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Performance of crushed silexite 0 / 31.5 in a seat layer

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ABSTRACT: In Senegal, as in most Sahelian countries, the majority of pavement beds are of lateritic or basaltic gravelly material. These types of materials become scarce, become more expensive and lose their mechanical performance year after year. The possibility of using the silexite material, from the residues of the phosphates exploitation of the Chemical Industry of Senegal which are available in quantity remains a favorable asset if it respects the technical specifications for a road material all the more as Senegal is currently planning major road infrastructure projects. Thus, in this study, it was proposed to carry out extensive research on the geotechnical performance of this silexite material in the form of a severe 0 / 31.5 crushed material in order to deduce its suitability for use as a base course.

First the material coming from the heap is tested first according to an experimental study of complete identification of the material. It turns out that the results were not satisfactory considering the value of the IP 41.5 plasticity index. very high, a very low CBR index of 16.67, a high methylene blue value of 2.6 and a granulometric curve coming out of the acceptance zone. The results did not meet the technical requirements and specifications expected because they are very contaminated by other foreign bodies.

Nevertheless, a study to improve the cement material is discussed at 1%, 2%, 2.5% and 3%. The CBR indices found are respectively 127.60, 287.92, 298.77 and 373.46 with plasticity indices that vary between 27.65 and 34.35%. The characteristics of the material have improved significantly in terms of CBR and a decrease in the IP is noted that passes from 41.5 to 27.65 while being out of tolerance.

The study is continued using granular fractions from industrial crushing to reconstitute crushed gravel 0 / 31.5.

The results were conclusive as the particle size curve fits perfectly into the acceptance zone. An IP value of 19.99% is obtained certifying a good possibility to use the material in foundation layer but not in base layer. A CBR index of 149.27 and a density of 2.01 meeting the specifications required for its use in bedding.

KEYWORDS: spindle, silexite, severe crushed, material reconstituted, enhancement, IP, CBR.

1 INTRODUCTION

The road remains a true instrument of development and integration. It is a significant investment. Senegal in its Plan Senegal Emergent (PSE) programme has reserved important resources for the development of infrastructures including the ILA TOUBA motorway projects, the Regional Express Train, the promoville ect. These projects require high demand and consumption of road materials. The known material, commonly used in Senegal in basement and rolling is basalt and laterite. However, reserves are depleting and performance is decreasing. This situation pushes the researchers that we are to orient ourselves to another local material such as silexite from the mining residues of the Chemical Industry of Senegal located in Thiès 70 km from Dakar Senegal.

Silexites are hypersilicant sedimentary rocks in the form of kidneys or grouped in more or less horizontal passes in the phosphate levels. They are residues of phosphate mining, located in Taiba in the region of Thies [1]. A sample of an all-out flint from silexite shows that the rock consists of 91% flint, 6% phosphated indurate, and 3% phosphated and clay fines [2]. These flints are developed in the quarry to produce aggregates of several classes. A serious is a natural mixture or not of pebbles, gravel or sand, with sometimes addition of finer particles. If the proportion of these fine particles in the grave is insufficient to give plasticity to its mortar, the serious is said to be lean. Otherwise, it is called silty or clay, depending on its active fines content [3]. In Senegal, a study on tailings or sterile silexites grouped in slag heaps in the region of Thiès, in Mboro is previously absent and their use as a base layer has not yet been prospected. . Thus we have considered through this article to make a study on these sterile silexites in order to measure the geotechnical performance of the material for its possible use as a base layer.

2 MATERIAL AND METHOD

SILEXITE MATERIAL PRODUCTION PROCESS

The slaughtered ore is delivered by 100-tonne trucks or dumpers in the form of a granulometry of 0/2000mm at the level of the sieve called scalper or epimetre, which subjects it to water jets at 20 bars to separate blocks from mineral particles. Blocks with a diameter greater than 200 mm are evacuated to the alveoli from which they are taken up by the dumpers to be arranged into small dispersed clusters. The remainder of the elements (0/200 mm) progresses through the clearing process to sieve No. 3, from which, after being subjected to 100 bar jets of water, it is divided into a mineral pulp (d 25 mm) for the laundromat station and into a residue transported by a sterile conveyor to a heap [4].

