IDENTIFICATION OF CLASTIC LIMESTONE CHARACTERISTICS AS A BUILDING MATERIAL IN SURADE AREA, WEST JAVA, INDONESIA

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Abstract

Surade subdistrict is located in Sukabumi District, West Java with an area of 364.19 km² which is about 60% lithology of this area is in the form of clastic rock of Cibodas Formation. Surade Subdsitrict is also included in Geopark Ciletuh-Palabuhanratu area. As a quarry material, limestones are beneficial in the interests of industry and building materials. Locals use limestone for construction material as a bricks. Material are dig in small scale for both individual and large-scale use fo resale. Material mined manually by sawing a massive limestone according to a certain size. Macroscopically, this limestone has a yellow color, allochtonous type, calcarenite grain size, open fabric, good sorting, exposed with massive or parallel laminate structures with a thick outcrop up to 7 meters. Microscopically, the type of limestones is packstone and wackestone locally. Composed of shell and non-shell fragments in the form of rock fragments, as well as other mineral fragments. Limestone has been dissolved and visible cementation of the found voids. Limestone is not too good as a substitute for bricks in the building construction because it has low value of compressive strength that will affect the resistance of the building's burden. This limestone is easily soluble and less resistant to the weather so it can reduce the quality of building, but has the advantage to store more water vapor it is good to regulate humidity in tropical buildings. The existence of clastic limestone becomes the potential of geological diversity in Geopark Ciletuh-Palabuhanratu area. Locals take this advantage to boost the economy, but needs sepecial attention to watching of mining activities to avoid adverse affect at conservation area.

Keywords: *clastic limestone, Surade, Indonesia, building materials, Ciletuh-Palabuhanratu Geopark*

INTRODUCTION

Surade subdistrict, administratively located in Sukabumi District, West Java Province and physiographically located in the Southern Highlands zone of West Java (Van Bemmelen, 1949). Geographically, the study area is located at 106^o 30 '25.03 "to 106^o 38' 20" E, and 7^o 15 '32 "to 7^o 22' 26.41" S (Figure 1). Surade is also included in Geopark Ciletuh-Palabuhanratu area. According to Sukamto (1975) this area has several tertiary terrestrial formations such as sandstone, tuffaceus sandstone, limestone, and tuff, which divided into 5 formations, from the oldest is Cikarang Member of Jampang Formation, upper part of Bentang Formation, lower part of Bentang Formation, Cibodas Formation, Citanglar beach sediment, and Aluvium.

Limestone is one of the most widespread sedimentary rocks in research area as a clastic limestone which is included in Cibodas Formation (Sukamto, 1975). Locals use this limestone as a material of construction material construction as a brick. The purpose of this reseach is to know the characteristics limestone so that it determined the level of feasibility of rock as a construction material.

