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INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/16841
DOI URL: http://dx.doi.org/10.21474/IJAR01/16841

RESEARCH ARTICLE

IDENTIFICATION STUDY AND MECHANICAL CHARACTERIZATION CLAY STABILIZED BY GUM ARABIC SEYAL

A. Ban-Nah Mahamat, Abdallah. Dadi Mahamat, Mahamat Barka, Ali Abakar and Salif Gaye

Manuscript Info

Manuscript History
Received: 05 March 2023
Final Accepted: 09 April 2023
Published: May 2023

Key words:-
Clay, Gum Arabic seyal, Mechanical characteristic, Geotechnics

Abstract

The construction of infrastructures contributes to the development of a country, in particular that of sustainable, economic and ecological social housing. Chad, with its demographic boom, is facing this housing and energy crisis. This experimental study aims to determine the mechanical resistance by the compression simple of local construction materials. A geotechnical study of the material was made, including the grain size, Atterberg limits, methylene blue and normal Proctor tests.The experimental results of the mechanical tests show that the mechanical strength goes from 3.17 MPa for 100% clay to 4.04 MPa for 8% of gum arabic. From this result it can be confirmed that gum Arabic can be used as a stabilizer for clay-based building materials.

Introduction:-

The improvement of housing has become a necessity for the country, by promoting local building materials, the latter are currently experiencing a resurgence of interest thanks to their availability and their easier and less expensive exploitation [1]. They can also reduce the use of imported materials for their inaccessibility to the whole population and also for their hostility towards the environment.

The gradual increase in the energy cost of certain construction and insulation materials requires a return to the use of local materials [2]; [3], the latter have many advantages in terms of environmental impact, performance and comfort. Made from natural materials, they are also often favorable to the good health of the inhabitants. Under the influence of globalization, however, these practices have tended to disappear.

As a substitute or complement to industrial or “thermo-industrial” materials which require transformation stages with significant energy consumption and the production of greenhouse gases and waste, some of which are highly polluting [4];[5].The use of this type of material fits well into an approach aimed at high environmental quality, since the process uses a locally abundant material that requires little energy for its transformation [6]; [7].

As part of our study we have chosen local materials such as clay and gum arabic, we are doing a study for the improvement of local materials in order to design new ecological and economical materials. The general objective is the experimentation of these new local construction materials in the safety of buildings and energy consumption.

Corresponding Author:- A. Ban-Nah Mahamat

Material and Methods:-

In this part we approach the methods for the determination of mechanical parameter as well as the material used. It is necessary to identify the soil before determining it, hence the geotechnical study.

Clay

Clay is the oldest natural material used by man to build his home. It is available almost every where in the world and its exploitation does not require any particular effort or advanced knowledge [8].

The use of this type of material fits well into an approach aimed at high environmental quality, since the process uses a locallya bundant material that requires little energy for its transformation [9]. In our research work, we have chosen clay from the Kangartoulou brick works site in Massakory.

Figure N°1:- Photograph of the clay taken from the brickyard site and the grinding.

Chemical analysis of clay

The chemical compositions of the raw sample were determined by X-ray spectrometry. The test is carried out at the laboratory level of the office of expertise in water, energy, environment and agriculture (Burex-3eA) of Benin.

Table 1:- Composition of the chemical elements of clay.

Oxydes	SiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	PF	Total
Mass (%)	58,96	3,57	25,31	7,05	1,87	0,072	0,27	0,31	0,83	1,05	6,89	99,29

Où PF: FirelossLOI

Gumarabic

Exudate of solidified sap, produced naturally or following an incision, on the trunk and at the foot of trees of the acacia family, gum Arabic is certainly the oldest and best known gum. It is edible, also for medicinal, artisanal and today industrial use [10]. It is also used in construction where masons use it to ensure the impermeability of roofs based on clay and straw.

Gum Arabic is a polysaccharide, highly branched acid that occurs as mixtures of potassium, magnesium and calcium salts. The monomeric elements of free acid (Arabic acid) are D-galactose, L-arabinose, L-rhamnose and D-glucuronicacid. It is accepted that gum Arabic consists of at least two polysaccharide fractions with different structures [11].

Figure N°2:- Photograph of gum arabic (a) powder and granulate (b).