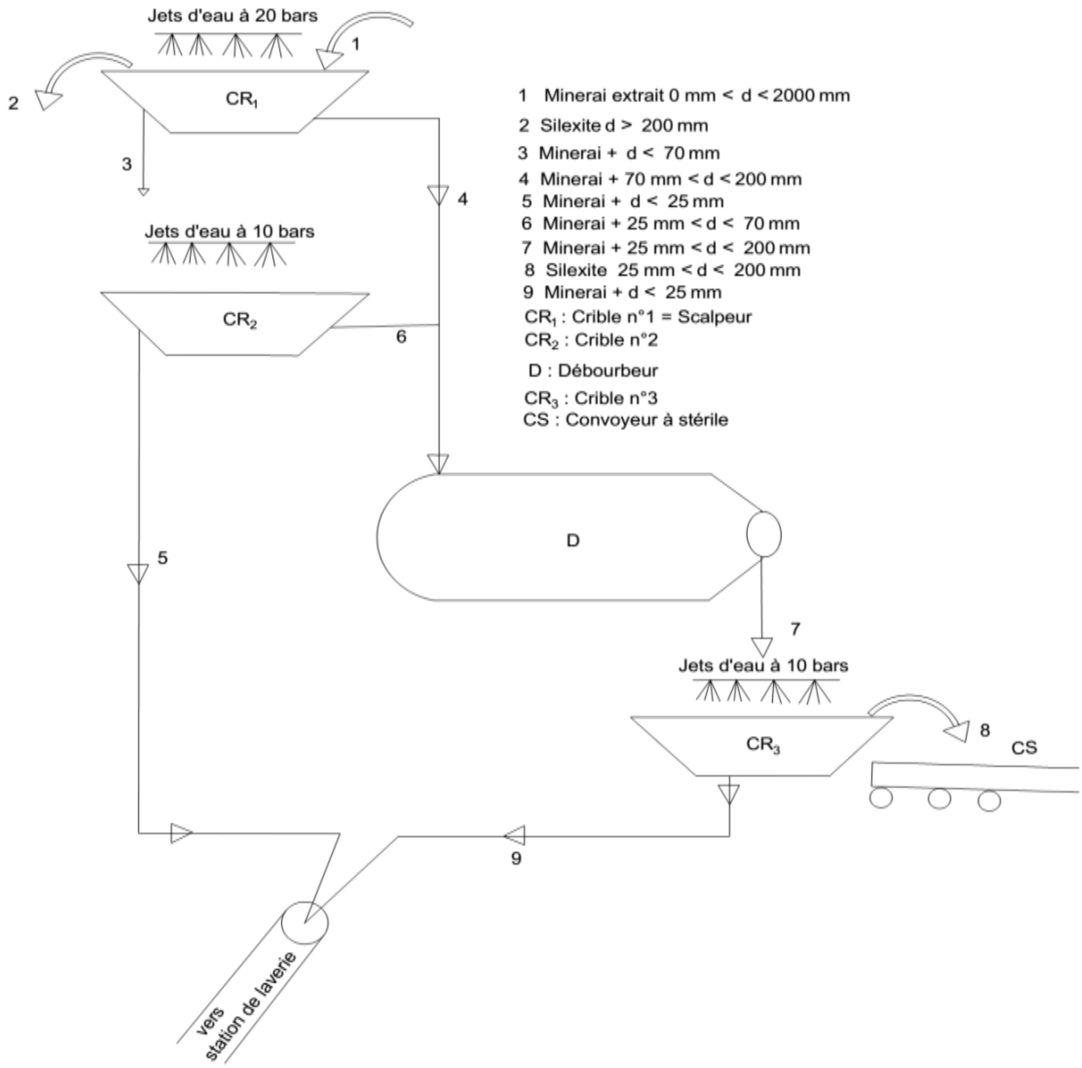

Fig. 1. Diagram of the clearing operation

A future use of a material in road construction necessarily requires a mastery of its physical and mechanical performance, which are known through geotechnical testing. Thus, all the tests carried out on the material were carried out at the Geotechnical Laboratory of the Experimental Centre for Research and Studies for Equipment (CEREEQ). A specimen of silexite waste rock was collected from the Taiba quarry specifically from the Keur Mor Fall heap for laboratory testing to characterize the geotechnical parameters of the material: • a complete identification will be made on the raw material, • on material after cement improvement; • and finally on the material after reconstitution of the granular class.

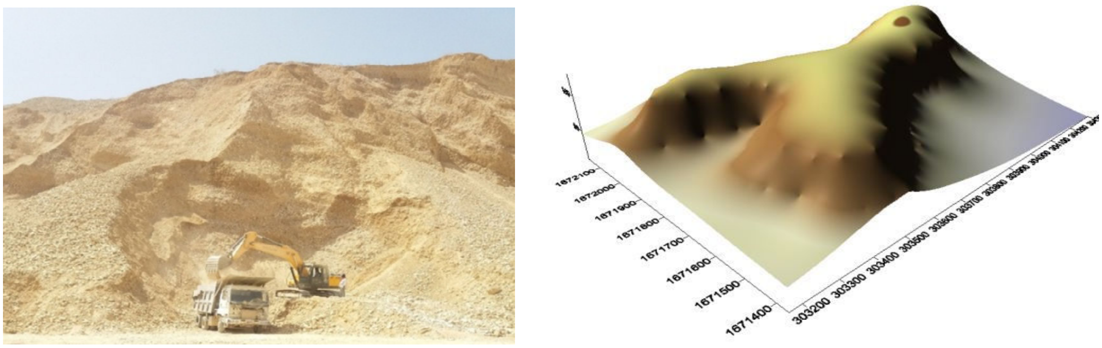

Fig. 2. Sample location at Keur Mor Fall.

3 RESULTS AND DISCUSSIONS

3.1 PARTICLE SIZE ANALYSIS

This analysis is conducted in accordance with NF EN 933-1 and NF EN 933-2[5].

- After washing, the particle size curve of the 0/31.5 granularity silexite waste rock in the raw state is shown in Figure 3 below. It is found that the granular distribution of the material has a high percentage of fines of 20,04 %, therefore it does not enter the acceptance zone.

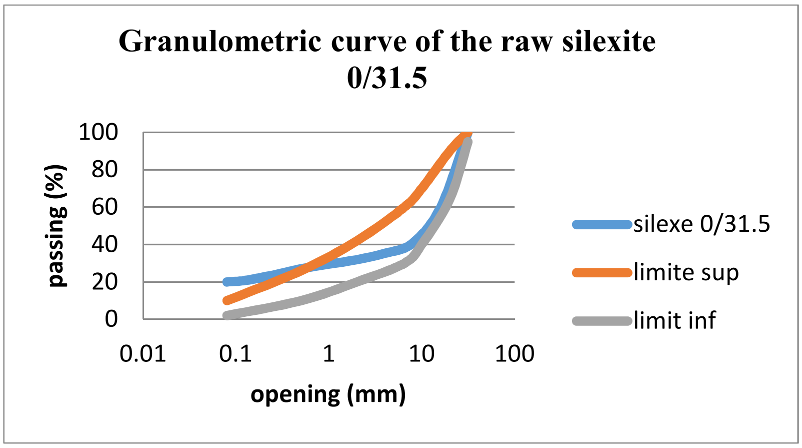

Fig. 3. Particle size of the crushed bass 0/31.5

- After CBR test

  The particle size test on the 0/31.5 silexite material after compacting gives a percentage of fines of 25,7%. It is higher than that found in the raw state (20.04%). The curve does not fit into the specification spindle.