RESEARCH METHODS

Data was collected at Surade and some area in the surroundings. The samples

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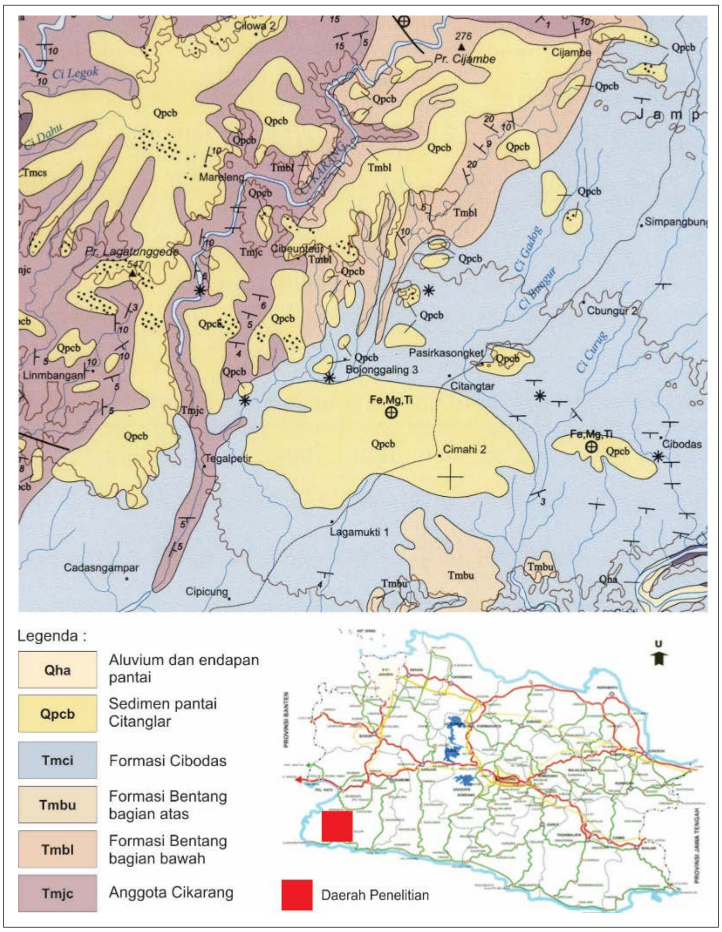

Figure 1 Regional Geological Map of research areas according to Sukamto (1975).

Were taken at 10 locations from 65 limestone outcrop.

The samples were analyzed as a hand speciment, thin section and brick. These samples were analyzed trough petrography analysis, physical properties, and mechanical properties.

Petrographic analysis aims to determine the texture, fabric, composition, mineral contained, and the rock structure. 15 samples were selected for macroscopic and 4 thin sections are prepared for microscopic analysis.

Physical properties of rocks were tested to determine the dimensions of size, weight of contents, moisture content, porosity, and absorption (void ratio) of rocks.

Mechanical properties of rock, are known by Point Load Test and Uniaxial Compression Strength (UCS). Both were determine the value of rock resistance to load. The point load test is used for sample that has an irregular shape, while UCS is performed on a regular shape. To find out the compressive strength of UCS from point load test is used the formula :

$$\mathbf{UCS = 22 \times I_s \times Fa}$$

I_s is the value of point load, Fa is the value of the axial compressive stress.

SPECIFICATION FOR BRICK AND BLOCKWORK

The concrete or brick concrete to be arranged into pairs of building walls has the provisions set forth in the Indonesian Materials Regulations (PUBI) of 1982 (Tables 1 and 2) and Indonesian National Standard Number 03-0349-1989 (Tables 3 and 4). These requirements include physical dimensions and qualities that are divided into several classes. In the rock mass rating system, Bieniawski divides intact rocks in several classes of compressive strength values (Table 5).

E-ISSN : 2579 – 3136

Table 1. Size and Tolerance Requirements Based on PUBI, 1982.

Type	Size and Tolerance Requirements (mm)		
	Lenght	Width	Thick
Large	400 ± 3	200 ± 3	100 ± 2
Medium	300 ± 3	150 ± 3	100 ± 2
Small	200 ± 3	100 ± 3	80 ± 2

Table 2. Physical Requirements of Bricks Based on PUBI, 1982.

Physical Requirement of Bricks	Minimum compressive strength (kg / cm^2)		
	Average of 5 pieces	Each Brick	Maximum water absorption (% of volume)
A1	25	21	-
A2	40	35	-
B1	70	65	35
B2	100	90	25

Table 3. Size and Tolerance Requirements Based on SNI 03-0349-1989.

Type	Size and Tolerance Requirement (mm)		
	Lenght	Width	Thick
1.Massive	390 + 3	90 ± 2	100 ± 2
	390 - 5		
2.Perforated			
a. Small	390 + 3	190 + 3	100 ± 2
	390 - 5	390 - 5	
b. Large	390 + 3	190 + 3	200 ± 2
	390 - 5	390 - 5	

Tabel 4 Physical Requirements of Bricks SNI 03-0349-1989.

