namely initial observation, literature study, sampling, laboratory testing, data processing and evaluation.

The research procedures began with an initial observation stage, which was carried out by inspecting the excavation location and coordinating with the quarry owner. Following this, a literature study was conducted to obtain sources relevant to the research topic; in this case, the literature consisted of research journal articles, books, Indonesian National Standards (SNI), and the 2018 General Specifications for Roads and Bridges. Subsequently, sampling was carried out by collecting material from the Wae Lengkas Quarry according to testing needs. After the samples were collected, the testing stage took place in the Civil Engineering Study Program Laboratory, Faculty of Engineering, Catholic University of Indonesia St. Paulus Ruteng, where the materials underwent several tests, including grain size distribution, liquid limit (LL), plastic limit (PL), specific gravity (Gs), light density, and abrasion.

After the material is tested, the data obtained is then processed using Excel software with reference to the relevant SNI. The results of the grain size distribution test are presented in the Class B Aggregate grain gradation table and compared with Table 5.1.2.1 Division 5 General Specifications for Roads and Bridges 2018. Next, the percentage of grain division is plotted in a USDA (U.S. Department of Agriculture) triangle chart to determine the type of

soil based on grain. Next, calculate the plasticity index (PI) value, which is the difference between the liquid limit and plastic limit values, or can be written as follows:

$$\text{Plasticity index, } PI = LL - PL$$

The G_s value is required for calculating the maximum dry density in the light density test. The formulas are as follows (Das, 2002) :

$$\text{Spccivik gravity, } G_s = \frac{W_s}{V_s}$$

$$\text{unit weight, } \gamma = \frac{W}{V}$$

$$\text{dry unit weight, } \gamma_d = \frac{\gamma}{1 + w}$$

$$\text{Zero Air Void unit weight, } \gamma_{ZAV} = \frac{G_s \cdot \gamma_w}{1 + G_s \cdot w} \times 100\%$$

Where:

W = total mass

w = moisture content

G_s = specific gravity

γ_w = unit weight of water

V = total volume

The abrasion value is calculated after the test by dividing the weight retained on sieve No. 12 by the initial weight. The calculation is as follows:

$$\text{Abrasion} = \frac{a-b}{a} \times 100$$

Where:

a = original weight of test object

b = weight retained on sieve No.12 after test

Finally, the researcher made evaluation. At this stage, the research results are compared with the 2018 PUPR Ministry technical specifications which regulate road material quality standards. In this case, Division 5 General Specifications for Roads and Bridges 2018.

RESULT

1) Evaluation

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RESULT

1. Grain size distribution

Grain size distribution tests were carried out on test specimens weighing 1500 grams and 3000 grams respectively. The results of the sieve analysis with a sample weight of 1500 grams are shown in Table 1.

Table 1: Results of one sample test weighing 5000 gr

Sieve No.	Sieve opening (mm)	% of soil retained on each sieve	% of mass of soil retained	cumulative percent retained	% finer	lower limit spec	upper limit of spec
2"	50	0	0	0	100,00	100	100
1 1/2"	37,5	127,2	8,47	8,47	91,52	88	95
1"	25	190,4	12,68	21,16	78,84	70	85
3/8"	9,5	358	23,85	45,02	54,98	30	65
4	4,75	99,1	6,60	51,62	48,37	25	55
10	2	187	12,46	64,08	35,91	15	40

40	0,425	262,8	17,51	81,60	18,40	8	20
200	0,075	217,1	14,46	96,06	3,93	2,0	8
Pan		59	3,93	100	0		

Furthermore, the percentage of grains is depicted in the curve of the relationship between grain diameter and the percentage of passing as shown in Figure 1.

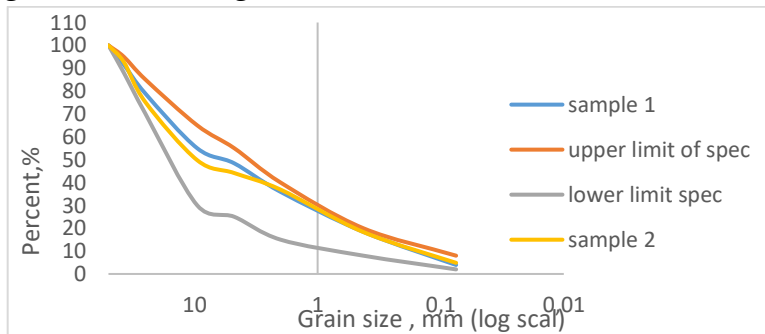


Figure 1. Grain gradation curve

Based on Figure 1, the Wae Legkas quarry material is in the Class B Aggregate grain gradation section.

2. USDA Classification

Generally, the USDA system groups soil types based on grain size, namely gravel, sand, silt and clay. Where gravel is for material measuring >2 mm, sand 2 mm to 0.05 mm, silt 0.05 mm to 0.002 mm and clay measuring <0.002 mm (Das, 1995). Table 2 percentage distribution of material grains from the Wae Lengkas quarry. Based on these percentages, they are plotted in a USDA triangle chart as presented in Figure 2.