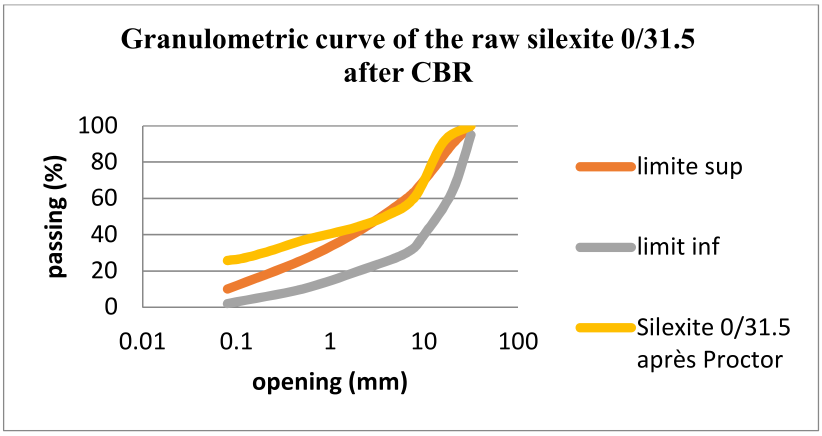

Fig. 4. Particle size of the crushed bass 0/31.5 after CBR.

3.2 Limit of Atterberg

This test, conducted in accordance with NF P 94 051 [6], determined the liquidity limit to the cup and the plasticity limit to the roll of the material and applies to soils whose elements pass through the 400µm mesh opening sieve.

Table 1. Atterberg Limit Test Values

Liquidity					plasticity	
number of strokes	15	19	23	27		
Moisture content	80,3	79,8	79,2	78,7	36,3	38,5

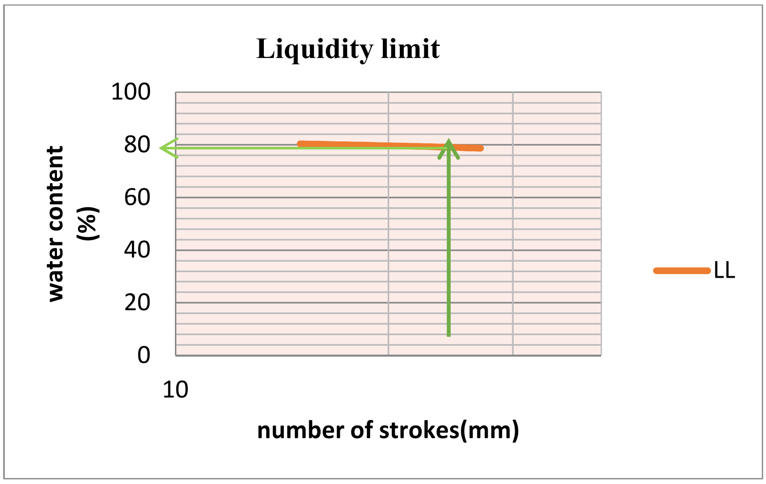

Fig. 5. Limit diagram of liquidity

The values obtained are as follows:

Liquidity limit WL=79

Plasticity limit WP= 37,4

IP Plasticity Index = WL - WP = 41.6

According to the CEBTP Specification, the IP must be less than 25 and 15 for the use of a material in foundation layer and base layer respectively.

The found IP is then high and requires a reduction to enter the acceptability threshold.

3.3 Methylene Blue Test

The methylene blue test according to NF EN 933-9 + A1 [7] was carried out on the soil fraction passing through the sieve 5 mm. The blue value, VBS, expressed in g of methylene blue per 60 g of dry material, is the amount of this dye needed to cover the internal and external surface of all clay particles. A value of 2.6 g is obtained.

Table 2. Values obtained from the methylene blue test

Dry mass (g)	Poured volume (ml)	VBS (0/5)
60	49	2,6

3.4 Modified Proctor Test

The purpose of the Proctor test according to NF EN 13286-2 [8] is to determine, for a given intensity compaction, the water content to which a soil must be compacted to obtain the maximum dry density.

Table 3. Proctor Test Values

Water content %	9,10	11,20	13,40
Dry mass	1,885	1,923	1,836

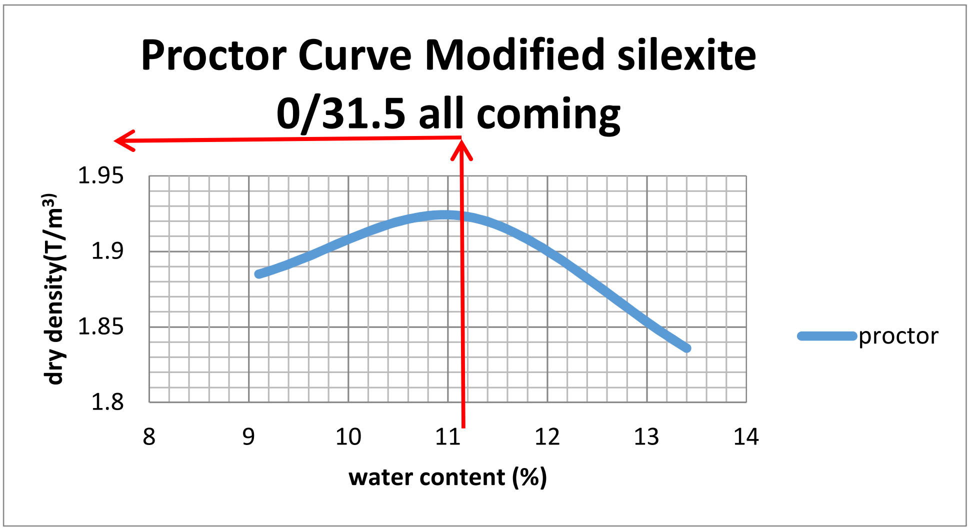

Fig. 6. Modified Proctor Curve Silexite 0 / 31.5 Raw

The Proctor curve was used to determine the optimum water content and the maximum dry density.

- wOPM (%) = 11
- Ds (T / m3) = 1.925.

It is found that the water content is a little high and the dry density low. These values may be due to the clay and phosphatic fraction that are very present in the material.

CBR test

The California CBR bearing index according to NF P 98 078 [9] is the ratio, expressed in percentage (%) of the pressure producing a given depression by means of a standardized cylindrical punch (of section 19.32 cm²) moving at a determined speed (1.27 mm / min) and the pressure necessary to drive the same punch under the same conditions, in a typical material. The test is carried out on sieve loops smaller than 20 mm in the CBR mold. The results obtained are recorded in this table 4 after the exploitation of Figure 7 below.

The CBR values obtained are therefore very low, so that the all-round material, in its present state, cannot be used as foundation layer even less as a base layer.

