PHILIPPINE ENGINEERING JOURNAL
PEJ 2025; Vol. 46, No. 2: 1-15

Received: 21 March 2025
Received in Revised Form: 06 July 2025
Accepted: 14 October 2025

Characterization of Locally Sourced Perlite from Camarines Sur, Philippines

Jesha Faye T. Librea[1, 2*], Clarence R. Guanzon[2], Paolo S. Valencia[2],
Jomar Christian J. Camposano[2], Rosabelle Louise A. Caram[2], Jan Lowell P. Buquiz[3]
[1]Department of Engineering Science, University of the Philippines Los Baños, Laguna, Philippines
[2]Institute of Civil Engineering, University of the Philippines Diliman, Quezon City, Metro Manila, Philippines
[3]Department of Mining, Metallurgical and Materials Engineering, University of the Philippines Diliman, Quezon City, Metro Manila, Philippines
**Corresponding author: jtlibrea@up.edu.ph*

Abstract *– Locally sourced perlite has significant potential for commercial, and industrial applications. This study focuses on characterizing Philippine perlite sourced from an aggregate mine in the Bicol Region for its potential as possible construction aggregate. X-ray diffraction result showed presence of amorphous broad peak of perlite as well as some narrow sharp peaks of crystalline components like silica and feldspar. Chemical analysis revealed a composition of 64.35% silica and 25.36% alumina. Notably, the high aluminum oxide content suggests that Philippine perlite can withstand high-temperature processes while maintaining structural integrity. The samples contained 0.60% free moisture and 4.55% locked moisture, with thermographic analysis identifying the release of chemically bonded water for pore expansion at 595°C. This establishes a foundational processing temperature for the utilization of native Philippine perlite. Optical microscopy confirmed the silicious nature of the perlite samples, displaying glassy features. Physical properties of both coarse and semi-processed samples were within acceptable ranges. Coarse perlite, in particular, exhibited the highest bulk density (1390 kg/m³), effective size (0.10 mm), and fineness modulus (2.02), indicating that it can yield a diverse range of particle sizes suitable in construction applications. In conclusion, this study highlights the significant potential of locally sourced Philippine perlite for various applications. Comprehensive analysis, particularly in physical characterization, affirms its potential as a raw material for aggregate production, contributing to the utilization of this resource in construction and related industries.*

Keywords*: perlite, Philippine perlite, perlite aggregate*

I. INTRODUCTION

Perlite is an amorphous glassy volcanic rock of rhyolitic and siliceous composition formed from the hydration of lava flows [1]. It has a water content higher (around 2-5%) than that of common obsidian rocks [2-3]. When rapidly heated to temperatures between 700 and 1000°C, perlite undergoes a remarkable transformation. This process releases trapped water molecules as steam, causing the perlite structure to expand, resulting in a highly porous and lightweight material. Perlite can expand up to twenty times its original size upon heating, and it changed color from gray to brilliant white [4, 5]. This unique property has led to its versatile use in horticulture, insulation, filtration, and construction applications [6]. In construction, the expanded perlite aggregates (EPA) are used as lightweight aggregates to minimizes the overall structure weight, which translates to the decrease in both dimensions of structural members and the materials needed [7].

As such, the potential of perlite as a construction material has driven perlite production. Extraction of perlite includes surface mining methods such as direct stripping or drilling and blasting. The raw perlite is crushed and processed according to market standards. A report by the United States Geological Survey states that the environmental impact of perlite mining is not severe since rejected ores are utilized to reclaim mined-out areas, and runoff is perceived to be virtually a non-threat to water pollution [8]. Current estimates of annual world production of perlite are at 4.1 million metric tons, led by China, Greece, Turkey, and the United States, with about 47%, 20%, 16%, and 13%, respectively [8].

Various studies have determined several properties of perlite from different regions of the world. Dogan and Alkan [4] characterized the cation exchange capacity, an important property to consider when improving soil quality, of expanded and unexpanded perlite samples from Izmir, Turkey, using the ammonium acetate method. Sánchez et al. [9] investigated the pozzolanic effect of natural and expanded perlite as partial substitute for cement in mortar mixtures and found that a 5% replacement with natural perlite provided the best mortar mechanical properties. Reka et al. [10] determined the physio-chemical properties of native perlite from the Mariovo Region, Macedonia and found that the material was suitable to use as ceramic flux. Currently, much of the research on perlite characterization focuses on European and Turkish perlite while limited data are available for Philippine perlite.

Situated in the Pacific Ring of Fire and composed of eight (8) major volcanic arc regions, the Philippines has rich deposits of perlite owing to the persistent volcanic activities in these regions. The Bicol region, whose volcanic arc formations contain basalt flow, pyroclastic rocks, volcanic breccia, and tuffs [11-12], has two (2) perlite mines located at Camarines Sur and Legazpi City, Albay. In year 2013 alone, 14, 249 MT of perlite was mined in the Philippines [13]. Production of EPA in the Philippines is a potential growing industry because of the sizable reserves and establishment of plants, but most of the products are exported to other countries such as Taiwan, Thailand, Singapore, and Australia [14]. Despite the abundance of perlite in the Philippines, there is still limited information about its properties, usage, and applications in the country.

This paper aims to bridge this information gap by examining the chemical and physical properties of native Philippine perlite. The study is confined to characterizing perlite extracted from Baao, Camarines Sur, providing valuable reference data for future research endeavors aiming to utilize Philippine perlite as a potential construction material.

