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Preliminary Geotechnical Properties of Uncemented Sandstone Kati Formation

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***Abstract*—**Assessment of geotechnical properties of the subsoil is necessary for generating relevant input for the design and construction of a foundation. It is significant for the future development in the area. The focus of this research is to investigate the preliminary geotechnical properties of the uncemented sandstone from Kati formation at Puncak Iskandar, Seri Iskandar. A series of basic soil tests, oedometer and direct shear box tests were carried out to obtain the soil parameters. The uncemented sandstone of Kati Formation was found to have well-graded and poorly graded sand distribution, depending on the location where the samples were obtained. The sand grains distribution was in a range of 82%-100% while, the specific gravity of the uncemented sandstone is in the range 2.65-2.86. The preconsolidation pressure for USB3 was 990 kPa indicating that the sandstone at USB3 sample had undergone 990 kPa of overburden pressure. The angle of friction for uncemented sandstone was ranging between 23.34°-32.92°.

***Keywords*—**Geotechnical properties, Kati formation, uncemented sandstone, oedometer test, shear box test.

I. Introduction

ASSESSMENT of geotechnical properties of the subsoil is necessary for generating relevant input data for the design and construction of a foundation. Therefore, the knowledge of it is significant for the future development in that area. Geotechnical information is useful to ensure that the environmental and natural resource impact of projects are adequately measured and mitigated where necessary [1].

Kati formation, as shown in Figs. 1-3, was established in the western zone of Peninsular Malaysia consisting of an upper paleozoic rock. It lays below the granites of Klebang and Bintang ranges [2]-[5] and expands southward of Teluk Intan and Tapah. Previous studies showed that Kati formation was mainly found at Kinta Valley and Seri Iskandar area [2], [6]. The depositional setting of Kati formation is a deep marine slope environment [6] as it suggested regionally to the slope and basin in the western belt of Peninsular Malaysia.

In this study, the main objective is to investigate the geotechnical properties of the uncemented sandstone from Kati formation. This is very important for further research in the area of Puncak Iskandar, Seri Iskandar for further development. Some basic soil tests such as particle size distribution, moisture content, and specific gravity were carried out using the disturbed sample, while the undisturbed block sample, as shown in Fig. 4, was used for oedometer and shear box test.

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II. Methodology

Some basic and engineering soil tests were conducted on the uncemented sandstone samples according to BS 1377:Part 1:1990, BS 1377:Part 2:1990 and BS 1377:Part 5:1990 to determine the geotechnical properties and the compression behaviour of the uncemented sandstone and shale samples.

A. Sample Collection

Four samples of disturbed uncemented sandstone were collected from the entire exposed thickness of the Kati formation in this study area. One block sample of undisturbed sample was collected as shown in Fig. 4. All the disturbed samples were labelled as US1, US2, US3 and US4, while the block undisturbed sample was labelled as USB3. The number of US1, US2, US3 and US4 is according to their location.

B. Sample Preparation

For the preparation of the disturbed sample collected from the field, some of the intact samples were broken down into aggregation after drying using oven drying for 24 hours. For the block undisturbed sample, the sample was placed on the soil lathe. By using a wire saw as shown in Fig. 5, the sample was trimmed by moving the wire saw vertically against the block sample. Although the sample looks intact, the oxide cementation makes it fragile and easily broken and with only the pressure of a fingertip.

C. Basic Soil Tests

Geotechnical basic soil tests such as particle size distribution, moisture content and specific gravity were conducted.

D. Oedometer Test

The oedometer test was designed to measure soil consolidation parameters in the vertical direction and with drainage conditions that soil experience in the field. For this research, the oedometer test was carried out to investigate the preconsolidation pressure of the uncemented sandstone. The test was carried out using a 38 mm x 20 mm cylindrical shape of saturated soil sample. The sample was loaded until 6400 kPa. Fig. 6 shows the oedometer test set up.

E. Direct Shear Box Test

The uncemented sample with dimensions of 100 mm x 100 mm was used to conduct the direct shear box test under three different loadings of 100 kPa, 200 kPa and 300 kPa.

F. Sample Characterization

A total of two samples namely USI and USB3 were used for conducting the Scanning Electron Microscope (SEM) and

Energy-disperse X-ray (EDX) analysis to study surface topography and the elemental composition of the sample.