It is then envisaged an improvement in cement despite a much lower CBR value 60 to push the study and see if it will meet the technical specifications for its use in seat layers.

Table 4. CBR Values Based on Compactness

Compactness	**90%**	**95%**	**100%**
CBR	16,11	16,7	18,2

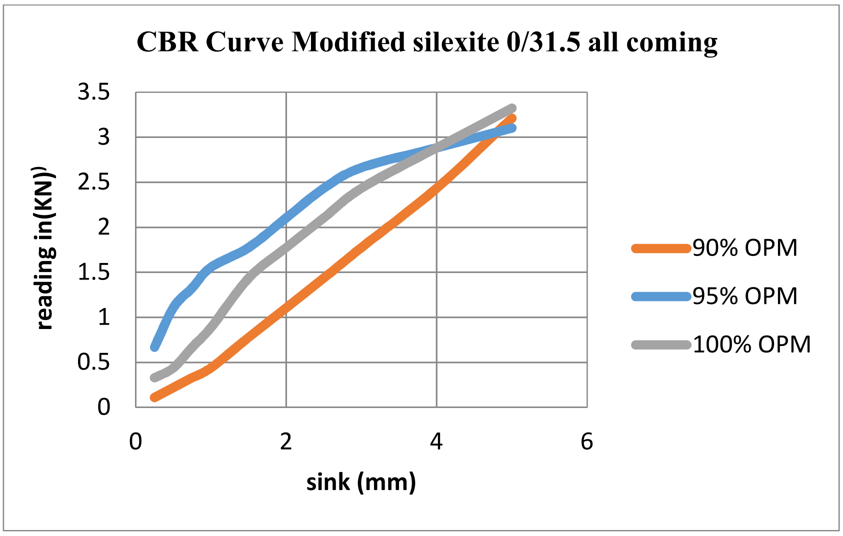

Fig. 7. Curve CBR silexite 0 / 31.5 raw

3.5 Characteristics of cementitious modified 0 / 31.5 silexite material

The material is improved with SOCOCIM CEM I 42.5 R cement at percentages of 1%, 2%, 2.5% and 3%.

3.5.1 Atterberg limit test

The results of the test obtained are shown in Table 5 below.

There is a decrease in the value of PI as a function of the increasing cement content which varies from 27.65 to 34.35.

The services that can be expected from the incorporation of a hydraulic binder are varied. In the first place, it neutralizes the fine plastics of a water-sensitive soil. The fines are agglomerated into much larger particles, more or less impermeable surface. Their specific surface being reduced, they are less sensitive to swelling by imbibition and consequently to the action of the gel. The plasticity index of a treated soil is very significantly lowered. The role of the cement is essentially to correct the granularity by the contribution of fine elements and to improve the insufficient cohesion of this material [10].

However, the values obtained remain always above the threshold values 15 and 25 sought for use of a material respectively base layer and foundation.

Table 5. Index of plasticity according to the percentage of cement

% Cement	1	2	2.5	3
W_L	75,8	82,2	84	68,2
W_P	41,45	48,15	50,4	40,55
Ip	34,35	33,85	33,6	27,65

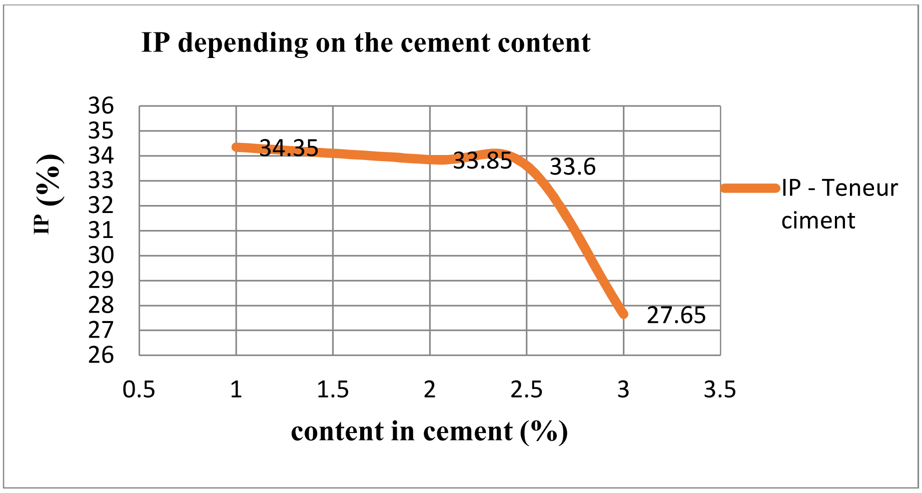

Fig. 8. IP by Cement Content

3.5.2 Modified Proctor Test

Dry density is shown to decrease with increasing cement content. On the other hand, the water content increases with the increase in the cement content. Cement in the material tends to absorb water, thus an increase in water content and therefore a decrease in dry density.

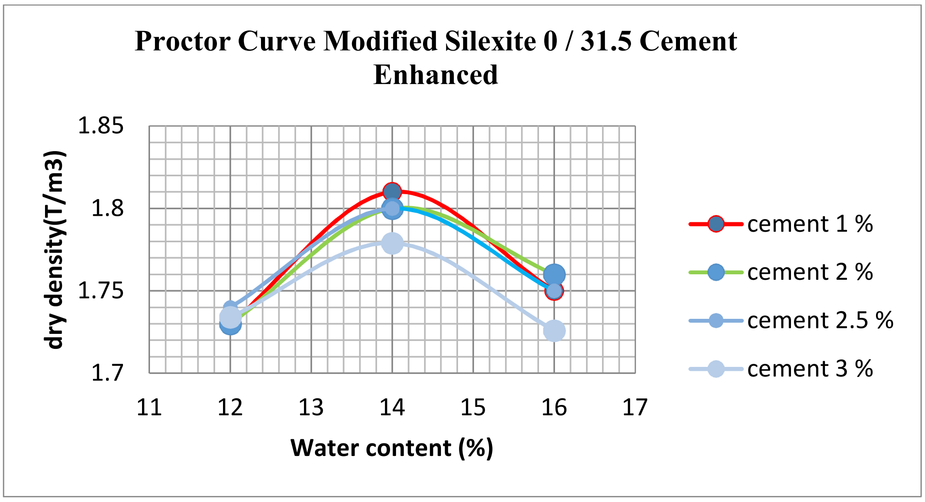

Fig. 9. Proctor curve modified with 0 / 31.5 silexite with cement improvement

3.5.3 CBR test

We realize that the value of CBR increases with the increase in the percentage of cement. As we have seen the CBR goes from 16.7 for the 0 / 31.5 silexite material all coming in at 127 with a 1% improvement in cement. The value of 287.92 found with a 2% improvement in cement greatly exceeds the threshold value of 160 generally required as a base layer for the improved material.