II. METHODOLOGY

2.1 Sample Preparation

Raw perlite samples (Figure 1) were obtained from a perlite aggregate mine in La Medalla, Baao, Camarines Sur, Philippines. Three types of samples were used: unprocessed perlite (Coarse Perlite – Figure 1a) and semi-processed perlite samples (Semi-processed A – Figure 1b and Semi-processed B – Figure 1c). Coarse perlite was dark gray in color, while semi-processed samples had a lighter gray color. Coarse perlite was directly obtained from the mine

through shovel sampling, after which the collected samples were washed and dried. On the other hand, semi-processed perlite samples were produced from coarse perlite that had been crushed and screened to specific gradation to meet market requirement.

(a) **(b)** **(c)**

Figure 1. Local perlite samples (a) Coarse, (b) Semi-processed A and (c) Semi-processed B.

2.2 Chemical Characterization

Chemical assessment included determining mineral composition and moisture content. Characterization and identification of the perlite sample was done through joint analysis using x-ray fluorescence (XRF) and x-ray diffraction (XRD) test under the Earth Materials Science Laboratory in the National Institute of Geological Sciences, University of the Philippines Diliman. For the XRF test, Olympus Innov-X Pro X-Ray Fluorescence Spectrometer was used to determine relative elemental composition of the sample. Around two (2.0) grams of sample was ground until it reached a grain size of about 75 microns. It was then pelletized, and the pressed sample pellets were scanned at three different points to ensure maximum sample representability. Then, the test was conducted with five replicates to ensure reliability.

For XRD test, InXitu BTX II XRD Analyzer X-ray Diffraction was used. Powdered samples were mounted on the XRD sample holder and then subjected to a full scan X-ray diffraction analysis set at 5 to 55 degrees, two theta angles. For the test, X-ray beams were generated from a Cu-Kα radiation source (40 kV; 30 mA) with a wavelength of 1.54Å, the resolution was set at 150 exposures, with scan speed maintained at two degrees per minute. The detection limit is set at 5% and strongly dependent on the crystallinity. The sample was identified by matching the high-intensity peaks in the XRD pattern with reference patterns from the Match! database and the Open Crystallography Database (COD).

Thermogravimetric analysis was used to determine the moisture content and the water composition of the samples since Perlites are classified based on the water content (%w/w), i.e., obsidian (less than 2%), perlite (2–5%) and pitchstone (greater than 5%) [15]. The free and locked water composition of the perlite samples were determined through thermogravimetric analysis. The test was conducted using a thermogravimetric analyzer (TGA TA Q5000 IR). Around one gram of sample was loaded in aluminum pan and was heated to

900 ºC at 10 ºC/min and 75 mL/min air flow. Upon reaching 900 ºC, the temperature was held for 15 minutes while monitoring the change in the weight of the sample.

2.3 Morphology

The structure of the coarse perlite sample was observed through optical microscopy and scanning electron microscopy (SEM). Optical microscopy was conducted using Zeiss optical light microscope, and the samples were viewed at 50x, 100x, 200x, and 500x magnification while scanning electron microscopy employed the Hitachi SU-8230 FE-SEM. Prior to viewing under SEM, the samples were directly dispersed on carbon tape and then coated with platinum to prevent charging of the sample surface. Then, it was viewed at higher magnifications up to 25,000 x to observe the morphological features.

2.4 Physical Characterization

Table 1 provides the material properties determined to characterize raw perlite samples. Each test was replicated five times to ensure the reliability of the results. Standard test methods specified by the American Society for Testing and Materials (ASTM) were utilized for physical characterization procedures.

Table 1. Standard test method used for the physical characterization of perlite.

Physical Property	**Standard Used**
Gradation	ASTM C 136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
Loose Bulk Density and Bulk Density	ASTM C29 – Standard Test Method for Bulk Density and Voids in Aggregates
Voids in Aggregates	
Specific Gravity	ASTM C128– Standard Test Method for Relative Density and Absorption of Fine Aggregates
Absorption	

In addition to the physical properties, parameters that describe the particle size distribution of the samples were also obtained. Fineness modulus, given by Equation 1, is the sum of the cumulative percentages coarser than each specified sieve under ASTM C136, divided by 100. It describes how coarse or fine the material is, with a higher fineness modulus indicating a coarser material. The gradation coefficient (C_c) and uniformity coefficient (C_U), on the other hand, are given by Equations 2 and 3, respectively and are descriptors of the sample particle size distribution. The effective size is the grain diameter or the sieve opening corresponding to 10% passing and is denoted by D_{10}. D_{30} is the grain size at 30% passing while D_{60} is the grain size at 60% passing. These values are calculated through linear interpolation by the least squares method.

$$FM = \frac{\sum \%\ retained\ in\ No.4, No.8, No.16, No.30, No.50, No.100\ Sieves}{100} \quad (1)$$

$$C_C = \frac{D_{30}^2}{D_{60} \cdot D_{10}} \quad (2)$$

$$C_U = \frac{D_{60}}{D_{10}} \quad (3)$$

An analysis of variance (ANOVA) was employed to evaluate differences in the physical properties between the coarse perlite and semi-processed perlite samples. All measurements were conducted in five replicates to ensure adequate statistical power and reliability of the results. Statistical analyses were performed using Microsoft Excel, and a significance level of $p < 0.05$ was adopted for all tests.

III. RESULTS AND DISCUSSION

3.1 Chemical Composition

The XRF result showed the average elemental composition of the raw perlite samples (Table 2), with silicon being the most abundant element. Other elements found in the raw perlite samples include aluminum, magnesium, potassium, and iron.

Table 2. Average elemental composition of the Philippine perlite.

