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Geotechnical and Engineering Properties of Igbokoda Clay Deposit

¹A.T. Oyediran and ²O.O. Akinkurolere

¹Department of Civil Engineering, Faculty of Engineering, University of Ado-Ekiti, Nigeria

²School of Civil Engineering and Architecture, Wuhan University of Technology, West Manfashang Campus, Wuhan 430070, Hubei, People's Republic of China

Abstract: The engineering and geotechnical properties of Igbokoda clay deposit was investigated due to its economic and engineering significance. Samples were collected at three different locations and subjected to laboratory tests and analysis. The laboratory experiments confirm some previous work on Igbokoda clay. The clay has a specific gravity of 2.55 and 55% *in situ* moisture content. Liquid limit and plasticity index of 38.93 and 18.1 were obtained, respectively. The permeability co-efficient was found to be $2.42 \times 10^{-4} \text{ cm sec}^{-1}$. The optimum moisture content and maximum dry density were 17.05% and 17.1 KN m^{-3} , respectively. The California Bearing Ratio (CBR) was 8.68% with cohesion of 3.83 KN m^{-2} and angle of shearing resistance of 7° . Plotting the liquid limit against plasticity index in the casagrande soil and clay mineral classification, chart reveals that Igbokoda clay is a firm, closely fissured greyish illite clay of intermediate plasticity.

Key words: Igbokoda clay, geotechnical properties, engineering properties

Introduction

The strategic location of Igbokoda in the southern riverain area of Ondo state in south western Nigeria informed the keen interest for investigating the properties of the wide deposit of clay in the area. It is on record that the community is by and large becoming an island of industrial set up therefore necessitating the need for researching the clay properties in anticipation of the use to which the soil would be subjected to both in terms of road networks and building structures.

Earlier studied by Loto and Omotoso (1999) revealed that clay obtained from the Igbokoda deposit was characterized as containing kaolin, illite and montmorillonite with kaolin having the highest percentage necessitating the need for researching the clay properties in anticipation of the use to which the soil would be subjected to both in terms of road networks and building structures.

Previous work by Loto and Omotoso (1999) revealed that clay obtained from the Igbokoda deposit was characterized as containing kaolin, illite and montmorillonite with kaolin having the highest percentage. The work further confirmed the presence of montmorillonite by the flame test, which shows the existence of exchangeable cations not present in kaolin.

Soil classification does not eliminate the need for detailed soil investigation or for testing engineering properties. However, the engineering properties have been found to correlate quite well with the index and classification properties of soil deposit (Braja, 2001). Thus, by knowing the soil classification, the engineer already has a fair knowledge of the likely behaviour of the soil under engineering situation during construction and under structural loads.

Also in the work of Loto and Omotoso (1999) the clay deposit also show the presence of Na^+ , K^+ , Ca^{2+} and Fe^{2+} with sodium as the most potent and exchangeable cation and ions observed not to

Corresponding Author: O.O. Akinkurolere, School of Civil Engineering and Architecture ,
Wuhan University of Technology, West Manfashang Campus,
Wuhan 430070, Hubei, People's Republic of China

swell when water was added. Their research work shows further that Igbokoda clay is acidic with a pH of 4.2 and tendency towards flocculation of the clay platelets due to its high viscosity when mixed with water. It was also reported that the deposit shows a very low illite group presence (0.003%K⁺) and a specific gravity of 2.2.

Loto and Adebayo (1990) also attempted to improve the properties of the clay for use as a binder in place of the imported bentonite from America. Igbokoda clay was said to be of low water retention or swelling capacity.

The above are general testings and purely with the motive of using the clay deposit for metallurgical works in synthetic moulding, therefore the need for further research with the view to explore more of the properties of the clay deposit especially as it affects supports for structures that can detrimentally stress such deposits.

This research was a concise effort to gather a sample population of Igbokoda clay deposit and carry out standard tests on them so that a statistical method can be employed in predicting an accurate and reliable engineering and geotechnical properties. The research was able to throw more light on class of Igbokoda clay deposit, engineering and geotechnical properties of the clay deposit and also engineering and economic use to which the clay deposit can be put.

Materials and Methods

A field exploration visit was carried out to obtain samples for visual inspection and hand filling and also to determine the physical and index properties. Hand dug bores were used to determine the stratigraphy and to obtain disturbed and (relatively) undisturbed soil samples for testing.

After a careful site investigation, the samples were collected at points directly opposite the Igbokoda main market. The disturbed and undisturbed samples were collected at intervals of about 15 m at an average depth of 0.4 m. Three samples were collected in all.

Undisturbed samples were obtained at considerable depths with great care while surrounding clays were used as the disturbed samples as well as for natural water content samples. The undisturbed samples were carefully wrapped with melted candle wax to preserve its natural water content. The evaluation of the engineering and geotechnical properties were then carried out at the civil engineering laboratory of the Federal Polytechnics Ado-Ekiti.

Physical Appearance

The clay is gray in colour, very fine grained cohesive and plastic in nature. It represents a true clay deposit. There is however no physical differences among the three samples.

Also, the clay deposit is smooth to touch, exhibits plasticity, sticks to the fingers, soft moulded by light finger pressure and interstratified.

Results and Discussion

Classification

Using the casgrande plasticity chart for soil classification all the three samples plots above the A-line and hence classifies Igbokoda clay as fine soil of intermediate plasticity, as shown in Fig. 1.