Identification tests

These tests include particle size analysis by sieving and sedimentometry, Atterberg limits, normal Proctor tests, pycnometer and methylene blue that we present the curves as well as the values in different tables.

Determination of the specific mass of solid grains

The water pycnometer test makes it possible to determine the specific mass γs of solid grains, three tests were carried out. The formula of the equation below allowed us to find the specific masses of three tests and the average is retained for the experimental specific mass of our clay. According to [13] the soil sample is dried in an oven and then weighed. The volume of the particles is deduced by weighing using a water pycnometer by substituting water of known density for the solid particles.

$$\gamma_S = \frac{m_2 - m_1}{(m_2 + m_4) - (m_1 + m_3)} \qquad (1)$$

Tableau N°2:- Experimental value of the specific mass.

specific mass	Clay of Massakory
γ_S (g /cm^3)	2,40

Particle size analysis

A series of sieves allowed us to perform the particle size test by sieving according to [14]. The test consists in separating the agglomerated grains of a mass of 500 g of clay by stirring under water, in splitting this soil, once dried, by means of a series of sieves and in successively weighing the accumulated refusal on each sieve up to the last sieve with a diameter of 80 µm. The granulometric test by sedimentometry supplements the first test and makes it possible to quantify the fractions of particles whose diameter is less than 80 µm for which sieving becomes impossible according to [15]. Two cylindrical test tubes, one containing, demineralized water plus the solution and the other only demineralized water to immerse the torpedo hydrometer, all in transparent glass, graduated and with a minimum capacity of 2500 cm3 allowed us to run the test.

Figure N°3:- Photograph of the series of sieves and two test specimens.

According to the diameters of the sieves, the soils through these two granulometric tests by sieving and by sedimentometry can be classified according to the following table:

Table 3:- Soil classification.

Sievediameters (mm)	Soil type
< 0,002	Clay
0,002 – 0,02	Silt
0,02 – 0,2	Fine sand
0,2 – 2	coarsesand
2 – 20	Gravel
> 20	pebbles

Atterberglimits

The Atterberg limit test according to [16], make sit possible to characterize the state of consistency of fine soils, which consists in finding the liquid limit (WL), for which a groove of standardized dimension, applied in the clay located in the Casagrande dish, closes under the action of 25 shocks and also to find the plastic limit (WP), for which soil cylinders 3 mm in diameter over a length of 10 cm are made. The limit is reached when these cylinders begin to crack by simple lifting. From these two parameters, the plasticity and consistency indices given by the following formulas (1) and (2) were determined:

$$I_P = W_L - W_P \quad (2)$$

$$I_C = \frac{W_P - W}{I_P} \quad (3)$$

Table 4:- Soil type according to Ip and Ic.

Plasticity index (Ip)	Soil condition	Consistency index (Ic)	Soil condition
0 - 5	Not plastic	Ic < 0	liquid
5 -15	little plastic	0 < Ic < 1	Plastic
15 - 40	Plastic	Ic > 1	Solid
> 40	Very plastic		

Normal Proctor Test

The Proctor mold his model consists of amold body, a base and an extension. The shapes and functional dimensions of these elements must comply with the indications, the manual compaction rammer is called "normal Proctor rammer" and is made up of a cylindrical hammer 51 mm in diameter. This sheep slides in a sheath which allows it a drop height of 305 mm. The mass of the moving assembly is 2,490 g and the leveling rule consists of a steel blade whose shapes and dimensions must comply with the indications (see figure below). The water content is determined by the Proctor Normal method according to [17]; [18] which consists of compacting the clay in a standardized mold

using a standardized rammer and measuring its optimum water content and itsdensity or dry density after compaction.