Table 2: Percentage of grain size

Grain type	grain (mm)	size mass (gr)	Percent t (%)	correct(%)
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Gravel	4,75	180,1	30	
Sand	2	101,5	16,9	
	0,425	96,9	16,14	
	0,075	103,4	17,2	
	0,053	89	14,8	93
Silt	0,01	23	3,8	5,4
Clay	0,002	6,3	1,0	1,5

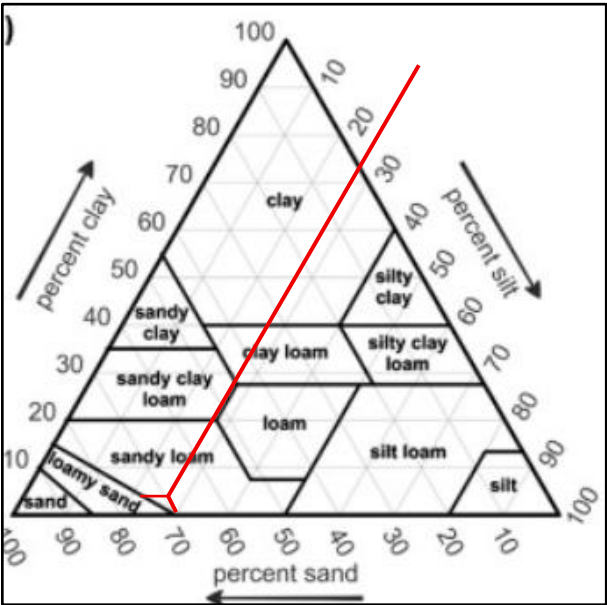


Figure 2. USDA (U.S. Department of Agriculture) chart

Based on Figure 2, the material from Wae Lengkas is included in the sand group.

3. Liquid limit (LL) and plastic limit (PL)

Liquid limit (LL) and plastic limit (PL) tests are carried out on materials passing sieve No. 40. The test refers to SNI 1967:2008 for the liquid limit and SNI 1966:2008 for the plastic limit. The PI value is obtained from the difference between the LL value and the PL value (BSN, 2008b). The results of the Atterberg limits test are shown in Table 3 and Figure 3.

Table 3: Atterberg limits test results

No.	LL	PL	PI
1	31	26,3	4,7
2	33	27,18	5,8
Average	31,5	26,5	4,98

4. Specific gravity (Gs)

Specific gravity test follows SNI 1964:2008 guidelines. From the test results, the specific gravity of the material from the Wae Lengkas quarry was 2.5 gr/cm³. In this study, the specific gravity value is needed to calculate the maximum dry density.

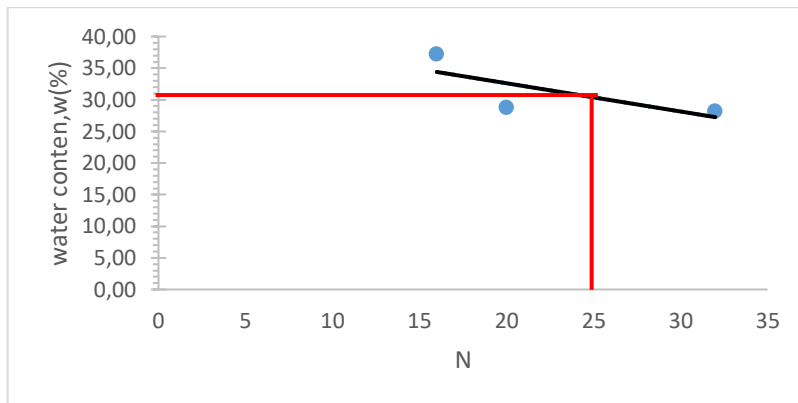


Figure 3. Liquid limit (LL) curve

5. Standard Proctor Compaction Test

The standard proctor compaction test in the laboratory refers to SNI 1742:2008 by following method D. The material was compacted in a mold of 3 layers using a 2.5 kg poulder and pounded 56 times per layer (BSN, 2008c). The test results are read in Figure 4.

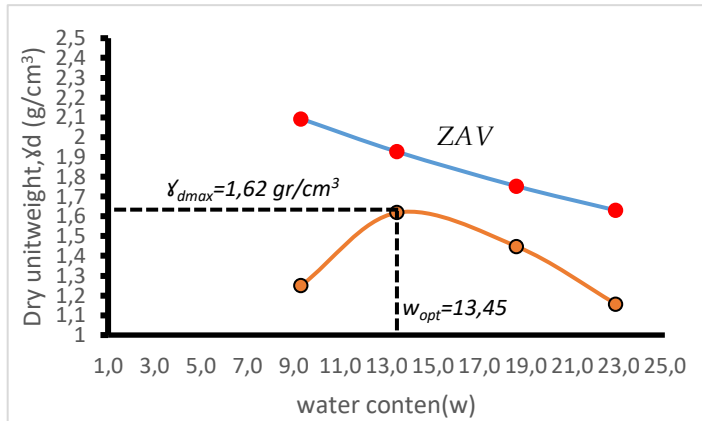


Figure 4. Proctor standard compaction curve

Based on Figure 4, which is a curve of the relationship between water content and dry unit weight, the maximum dry unit weight (γ_{dmax}) is 1.62 gr/cm³ at an optimum water content of 13.45%. This value can be used to control density in the field and as a reference for testing CBR (California Bearing Ratio) values.

