Characterization of eastern Senegal aggregates and gravel lateritic and comparison with western ones in purpose of use on pavements

Adama DIONE

Laboratoire de Mécanique et Modélisation - UFR Sciences de l'Ingénieur
University of Thiès, Thiès, Senegal

Déthié SARR

Laboratoire de Mécanique et Modélisation - UFR Sciences de l'Ingénieur
University of Thiès, Thiès, Senegal

Oustasse Abdoulaye SALL

Laboratoire de Mécanique et Modélisation - UFR Sciences de l'Ingénieur
University of Thiès, Thiès, Senegal

Abstract- The purpose of this article is to characterize eastern Senegal's material to evaluate their potential use in road engineering. In fact, laboratory tests were carried out on laterites, basalts and metamorphic limestones collected from different locations in eastern Senegal and the results compared to data from similar materials in western Senegal. The results show that Nieméniké basalts and Ibel marbles are well usefull on founding layer, while Bakel quartzites are suitable for founding layer and for a base layer. So these materials could substitute the basalt and laterites of western Senegal with which their properties are comparable in order to overcome the exhaustion of the last ones and the constraints related to distance. This study is made not only on the basis of geotechnical but also on petrographic properties

Keywords – Laterites, basalt, limestone, petrography, mineral, eastern Senegal, base, foundation

I. Introduction

This Senegal is constituted in its largest area (more than ¾) of the Senegalo-Mauritanian sedimentary basin located to the west side of the country and at the east by the Kedougou-Kéniéba inlier corresponding with volcanic and volcano-sedimentary rocks. These two sets are separated by a pan-African metamorphic band called chain of mauritanides. The latter is composed of the Koulountou series consisting of two branches, a western and an eastern separated by the Youkounkoun basin and limited to the east by the sedimentary formations of the Faleme series [1]. This offers Senegal a wide range of rock materials both exogenous and endogenous. However, we find in the magmatic domain, slightly under metamorphic alteration, sedimentary facies. The sedimentary area is also subject to two magmatic events tertiary and quaternary whose characteristics outcrops are encountered especially in western Senegal in Dakar coast and Diack in the Municipality of Ngoundiane [2]. These basin magmatic materials are widely used in road construction because of their good characteristics. Studies are also conducted on other materials in the basin that often show divergent properties with respect to different evaluation parameters. Among these materials, we can mention flints [3], limestones ([4]; [5]) and laterites ([6]; [7] ; [8] ; [9]). Being mainly of magmatic or metamorphic origin or possibly endogenous derivatives, the materials targeted in Eastern Senegal would be of good quality, but they have not yet been characterized for possible uses in civil engineering and more particularly in the roadway layer. With the extension and rehabilitation of national roads and the establishment of rural roads, traditional quarries are becoming more and more distant from the work sites and therefore it is appropriate to find materials capable of fulfilling the requirements of these constructions. The methodology will be then to characterize the Mako basalts, the Nieménéké and Dindifello laterites as well as the carbonates. This is in addition to the results of [5]) on Bakel quartzites. The results from these studies will be compared with the properties of carreer materials in western Senegal, which are extensively studied in the bibliography.

II. METHODOLOGY

Laboratory identification tests will be carried out on laterites, basalts and metamorphic limestones collected from various localities in eastern Senegal. A laterite specimen comes from Dindifello and the other from Niéménéké where they come respectively from the alteration of the Ségou-Madina kouta sandstone and the basic and granitoid facies of the Mako Supergroup. Basalt is a metabasalt derived from the Mako Supergroup and is rich in phyllitic minerals such as epidote and chlorite. The metamorphic limestone corresponds with the Ibel marble whose formation is linked to the intrusion of dolerites. The massive materials were first crushed before making physical and mechanical identification tests in accordance with the standards at France in effect. The particle size analysis will be carried out in accordance with standard NF P 94-056 (1996).

The Proctor test is carried out in accordance with standard NF P 94-093 (1993) and the Californian Bearing Ratio (CBR) test with standard NF P94-078 (1997). The test results of materials of eastern Senegal will be compared with the technical specifications on the one hand and on the other hand with properties of materials from western Senegal which are reference one for pavement uses. This will permit to adjudicate the possibility of using materials from eastern Senegal for substitution of west ones. The work is conducted in crushing materials and laterites.

III. RESULT AND DISCUSS

For aggregates

Particle size analysis of Bakel quartzites, Niéménéké basalt, Ibel marble and the laterites of Niéménéké and Dindefello are conducted (Figure 1 and 2).

