Potentials for construction application from the point load strength index of sedimentary rocks at soil quarry Satun Geopark area

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Abstract. The studied hardness values of rocks at soil well in Satun Geopark area for the feasibility of utilization in construction. Rocks samples was collected from a rock hills that is 60 meters long and 9 meters high. The rock hills are characterized by geological features, with a clear layered rock formation. Rock samples were collected 3 points, 5 layers each, approximately 1-1.5 meters from each other. Analysis results followed the geology methodology can be categorized into 3 rock types: calcareous siltstone, shale, and limestone. The result of average density is 2,594±618 kg/m^3, 2,803±916 kg/m^3 and 2,850±361 kg/m^3 respectively. The point load strength test of rock samples was performed with point load equipment according to standard ASTM D5731. An average point load strength (PLS) is 3.39±1.78 MPa, 3.36±1.70 MPa, and 3.28±1.15 MPa, respectively. The uniaxial compressive strength (UCS) was 74.75±39.15 MPa, 73.60±37.16 MPa, and 72.00±25.34 MPa respectively. Comparison of the hardness of rock samples in the study area with the hardness values other research to use for construction in Thailand and abroad, the sedimentary rocks in the study area were strong enough and can be utilized in engineering construction due to their appropriate compressive strength.

Keywords: sedimentary rock, point load strength, uniaxial compressive strength

Introduction

The mechanical characteristics of rock have been extensively investigated to improve the efficiency of the design and safety of the construction of engineering structures [1]. The knowledge of physical and mechanical properties of sedimentary rocks is required for the safe design of structures in constructions such as residence, bridges, building commercial and engineering applications. The geological properties of rock play a significant role in the design, operation, safety, and stability of both constructions underground and surface operations [2].

Satun Province is in the south of Thailand and adjacent to the Andaman Sea. It was designated a UNESCO World Geopark (United Nations Educational, Scientific and Cultural Organization: UNESCO) on 17 April 2018, since Satun Province has a valuable source of geology, archeology, ecology, and culture. Satun Geopark covers an area of 4 districts, namely Manang, La-Ngu, Thung Wa, and parts of the Muang district that contain various marine animal fossils. All the fossils six eras of the Paleozoic Era appear in rocks throughout Satun Province, as a result, the local community of Satun and the Department of Mineral Resources have jointly pushed the Satun Geopark to become a world geopark. This is considered the first and only world geopark in Thailand at present [3]. The area of Thung Sa-Met soil well, La-Ngu district, Satun province, is part of the Satun Geopark that still needs to be surveyed and examined fossils. And the physical characteristics of the rock found in the fossils to provide knowledge to the community.

The purpose of this research is to study the mechanical properties from the hardness values of sedimentary rocks discovered in fossils in the study area. The relationship between uniaxial compressive strength and point load index was analyzed to determine the potential and feasibility of using these rocks as building materials or engineering applications.

Geology setting of study area and experimental.

In the study area of the soil quarry, La-Ngu District, Satun Province, at the coordinate UTM0770260 47N058478 (in Figure 1). Around the study area is a rubber plantation, the rock sampling area is an outcrop hill with a length approximately 60 meters and a height about 9 meters. Considering the physical appearance, found that the color of the outcrop hill is dark black mixed with brown, alternating layers clearly as shown in Figure 2.