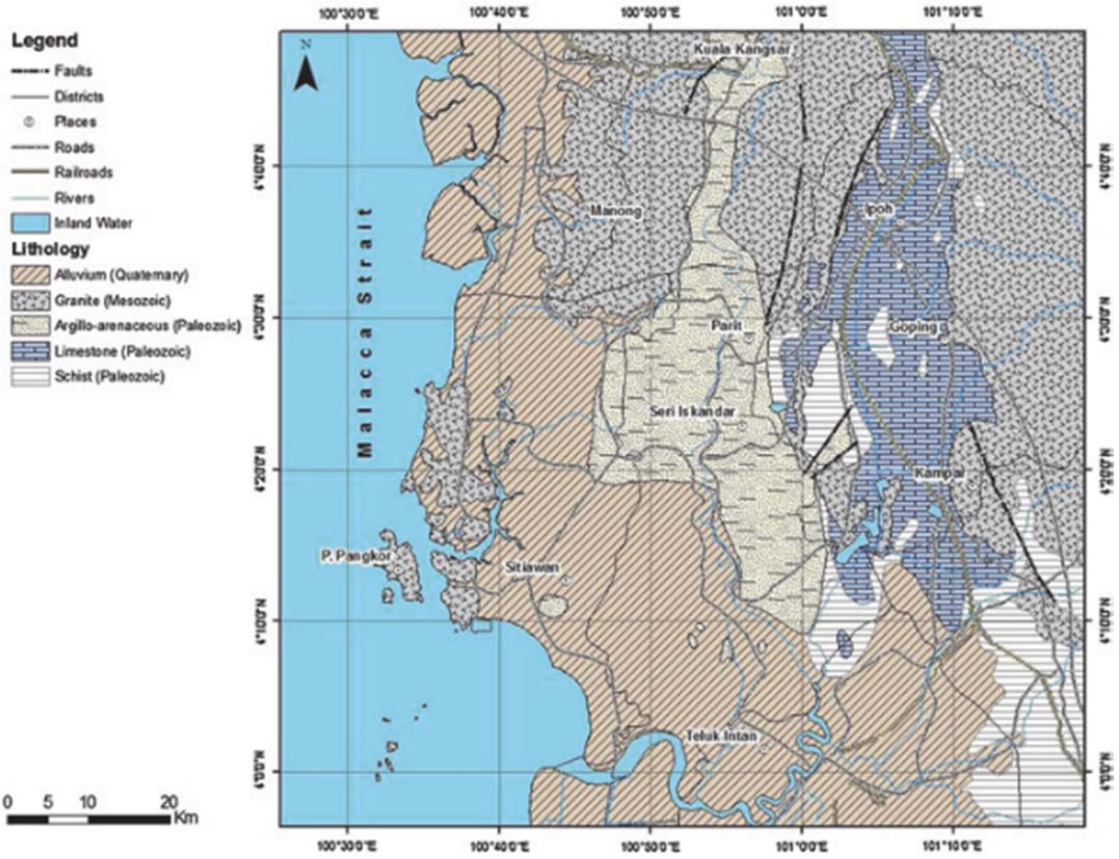

Fig. 1 Northern and central areas in yellow colour represent the Kati formation [6]

Fig. 2 The outcrop of Kati formation

Fig. 3 The overview of the study area

III. Result and Discussion

A. Particle Size Distribution

The percentage breakdown of the grain particles and the particle size distribution curve of each sample are shown in Table I and Fig. 7. Sample US1 consisted of gravel and sand particles with a value of 18% and 82%, respectively. While samples US2 and USB3 consisted of 100% of sand particles. Samples US2 and US3 mostly consist of 65% of fine and medium sand, respectively. From the Unified Soil Classification System (USCS), sample US1 is well-graded sand. Meanwhile for samples US2 and USB3 are poorly graded sand.

Fig. 4 Block sample of uncemented sandstone

B. Basic Soil Properties

Table II shows some results of moisture content and specific gravity of the uncemented sandstone. The moisture

content of the uncemented sandstone was in the range of 0.4%-2.2%. The specific gravity for uncemented sandstone samples was in between 2.65-2.86.

Fig. 5 Uncemented sandstone trimming process

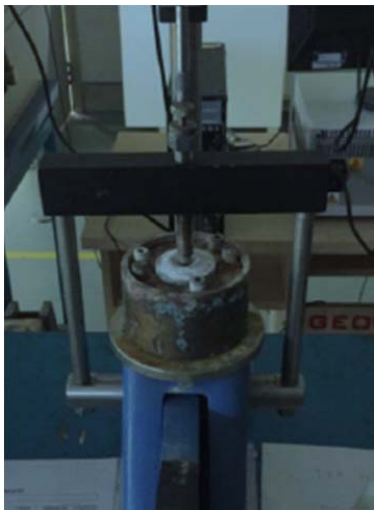

Fig. 6 Oedometer test set up.

