PACE-2021
International Congress on the Phenomenological Aspects of Civil Engineering
Research Article 20-23 June 2021

The İnfluence of Varying Percentage of Sand on The Properties of Coherent Soil

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Keywords

Clay,
Geotechnical Testing,
Mixture,
Sand.

Abstract

This article is a contribution to understanding and enriching soil knowledge. The influence of the varied percentage of pulverulent soil like sand on the physical and mechanical parameters of a coherent soil such as clay is evaluated in the laboratory. Sand and clay are the most important soil compounds, each has physical and mechanical properties that distinguish one from the other, they also differ in terms of degree of water absorption, degree of cohesion, The value of the angle of friction and several other differences. In this study, we conducted several experiments on a mixture of sand and clay in the Eastern Public Works Laboratory, in Annaba, Algeria, to see the changes in physical and mechanical characteristics that will occur in the clay, and to see the role of the sand that we found favorable for these and the results are motivates to use this mixing technique in foundation works and road projects.

1.Introduction

Geotechnics is the set of activities related to the applications of soil mechanics which studies more particularly the behavior of soils in their aspects resistance and deformability, from laboratory tests and in situ more and more sophisticated. The problem of swelling soils has become a hot topic because of the scale of damage it has caused in many countries around the world. Geological data are essential for a better understanding of their intimate behavior. It is to the latter that the present study attempts to make a contribution devoted to clay and sand mixtures, recent studies have been conducted by many researchers [1-4] it is part of, in fact, in the series of experimental works aimed at identifying the influences of the addition of different percentages of sand on the physical and mechanical properties of swelling clays [5], [6] more precisely the influence of a mixed soil mix to a coherent soil in order to provide solutions to the problems caused by the phenomenon of soil swelling.

2. Experimental study of used materials

2.1. Geotechnical identification of clay

From a general point of view, soil identification involves at least the following tests: Granularity by sieving and sedimentation, water content test shown in table 1.

Table 1. The physical properties of clay

Parameter	Value
Water content W (%)	23,4
Moist density ρh (g/cm^3)	2,11
Dry density ρd (g/cm^3)	1,71
Saturation level %	21,5
Degree of Saturation %	100 %
The empty index %	46%
Porosity %	31,5%

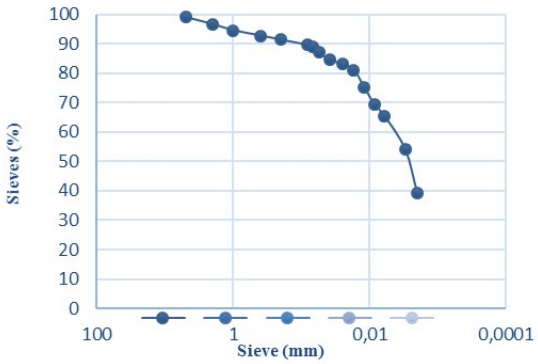

Figure 1. Caption Particle size curve of the clay

The particle size curve indicates that the percentage of fines (less than 80 µm) is between 40% and 80%, so it's indeed a fine soil, the last one between silt and clay knowing that the silt belongs to clays family, figure 1.

2.2. Geotechnical Identification Of The Sand

Sand equivalent, Value of blue introduced (solution at 10 g / l) are shown in table 2, granulometric analysis of sand is shown in curve of figure 2.

Table 2. Sand test results

Parameter	Value
Sand equivalent	93 %
Value of blue introduced (solution at 10 g / l) VB	0,18

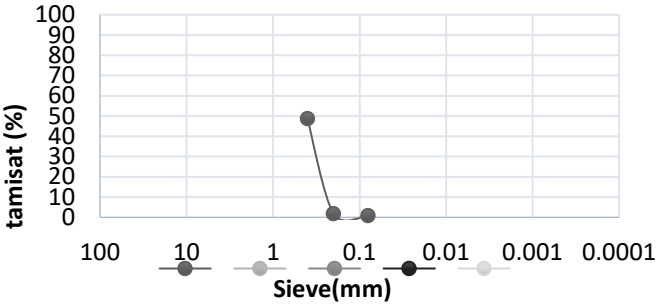

Figure 2. Curve of granulometric analysis of sand

2.3. Preparation Of The Mixture

The method used for the preparation of the mixtures (clay+sand) is simple; it requires appropriate laboratory equipment (bins, small shovels, oven, electric scale, sieve, etc.). The clay and sand materials are first dried and screened, then moistened and homogenized at water contents of:

W clay = 27% and Wsand = 10% respectively. These are water contents between liquid and plastic limits WL and Wp generally approaching the natural moisture content [7]. Among the different methods of homogenization proposed, we chose to mix sand and clay dry, then moisten and homogenize the mixture [8], which circumvents the difficulties of homogenization encountered by other methods. The samples are then compacted based on the method of wet wrap in successive layers exposed by [9]. Each time, a quantity of sieved clay with different particle sizes is taken according to the specificity of each test and then increasing amounts of sand are added according to the designated percentage (5, 15 and 30%). The sample taken is a clayey material that comes from a site near the eastern periphery of the town of Oued Aneb in Berrahal in Annaba, Algeria. This material is a brownish-red plastic clay that results from the disintegration and weathering of Micaschists.