6. Abrasion

The material wear or abrasion test refers to SNI 2417:2008. The size of the material as a test object follows gradation A and gradation F. The material is inserted together with 12 steel balls into the machine, then rotated at a speed of 30 rpm for 500 rotations for gradation A and 1000 rotations for gradation F (BSN, 2008a). From the test results, the abrasion value of gradation A was 45.5% and the abrasion value of gradation F was 47%. The average for both is 46.28%.

DISCUSSION

The test results show that the grain size distribution of the material from the Wae Lengkas Quarry meets the upper and lower gradation limits specified in the 2018 technical specifications. This finding is notable because, in the implementation of material collection in quarries, it is often difficult to obtain grain gradation that fully aligns with specifications. Therefore, mixing is usually

required to ensure the presence of all necessary grain sizes so that a high level of density can be achieved during compaction at the work location (Oktariza & Gofar, 2023). These results indicate that quarry material has naturally favorable gradation characteristics, which reduces the amount of processing needed before field use. Achieving compliant gradation at the source is advantageous because it minimizes cost and time associated with additional material blending. Moreover, good gradation contributes directly to improved shear strength and stability of the final compacted layer. Thus, the conformity of Wae Lengkas material to specification limits enhances its feasibility as a reliable construction material.

In addition to grain size distribution, the results of other physical property tests—specifically the Atterberg limits measured through LL and PI values—indicate that the material meets the requirements as Class B Aggregate, as the LL value is <35 and the PI value is <10. This low plasticity is attributed to the very low clay content within the material. If the clay content were higher, the soil would exhibit greater plasticity, which would negatively affect its technical performance by reducing strength and making compaction more difficult during fieldwork (Adelina A.R Runtuwene & Oscar H. Kaseke, 2021). The compliance with Class B Aggregate standards suggests that the material will maintain dimensional stability under moisture variations. Low plasticity also means the material is less susceptible to swelling or shrinking, which is important for long-term pavement durability. These characteristics contribute to predictable engineering behavior, reducing risks associated with deformation or softening. Overall, the Atterberg limit results reinforce the suitability of the material for base or sub-base applications where consistency is crucial.

Furthermore, the mechanical test results show a maximum dry density of 1.62 gr/cm³ at an optimum water content of 13.45%, demonstrating the material's compaction characteristics. However, despite these favorable properties, the abrasion value of 46.28%,

which exceeds the allowable limit of 40%, indicates that the gravel from the Wae Lengkas Quarry does not meet the required technical specifications. This limitation suggests that, although the material performs well in terms of gradation, plasticity, and density, its resistance to abrasion remains insufficient for use in accordance with the standards. High abrasion values imply that the aggregate is prone to degradation when subjected to mechanical loads, which can compromise structural longevity. This weakness could lead to accelerated wear in pavement layers, resulting in increased maintenance needs. Because durability is a critical factor in aggregate selection, the abrasion performance significantly reduces the material's potential for heavy-duty road applications. Therefore, further treatment or alternative sourcing may be necessary to ensure compliance with durability requirements.

The findings of this study also imply that local quarries such as Wae Lengkas hold significant potential to support regional infrastructure development if material limitations are addressed through proper quality control measures. While the material demonstrates acceptable gradation, plasticity, and compaction characteristics, the high abrasion value highlights the need for quarry operators to improve aggregate processing or consider selective extraction of more durable rock sources. Strengthening quarry management practices could enhance the consistency and reliability of materials supplied for public works, thereby reducing project delays and minimizing the need for imported aggregates. Moreover, collaboration between local governments, engineers, and quarry owners may lead to the development of training, monitoring systems, or technological interventions that elevate material quality to meet national standards.

CONCLUSION

Based on the results of the grain size distribution, physical properties, and mechanical tests, it can be concluded that the

material from the Wae Lengkas Quarry generally demonstrates characteristics that align with several requirements of the 2018 technical specifications. The material meets the upper and lower gradation limits and satisfies the Atterberg limit criteria for Class B Aggregate, indicating low plasticity and minimal clay content, which support good workability and stability during compaction. Moreover, the maximum dry density of 1.62 gr/cm^3 at an optimum water content of 13.45% reflects favorable compaction behavior suitable for base or sub-base applications. However, despite these strengths, the abrasion value of 46.28%, exceeding the allowable 40%, shows that the material does not fully meet durability standards, thereby limiting its suitability for use in pavement structures that require high resistance to mechanical wear. Overall, the study concludes that while Wae Lengkas Quarry material holds potential for certain construction uses due to its gradation and plasticity characteristics, improvements in aggregate durability or selective material sourcing are necessary to ensure full compliance with technical specifications for roadwork applications.

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