Journal of Engineering and Applied Sciences
MEDWELL PUBLICATIONS SINCE 2000

Analysis and Mechanical Exploitation of the Soil Clay of Diamniadio with Typha Australis

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Key words: Typha Australis, mechanical resistance, valorization, clay-fill wall-fineness module

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Page No.: 3741-3746
Volume: 15, Issue 23, 2020
ISSN: 1816-949x
Journal of Engineering and Applied Sciences

Abstract: The use of bio-based materials is becoming a growing need, especially for sub-Saharan countries. Moreover, in a context marked by the level of land pressure of Dakar region in Senegal, the city of Diamniadio is chosen by the Senegalese authorities as an administrative city seems relevant because of its proximity to Dakar. However, the land of this area formerly reserved for market gardening create some difficulties for its use in the setting up of buildings. That's the reason why, we proposed this study which main objective is to propose a method of implementation of this land in the construction by improving its properties to the Typha Australis which is a wild and harmful plant. So, after a characterization of the earth that confirmed its clay and plastic character with a fineness module of 1.32 and a plasticity index of 20.47%, we mixed it with Typha Australis to analyze its mechanical properties. The experiment with the press shows a mechanical resistance to compression of 1.08 MPa for the soil alone and 0.71 MPa for that treated with 10% by mass of typha through 0.89 MPa for the soil treated with 4.48% of crushed typha. These values are sufficient for land use mixed with Typha Australis in the walls of the buildings. This gives this study a double impact, namely the development of the land of Diamnidio and Typha Australis.

INTRODUCTION

The city of Diamniadio has become for some years the new attraction site in Senegal because it aims to relieve congestion in the Senegalese capital. However, in order to build buildings, companies are faced with several problems related to the clay nature of the soil. During the last 30 years much research on the transformation of clays by the exchange of interfoliar cations and organic molecules has been published[1, 2] but also by metals[3, 4] in order to obtain microporous materials with a rigid structure. To use the clays in the building some will cook them in ovens, with sintering the material will be harder. At about 800°C the calcium carbonate breaks down into quicklime under the CaO formula with release of carbon dioxide[5, 6]. In this research, the objective is to develop this land of Diamniadio considered buky in construction industry. This will be done through its association with Typha Australis which is a plant whose development causes problems for rice crops. To achieve this value, we draw inspiration from the value of materials of agricultural origin (rice straw) published by many researchers[7, 8]. Therefore, we will determine the mechanical properties of the Typha Australis-Earth mixture by an appropriate characterization method[9]. Some work has already characterized the cement associated with typha and had results that did not exceed 0.89 MPa on the 28th day. Therefore, this study will build on the mechanical constraints of the earth/typha in order to judge their ability to serve as materials in the partition walls.

MATERIALS AND METHODS

The method used in this research is based on a mechanical characterization of the land of Diamniadio and the characterization of the land associated with Typha Australis at progressive mass proportions. Indeed, since it is raw earth, the typha will be crushed through a mill so that it has a better adhesion with the earth matrix.In order to achieve these results, devices and machines are needed. Among them, we can mention the mill to grind typha, the sieves for the particle size of typha and that of the earth, a press for the determination of the constraints.

Study and sampling area presentation: The town of Diamniadio consists of the municipalities of Diamniadio, Sendou, Bargni and Séibikoutane. The area is located between altitudes 14°43'13'North and 17°10'57'West. The area is bounded to the west by the Dakaroise agglomeration; to the North by the Niayes pole; to the east by the Diass pole; to the south by the Atlantic Ocean. The pole of Diamniadio is shown in Fig. 1.

The collection of the earth at Diamniadio site began with a phase of recognition of different soils of the environment. Indeed, it was pressure boreholes that made this recognition possible. We collected a quantity of 4 bags of 50 kg of soil at Diamniadio West, near the treatment plant 200 m behind the Arena stadium in Dakar. The dug depth is 1m10 and the material is wet and blackish as shown in Fig. 2.