3. Results

Variations in physical and mechanical properties as a function of percentage of sand are shown in table 3.

Table 3. Variations in physical and mechanical properties as a function of percentage of sand

Parameter		Clay	5% Sand	15% Sand	30% Sand
Atterberg limits	$W_L(\%)$	53	49	42	32
	$W_P(\%)$	32	29	25	20
	$I_P(\%)$	21	20	17	12
Methylene bleu Test	VB(%)	6,66	6,33	5,33	4,33
The Proctor Test	W_{op} (%)	15,80	15,60	14,70	14,60
	γd_{op} (t/m^3)	1,55	1,60	1,68	1,74
The Oedometric Test	Pc (t/m^3)	0,215	0,215	0,215	0,215
	Cc	0,161	0,157	0,145	0,135
	Cg	0,055	0,050	0,040	0,025
The direct shear test	C (t/m^3)	0,448	0,395	0,295	0,225
	Øcu (°)	9	10	16	21

3.1. Results Atterberg limits

The variation of plasticity index (Ip) according to the percentage of sand is shown in figure 3.

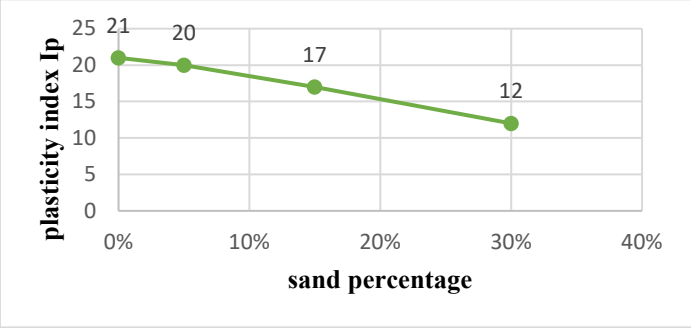

Figure 3. Curve of plasticity index variation (Ip) according to the percentage of sand

With each increase in the percentage of sand added to clay, the plasticity index decrease.

3.2. Results Methylene Bleu Test

The variation of blue value (V_B) according to the percentage of sand is shown in figure 4.

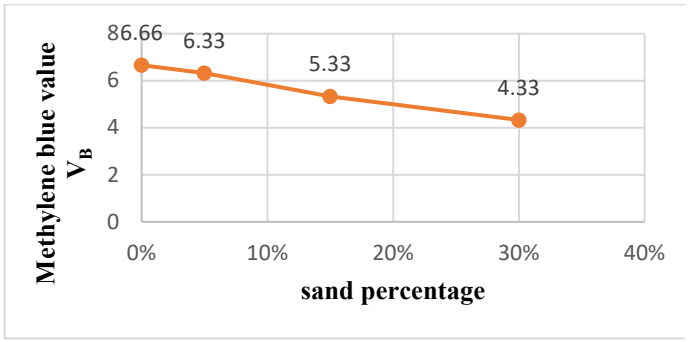

Figure 4. Curve methylene blue value variation(VB) according to the percentage of sand

Figure 4 show that with each increase in the percentage of sand added to clay, the Methylene blue value (VB) decrease.

3.3. Results Proctor Test

Figure 5 shows The variation of dry density (γ_d) as a function of water content (W) for each percentage of sand.

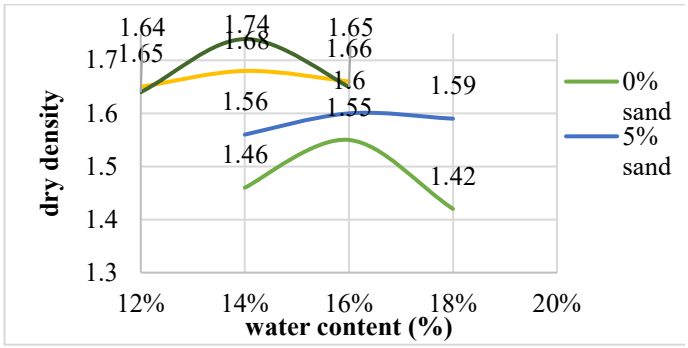

Figure 5. The variation of dry density (γ_d) as a function of water content (W)