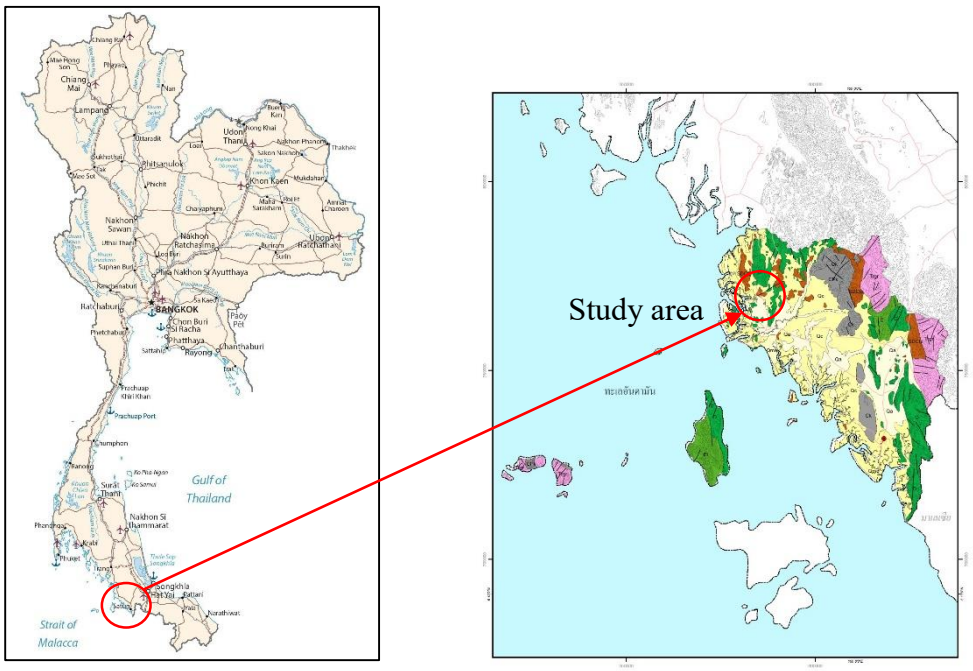

Fig. 1 Study area

Geology setting of study area. The nature of the rock at the outcrop hill is clearly arranged in layers. From the Satun Provincial Geological Map at the Thung Samet soil quarry location, La-Ngu District, Satun Province, there are geological characteristics that are shale, chert, calcareoue dark grey, and limestone thin layer and grain found graptolites, tentaculites, nuatiloids and brachiopods [4]. In the period Ordovician to Devonian (490 – 360 Ma) [3].

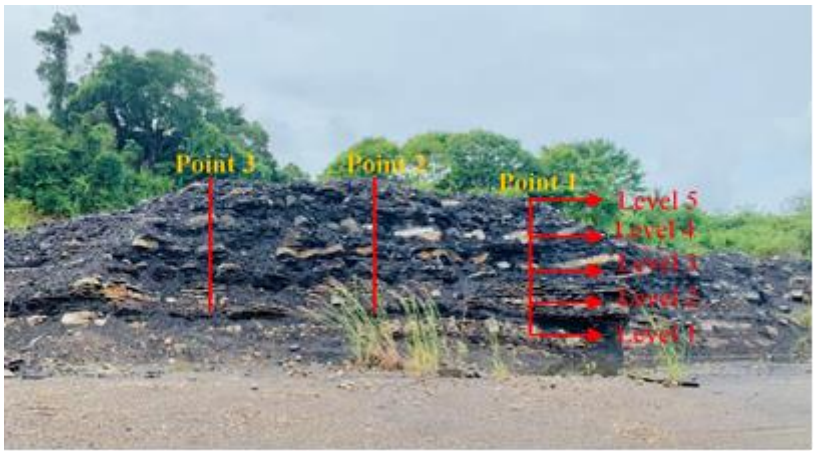

Fig. 2 Outcrop hill and sampling points

Description of rock sample. Collected 5 layers of rock samples according to the arrangement of the rock layers, 1-2 meters apart, and collected 3 samples per layer, amount 3 points, distance from each point 4-5 meters, all 45 samples (refer with: Fig. 2). Rock types were tested in the field by observation method, and test to be correct according to geological principles. The results were sedimentary rocks, which were divided into 3 types: calcareous siltstone, shale, and limestone.

Table 1 Rock types and characteristic in study area.

Rock types	Characteristics of rocks
Calcareous siltstone	black, tight texture, reacts with hydrochloric acid to form small air bubbles.
Shale	dark gray, tight texture clearly shows exfoliation.
Limestone	grey, tight texture, reacts with hydrochloric acid to form many air bubbles.