Elements		Philippine Perlite
Mg	Magnesium	2.29
Al	Aluminum	6.71
Si	Silicon	30.08
K	Potassium	1.17
Ca	Calcium	0.5
Ti	Titanium	0.17
V	Vanadium	0.02
Mn	Manganese	0.04
Fe	Iron	0.89
Zr	Zirconium	0.02
Sb	Antimony	0.02
LE	Light, <Mg	57.97

Elemental composition from XRF data, and a mineral reference database were used as the basis for the identification of the minerals in the Philippine perlite. The diffractogram in Figure 2 shows that the sample is predominantly amorphous, with some well-defined crystalline peaks corresponding to quartz (SiO_2) and feldspar minerals. A broad peak observed between 15 to 30 degrees the 2 theta suggests the presence of amorphous silica [16]. Based on the absence of sodium and the presence of calcium in the elemental analysis (Table 2), the feldspar peaks are

more likely attributed to anorthite ($CaAl_2Si_2O_8$) which is the calcium-rich feldspar instead of to albite ($NaAlSiO_8$), the sodium-rich feldspar. Amorphous silica is preferred due to its high expansion efficiency as the crystalline phase tends to be denser and has fewer pores which consequently results in lower locker moisture necessary for higher expansion efficiency.

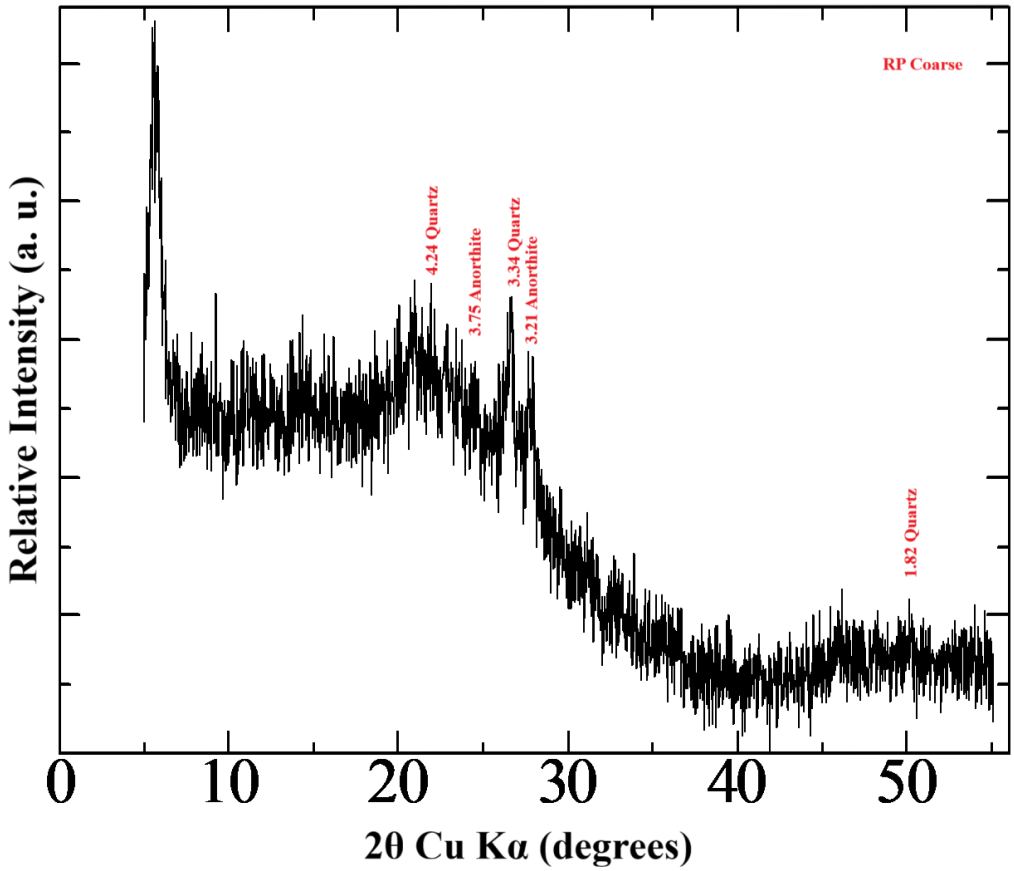


Figure 2. Diffractogram of coarse raw perlite.

Philippine perlite is found to be composed of 25.36% alumina and 64.35 % silica which is within the literature value for perlite samples which are typically composed of more than 60% alumina and silica contents [16]. The oxide compositions were calculated from elemental XRF data in Table 2 using standard stoichiometric oxide conversion factors. This approach is valid because, as shown in the diffractogram in Figure 2, the sample is primarily composed of amorphous silica with traces of quartz and feldspar which contribute mainly SiO_2 and Al_2O_3. Table 3 displays the oxide composition of Philippine perlite compared to perlite from Greece (CH and TR). Notably, raw Philippine perlite samples contain a higher aluminum oxide content than their Greek counterparts. This difference in composition may be attributed to various factors, including geographic location and environmental conditions [17]. The elevated aluminum oxide content suggests that Philippine perlite is more stable and resilient to high-temperature processes, making it suitable for high-temperature expansion processes.

Table 3. Oxide composition comparison of the perlite from Philippines and Greece [17].

Oxide	Literature Value [17]		Philippine Perlite
	Greece (CH)	Greece (TR)	
SiO_2	72.68	73.92	64.35
Al_2O_3	14.85	10.27	25.36
MgO	0.30	0.11	3.80

3.2 Moisture Content and Thermal Events

Two thermal events, as represented by the two observed decreasing slopes in Figure 3, were observed in the thermogravimetric analysis of Philippine perlite. The first significant loss of around 0.60 % was observed at around 100 ºC. This event is due to the removal of free moisture on the surfaces of the sample. The second loss, which was around 4.55%, occurred over a broad temperature range of 200 ºC to 600 ºC. The second event is due to the removal of locked moisture which is crucial for the expansion process of perlite. In literature, perlite has 2 – 5 % moisture which plays an important role in expansion by reducing the viscosity and expanding the soft grain during evaporation [16].