Physical Requirement of Brick	Minimum compressive strength (kg / cm^2)		
	Average of 5 pieces	Each Brick	Maximum water absorption (% of volume)
I	100	90	25
II	70	65	35
III	40	35	-
IV	25	21	-

Tabel 5 Classification of intact rock material strength value (modification of Bieniawski, 1989).

Parameter	Strength of intact rock material		Rating
	Point load strength index	Uniaxial compression strength	
Range of value	>10 MPa	>250 MPa	Very good rock
	4-10 MPa	100-250 MPa	Good rock
	2-4 MPa	50-100 MPa	Fair rock
	1-2 MPa	25-50 MPa	Poor Rock
	For this low range, uniaxial compressive test is preferred	5-25 MPa	Very poor rock
		1-5 MPa	
		< 1 MPa	

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RESULT AND DISCUSSION

Petrography

Clastic limestone spread out about 60% of research area from the northeast, central, to the southwest. The outcrop exposed either massive or in layers with the direction of rock layers relatively west-east N 90°-125° and dip 5°-14°. The outcrop has 40 cm to 7 meters thickness. Locally limestone outcrop was found with inserts of claystone or tuff. Good outcrops can be observed along the Ciparay, Cilembeng, Cigadog, Cibodas, Cibiyung, Cibarebeng, Cicurug, Cibungur, and intermittent rivers.

Macroscopically fresh limestone has a yellow or gray in some places, weathered limestone has brownish yellow color, clastic texture, calcarenite size, good sorting, open fabric, composed of shell and non-shell fragments. Shell fragments of 30-40% consist small and large forams fossil. Non-shell fragment of 20-25% consist medium sized limestone fragment , fair hardness , the dissolved cavities are locally visible

Microscopically, thin section sample with code AD 04 has slightly coarse texture which composed of :

- Shell fragments about 40%, which filled with carbonate minerals i.e. large foraminifera, planktonic foraminifera, bentonic foraminifera and coral fragments,
- Non-shell fragments about 20%, consist of carbonate rock fragments, carbonate minerals and subangular quartz,
- Matrix about 15%, as micrit, yellowish-brown, and has medium-fine texture,
- Cement about 5%, sparit, fills the gap between fragments and partially fills the fossil fragments, some recrystallised to fill the cavities between fragments,
- Void about 20%, in the form of holes due to dissolution.

Based on the classification of Dunham (1962), limestone classified as Packstone (Figure 2).

Sample with code D3, D20 and D36 have medium-fine textured which composed of :

- Shell fragments 25-30%, which filled with carbonate minerals, i.e. large foraminifera, planktonic foraminifera, bentonic foraminifera and coral fragments,
- Non-shell fragments about 20%, consist carbonate rock fragments, carbonate minerals and subangular quartz,
- Matrix 25-30%, as micrit, yellowish-brown, and has medium-fine texture,
- Cement about 5%, as sparit, fills the gap between the fragments and partially fills the fossil fragments, some recrystallised to fill the cavities between fragments,
- Void about 20%, in the form of holes due to dissolution.

Based on the classification of Dunham (1962), samples classified as Wackestone (Figures 3, 4 and 5). A summary of the results of petrographic analysis can be seen in Table 6.

Technical Properties

To determine the average size of brick, 4 pieces of intact bricks from 4 different sites were observed which each site has uniform size (Table 7). Sample is taken from 8 locations, i.e. 6 hand specimens and 2 bricks. All samples were calcarenite type (Table 8).

Based on PUBI, 1982 and SNI 03-0349-1989 the dimensions of bricks unqualified with size deviation that exceeds the tolerance limit. Physically, value of water absorption are qualified as medium quality bricks, but mechanical properties average value has not qualified to minimum compressive strength for all brick quality classes. Based on SNI 03-0349-1989 qualified sample have to pass requirements or done re-test if it is not.