Thus, the curves showing the variation of the CBR as a function of the compactness with the different percentages of cement are plotted below.

Table 6. Variation of CBR as a function of compactness and cement.

	90 %	95%	100%
3% cement	287	373	410
2,5% cement	250	299	390
2% cement	237	288	323
1% cement	119,85	127,6	295,23

Fig. 10. Curve CBR silexite 0 / 31.5 at 1% cement

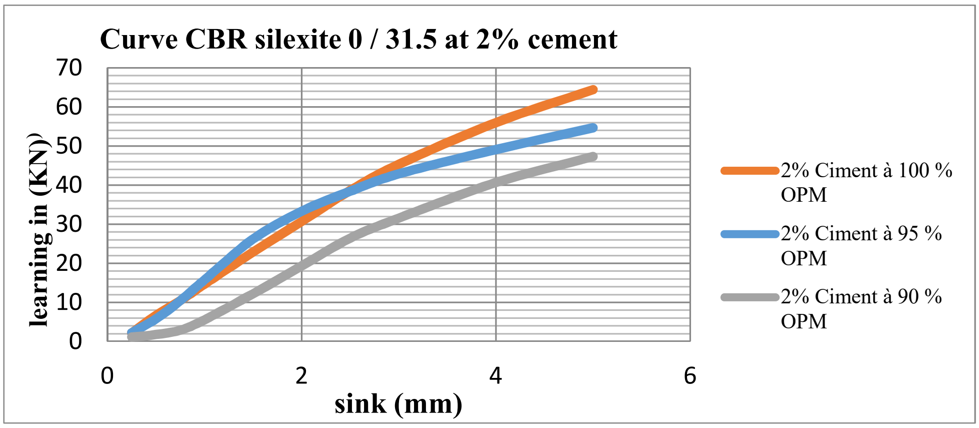

Fig. 11. Curve CBR silexite 0 / 31.5 at 2% cement

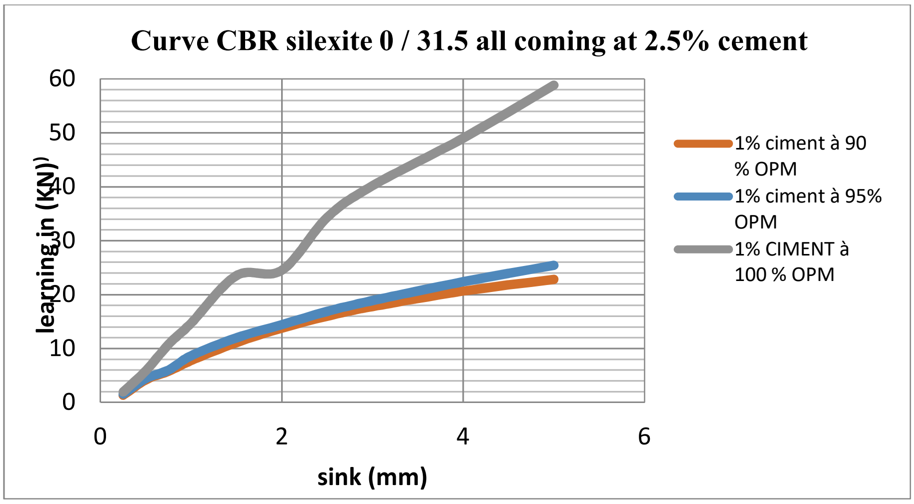

Fig. 12. Curve CBR silexite 0 / 31.5 all coming at 2.5% cement

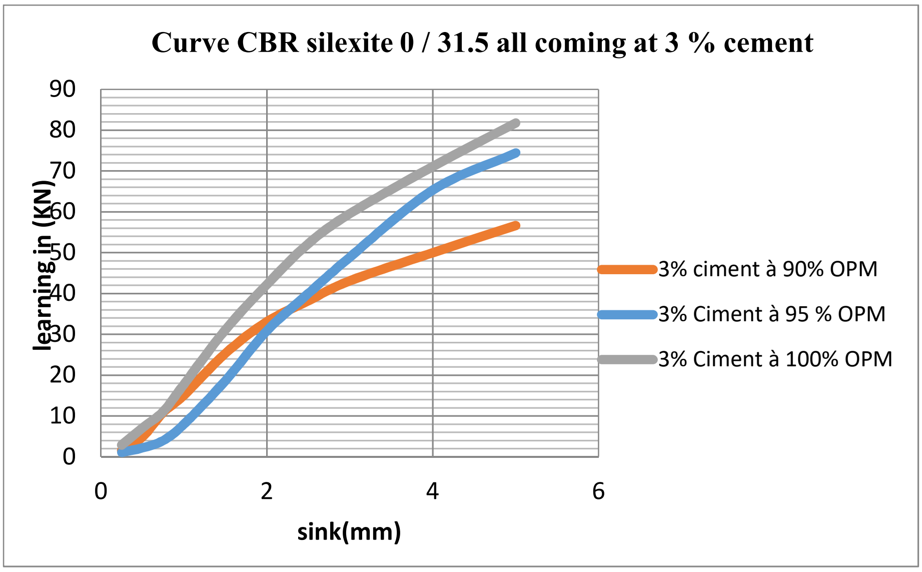

Fig. 13. Curve CBR silexite 0 / 31.5 all coming at 3 % cement

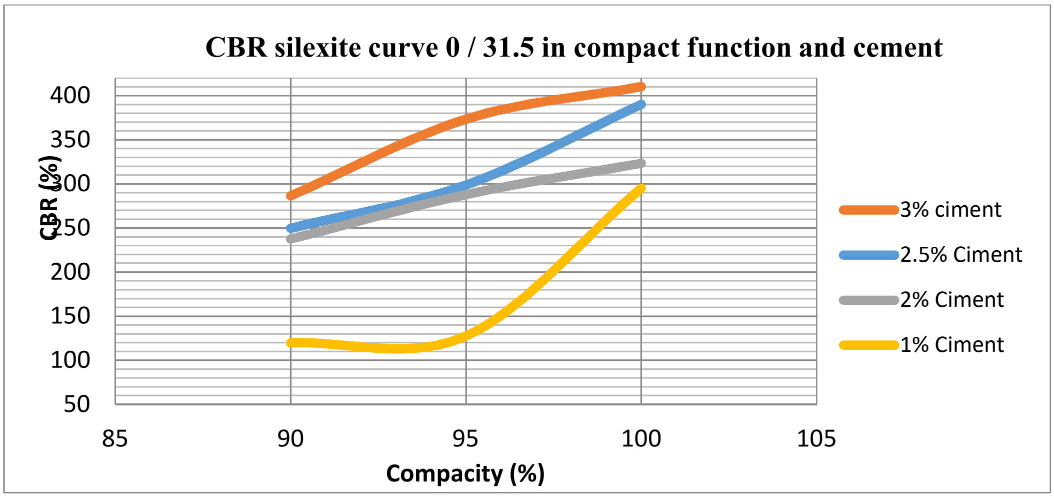

Fig. 14. CBR silexite curve 0 / 31.5 in compact function and cement

Table 7. Summary of results obtained

Materials	Particle size analysis (%)	Plasticity index (Ip)	Proctor modifie		ICBR a 95% OPM
	0,08mm		Wopm(%)	ρdopm(t/m^3)	
Silexite 0/31.5 all coming	20,04 (avant CBR) 25,7 (après CBR)	41,6	12,5	1,91	16,7
1 % Cement		34,35	16,25	1,80	127
2 % Cement		33,85	17,61	1,80	287,92