For the moisture analysis of the samples, only the coarse perlite was considered since the samples were all sourced from one location. From the thermograph in Figure 3, the free and locked (bounded) moisture was determined to be 0.60% and 4.55%, respectively. As the bounded moisture was between 2-5 %, the local sample was classified as perlite. Aside from the moisture content, the thermograph was further analyzed to determine the minimum temperature for moisture release as perlite is primarily used in its expanded form.

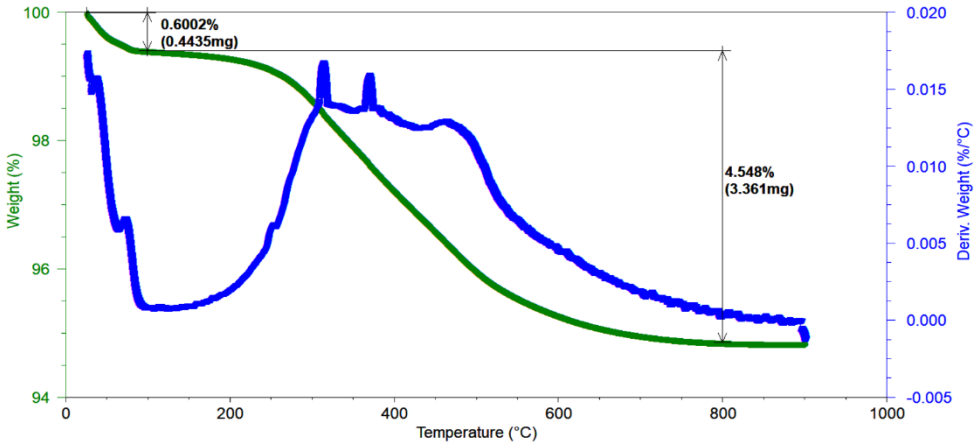


Figure 3. Thermogravimetric graph of raw coarse perlite sample.

For the expanded perlite production, the expansion temperature is a crucial factor [18]. Different studies showed that perlite expansion occurred upon the removal of hydroxyl groups associated with oxygen atoms through strong hydrogen bonding (non-bridging). This takes place when perlite is heated between 550ºC and 950 ºC [15].

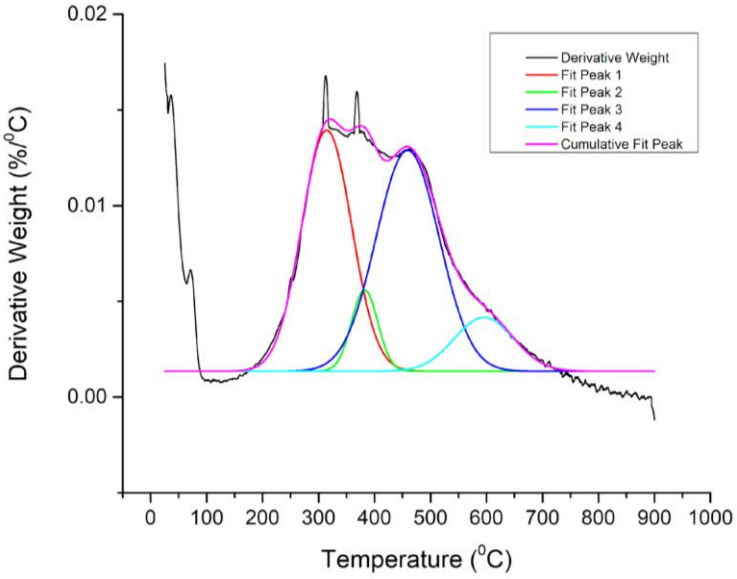


Figure 4. Deconvoluted DTG of raw perlite sample.

Deconvolution of the first derivative of weight with respect to temperature (DTG) thermograph using OriginPro software was done to determine the temperature associated with the perlite expansion. This method separates overlapping weight loss due to the removal of different types of moisture. Upon deconvolution of the DTG (Figure 4), four peaks were obtained corresponding to the locked moisture. The maximum temperature for each peak is listed in Table 4. This indicates that within this range, several thermal events occurred. Peak 1 to 3 occurred between 250ºC and 550 ºC, which are linked to the removal of hydroxyl groups and molecular water trapped in the inner pores [15, 18]. On the other hand, the last peak at 595 °C corresponds to water removal for pore expansion. This suggests that the minimum temperature for the expansion of raw perlite is around 595 °C.

Table 4. Identified peak temperature of the deconvoluted DTG of raw perlite sample.

Locked Moisture	Max Temp (°C)	Weight Loss (%)
1st Peak	314.5	1.08
2nd Peak	382.2	0.57
3rd Peak	459.1	2.24
4th Peak	595.6	0.66

3.3 Morphology

The optical microscopy images of different perlite samples presented in Figure 5 showed similar features across the three sample types as samples were sourced from the same location. Perlite particles were observed to have a granular shape with glassy features. At 50x

magnification, it was observed that the particles contained some inclusions that looked like bubbles. Most of the samples were transparent-like which is a property of perlite. However, in Figure 5d, a distinct reddish-brown impurity grain within the mostly translucent to white volcanic glass matrix was observed. The color of the impurity was matched on a Munsell Rock Color Chart by which its color and intensity is approximately 5YR 4/4 to 7.5YR 5/6, suggesting the presence of iron oxide or hydroxide minerals such as hematite [19–20].