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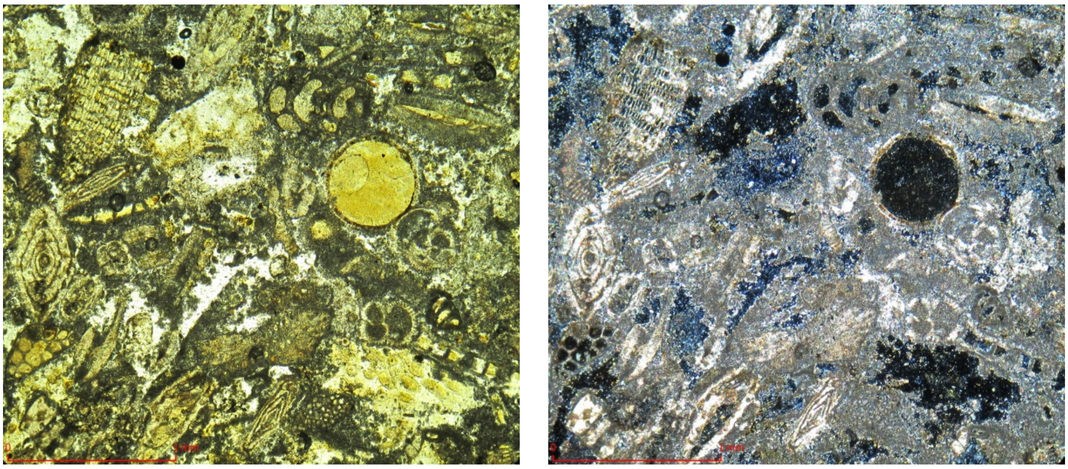

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Figure 2. Thin section code sample AD 04 is classified as packstone (Dunham, 1962).

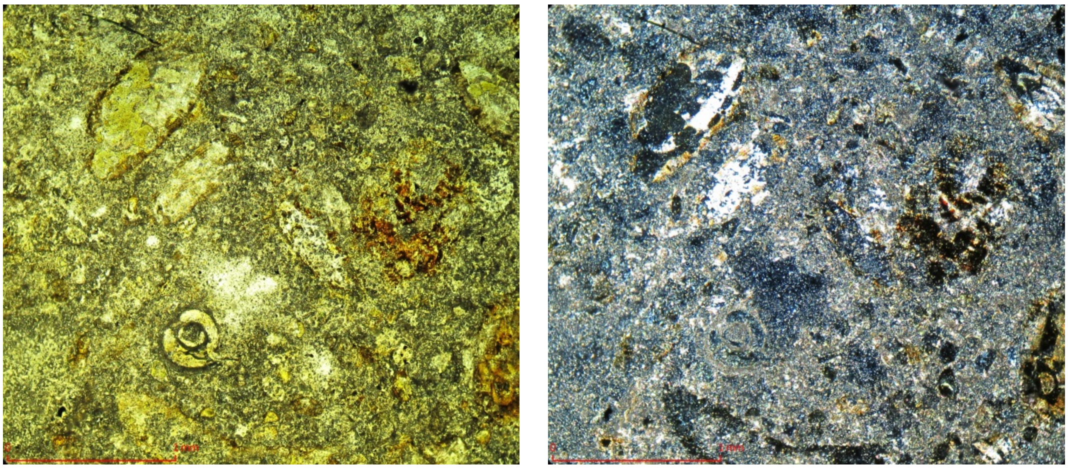

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Figure 3. Thin section code sample D3 is classified as wackestone (Dunham, 1962).