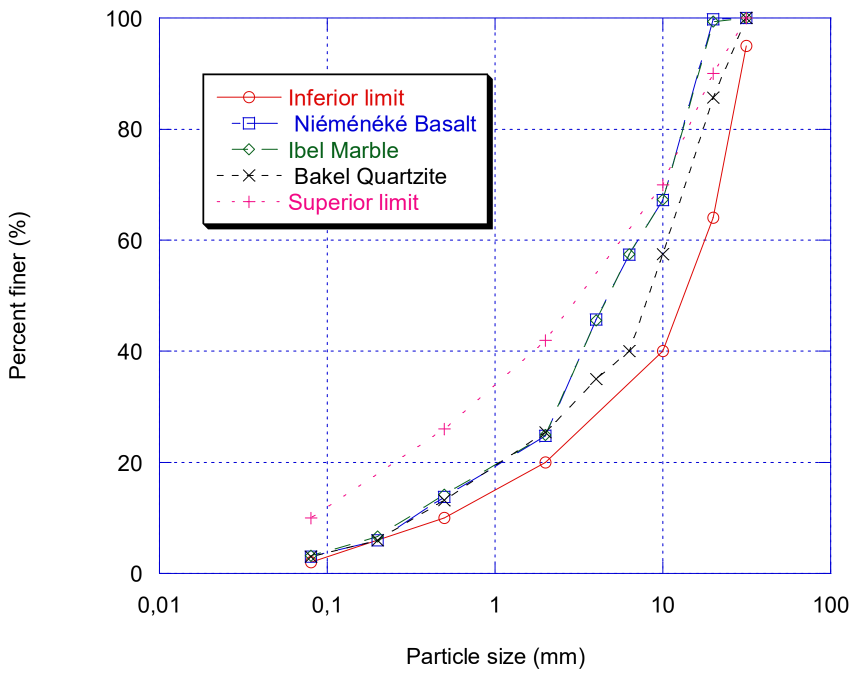

Figure 1. Grain size distribution of eastern Senegal aggregate

The results show that grain size distribution are all spread out and therefore the materials have the advantage of having high densities and mechanical characteristics. These granulometries are preferably used as a bedding layer for road structures.

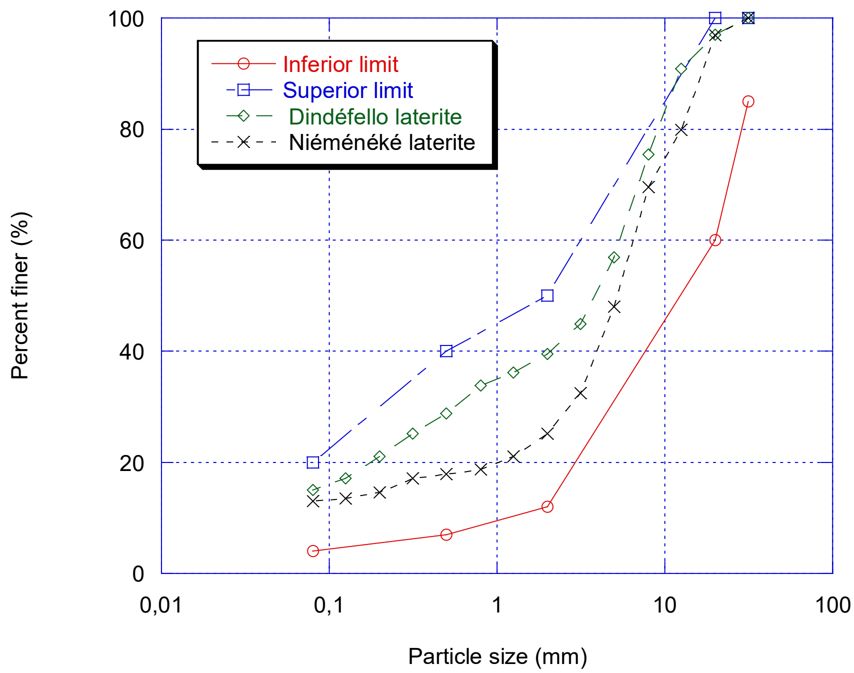

Figure 2. Grain size distribution of gravel lateritic of the Niéménéké and Dindefello

Gravel lateritic have a particle size similar to aggregates with higher fine contents. They are not very plastic with the plasticity index (IP) of 15.5 for the gravel lateritic of Dindefello and 16.8 for that of Niéménéké. These IP gravel lateritic are B6 class testifying then the presence of gravelly soil with fines. Compaction parameters are summarized below (Figure 3 and Table 1).

