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Research Article

EFFECTS OF SAND ON DENSITIES OF SWELLING CLAY FROM THE FAR NORTH REGION OF CAMEROON

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ABSTRACT

A study was carried out on the effects of the addition of sand on swelling clays from the Far North Region of Cameroon is studied. Results of Modified Proctor tests performed on the samples of mixtures of sand and swelling clays in Maroua and Fotokol showed that their dry densities increase as the sand content increases. The optimal dry densities of experimental curves of mixtures according to the contents of sand added are in the shape of an inverted bell, which indicates the existence of an optimum content of sand added. The main results that could be drawn from this study were as follows: the optimal content of the added sand is 30% for the swelling clay in Maroua and 20% for that of Fotokol. For the optimum values of the levels of sand, the increase of optimal dry densities is about 7.4% for the corresponding water content values of about 9.00% to 9.95%.

INTRODUCTION

The urgency of the subject

The Far North Region of Cameroon, situated between the 10th and the 13th parallel is subject to geotechnical disorders that can be noticed on a good number of infrastructures (geotechnical degradation of works, cracking of buildings and road infrastructures). Most of these damages are caused by the soil nature and the inadequacy between its geotechnical features and the structure of supported buildings. Works by Thebe, 1987; Humbel, 1972; Lienou, 2003; Mamba Mpele, 2011 and then Youdjari, 2010 seem to show that the blame is on the presence of swelling clay, also known as karal (Dumort, 1968) which all belong to the vertisol family: lithomorphic when clayey minerals are mostly montmorillonites, or hydromorphic when the clayey predominance of this mineral can no longer be proven. In addition to the above-mentioned damages on infrastructure, we also noted that maintenance and construction overcosts for works carried out in the Far-North Region of Cameroon are mainly due to the presence of these swelling soils and to stabilization methods used for their treatment.In their works on swelling clays of the Far-North Region of Cameroon, (Baana, 2015) proposed a stabilization method that can be implemented in this sand rich region, Mamba, 2014 and that is the most environmentally-friendly: that is litho-stabilization of the Karal with sand. A study on the effects of sand on karal linear shrinkages carried out by Baana, 2015 reveal that this shrinkage reduces as the sand percentage increases, and this irrespective of the water content of samples tested. This article aims at mastering the influence the addition of sand could have on the density of swelling clays of the Far-North Region of Cameroon.

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MATERIALS AND METHODS

Tested soils were taken from the Far-North Region of Cameroon They were taken from two sample drillings, one from the near outskirts of Maroua, at a point whose geographical coordinates are 10°38’20’’ North latitude and 14°24’53’’ East longitude, and the other in Fotokol at a point whose geographical coordinates re 12°22’20’’ North latitude and 14°14’25’’ East longitude. Identification tests carried out by Baana, 2015 reveal that the soils tested are made up of swelling clay. Light grey sand type used come from the Sanaga River. It was chosen because it has the same structure and components as the sand found in the northern part of Cameroon (Baana, 2015). According to Table 1, samples of swelling clays from Maroua and Fotokol belong to the category of soil with a high swelling potential as defined by Holtz (1973).

Tests carried out: Granulomeric, Sedimentometric and Proctor tests were carried out on samples of swelling clay mixed with sand.