Fig. 1: Pole of Diamniadio

Fig. 2: Diamniadio soil

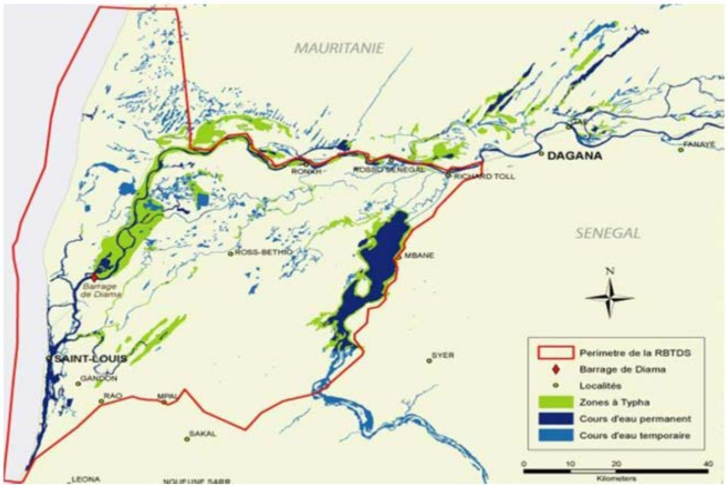

Fig. 3: Distribution of typha in Senegal

Fig. 4: Preparation of typha particle size analysis

Fig. 5: Preparation of soil washing

Presentation of Typha Australis: Typha Australis is a plant that grows in Senegal especially in the north and in the centre in the regions of Thiès and Dakar. The rate of typha proliferation is 10% per year. It occupies ~3 million hectares with a production capacity of 520,000 tonnes of dry matter per year. This biomass is highest at flowering. Figure 3 shows primarily the distribution of the typha plant. The two materials used have undergone some preliminary processing for geotechnical testing as shown in Fig. 4 for typha and Fig. 5 for land.

Soil and Typha Australis particle size analysis: The typha is ground with a mill before passing through the sieves for particle size analysis. A quantity of 200 g of typha is weighed which represents a large volume since typha has a low density of about 65 kg m^3. Figure 5 shows the preparation for wet particle size analysis of the soil.

For the soil, a wet particle size analysis is performed. The materials used in this test are, 1 series of sieves, 1 electronic balance, 1 brush and 2 containers, implementation of the test. A sample of 2.5 kg of material

Fig. 6: Sample for the Cassagrande experiment and apparatus

Fig. 7: Earth-only cylindrical sample

Fig. 8: Typha soil and water mix

is washed with an appropriate amount of water to retain only the material required through a sieve. Indeed, after washing and drying the weight weighed is 732.1 g. It is this mass that will be passed on to a sieve series.

Determining the atterberg limits of diamniadio land: The use of the earth must be based on its good knowledge, hence the interest of determining its plasticity index that is a geotechnical property allowing us to know the liquid and plastic limits of a soil. Figure 6 shows the mechanism of experimentation.

For its realization the following materials and equipment are used, 1 sample of 250 g of soil sieved with a sieve of 400 µm, 1 plate on which the material is spread, 1 spatula, 1 groove, tares, 1 pisette, 1 electronic balance and the apparatus of Cassagrande.

Sample formulation for determination of mechanical compressive stresses: For formulations three series are manufactured. The first series is composed of 26.1% earth and 73.9%. The second series consists of 4.48% typha, 71.64% land and 23.88% water. The latest formulation is composed of 10% typha, 20% water and 70% land. For each formulation A, B and C, five cylindrical samples of size 15 cm in diameter and 30 cm in height are manufactured. These samples were crushed through a press to determine the compression force and then the mechanical resistance to compression. Figure 7 and 8 show the samples before they are crushed.

RESULTS AND DISCUSSION

The results of the typha particle size analysis are presented as a graph as shown in Fig. 9.

This analysis shows the proportions of typha that pass through the sieve mesh. This distribution is very important because the percentage of passers-by in the different cells will facilitate the information on the adhesion of typha/earth mixture. For soil, the results of the particle size analysis are recorded in this Table 1.

Like the analysis done on TYpha, the table also tell us about passers-by according to the size of the mesh. In addition, this analysis allows us to determine other geotechnical parameters such as, the coefficients of curvature C_c of, of uniformity C_u and the fineness module and $M_f C_c = 0.311/0.132 = 2.36$ and $C_c = 0.19^2/0.31\times0.132 = 0.88$. In addition the fineness module is given by the following relation:

$$M_f = \frac{1}{100}\left(0.55+2+9+33+80\right) = 1.32 \tag{1}$$

So, in conclusion, we can say that the earth has a close and uniform grain size. Due to its fineness module, we have a majority of fine particles and therefore will