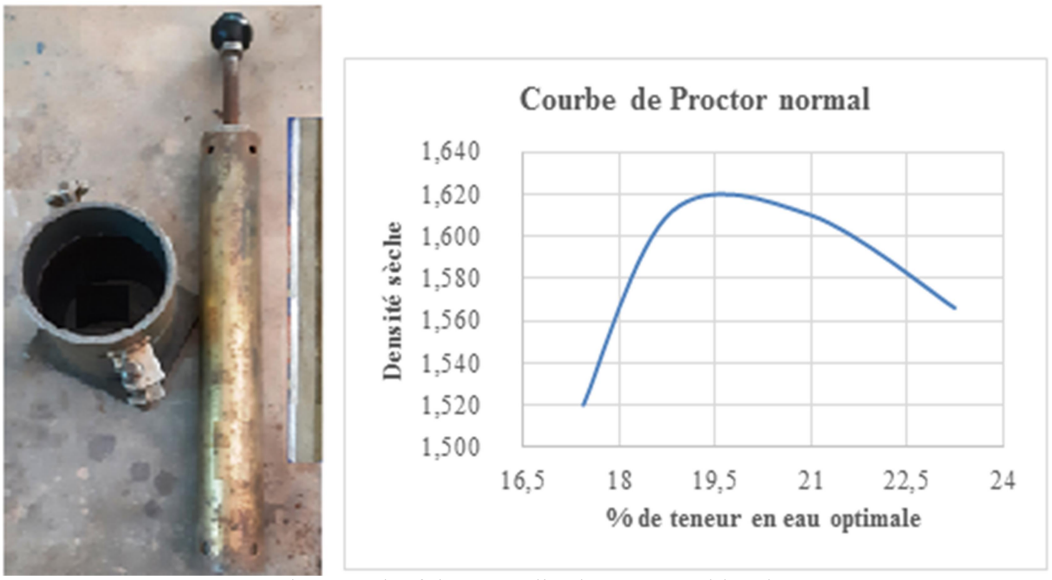

Figure N°4:- Photograph of the normalized Proctor mold and Proctor curve.

Methylene blue test

The test consists of measuring by assay the quantity of methylene blue adsorbed by the material suspended in water according to [18]; [19]. This quantity is reported by direct proportionality to the 0/5 mm fraction of the soil. The soil blue value is directly related to the specific surface of the particles constituting the soil.

Table 5:- VBS values and associated soil type.

VBS values	Type of soil
< 0,2	Sandy
0,2 – 2,5	Loamy
2,5 – 6	Loamy and clayey
6 – 8	clayey
> 8	Very clayey

Mechanical characterization test

The uniaxial compression test of the specimen consists of placing them on a compression plate, which consists of two pistons. A fixe dupper piston, on which I splaced a ring with a force of 30 kN and a displacement comparator is fixed on the upper piston to evaluate the deformation of the sample during crushing and a movable lower piston at the using a flywheel, which puts the sample in contact with the upper piston. Two steel discs are placed, one above and the other below the sample to evenly distribute the pressure on the specimen.

The compressive and flexural strengths which are the most determining mechanical properties for the choice of a building material [20].

Figure N°5:- Photograph of the hydraulic press.

Formulation of samples

As part of this study, a descent to the site for sampling was made with the objective of identifying the level (at least one meter deep as shown in fig1) for mechanical characterization. The method of the latter consists of having loops through a 5 mm sieve for clay and a 1 mm sieve for gum arabic. A grinding with checkers of 5 kg and 10 kg was carried out, the mixture of two is done in the dry state by substitution with well-defined proportions following the mixing water is added with well-defined contents beforehand .

For these tests we chose the normal Proctor mold in order to have afixed compaction energy for all our samples.

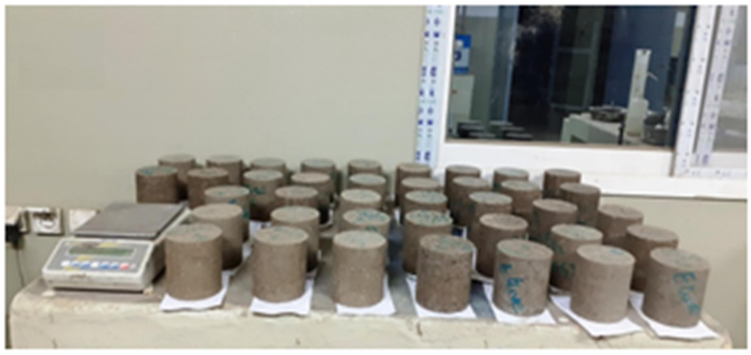

Figure N°6:- Samples for mechanical tests.