2,5 % Cement		33,6	16,64	1,81	298,77
3 % Cement		27,65	17,41	1,78	373,46
CEBTP specification (1984)	Foundation layer	**≤ 25**		**≥ 1,9**	**≥ 30**
	Base layer	**≤ 15**		**≥ 2**	**≥ 80**

3.6 Characterization of the material 0 / 31.5 silexite from a SOCAM crushing plant

The state all coming silexite 0 / 31.5 shows limits to satisfy the requirements. The study is deepened by using the granular grades from the SOCAM crushing industry Thus a complete identification was made to have the performance of the material resulting from industrial crushing.

Table 8. Granular Class Reconstitution 0 / 31.5

Granular class	Filler	0/3	3/8	8/16	16/25	25/31,5
Percentage used	10%	12%	14%	16%	18%	30%

The granulometric curve before washing the 0 / 31.5 mixture of the crushed silexite waste material obtained fits well into the spindle.

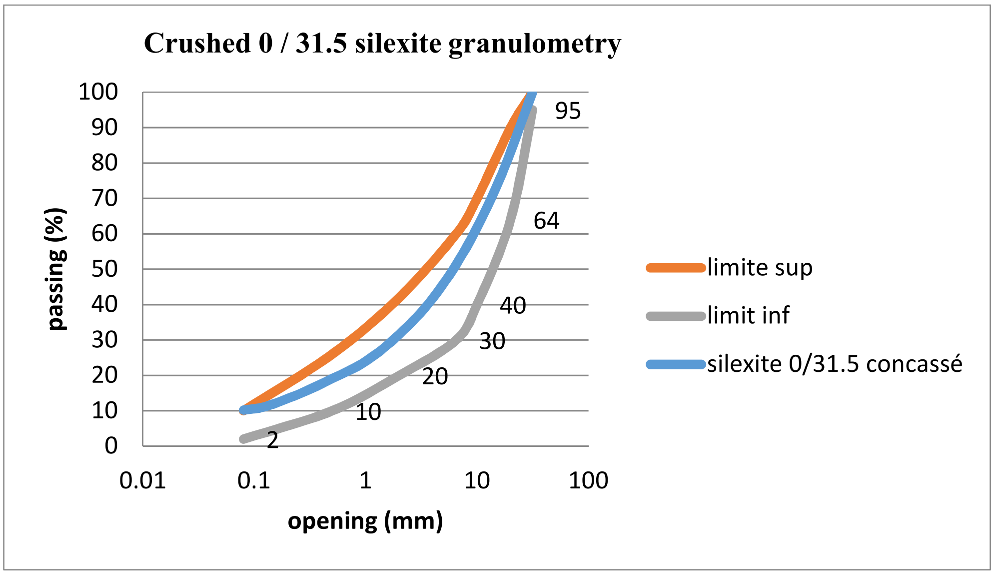

Fig. 15. Industrial crushed particle size 0 / 31.5 according to the spindle

3.6.1 Atterberg limit test

Table 9. Values obtained on the limits

Liquidity limit					Plasticity	
number of hits	15	19	23	27		
Water content	41,98	41,39	40,84	40,28	20,643	20,363