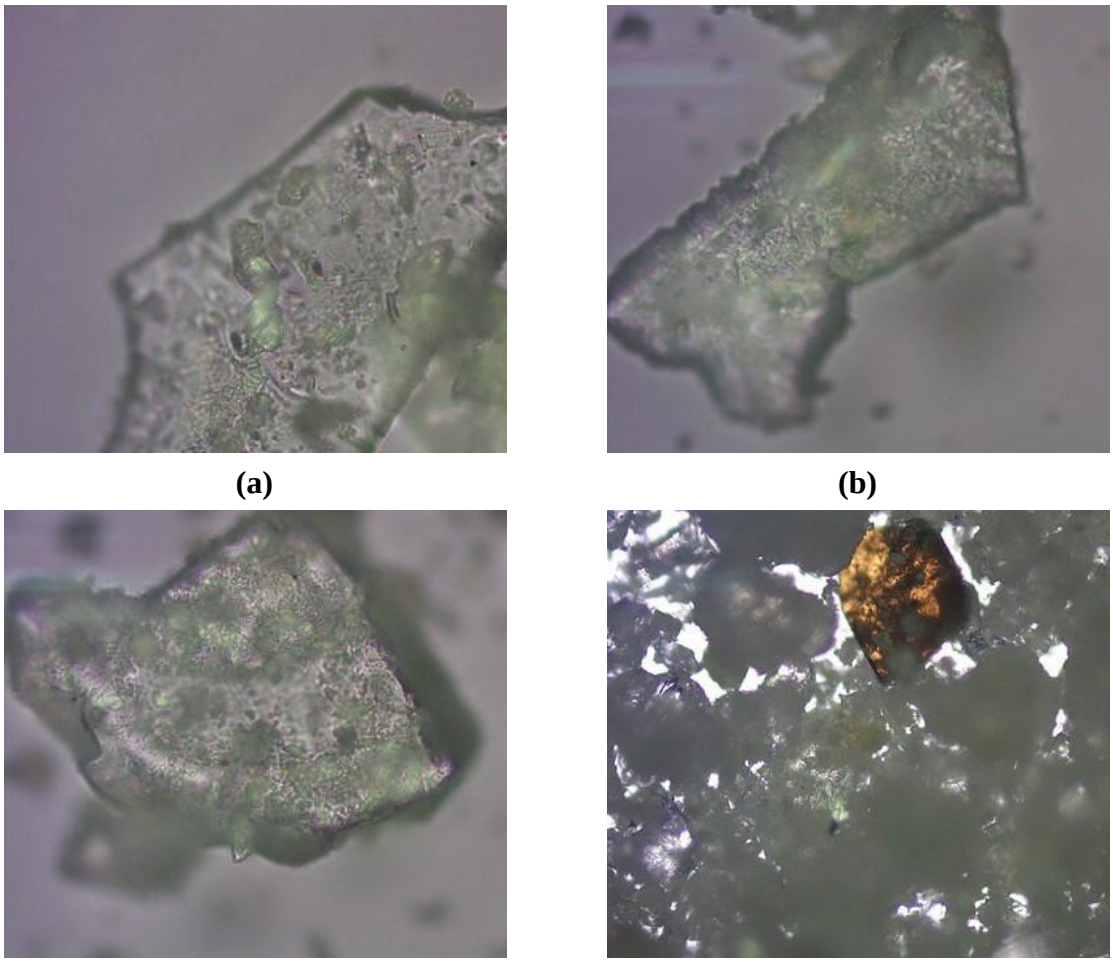
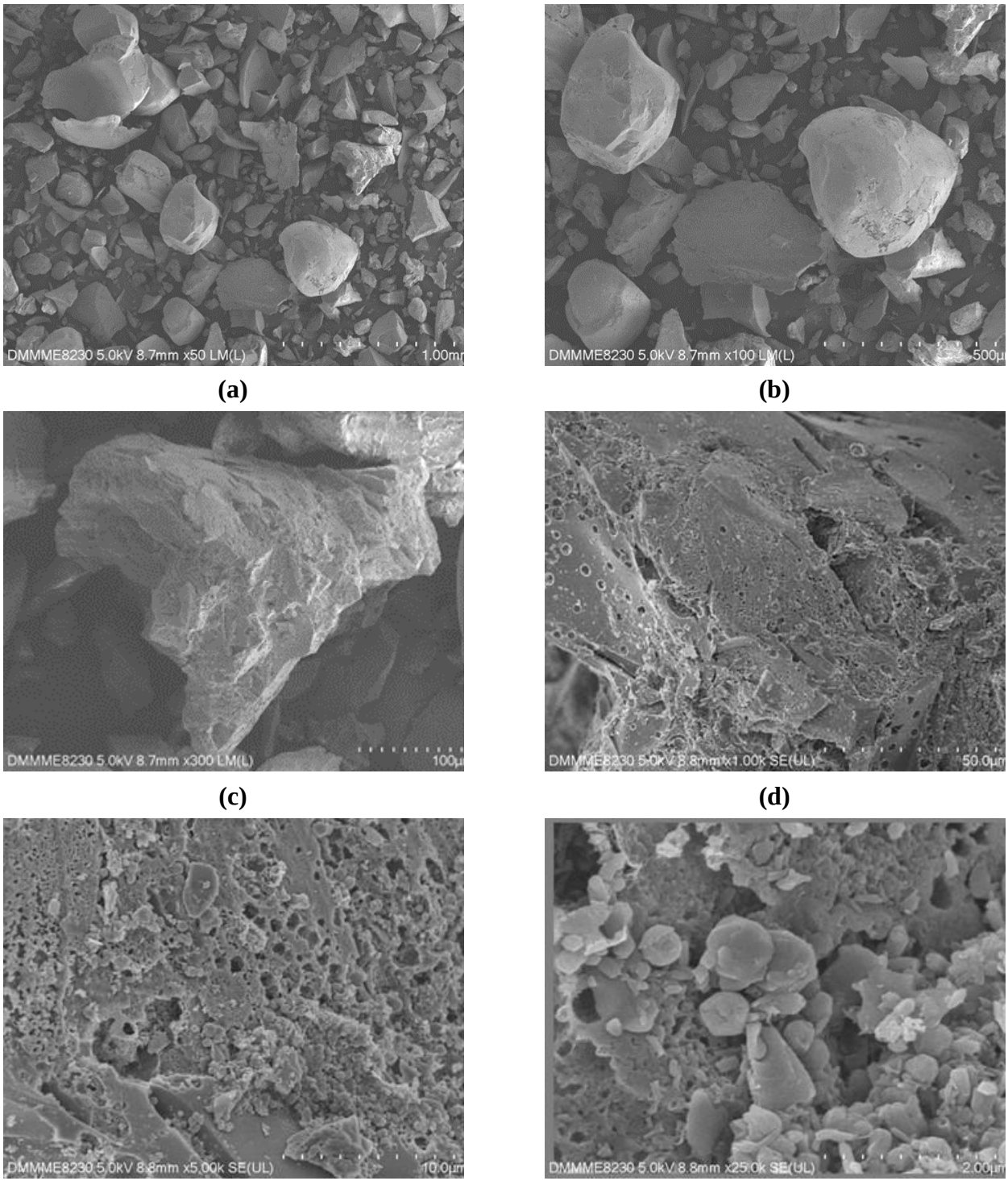