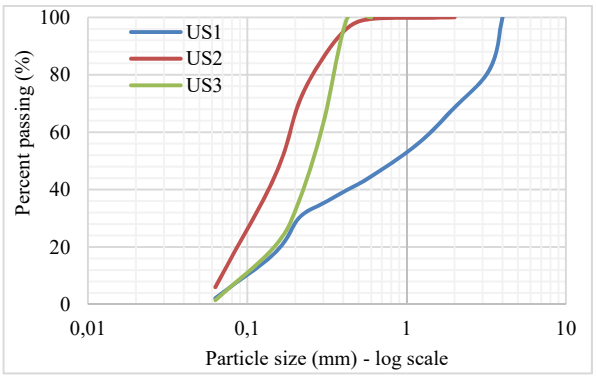

Fig. 7 Particle size distribution curve

TABLE I
PARTICLE SIZE CLASSIFICATION OF UNCEMENTED SANDSTONE

Sample	Percentage (%)				Cc	Cu
	Gravel	Sand	Silt	Clay		
US1	18	82	0	0	0.30	15.15
US2	0	100	0	0	0.65	1.94
USB3	0	100	0	0	1.78	4.12

US: Uncemented Sandstone; USB: Uncemented Sandstone Block

TABLE II
UNCEMENTED SANDSTONE PROPERTIES

Sample	Moisture Content (%)	Specific Gravity, G_s
US1	0.5	2.86
US2	0.4	2.65
USB3	2.2	2.65

US: Uncemented Sandstone; USB: Uncemented Sandstone Block

C. Oedometer Analysis

The compression curve for USB3 sample is plotted in Fig. 8. The initial void ratio of the intact uncemented sandstone was 0.615. The preconsolidation pressure, σ'_c was found to as 990 kPa. This indicated that sample USB3 had undergone 990 kPa of overburden pressure.

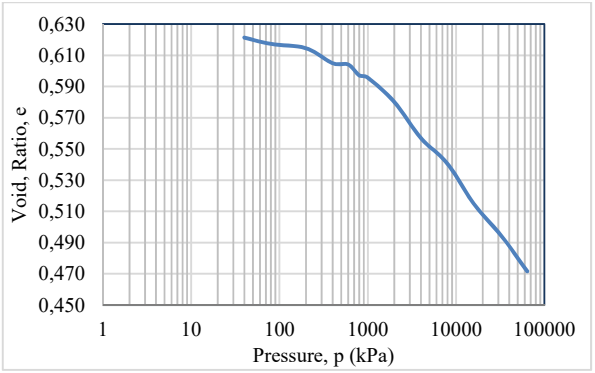

Fig. 8 Compression curve for USB3 sample

D. Direct Shear Box Test Analysis

Table III shows the angle of friction for uncemented sandstone samples. The angle of friction for uncemented sandstone samples were between 30°-33°, and in agreement with typical range of friction angle for angular grains except for USB3 which was 23°.

TABLE III
COHESION AND ANGLE OF FRICTION FOR SAMPLES OF US1, US2, USB3 AND US4

Sample	US1	US2	USB3	US4
Angle of Friction, Ø (°)	31.98	32.92	23.34	30.17

US: Uncemented Sandstone; USB: Uncemented Sandstone Block

E. Sample Characterization

An example of EDX results for samples US1 and USB3 are shown in Table IV. The elements presented in US1 and USB3 were mostly Silica and Oxide, which were the major elements comprising of 87.3% and 91.3%, respectively. Ferum element of 7.5% in sample US1 is due to the colorations from the oxidation process. This happened when the ferum comes in contact with water due to dissolved oxygen within the surface.