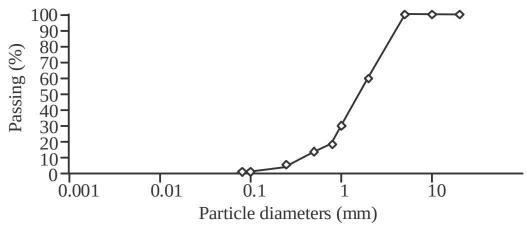

Fig. 9: Results of particle size analysis for typha

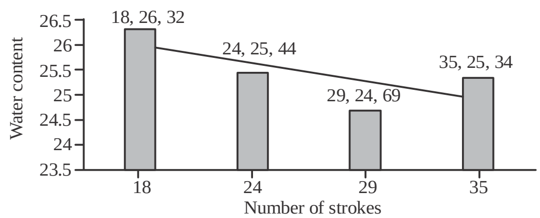

Fig. 10: Determination of plasticity index

Fig. 11: FORDIA compression machine with sample

Table 1: Soil size analysis result

Sieve diameter	Partials refusals	Cumulative refusals	Cumulative refusal (%)	Passing (%)
8 mm	0	0	0	100
5 mm	4	4	0.55	99.45
2 mm	6.2	10.2	1.39	98.61
1.60 mm	1.7	11.9	1.62	98.38
1 mm	5.9	17.8	2.43	97.57
800 µm	5	22.8	3.11	96.89
500 µm	19.3	42.1	5.75	94.25
250 µm	287.4	329.5	45.00	55
200 µm	152.3	481.8	65.81	34.19
125 µm	207.6	689.4	94.61	5.39
100 µm	26.3	715.7	97.76	2.24
63 µm	8.7	724.4	98.94	1.00

need a lot of water for its use. The results on the determination of the Atterberg limit are shown in Fig. 10.

To determine the plasticity index, we will need two other parameters that are the limit of liquidity and the limit of plasticity which are calculated from this graph we will obtain the limit of liquidity which corresponds to the

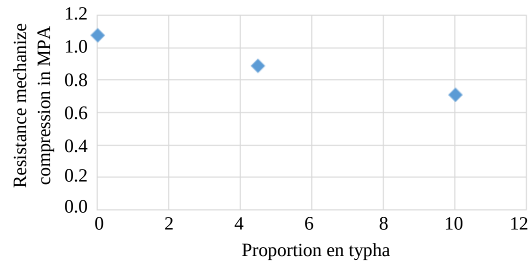

Fig. 12: Evolution of mechanical resistance to compression as a function of typha treatment

water content at the 25th stroke. Which is giving by. The plasticity limits is the average of the water content of the 4 ans 5 tare. From these two values, we can determine the plasticity index which is the difference between the limit of liquidity and that of plasticity.

$$I_p = W_L - W_p = 25.2\% - 4.72\% = 20.47\% \quad (2)$$

So, in conclusion the soil of Diamniadio is plastic based on the previous indications. For the determination of the mechanical stresses of the different formulations a press was used as shown in Fig. 11. This press is used frequently and allows us to obtain the crushing force of the samples. Therefore, the relationship that allows to calculate the mechanical resistance to compression by having the force and the section is given by:

$$R_m(MPa) = \frac{F(KN)}{S(m^2)} \quad (3)$$

The results showed that the land of Diamniadio can be used after treating it with Typha Australis. The latter certainly affects the mechanical strength of the final material which goes from 1.08-0.71 MPa but allows to stabilize the material so that it can be used in partitioning structures. These mechanical stresses prove that these materials are able to be used for partition walls since they can support their weight. It is also shown that the earth has a fine modulus of 1.32 which further shows its clay character and thus the presence of cracks and shrinkage that are resolved by typha thanks to its fibers. The typha thus allows to stabilize the material with mechanical properties affordable for their use in the building as a carrier structure.

CONCLUSION

The reclamation of the Diamnidio soil is achieved by mixing it with Typha Australis which has reduced cracks and shrinkage. However, the mechanical stresses of the materials have decreased with the typha content but can still be used in separation or partition walls. More analytically, the mechanical resistance to compression increased from 1.08% MPa for land alone to 0.71 MPa for land treated with 10% in typha mass and 0.86 MPa for land treated with 4.48% in typha. It should be noted that since the idea is to use these future bricks in partition and filling walls that are not supporting structures then the results found are interesting and can play a big role in the future.In addition, the characterization of the materials will have to continue by carrying out thermal analyses and studying the behavior of the materials in relation to water in order to decide where it would be better to place these bricks and their ability to reduce consumption energy of these buildings in the future.

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