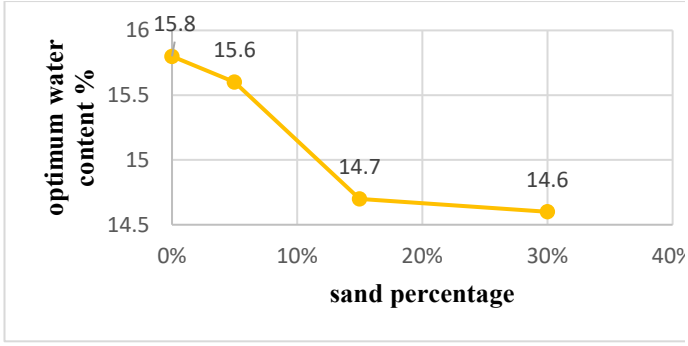

Figure 6. Curve of the optimum water content variation (W_{op}) according to the percentage of sand

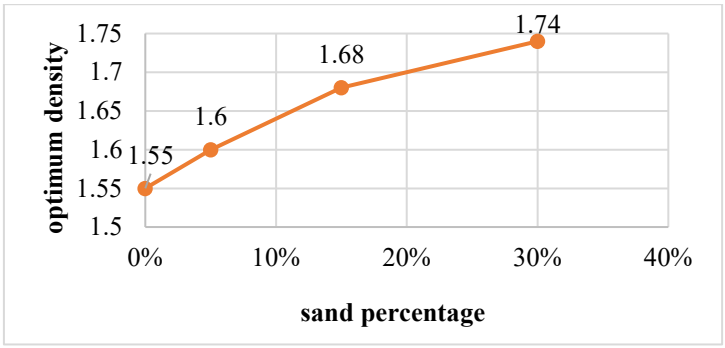

Figure 7. Curve of the optimum density variation (γ_{dop}) according to the percentage of the sand

Whith each increase in the percentage of sand added to clay, the optimum density (γ_{dop}) increases, and the optimum water (W_{op}) content decrease , as shown in figures 5, 6 and 7.

3.4. Results Oedometric Test

Oedometric test give us the consolidation Pressure P_c (t/m^3), compressibility index (C_c), and the swelling coefficient (C_g).

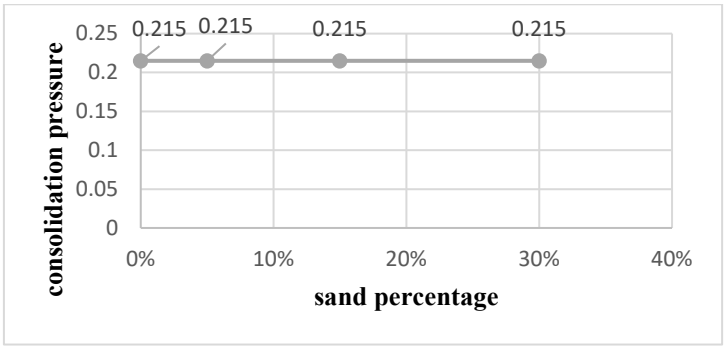

Figure 8. Curve of variation of the consolidation Pressure (Pc) according to the percentage of sand

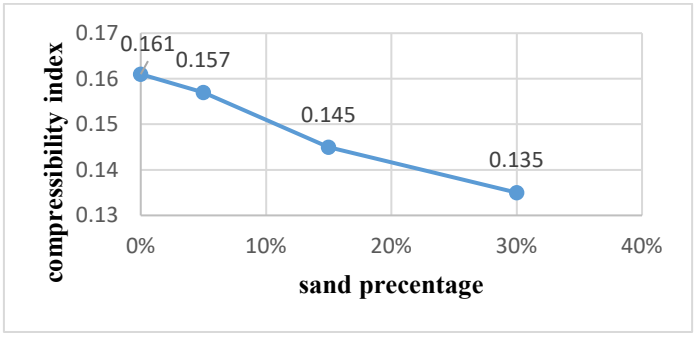

Figure 9. Curve of variation of the coefficient of compressibility index (Cc) according to the percentage of sand

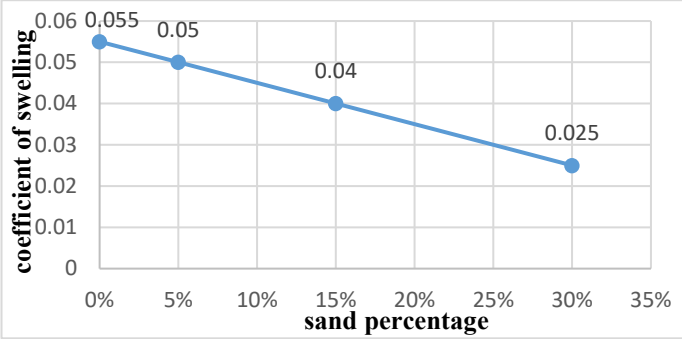

Figure 10. Curve of variation of the swelling coefficient (Cg) according to the percentage of sand

After oedometric test, curve shown in figure 8, 9, 10 are drawn and compressibility index (C_c) and the swelling coefficient (C_g) decreases according to the increasing percentage of sand, but there isn't variation in the consolidation Pressure (P_c) value.