Simple compressive strength

The resistance is measured by axial compression of right cylinder of revolution of section S isexpressed by the following relation:

$$\sigma_C = R_C = \frac{F_r}{S} \qquad (4)$$

With :

σc or Rc: simple compressive stress or resistance in mega pascal (MPa)

S: section of the specimen in square millimeters (mm2)

F or Fr: the force applied in Newton (N)

Results And Discussions:-

The result of the chemical analysis shows that silica (SiO2) and ironoxide (Fe2O3) are in the majority in this clay with respective percentages of 58.96 and 25.31.

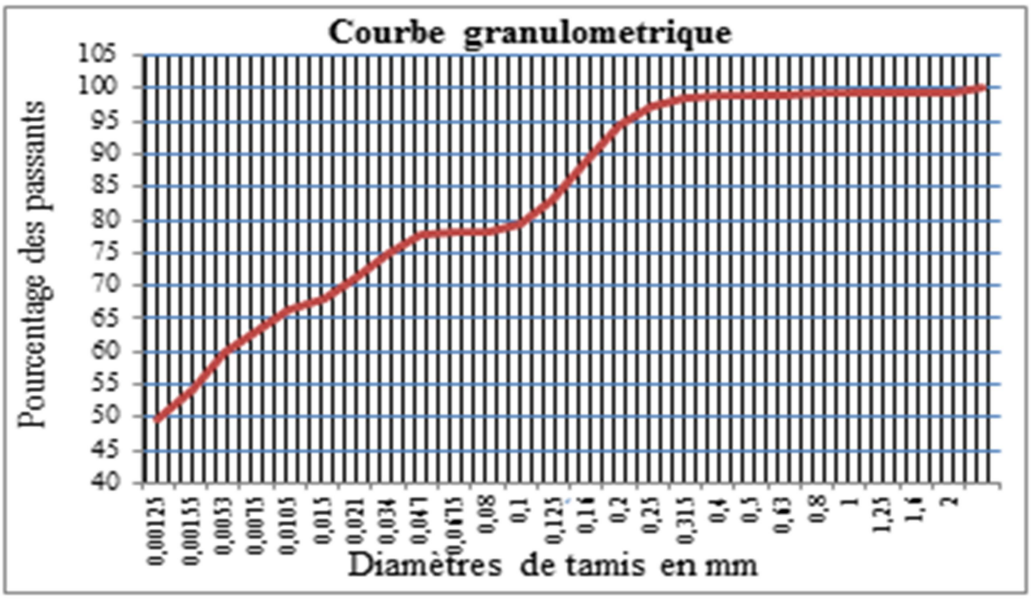

Figure N°7:- Particle size analysis.

According to the particle size curve obtained, we have a percentage of 78.08 of passers-by at the 80 µm sieve and for the classification of table 3, the soilis made up of 55% clay, 17% silt and 28% sand.

In the sameway the result obtained for the limits of liquidity WL and plasticity WP the values in percentage are respectively 43.4 and 21.04 and the values of the indexes of plasticity IP and consistency IC are also 0.223 and 0.073 confirm that this soilis of the clayey-silty type.

The Casagrande diagram below also proves the plastic state of the soil like the other tests carried out: it is the green point which is located in the middle of the interval of low plastic silt and low plastic clay.