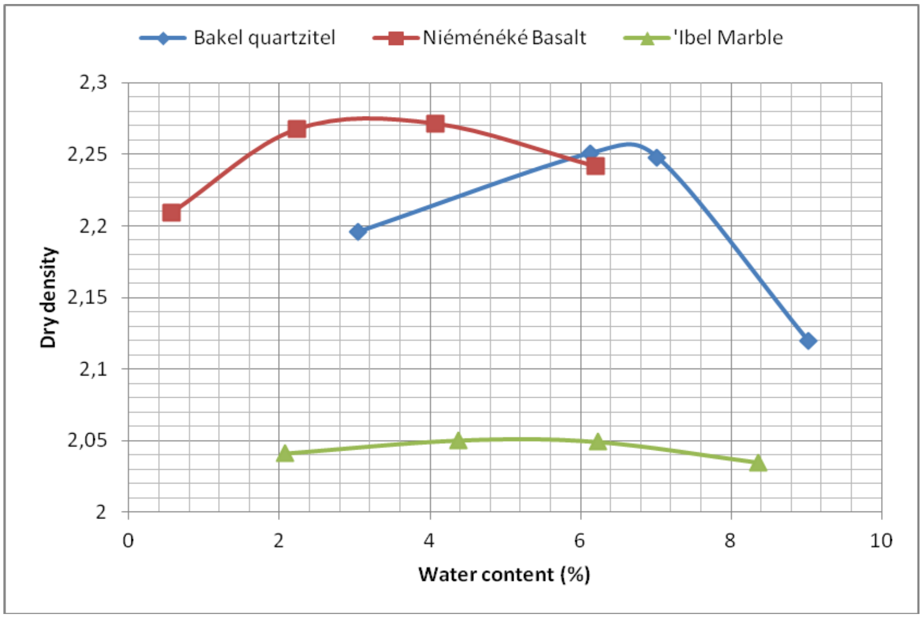

Figure 3. Proctor analysis of aggregates

Table 1: Material characteristics of compaction

Materials	Geometric and mechanical charactristics					
	W_{opt} (%)	$\gamma_{d\ max}$ (kN/m^3)	CBR	LA	MDE	A
Niéménéké Basalt	3,2	22,75	77	10	6,03	10,4
Ibel Marble	5,2	20,55	53	25	20,3	24
Quatzite de Bakel	6,45	22,51	178	15,72	5,9	12, 35
Bargny Limestones	8,9	20,60	32	-	-	-
Bandia Limestones	6,9	20,83	138	-	-	-
Diack Basalt	4,4	22,05	86	12,54	16	-

According to the results, Bakel quartzites are more sensitive to water than basalt and marble. A relative sensitivity to water that would be related to the greater porosity of quartzites and their clay content even if it is low. For Mako basalts and marble which are endogenous rocks, the lower sensitivity and porosities are related to their crystalline structure and their genesis. We can also note that the greater sensitivity to water of marble compared to basalt because it can be more easily attacked by acidic water. The results show that basalt has a higher dry density than quartzite and marble. Quartzite has a higher Bearing than basalt and marble. These are linked to their very rich quartz composition, a very hard and very resistant mineral, unlike Mako basalt which, even though it is tholeiitic, is weakly metamorphic and enriched with epidote and chlorite. As for marble, its low Bearing will be correlate to its rich calcium mineralogy. Thus, the Niéméniké basalt and the Ibel marble are satisfactory for a foundation layer whereas the Bakel quartzites can be used for pavement foundation and as a base layer. In comparison with the results of [5], we find that the basalts of Niéménéké has a density slightly higher than those of Diack. This would be related to the tholeiitic nature of Mako basalts, the presence of phyllitic minerals, and more advanced meteoritic-metamorphic weathering and hence greater sensitivity to compaction. Tertiary basalts of Diack have higher CBR than those of Niéménéké. In fact, the basalts of Diack kept their original properties unlike those of Mako whose presence of phyllitous minerals made it more sensitive to loading. This explains the difference in bearing between Mako basalts (CBR = 77) and Diack basalts (CBR = 86). For carbonated rocks, CBRs vary by type and source. Thus, CBR of Ibel Marble (CBR = 53) is higher than that of Bargny limestones (CBR = 32) and lower than those of Bandia (CBR = 138). Even if the carbonates of Bargny and Ibel are of different origins, their CBRs are closer to that of the Bandia limestone. The first two are cleaner even though the marble is harder and without a weak water absorption compared to the Bargny limestone. On the other hand, the very high bearing of the Bandia limestone is linked to its high silica content (up to 35%). Bakel quartzites give higher CBR (CBR = 178) than all these materials. That is the consequence of the very rich silica composition of this quartzite, with a good maturity at the border of metamorphism. The thin minerals present in the rock will permit to ensure cohesion between the components of the rock.

For the quality of these aggregates, it is found that the resistance to fragmentation is consistent for quartzite sandstone, Ibel marble and Niéménéké's basalt class 0/20 because less than 30. The resistance to wear is also less than 25 for all the materials and the flattening coefficient at 20 except for Ibel marble, which may be due to a crushing failure or the probable fragmentation of this material according to preferential plans. These results show that Ibel marble is less efficient than quartzite sandstones and Niéméniké basalt.

For gravel lateritic

Studies are also conducted on lateritic gravel and mechanical parameters are defined (Figure 4 and Table 2).