Figure 5. Optical microscope images of perlite samples: (a) raw, (b) semi-processed A, (c) semi-processed B viewed at 50 x magnification, and (d) reddish-brown perlite sample viewed at 10 x magnification.

Scanning electron microscopy on coarse perlite was performed to further check the microstructure of the liberated perlite particles in the samples. Figure 6 displays the images of perlite at different magnifications. Low magnification imaging (Figure 6a) revealed that the perlite samples include angular and rounded particles. Upon closer examination, the rounded particles were also faceted with a porous surface as shown in Figure 6b. A similar observation on the angular particles is shown in Figure 6c. The faceted and angular features of the samples were in line with the observations in optical microscopy. These are typical features of perlite samples as glassy alumino-silicious rocks [3].



(a) **(b)**

(c) **(d)**

(e) **(f)**

Figure 6. Scanning optical images of perlite sample (a-c) low magnification of perlite at 50, 100 and 300 x, respectively, (d-f) surface imaging viewed at 1.00 k, 5.00k and 25.0k, respectively.

The angular sample was observed at higher magnification up to 25.0 k to check the surface features. Micropores are observed at 1.0 k magnification as shown in Figure 6d. Closer inspection of these pores (Figure 6e and Figure 6f) showed spaces between agglomerated rounded particles. This observed feature indicates a micro-vesiculated structure on the surface of the liberated grains measuring less than 2 microns. It is noted that volcanic textures do not define vesicular or pumiceous textures in such microscopic dimensions where the actual granular size of phenocrysts are in the range of 1 mm or larger. Otherwise, these particles are considered part of a groundmass called microlites [21].

3.4 Physical Properties

For the physical properties, coarse and semi-processed perlite (A and B) were compared with each other to determine the effect of sizing on the potential of the perlite sample for expansion. The physical properties obtained following the ASTM standards shown in Table 1 are tabulated in Table 5. The loose bulk density and specific gravity of all perlite samples are comparable with the values reported by the Perlite Institute (2011), 960 – 1200 kg/m^3 for loose bulk density and 2.2 – 2.4 for specific gravity [22]. The physical properties obtained following the ASTM standards shown in Table 1 are displayed in Table 5.

Table 5. Summary of the physical properties and ANOVA for perlite samples.

Property	Raw Perlite Samples			p-value
	Coarse	Semi A	Semi B	
Bulk Density (kg/m^3)	1390 ± 10	1270 ± 10	1380 ± 10	0.000
Loose Bulk Density (kg/m^3)	1220 ± 10	1110 ± 20	1220 ± 10	0.000
Voids in Aggregates (%)	34 ± 1.0	41 ± 0.3	39 ± 1.0	0.007
Specific Gravity, SSD	2.22 ± 0.01	2.22 ± 0.01	2.32 ± 0.02	0.000
Specific Gravity, OD	2.11 ± 0.01	2.15 ± 0.01	2.27 ± 0.03	0.000

Results showed that coarse perlite had higher bulk and loose bulk densities compared to both semi-processed raw perlites. This was unexpected, as size typically increases bulk density due to the disintegration of particle agglomerates, leading to better particle packing and compaction. However, the difference in bulk density may be attributed to the gradation of the materials.

Sieve analysis was performed according to ASTM C136 standard procedures to assess the particle size distribution of the three samples. Figure 7 presents the gradation curves of the samples along with the upper and lower limit specified in ASTM C33, which define the permissible grading envelope for aggregate size distribution. A gradation curve within these limits indicates a well-graded aggregate with adequate packing and reduced void [23].

FAs shown in Figure 7, coarse raw perlite has a relatively well-graded particle size distribution as compared to semi-processed raw perlites; therefore, voids between aggregates are smaller in comparison. The term 'voids in aggregates' refers to the spaces between individual particles within the aggregates, not the voids within the particles themselves. A higher percentage of voids in aggregates indicates increased space between particles, resulting

in lower bulk density [24]. This observation aligns with the measured voids between aggregates in Table 5, where coarse perlite exhibited the lowest value.