3.5. Results direct shear Test

Direct shear test give the mechanical parameter of soil, the cohesion (C) and friction angle (Ø).

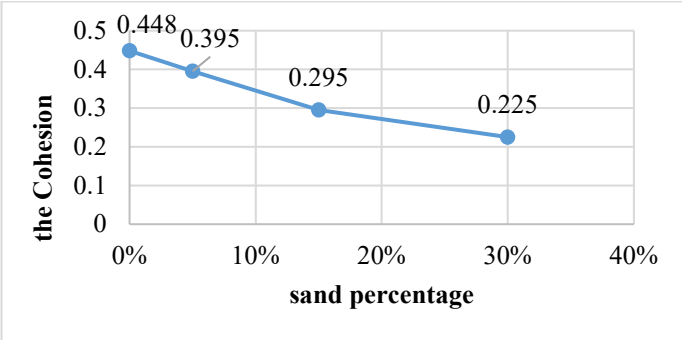

Figure 11. Curve of variation of the cohesion (C) according to the percentage of sand

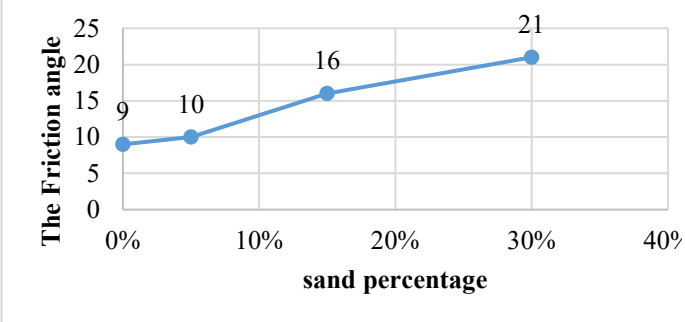

Figure 12. Curve of the friction angle variation (Ø) according to the percentage of sand

After shear test, curves in figures 11, 12 show that increasing percentage of sand produce decreasing of the cohesion (C), and increasing of the friction angle (Ø).

4. Discussion

The values obtained from the Atterberg limits of clay W_L=53%, W_P = 32%, W_I = 21%, interpreted according to the plasticity diagram of casagrande, indicate a plastic organic sol. The liquidity limit of our sample is high. Note that the value of the plasticity index Ip of the mixture decreases when different amounts of sand are added such as [5], [10].

Another criterion relating to the methylene blue test is that the soil can be considered as a clay, from $V_B \geq 6$. V_B decrease with increasing sand addition to the clay sample.

A small decrease in the optimum water content value whenever increasing amounts of sand are added such as [10], [11]. A considerable increase in the value of the optimum dry density resulting from the increase in the amount of sand added to the amount of clay used in the Proctor test such as [10], [11].

The P_c, C_c, C_g values, obtained on a compacted clay specimen under the conditions of the Oedometric test gave the following values: P_c = 0.215 t/m^3, C_c = 0.161, C_g = 0.055, indicating a moderately compressible soil. The coefficient of swelling decreases with the increase in the amount of sand added each time such as [5].

There is a decrease in the value of the cohesion each time the sand is added. It is found that the value of the angle of friction increases with the added sand each time.

5. Conclusions

The main conclusions of the study are summarized:

The addition of sand affects the characteristics of the clay differently, depending on its grain size and grain shape on the one hand, and the percentage added on the other hand. According to the results obtained in the various tests, namely the oedometric test, the shear test, the Proctor test and the Atterberg limit test, we observe a decrease in the swelling potential such as [12]. The direct shear strength, tends to increase the angle of friction and decrease the cohesion, thus improving the shear strength such as[12] and swelling of the clay by the addition of sand.

Sand is a good reducer of the consistency limits, or it offers the reduction of the Atterberg limits such as [10], thus decreasing the sensitivity to water that allows the transition from a plastic state to a solid state.

Proctor's optimum is influenced by sand by increasing maximum dry densities and reducing the optimum moisture content such as [11], which facilitates on-site implementation.

The compressibility of the clay is reduced by the addition of sand that is an inert and incompressible element that is characterized by a high angle of friction. This indicates the positive role of sand in decreasing clay swelling such as [12] which has become a hot topic because of the magnitude of the damage it has caused in several countries around the world has improved the characteristics of such a soil.

Acknowledgements

This work was supported by the collaboration of the Department of Civil Engineering, Faculty of Engineering sciences, University Badji Mokhtar, Annaba, Algeria and the laboratory LMGHU, University of Skikda , Algeria, and LTP EST Laboratory, Annaba, Algeria.

Declaration of Conflict of Interests

The authors declare that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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