Measurement Density. Take all the rock samples collected and crack pieces of approximately 1.5-2 kg each. And dry weighing of rock samples, The entire rock samples were then immersed in water to remove air bubbles from the rock for 24 hours, allowing the water to replace the air gap and become the wet weight of the rock. According to Archimedes's principle. Calculate the rock density from equation (1).

$$\rho_d = \rho_W \left(\frac{M_1}{M_1^* - M_2^*} \right) \quad (1)$$

When ρ_d is density of rock (kg/m^3)
ρ_W is density of water (kg/m^3)
M_1 is the weight of the rock in the air (kg)
M_1^* is the weight of the rock saturated with water in the air (kg)
M_2^* is the weight of the rock saturated with water in the water (kg)

Note in the rock samples, no instantaneous dissolved minerals were found. However, chemical compounds that can react with hydrochloric acids, such as calcium carbonate, and the water in which the rock samples were immersed was non-acidic tap water.

Sample preparation and mechanical test. The rock samples collected from the study area are irregular in shape. And prepared to be suitable for the 50 mm diameter acupressure, the stone is approximately 50 mm x 100 mm x 50 mm. The rock samples were subjected to a point load test (PLS) with point load equipment according to standard with ASTM D5731, and the hardness values in the rock samples were determined based on the point load strength index (I_{p50}) which can be used to estimate the uniaxial compressive strength (UCS) [5].

Results

Density and mechanical properties analysis of PLS (Point load strength index) and UCS (Uniaxial compressive strength) of 3 types of sedimentary rocks in the study area were calcareous siltstone, shale, and limestone. The density and mechanical properties of PLS and UCS. Compared the results of rock analysis in the study area with other researchers' sedimentary rocks. are shown in Table 2.

The average density of calcareous siltstone, shale, and limestone is as follows 2,594±618 kg/m^3, 2,803±916 kg/m^3, and 2,850±361 kg/m^3 respectively.

The PLS is an index test that can be used to estimate from the UCS [5]. The graphs in Fig. 3 are the results of the PLS and UCS values of 15 rock samples. The calcareous siltstone contains 8 samples, its 1, 3, 6, 9, 10, 12, 14, and 15 there were an average of PLS and UCS 3.39±1.78 MPa and 74.75±39.15 MPa respectively, shale 5 samples, its 2, 4, 7, 8, and 11 have average 3.36±1.70 MPa and 73.60±37.16 MPa respectively, and limestone 2 samples its 5 and 13 have average 3.28±1.15 MPa and 72.00±25.34 MPa respectively.

Table 2. Comparison physical properties and mechanical data

Rock type	ρ [kg/m^3]	UCS [MPa]	PLS [MPa]	Authors
Calcareous siltstone	2,594±618	74.75±39.15	3.39±1.78	This research
	2,590	82±1.41	-	Danupon Tonnayopas (2015) [6]
Shale	2,803±916	73.60±37.16	3.36±1.70	This research
	2,586	118	-	Shuai Heng et. al (2020) [7]
Limestone	2,850±361	72.00±25.34	3.28±1.15	This research
	2,170	73	-	Mohammad Ghafoori et. al. (2017) [8]
	2,400	53.83	-	
	2,340-2,450	45.1-112.4	1.5-8.7	E. Yaşar et. al (2010) [2]
	-	100.43 (sankamphang)	4.11	

Rock type	ρ [kg/m^3]	UCS [MPa]	PLS [MPa]	Authors
		71.08 (Hangdong)	3.48	Amarin Boontun (year not appear) [9]
		42.15 (Hangdong)	2.25	