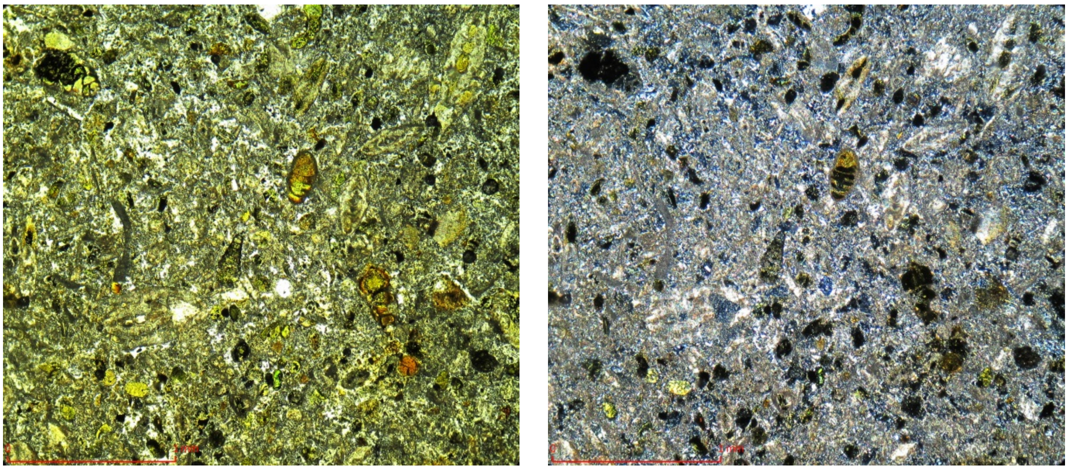

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Figure 4 Thin section code sample D20 is classified as wackestone (Dunham, 1962).

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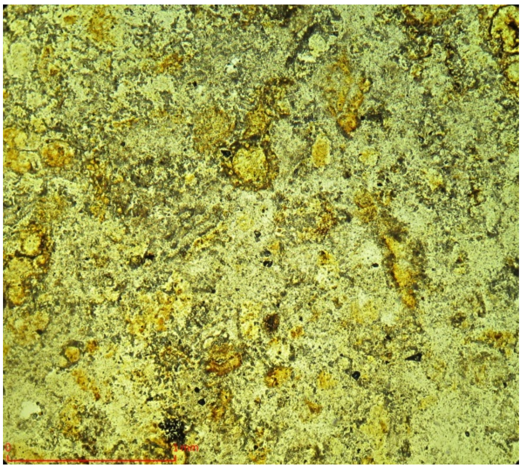

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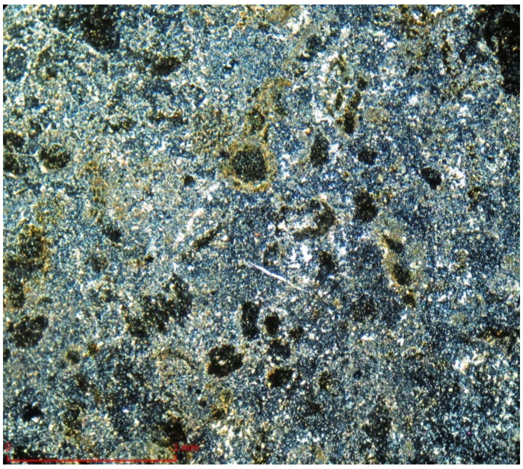

x-nicol ; 50 x

Figure 5 Thin section code sample D20 is classified as wackestone (Dunham, 1962).

Table 6. Summary of petrographic analysis results.

No.	Sample Code	Composition (%)					Name
		SF	NSF	Mt	Cm	Vo	
1.	AD 04	40	20	15	5	20	Packstone
2.	D3	30	20	25	5	20	Wackestone
3.	D20	30	20	25	5	20	Wackestone
4.	D36	25	20	30	5	20	Wackestone

Explanation:
SF : Shell Fragment
NSF : Non-Shell Fragment
Mt : Matrix
Cm : Cement
Vo : Void

Table 7. Dimension of brick samples.

Sample	Size and Tolerance Requirements (mm)		
	Lenght	Width	Thick
Grey	225	110	50
Yellow	220	110	50
Boyo	380	160	80
D28	240	100	50
Average	**228**	**106**	**50**

Table 8 Basic properties and compressive strength of limestone.