Further classification of the clay from field characteristics chart of soil reveals Igbokoda clay as fine, inorganic soil of medium compressibility. The British Soil Classification System (BSCS) symbol and Casagrande group symbol was C1, i.e., clay of intermediate plasticity (Warren, 1986).

Physical Properties

The samples have average moisture content of 55% due to the nearness to water table. Also samples A, B and C have liquid limits of 47.9, 30.0 and 35.0, respectively; plastic limits of 24.6, 19.1

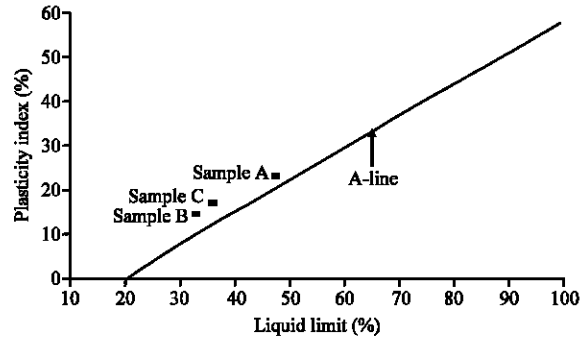


Fig. 1: Casagrande plasticity chart showing the soil classification

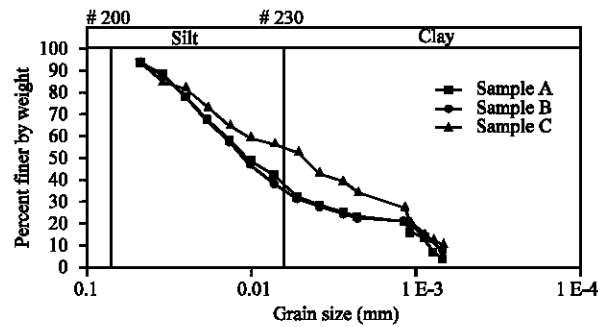


Fig. 2: Sieve analysis graph

Table 1: Engineering and geotechnical properties of Igbofokoda clay deposit

Test properties	Results			
	Sample A	Sample B	Sample C	Average value
A-Physical				
Insitu moisture content (%)	56.00	49.00	60.00	55.00
Plasticity limit (%)	24.60	9.00	18.00	20.50
Liquid limit (%)	47.70	32.80	36.30	38.93
Plasticity index (%)	23.30	14.00	17.00	18.10
Specific gravity	2.57	2.57	2.53	2.56
Dry unit weight (kg m^{-3}) $\times 10^2$	16.55	17.16	16.28	16.66
Bulk unit weight (kg m^{-3}) $\times 10^2$	19.00	19.22	18.75	18.99
Permeability coeff. ($\times 10^{-4}$) cm sec^{-1}	2.68	2.30	2.29	2.42
Shrinkage limit (%)	7.14	5.00	9.20	7.10
Maximum dry density (KN m^{-3})	17.40	17.30	16.50	17.07
Optimum moisture content (%)	16.80	15.00	19.35	17.05
Coefficient of uniformity	20.00	35.00	22.22	25.74
Coefficient of concavity	2.45	2.58	0.47	1.83
B-Strength				
Cohesion C, (KN m^{-2})	5.00	2.50	4.00	3.83
CBR 5.0 mm (%)	4.00	12.27	9.77	8.68
Shear resistance (σ)	5 ⁰	10 ⁰	6 ⁰	7 ⁰
Coeff. of consolidation C_{v90} (cmx min^{-1})	0.259	0.063	0.115	1.146
Coeff. of consolidation C_{v30} (cmx min^{-1})	0.1946	0.0441	0.0865	0.1084
Coeff. of compression	0.3393	0.2052	0.2367	0.2604
Field consolidation time (h)	8.54	35.05	19.20	20.93
Settlement AH (mm)	116.00	216.00	81.00	137.67

and 18.0, respectively. These accounted for their low permeability values. The permeability coefficient was $2.42 \times 10^{-4} \text{ cm sec}^{-1}$ on the average, furthermore, the specific gravity was 2.5 on the average, this

proved to be a confirmity test due to the fact that Lotto and Omotoso (1990) previously determined the specific gravity as 2.22. It was observed that 78.5% of the clay passed through No. 230 sieve, confirming its clays property as shown in Fig. 2. The shrinkage or swelling property was very high (7.10%), hence of a fair to poor value as road foundation when subject to frost action (Wayne, 1988).

Strength Properties

The strength characteristics showed that the samples are more of clay since it had value for cohesive and angle of shearing resistance as 3.83 and 7° (on the average), respectively. With CBR of 8.68 (on the average), it was found to be of poor value as a road base or sub base materials but, of fair sub-grade characteristic (Holtz and Kovaos, 1981). The summary of the results is presented in Table 1.

Conclusions

Igbokoda clay being a member of the illite family with the combinations of perfect cleavage, flexibility, elasticity, low thermal conductivity, infusibility and high dielectric strength makes it a unique mineral and crowned with numerous industrial potentials outlined below:

- Molding sand in metallurgical industry
- Drilling mud in drilling of oil wells in the petroleum industry
- Catalyst in petroleum refining
- Clarifier in processing mineral and vegetable oil (Smithand and Cains, 1988).
- A cleansing absorbent for oil, grease and chemicals
- Insulators in electrical industries (Mead and Bateman, 1981).
- Lining of furnace in smelting of iron.

In view of the economic potentials of Igbokoda clay and in line with Nigeria economic policy in sourcing local raw material for economic self reliance, it is recommended that Industrialists be invited for the exploration of the clay deposits for the development of the state and nation at large.

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