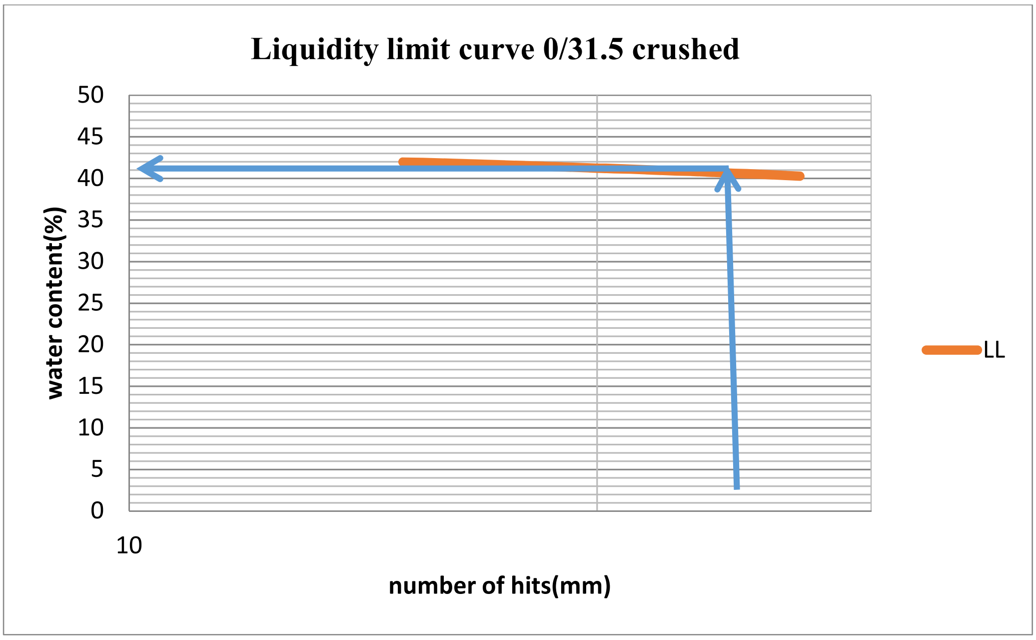

Fig. 16. Crushed granulometry 0/31.5 industrial as a function of the spindle

Wl = 40.5

Wp = 20.503

IP = 19.997

As IP 19.99%, this value exceeds the limit set out in the CEBTP (1984) specifications for a material that can be used in a base layer, but is less than an IP of 25 required in foundation layer in the CEBTP (1984) specifications. The material cannot be used in a base layer unless it is improved to lower the IP to less than 15.

Methylene Blue Test

The results of the reconstructed crushed silexite waste rock test are summarized above. The blue value obtained on this material is lower than that of the silexite waste rock shows that the crushed silexite sterile material is less plastic than the crushed silexite material.

Table 10. Values obtained from the blue test

Dry mass (g)	Poured volume (ml)	VBS (0/5)
60	35	1,83

Modified Proctor Test

Dry density = 2.01 and the water content is 10%. The dry density of the material being greater than 2 complies with the specifications required for its use as a base layer. So in terms of density the material is in accordance with the specification.

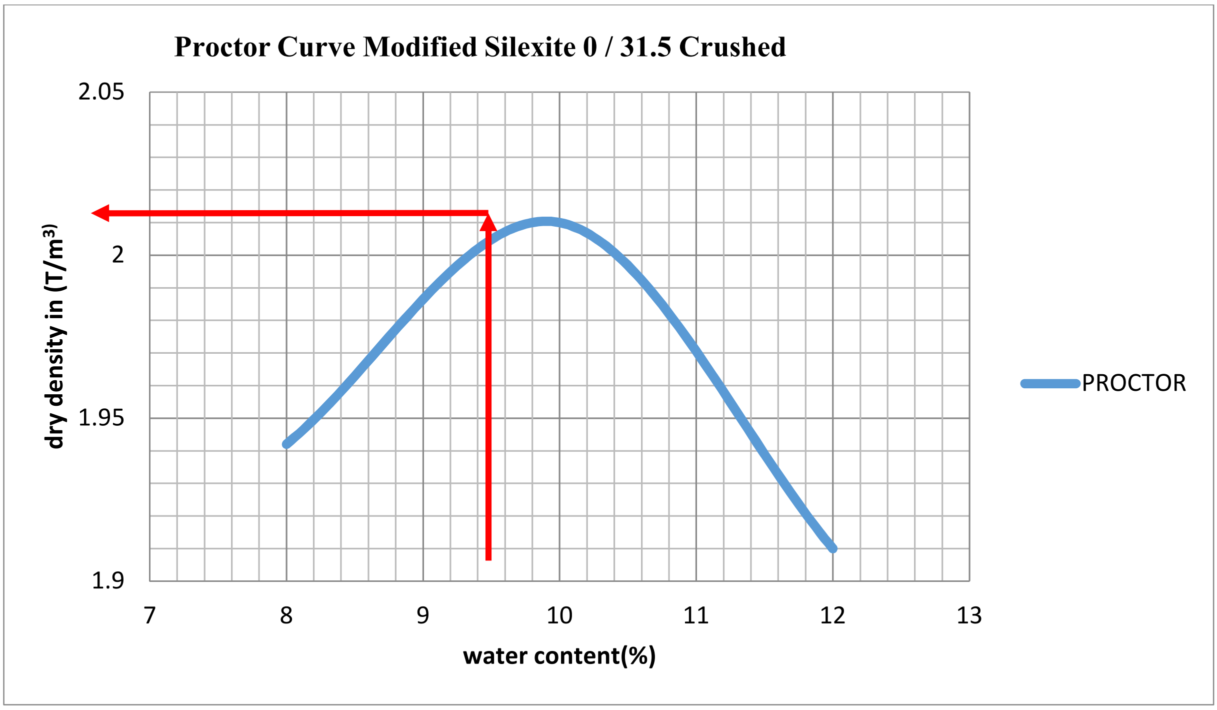

Fig. 17. Proctor Curve Modified Silexite 0 / 31.5 Crushed

3.6.2 CBR TEST

The test carried out on raw material, submerged for 4 days gives a CBR of 147,97 to 95 % of the modified Proctor optimum. This value is much higher than 30 and 80 requested in the CEBTP specifications in foundation layer and base layer respectively.