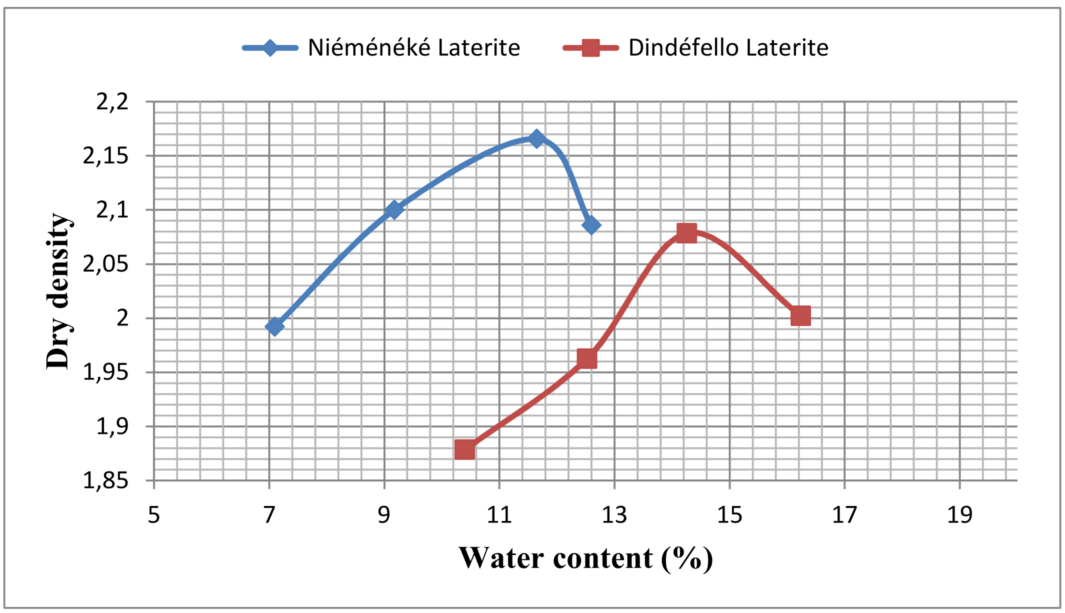

Figure 4: Proctor analysis of gravel lateritic

The properties of studied gravel lateritic of eastern Senegal (Dindefello and Niéméniké) are compared with those of western Senegal from ([7], [9], [10]) as shown in Table 2 below.

Table 2 characteristics of gravel lateritic compaction

Materials	Compaction charactristics		
	W_{opt} (%)	$\gamma_{d\ max}$ (kN/m^3)	CBR
Dindefello Laterite	11,7	21,70	53,1

Niéménéké Laterite	14,3	20,78	74
Sindia Laterite	10,5	19,5	42/71/64
Ngoundiane Laterite	11	19,22	29/40
Mont-Rolland Laterite	12,25	19,6	63/19,42
Keur Samba Kane Laterite	7,0	22,2	72

These results show globally that Niéméniké's laterite has the best bearing (CBR = 74). This gravel lateritic is deposed on granitic rocks and on tholeitic basic rocks giving them a balanced granular composition. So, thin assure the cohesion of the gravel by acting as a binder material between the coarse ones. However, there is a variation and a fall of bearing of the gravel lateritic of Sindia (CBR = 71 / 64 / 42) because it is deposed in the case of Sindia on sandstones rocks and limestones explaining similar CBR for certain location of the Niéméniké one and for others rather clayey explain low CBR. The variation and then the lower values of the bearing capacity of the Mont Roland gravel lateritic (CBR = 63 / 19,42) compared to those of Niéméniké would be related to the nature of their basement composed of sand and limestone. The low values for Ngoundiane (CBR = 40 / 29) included in the previous ones would be a consequence of their under saturated basaltic origin of which a fairly extensive alteration present very high rates of fines. . This could be related to two aspects: First of all to the targeting of the exploitation areas, the best of which are first operated. Indeed, on all their extents, the pedological layer of laterite often does not have the same properties. The laterization process and the leaching of the materials during weathering also reduce the quality of the gravel lateritic. Moreover, these results show that Keur Samba kane laterite has low water content and a high density. A comparative study with the specifications reveals that these materials can only be used as a foundation layer and not as a base layer because all of them have CBRs less than 80 unless they are improved.

IV.CONCLUSION

At the end of this work, we can notice that the materials of Eastern Senegal have mechanical properties comparable to the properties of the materials of Western Senegal with which they are found in same classes. However a slight variation is noted and correlated here to the petrographic composition of the material and / or its fine particle content. Thus, these materials, whether basalts, carbonate rocks or laterites, can substitute the materials of western Senegal on the pavement.

In the future, it would be a good idea to make a mineralogical study on laterite clays in order to draw more significant conclusions.

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