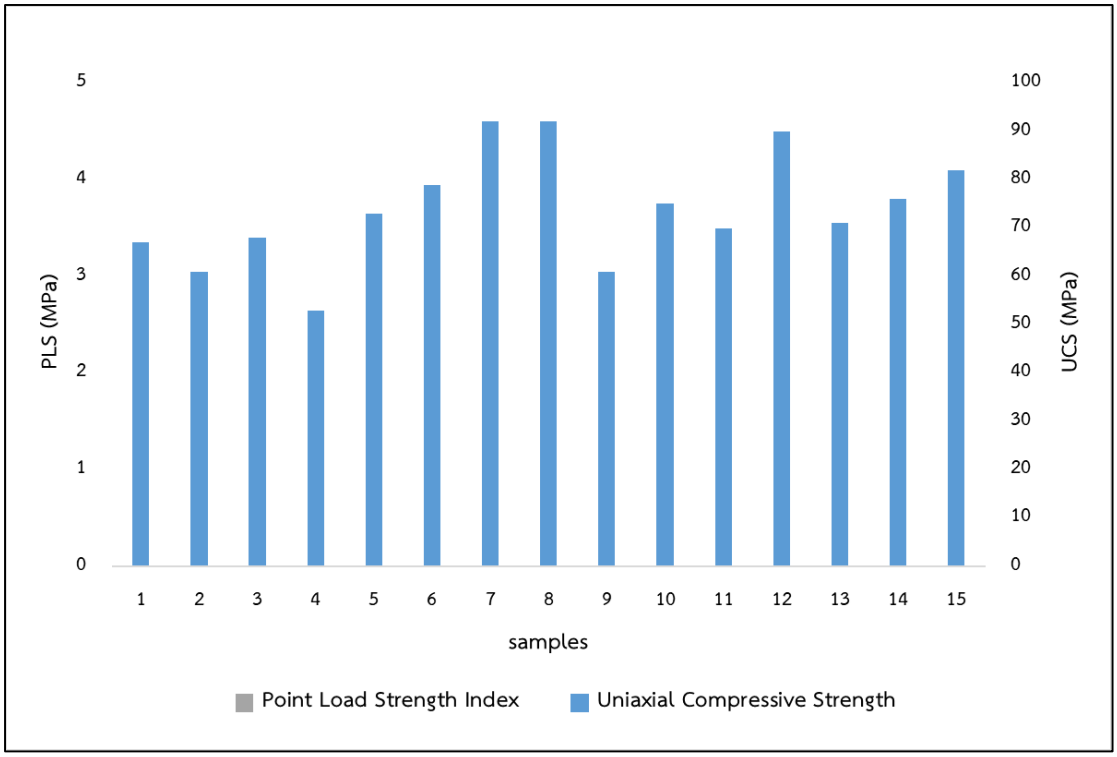

Fig. 3 Point load strength and uniaxial compressive strength of samples

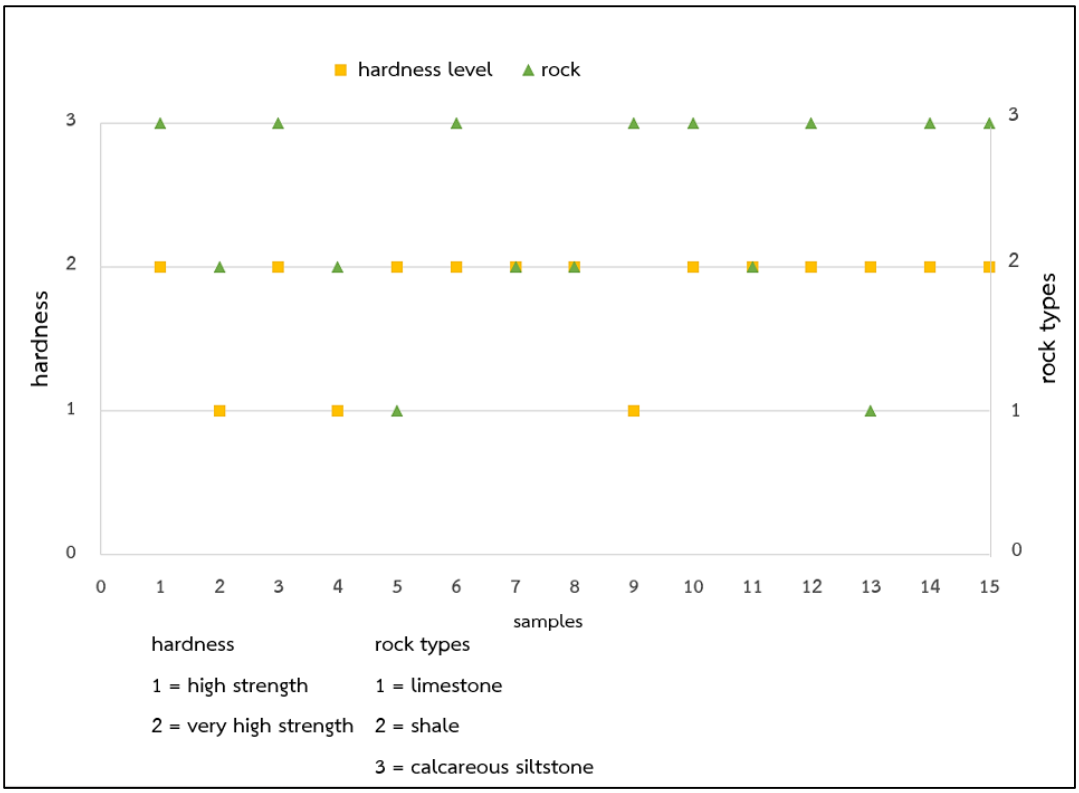

Fig.4 Relationships rock type and hardness of study area

Discussion and conclusion

The density of sedimentary rocks is one of its most fundamental properties [2]. Density of rock depends primarily on the composition by minerals and secondary on the porosity. The reason the sedimentary rocks density of the study area is higher than that of other sedimentary rocks, because the study area is part of the Satun Geopark. The geology of Satun Province consists of various types of sedimentary rocks including igneous rocks. The various terrain nature is formed by the processes of continental plate movement. Changes in the environment of sediment deposition uplift of rock layers, this process occurred from the beginning of the Paleozoic period to the present. It found indications that the area of Satun used to be both shallow sea, deep sea, and igneous rock intrusion. the elevation of the seafloor to land including erosion and weathering of rocks and soil layers [4,5]. The area has been explored to find fossils of many marine life inhabitants. Therefore, the origin of sedimentary rocks may be from the deposition of fossils at the time of their death, together with the topography and part of the coastal climatic conditions, the deposition and binding of the rock are denser, it is possible that the sedimentary rocks in the study area may have low porosity and water absorption. In addition, the mineral composition of the rock may differ from other regions, thus causing the rock density to different.

As for the rock hardness obtained from PLS and UCS when comparing the strength classification of the rock, according of E. Broch and J.A. Franklin (1972) [10], the sedimentary rocks of the study area are classified as a strong rock (refer with: Fig. 4). Compared with sedimentary rocks in other areas in Thailand [6,9], the rock hardness values were in the identical range, in particular, limestone in northern Thailand collected in front of the mining resource from research by Amarin Boontun (1992), if additional geophysical data in study area such as magnetic susceptibility, electric conductivity, or