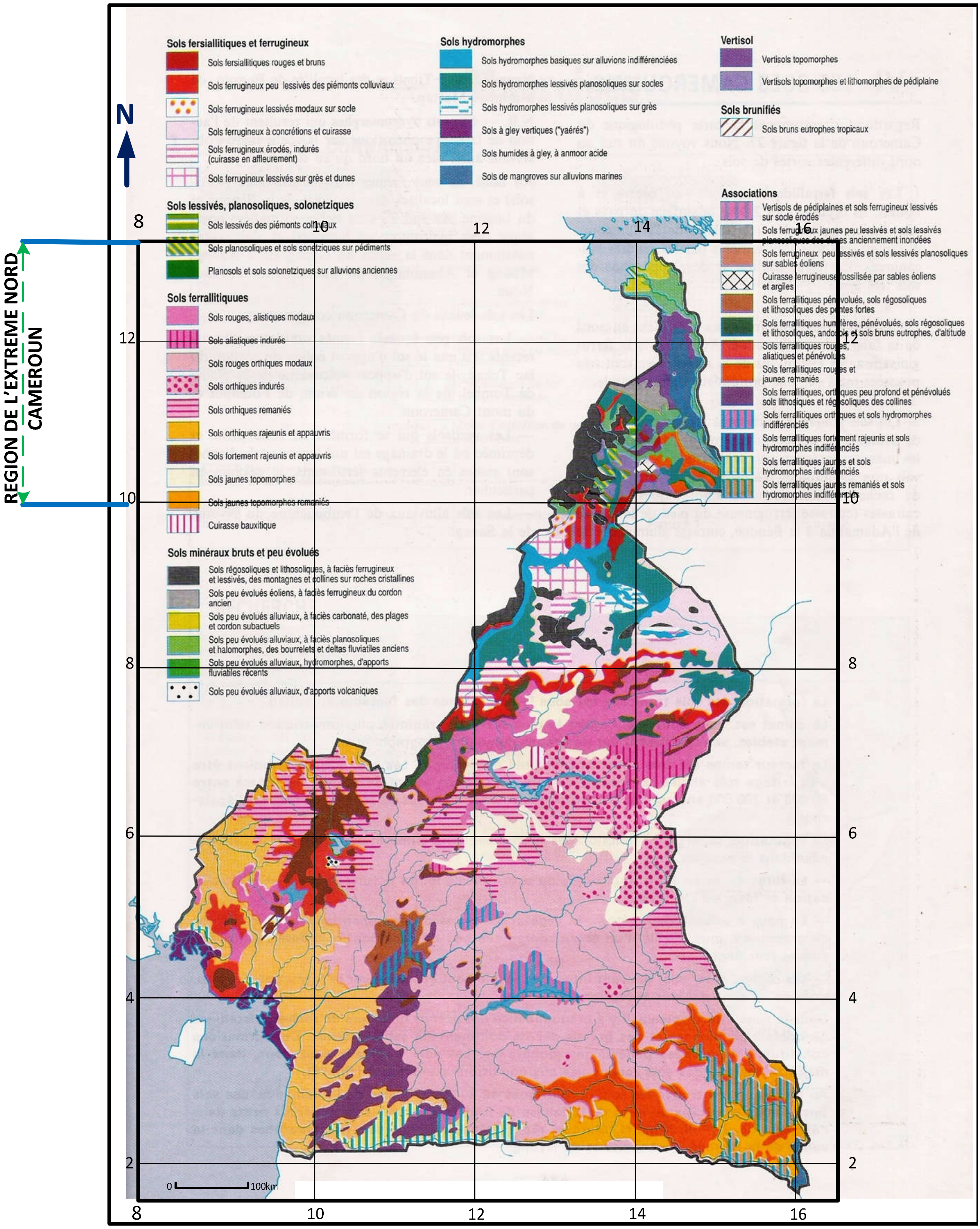

Figure 1. Localization and soils of the Far-North Region of Cameroon (Dumort J. C. 1968)

Granulometric and sedimentometric tests: Granulometric and sedimentometric tests carried out on Maroua and Fotokol sand and swelling clay samples according to the method indicated by the ASTM D 422-63 standard (ASTM, 2002).

Modified Proctor Tests: Modified Proctor Tests were carried out using the method proposed by the NF P94-093 standard (NF, 1993). These Proctor tests were performed on swelling clay samples from Maroua (Karal 1) and Fotokol (Karal 2), and on mixtures of the same types of clay with 0%, 5%, 10%, 20%, 30% and 40% of Sanaga sand. In the lines below, we shall use letters « K1 (resp. K2) » for swelling clay samples from Maroua (resp.from Fotokol) and « S » for samples of Sanaga sand.

RESULTS AND DISCUSSION

Granulometry

Granulometric and sedimentometric test analyses results, as summarized in Figure 3, suggest that Karal 1(swelling clay from Maroua) and Figure 2 (swelling clay from Fotokol) contain 45% and 35% of clayey materials respectively.

Dry densities of karal 1 (K1) and karal 2 (K2)

Results presenting densities of sand (S) and karal (K) compounds from the towns of Maroua « K1 », and Fotokol « K2 » according to water content are summarized in Table 2 and Figures 3 to 5.

Dry densities for Karal 1 et 2

Dry densities for Modified Optimum Proctor of sand (S) mixed with Karal K1 and K2 from the towns of Maroua and Fotokol are summarized in Tables 3, 4 and Figure 6.

Results obtained as summarized in Figures 3 to 6 and Tables 2 à 4 lead us to outline the following points:

- Dry density curves of various Karal 1 and 2 mixtures with sand according to water content are in the shape of an inverted bell (Figures 3 à 5).
- The effect of adding sand to swelling clay from Maroua (K1) and Fotokol (K2) is the improvement the density of mixtures, which confirms the results reached at by Mohamed H. Ben Dhia, 1998.