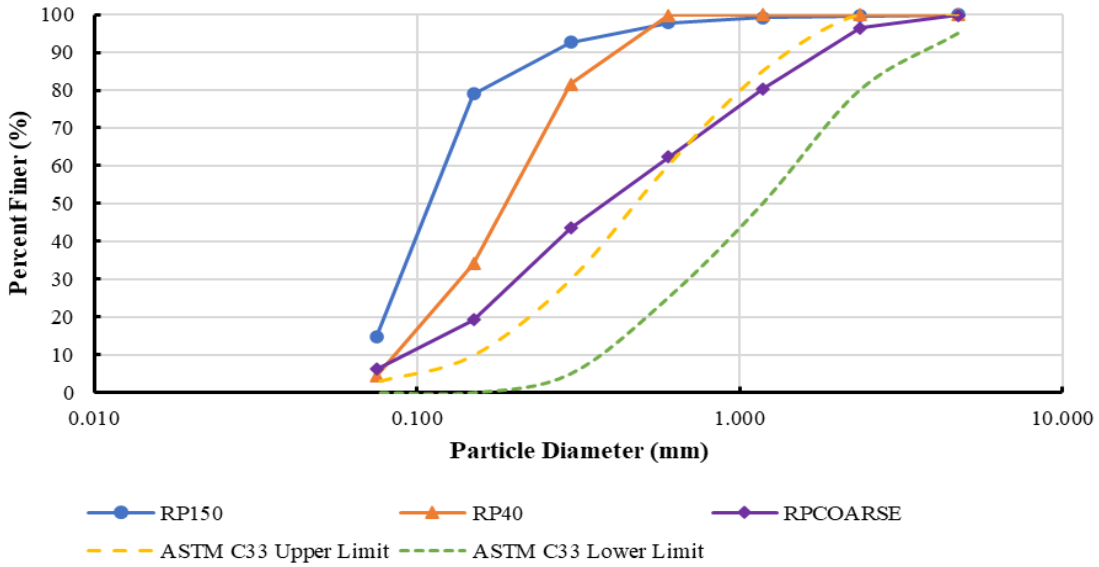


Figure 7. Particle size distribution of perlite samples

This observation may also be attributed to the distinct shape and structure of perlite particles as shown in Figures 5 and 6. Perlite particles have faceted, porous structures. While initial sizing may have disintegrated the agglomeration of perlite particles, the innate faceted and irregular shapes of perlite particles hinder effective packing, potentially leading to lower bulk densities. Additionally, further size reduction may also disrupt perlite micropore structure which leads to more interparticle spaces or voids between particles [24].

Through linear interpolation of Figure 7, parameters such as the effective size, uniformity, and fineness modulus were calculated and tabulated in Table 6. A comparative analysis revealed that Semi B exhibited finer particles compared to Semi A. This suggests that further sizing led to an increase in bulk densities. Faceted porous perlite particles in Semi A samples may further be broken down into smaller sizes by which irregular shape particles deform or disintegrate into particles that are more effectively packed. Further size reduction may also cause a reduction of the particle porosity which increases the bulk densities [24].

Table 6. Summary of ASTM C136 test and ANOVA results on raw perlite samples.

Property	Raw Perlite Samples			p-value
	Coarse	Semi A	Semi B	
Effective size (mm)	0.10 ± 0.002	0.09 ± 0.002	0.07 ± 0.00008	0.002
Uniformity coefficient	5.73 ± 0.06	2.65 ± 0.06	1.83 ± 0.01	0.000
Fineness modulus	2.03 ± 0.05	0.85 ± 0.01	0.31 ± 0.01	0.000

For the gradation of the perlite samples, it was also compared to the required gradation for mortar aggregate as set by ASTM C33. Based on Figure 7, it is notable that the gradation of coarse perlite even without expansion is almost within the gradation limit as a portion of the line is within the limit as visualized as the yellow and green line. This is important as the particle size is an important factor for consideration in using expanded perlite samples as possible lightweight aggregate

One-way analysis of variance, conducted at a 95% confidence level, indicated significant variations in physical properties among the different raw perlite types. This underscores the substantial impact of physical modifications on perlite samples, which has significant implications for their particle structure and suitability for various applications. This insight is crucial for planning perlite expansion processes, as they directly affect pore structures.

IV. CONCLUSION AND RECOMMENDATION

In this study, the chemical, morphological, and physical properties of locally sourced perlite from Baao, Camarines Sur, Philippines, were examined to assess its potential as a raw material for lightweight aggregate production. Each diffractogram showed the presence of an amorphous broad peak attributed to glassy perlite and narrow sharp peaks that are likely due to presence of crystalline silica (quartz) and felspar minerals. Compositional analysis showed that the sample is predominantly composed of silica (64.35 %) and alumina (25.36 %). The presence of the high aluminum oxide suggests that Philippine perlite is suitable for high-temperature expansion processes, as it can maintain structural integrity and desirable properties during expansion. Aside from chemical composition, Philippine perlite water content is within the literature value. Thermographic analysis also revealed that the chemically bonded water, which is essential for pore expansion, was released at 595°C. This suggests that, for the formation of expanded perlite for construction and agricultural application, local perlite must be rapidly heated to at least 595 °C. This is lower than literature values, where perlite typically expands between 700 to 1000 °C.

Philippine perlite exhibits a glassy appearance consistent with its high silica content. Impurities manifest as brown inclusions within the perlite samples. Scanning electron microscopy (SEM) reveals irregular and facetted perlite particles, with higher magnification exposing microlites and agglomerated rounded particles on the sample's surface. These observed micropores and agglomerated structures are crucial for facilitating the expansion process. Rapid heating causes these agglomerated microstructures to expand, forming the intricate porous structure characteristic of expanded perlite.