other values that show the possibility that the study area can be an economic mineral resource. The limestone of the study area can be used as a building material. Comparison the hardness of the sedimentary rock abroad is similar, in research Mohammad Ghafoori et. al. (2017) [8] tested limestone rocks collected at the Bazoft dam area, meaning the limestone of this study area can be taken as materials for constructing reservoirs, or dams can be built.

There is little comparative data on calcareous siltstone and shale, only available for comparison of Danupon Tonnayopas (2015) and Shuai Heng et. al (2020). Considering the relationship between the rock density and the rock hardness of the two types rock should have the following relation: the rock is more hardness should have a high-density value. The shale was consistent between hardness and density, only the density of shale in the study area was higher than that of other studies compared. For the calcareous siltstone of the study area, the relationship between hardness and density was inconsistent. This may be because there are some variables or factors that make calcareous siltstone harder than all three types of rocks, such as the binders of the rock that needs to be studied in the rock structure or the composition of minerals in the rocks that the researcher needs to study further.

Knowledge of the mechanical and engineering properties of rocks is very useful for site characterization and various engineering applications [2]. Therefore, the 3 types of sedimentary rocks at Thung-Samet Soil well, La-ngu District, in Satun Geopark, namely calcareous siltstone, shale, and limestone, have potential and are strong enough to be used in various constructions such as building houses, roads, or bridges and can be mixed with cement to make concrete. including various precast concrete products. Each type of rock has different useful characteristics depending on the type of construction. However, further study of other relevant parameters must be done to provide more complete information and to know the maximum efficiency of the rock that can be used in various constructions.

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