Sample Code	Water Content (%)	Porosity (%)	Absorbtion (%)	Point Load Strength (kg/cm^2)	UCS (kg/cm^2)	UCS (MPa)
AD-04	1.3	18.34	8.74	0.33	17.88*	1.75*
D-04	3.77	24.6	13.84	0.28	16.48*	1.62*
D-03	6.17	41.21	29	0.47	21.24*	2.08*
D-27	6.95	41.94	29.56	0.53	22.55*	2.21*
D-28	16.39	42.36	31.62	0.27	16.21*	1.59*
D-03X	6.7	38.21	27.21	0.26	16.00*	1.57*
Grey	10.21	41.47	29.6	-	12.57	0.66
Yellow	3.55	40.12	23.22	-	6.79	1.233

*) Converted from point load value

E-ISSN : 2579 – 3136

Figure 6 Brick cutting process by sawing.

Feasibility of Limestone as Building Materials

Based on petrology and engineering properties of limestone is not too good as a substitute for bricks, because it has a very low compressive strength with high porosity. This condition will affect the building by the loading and mass movement.

Based on rock mass rating, limestone in research area included in very bad rate due to the compressive strength value of the that less than 25 MPa. The quality of the low limestone as a brick is correlated with the texture of the rock. Characteristic of porous and well-porous limestone causes the rock cavity to be not well saturated so that the inter-grain relations are not interlocked. This makes the rocks easily loose so that the rocks are brittle and have a low compressive strength value.

High water absorption properties also reduce the quality of material. Grains of clastic limestone are bound together with carbonate cement and their adherence strength will decrease when affected by water as solvents. The properties of clastic limestone clearly reduce the quality of building, but it has the advantage to store moist inside the pores so well for tropical buildings.

Clastic Limestone Mining as Building Material in Conservation Area

Generally, Locals use limestone for construction material as a brick called batu bata kuning or batu kapur. Material mined manually by sawing a massive limestone according to a certain size. (Figure 6).

Limestone is used because it is not easily destroyed when cut. Materials are dig in a small scale for both individual and large-scale use for resale (Figure 7).

The post-mining site is usually flooded with water and used by locals as pond (Figure 8).

The existence of clastic limestone of Cibodas Formation can be a potential geological diversity potential for Ciletuh-Palabuhanratu Geopark area that needs to be conserved as a geological nature reserve. The term of Geological nature reserve area could be interpreted as a protected area and and its protection effort. area that needs to be conserved as a geological reserve.

Geological nature reserves area is geologically protected areas that inseparable from national protected area (Samodra, 2016).

E-ISSN : 2579 – 3136

Figure 7. Large-scale mining site in the Citanglar Village.

Figure 8. Limestone brick mining location is flooded with water to be a pond in Talagamurni village.

In accordance with Peraturan Pemerintah Nomor 26 Tahun 2008, Geological Nature Reserve Area covers aspects of uniqueness of rocks and fossils, uniqueness of the landscape, and uniqueness of geological processes. These three aspects are then interpreted as geological diversity (geodiversity).

Geological activities such as mining activities or excavation will cause physical changes of geodiversity environment. Contrass to the geopark concept that honor the earth's inheritance for society welfare, therefore mining activities need to be controlled and monitored to ensure natural maintenance of quality and geological diversity in the geopark region. Taking geological samples in geopark area is still permitted for scientific and educational purposes as long as its location is known and closely monitored

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by the government and the geopark management.

CONCLUSION AND SUGESTION

Limestone is not too good as a substitute for bricks in the building construction because it has a very low compressive strength with high porosity. Limestone is porous, easily soluble, and less resistant to the weather so that it can reduce the quality of building. High absorption capacity is good as groundwater aquifer in the research area. It is good to maintain its condition so it can be a catchment area. Extensive and continuous excavation activities can eliminate aquifers that result in difficulty for accessing clean water.

Monitoring of mining activities a special attention to avoid adverse-effects at geopark environment. By intensifying counseling by free, prior and informed consent (FPIC) to use red bricks or concrete bricks rather limestone could open the locals view about environmental ecosystem preservation when mining activities are stopped. Material substitution also increase the building resistance to damage and natural disasters

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