The physical characteristics of both the coarse and semi-processed perlite samples fell within the acceptable range of 960 – 1200 kg/m3 for loose bulk density and 2.2 – 2.4 for specific gravity. Coarse perlite displayed the highest bulk density at 1360 kg/m³, as well as an effective size of 0.10 mm and a fineness modulus of 2.02. This outcome was expected since coarse perlite, while processed, did not undergo size reduction. Conversely, semi-processed samples exhibited similar bulk and specific densities but differed significantly in terms of fineness modulus. The impact of sizing on the physical properties of perlite samples was

evident. This underscores the substantial influence of physical alterations on perlite sample properties, which, in turn, holds implications for perlite particle structure. Such insights are crucial for planning perlite expansion processes, as they directly affect pore structures. The gradation of coarse perlite, even without expansion, almost met the required limits for mortar aggregate in ASTM C33, indicating its potential use as a lightweight aggregate.

Overall, this study provides valuable insights into the properties of Philippine perlite to assess its viability as a raw material for lightweight aggregate production. Further research is needed to explore its expansion behavior and application potential in the construction industry, contributing to sustainable and lightweight construction practices in the Philippines and beyond. This paper serves as a reference for future studies aiming to utilize Philippine perlite as a valuable construction material.

V. ACKNOWLEDGEMENT

The authors would like to gratefully acknowledge the funding provided by the Philippine Department of Science and Technology – Philippine Council for Industry, Energy and Emerging Technology Research and Development. The authors would also like to express its gratitude to Orophil Stonecraft Inc. for providing the necessary equipment and perlite samples for this study.

References:

[1] Breese ROY, Piper JR. 1985. Occurrence and origin of perlite. Society of Mining Engineers of AIME. SME-AIME Fall Meeting Albuquerque, New Mexico. 85–359.
[2] Chesterman, CW. 1975. Perlite. The American Institute of Mining, Metallurgical, and Petroleum Engineers.
[3] Breese ROY, Barker JM. 1994. Perlite. Industrial minerals and rocks. 6:735–749.
[4] Dogan M, Alkan M. 2004. Some physicochemical properties of perlite. Fresenius Environmental Bulletin. 13(3b): 251–257.
[5] Kaufhold S, Reese A, Schwiebacher W, Dohrmann R, Grathoff GH, Warr LN, Ufer K. 2014. Porosity and distribution of water in perlite from the island of Milos, Greece. SpringerPlus. 3(1): 1–10.
[6] Perlite Institute. 2021. Perlite, safe and fully natural material. Perlite Institute.
[7] Celik AG, Kilic AM, Cakal, GO. 2013. Expanded perlite aggregate characterization for use as a lightweight construction raw material. Physicochemical Problems of Mineral Processing. 49(2): 689–700. https://doi.org/10.5277/ppmp130227
[8] United States Geological Survey. 2021. Mineral Commodity Summaries.
[9] Sánchez, MA, Molina, WM, García, HLC, Guzmán, EMA, Acosta, AAT, & Ortega, JMP. 2018. Properties of Portland Cement mortar with substitutions of natural and expanded perlite. Periodica Polytechnica Civil Engineering. 62(2): 508–516.
[10] Reka AA, Pavlovski B, Lisichkov K, Jashari A, Boev B, Boev I, Makreski P. 2019. Chemical, mineralogical, and structural features of native and expanded perlite from Macedonia. Geologia Croatica. 72(3):215–221. https://doi.org/10.4154/gc.2019.18
[11] Aurelio MA, Peña RE 2002. Geology and mineral resources of the Philippines. Geology.
[12] Yumul GP, Dimalanta CB, Maglambayan VB, Marquez EJ. 2008. Tectonic setting of a composite terrane: A review of the Philippine Island arc system. Geosciences Journal. 12(1): 7–17.
[13] Philippine Statistics Authority. 2013. Philippine Yearbook 2013: Mines and Minerals. Philippine Statistics Authority.
[14] Kogel JE, Trivedi NC, Barker JM, Krukowski ST. 2006. Industrial minerals & rocks: commodities,

markets, and uses. Society for Mining, Metallurgy, and Exploration, Inc.
[15] Roulia M, Chassapis K, Kapoutsis JA, Kamitsos EI, Savvidis T. 2006. Influence of thermal treatment on the water release and the glassy structure of perlite. Journal of Materials Science. 41(18):5870–5881. https://doi.org/10.1007/s10853-006-0325-z
[16] Gul D. 2016. Characterization and expansion behavior of perlite.
[17] Angelopoulos PM, Maliachova C, Papakonstantinou K, Taxiarchou M, Diplas S. 2016. Structural and physical characteristics of fine perlite expanded with a novel method in a vertical electric furnace. Mineral Processing and Extractive Metallurgy. 125(2): 71–80. https://doi.org/10.1080/03719553.2016.1156244
[18] Varuzhanyan AA, Varuzhanyan AA, Varuzhanyan HA 2006. A mechanism of perlite expansion. Inorganic Materials. 42(9):1039–1045. https://doi.org/10.1134/S0020168506090202
[19] Munsell Color. 2009. Geological rock-color chart. Geological Society of America. Grand Rapids, Michigan.
[20] Natural Resources Conservation Service. N.D. Exploring soil colors: Highlighting Wisconsin State Parks and Forests. U.S. Department of Agriculture.
[21] Winter JD. 2014. Principles of igneous and metamorphic petrology. 2.
[22] Perlite Institute. 2011. Physical characteristics of perlite. Perlite Institute.
[23] ASTM C33/C33M-18. 2018. Standard specification for concrete aggregates. West Conshohocken, PA: ASTM International.
[24] ASTM C136/C136M-19. 2019. Standard test method for sieve analysis of fine and coarse aggregates. West Conshohocken, PA: ASTM International.