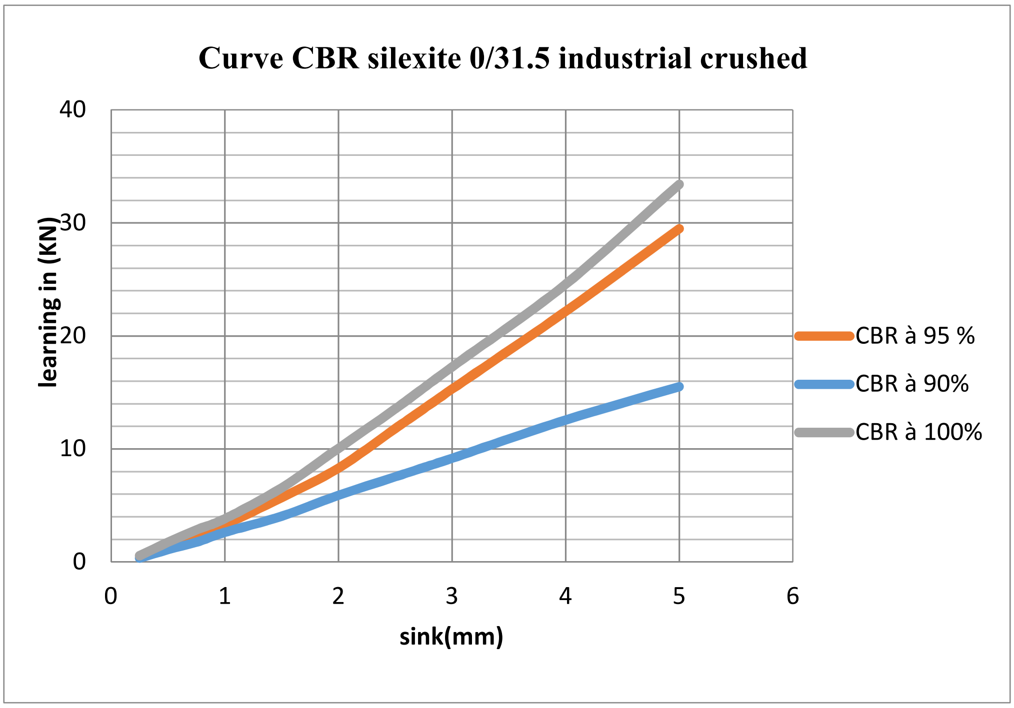

Fig. 18. Curved CBR curve 0 / 31.5 crushed industrial

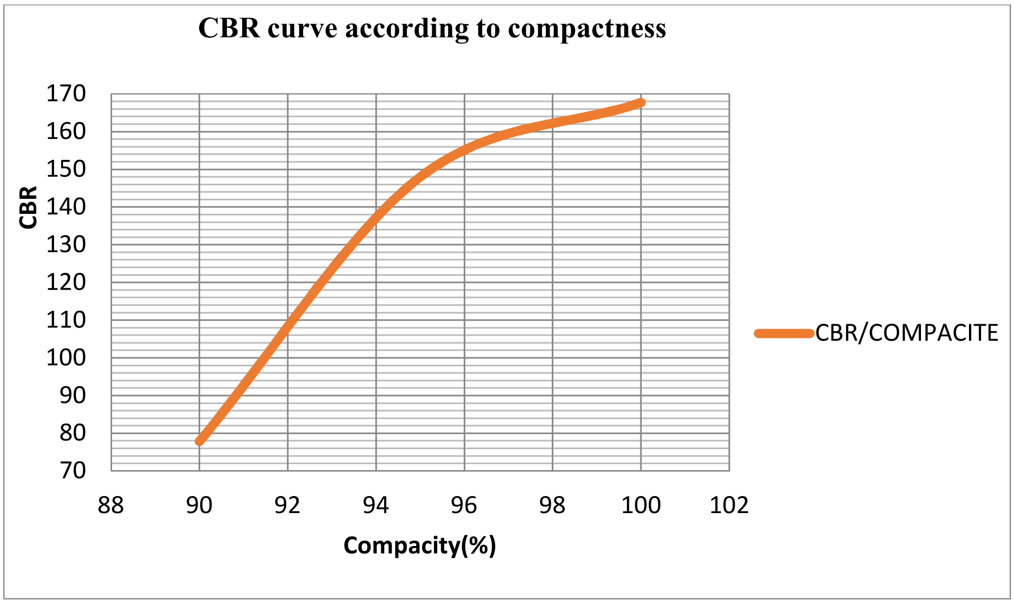

Fig. 19. CBR curve according to compactness

Table 11. Summary of results on the reconstituted material

Materials	Particle size analysis (%)	Plasticity index (Ip)	Proctor modifie		ICBR à 95% OPM
	0,08mm		Wopm(%)	Pdopm(t/m^3)	
Reconstituted materials	10,22 (before CBR)	19,99	11,29	2,01	147,97
	11,7(after CBR)				
CEBTP specification (1984)	Foundation layer	**≤ 25**		≥ 1,9	≥ 30
	Base layer	**≤ 15**		≥ 2	≥ 80

It is noted that the percentage of fines before and after compaction, the IP, the dry density and the CBR are well within the specifications of the CEBTP for the use of the material in foundation layer. Characteristics of the silexite material 0/31.5 except the IP remain consistent with the specifications for its use in base layer. Upgrading of the cement material is required in a base layer to drop the plasticity index to less than 15 to meet the specifications of the CEBTP (1984) [11].

4 Conclusion

In short, the objective of this work was to determine the geotechnical characteristics of Mboro's silexite waste rock in order to pronounce on its probable use in the base layers. It turns out that the material coming from the waste rock has unacceptable characteristics for use in basement layer. The improvement of all cement to increase its mechanical performance and lowered its plasticity index but not in the proportions required for a bedding layer. Once the material reconstituted its mechanical performance has improved significantly and meets the requirements requested in bedding layer except that the IP obtained 19.99 remains always greater than 15. A cement improvement could be considered to correct the IP.

References

[1] BA, Makhaly. (2008). Geotechnical identification of crushed-type materials in roadways and evaluation of their quality - pages 32 and 33.
[2] BA, Makhaly. (2008). Geotechnical identification of crushed-type materials in roadways and evaluation of their quality - pages 32 and 33.
[3] Road nomenclature page 14
[4] SIDIBE, Maïmouna. (1995). Study of the use of silexite-type aggregates in road geotechnics (especially in base layers and pavement coating). Thiès (Senegal): Polytechnic School of Thiès - 142 pages.
[5] NF EN 933-1 and NF EN 933-2 Size analysis by sieving.
[6] NF P 94 051 Determination of Atterberg limits - Limit of liquidity in the cup - Plasticity limit.
[7] NF EN 933-9 + A1 Tests for determining the geometrical characteristics of aggregates - Part 9: qualification of fines
[8] NF EN 13286-2 Determination of the relation between the water content and the density of a compacted material
[9] NF P 98 078 recognition and tests - CBR index after immersion
[10] Crusader, R. (1964). Soil treatment with hydraulic binders.
[11] CEBTP (1984). Practical guide sizing in tropical countries, French Ministry of Cooperation - 154 pages.