Table 1. Identification parameters of karal samples from Maroua and Fotokol

Sample	Clayey fraction in %	Plasticity threshold W_p(%)	Liquidity threshold W_L(%)	Plasticity index I_P(%)
Swelling clay from Maroua (K1)	45	31.64	56.84	25.2
Swelling clay from Fotokol (K 2)	35	27.06	53.49	26.43

Table 2. Dry densities of various compounds of swelling clay (K) and sand (S) according to water content

Water content (%)	Matérial	0S+1K	0.05S+0.95K	0.1S+0.9K	0.2S+0.8K	0.3S+0.7K	0.4S+0.6K
6	K1	1.88	1.90	1.97	2.02	1.98	1.97
	K2	1.90	1.92	1.80	2.06	1.91	1.90
8	K1	1.97	1.98	2.02	2.10	2.10	1.98
	K2	1.94	1.96	1.91	2.09	2.06	1.98
10	K1	1.94	2.04	2.07	2.05	2.10	1.95
	K2	1.96	1.99	2.00	2.10	2.07	2.06
12	K1	1.85	1.98	2.02	1.98	2.01	1.90
	K2	1.95	1.94	1.98	2.01	1.98	2.00
14	K1	1.75	1.88	1.88	1.88	1.87	1.85
	K2	1.88	1.84	1.87	1.84	1.89	1.90

Table 3. Values for dry densities in optimal water content for various k1 compounds related to Modified Optimum Proctor

Charactreistics for optimum Proctor	Sand (S) and karal K1 compound					
	0S+1K	0.05S+0.95K	0.1S+0.9K	0.2S+0.8K	0.3S+0.7K	0.4S+0.6K
W_{opt} (%)	8.40	10.00	10.00	8.20	9.00	7.96
γ_{opt}	1.97	2.04	2.07	2.10	2.115	1.98

Table 4. Values for dry densities in optimal water content for various k2 compounds related to Modified Optimum Proctor

Characteristics for l'optimum Proctor	Sand (S) and karal K2 compound					
	0S+1K	0.05S+0.95K	0.1S+0.9K	0.2S+0.8K	0.3S+0.7K	0.4S+0.6K
W_{opt} (%)	10.60	10.60	9.98	9.95	9.20	10.00
γ_{opt}	1.96	1.99	2.01	2.105	2.075	2.06

Dry densities

Dry density values presented herein were obtained on the basis of Modified Proctor Tests performed on swelling clay samples mixed with sand. Swelling clay no. 1 is referred to as « K1 », while swelling clay no.2 is « K2 » and sand is represented by « S ».

- Maximal dry density curves at Modified Optimum Proctor according to the percentage of added sand are shaped as an inverted bell.
- For k1 clay from Maroua, the maximal dry density at Modified Optimum Proctor is obtained when 30% of sand is mixed with 70% of clay. The resulting density value is thus 2.115 with an optimal water content of 9%.