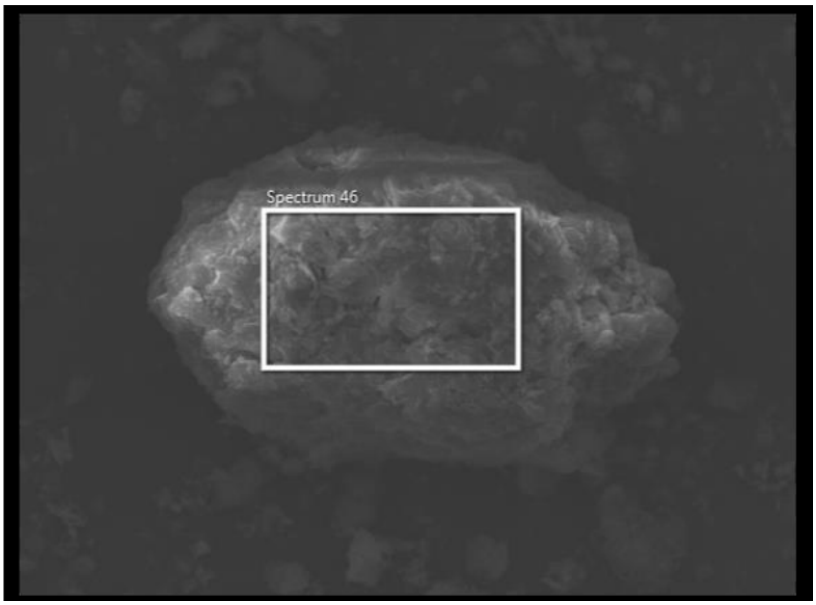

Fig. 9 SEM data for US1 sample

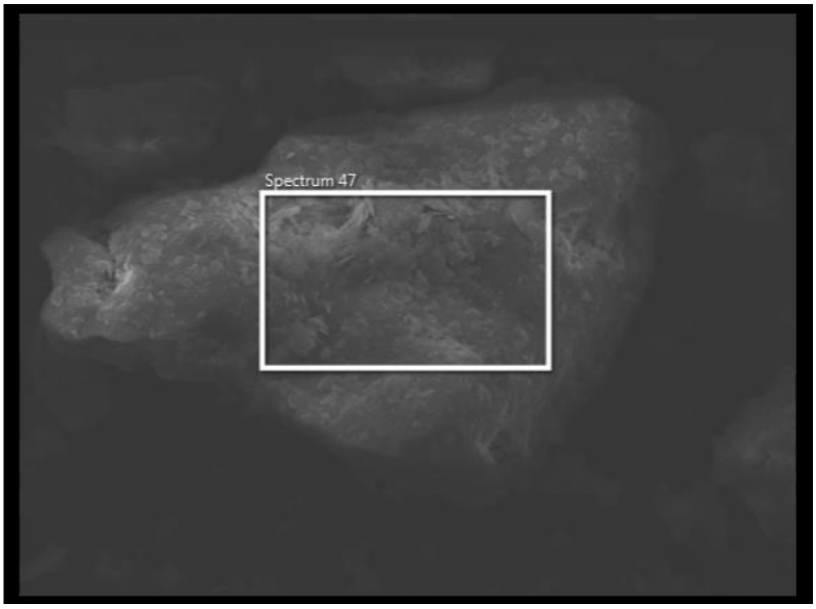

Fig. 10 SEM data for USB3

TABLE IV
EDX DATA FOR US1 AND USB3 SAMPLES

Sample	Element Symbol	Element Name	Percentage (%)
US1	0	Oxide	46.5
	Si	Silica	40.8
	Fe	Ferum	7.5
	Al	Aluminium	3.4
	K	Potassium	1.8
USB3	Si	Silica	46.3
	O	Oxide	45.0
	Al	Aluminium	6.0
	K	Potassium	2.2

US: Uncemented Sandstone; USB: Uncemented Sandstone Block

According to Figs. 9 and 10, the particle shape for sample US1 is subangular while sample USB3 is angular. The shape of sand particles for US1 and USB3 is due to the weathering process of the particles carried by water, wind and waves [7] before it is deposited as sediment and compacted.

IV. CONCLUSION

With some preliminary information of the soil properties obtained, the paper can be concluded as:

- The uncemented sandstone at Kati formation mostly consists of well-graded sand and poorly graded sand with a range of 82%-100%.
- The moisture content and specific gravity of the uncemented sandstone are in the range of 0.4%-2.2% and 2.65-2.86, respectively.

- Sample USB3 had undergone 990 kPa of overburden pressure on the location.
- The angle of friction for most of the uncemented sandstone samples ranged between 30°-33°.
- The main elements of the uncemented sandstone of Kati formation in this area are Silica and Oxide.

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REFERENCES

[1] H. O. Nwankwoala, P. O. Youndeowei, and S. A. Ngah, "Expanding Hydro-Geotechnical Considerations in Eia Studies : A Case Study of Ogorode - Spele, Delta State, Nigeria," *J. Appl. Sci. Environmental Manag.*, vol. 13, no. 1, pp. 67–71, 2009.

[2] F. K. Yee, *Geology and Mineral Resources of the Taiping-Kuala Kangsar Area, Perak Darul Ridzuan.* 1990.

[3] F. K. Yee, "The Palaeozoic Sedimentary rocks of Peninsular Malaysia - Stratigraphy and Correlation," *Work. Stratigr. Correl. Thail. Malaysia*, pp. 1–18, 1983.

[4] C. S. Hutchison, *Geological Evolution of South-East Asia*. 2007.

[5] C. S. Hutchison and D. N. K. Tan, *Geology of Peninsular Malaysia*. University of Malaya nad Geological Society of Malaysia, 2009.

[6] H. A. Alkhali and C. W. Sum, "The Kati Formation: A Review," *ICIPEG 2014*, pp. 303–312, 2015, doi: 10.1007/978-981-287-368-2.

[7] B. M. Das and K. Sobhan, *Principle of Geotechnical Engineering*, Eight Edit. 2014.