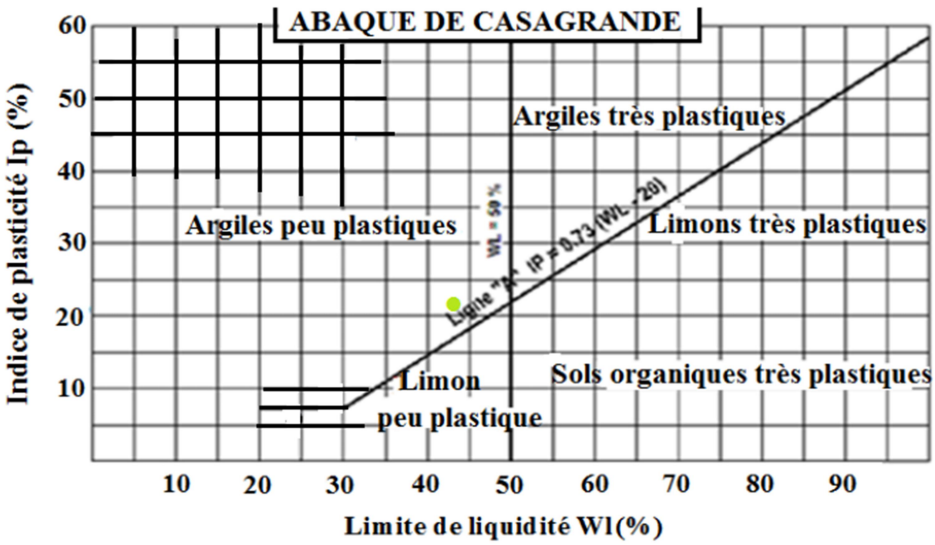

Figure N°8:- Casagrande diagram.

In the end, the tests end with the methylene blue test which also reassures that the soil studied is of the clayey silty type with a volume of 100 ml injected and the VBS is 2.65.
The normal Proctor curve gives us an optimum water content of 19.4% and a dry density of 1.62.
The knowledge of different water contents for the mixture allowed us to make the different formulations of our samples and the simple compressive strengths obtained are presented in the figure below.

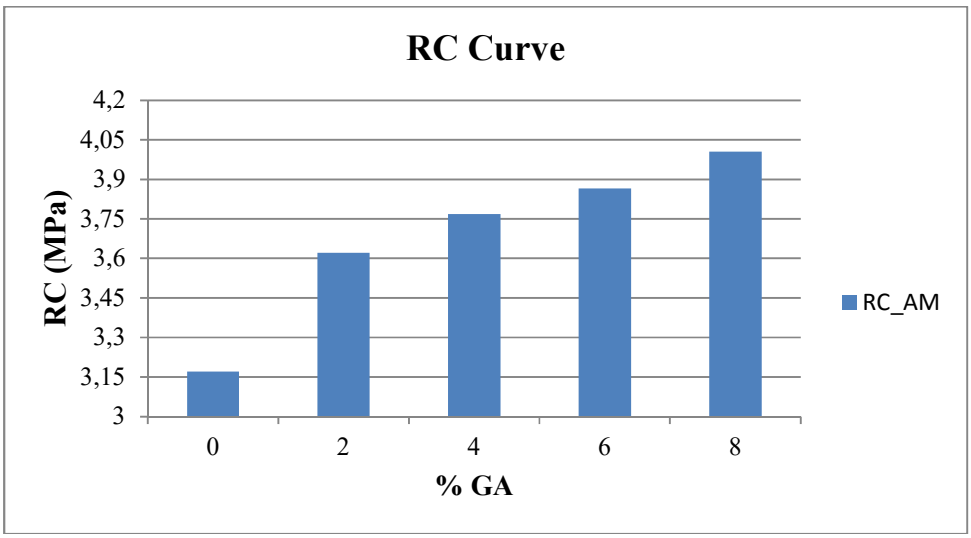

Figure N°9:- Mechanical strength as a function of percentage of gum arabic.

The simple compressive strength increases with the percentage of the adjuvant, with 2% of gum Arabic it goes from 3.17 MPa to 3.63 MPa, i.e. an increase of approximately half a megapascal.
When the cement content increases from 4% to 10%, the simple compressive strength almost doubles. Stabilization with cement renders the clay rewetting process ineffective [21].
Above 5% cement, we observe an increase in these two properties (mechanical and thermal) [22].

Conclusion:-

Construction with raw earth can erode, hence the addition of a stabilizer or adjuvant such as gum Arabic can significantly improve the mechanical characteristics. The soil identification study allowed us to determine the state of the material which is not very plastic and its optimal water content.
For the different formulations, the mechanical characteristic of the soil has improvedsignificantly with the mixture of gum arabic, more over it plays a similar and significant role as the classic binder such as cement in the stabilization of building materials.

The perspective is to carry out a thermal characterization study and control the compaction energy in order to plot the thermal conductivity as a function of the compaction pressure.

Thanks
We express our gratitude to the French Embassy in Chad for granting a mobilitygrant to Mr. A. Ban-nah Mahamat and to the heads of the ENSTP and INSTA laboratories.

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