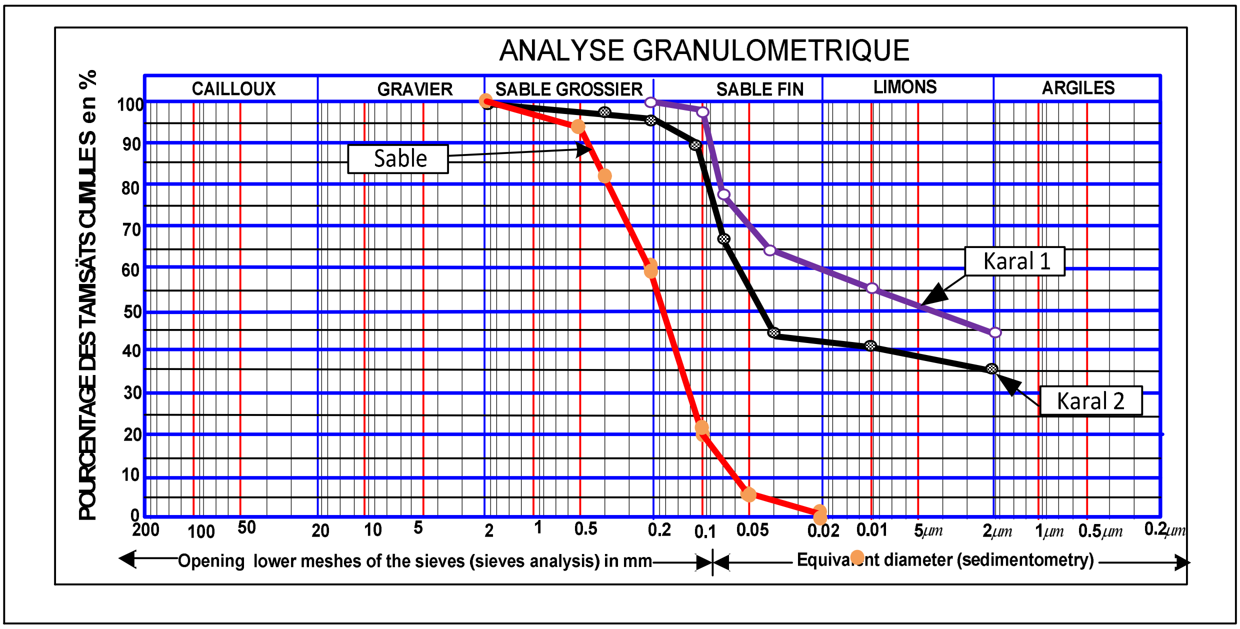

Figure 2. Résults of granulometric tests analyses of samples of Sanaga sand (sand) and swelling clay from Maroua (Karal 1 or K1) and Fotokol (Karal 2 or K2)

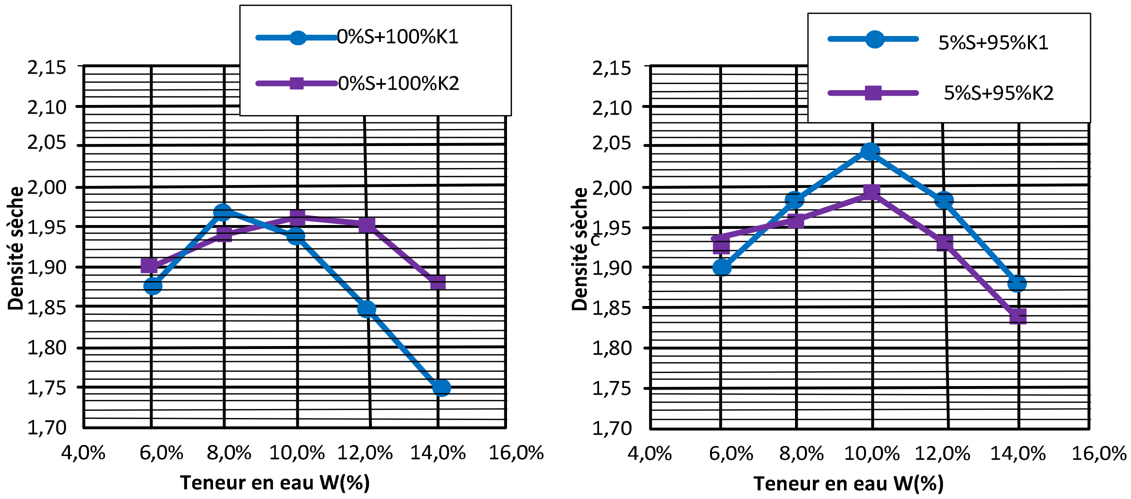

Figure 3. Densities according to water content for 0%S+100% (K1 or K2), 5%S+95% (K1 or K2)compounds

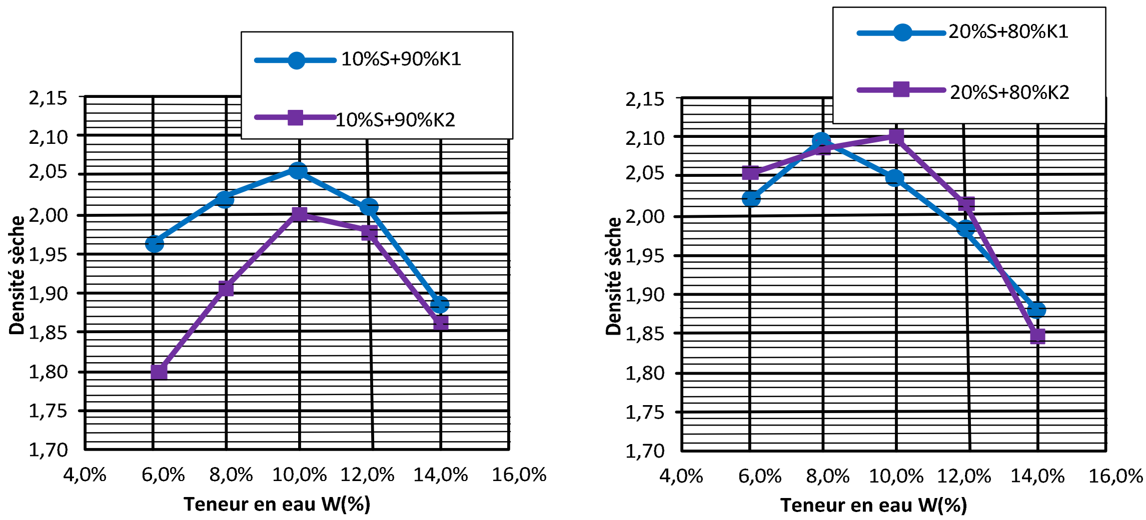

Figure 4. Densities according to water content for 10%S+90% (K1ou K2), 20%S+80% (K1ou K2) compounds

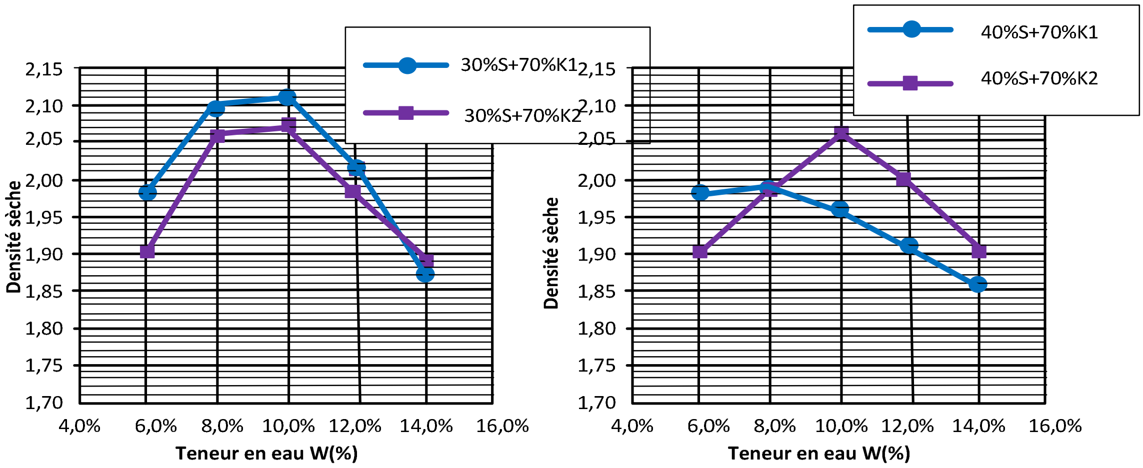

Figure 5. Densities according to water content for 30%S+70% (K1 or K2), 0%S+60% (K1 or K2) compounds

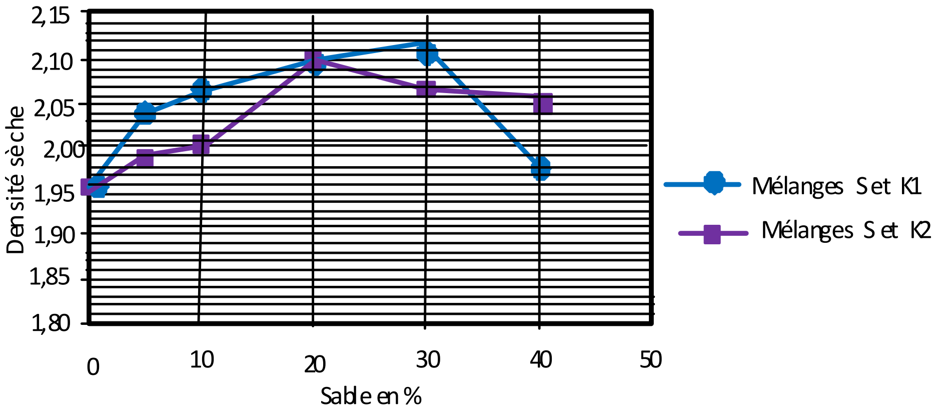

Figure 6. Dry density for Modified Optimum Proctor for compounds according to percentage of sand added

- For K2 clay from Fotokol, maximal density at Modified Optimum Proctor is obtained when 20% of sand is mixed with 80% of clay. The resulting density value is thus 2.105, with an optimal water content of 9.95%.
- The optimal percentage of sand added is 30% (and 20%) for clay from Maroua (and Fotokol).

Conclusions

Optimal dry densities at Modified Proctor test level of tested swelling clay increase as sand is added. Evolution curves of dry densities at Optimum Modified Proctor according to the percentage of clay added are shaped as an inverted bell. For optimal percentage of sand added which is 20% for swelling clay from Fotokol and 30% for clay coming from Maroua, resulting maximum dry densities are 2.105 and 2.115, which corresponds to density gains of about 7.4% as compared to density values given by samples with 0% of sand.

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