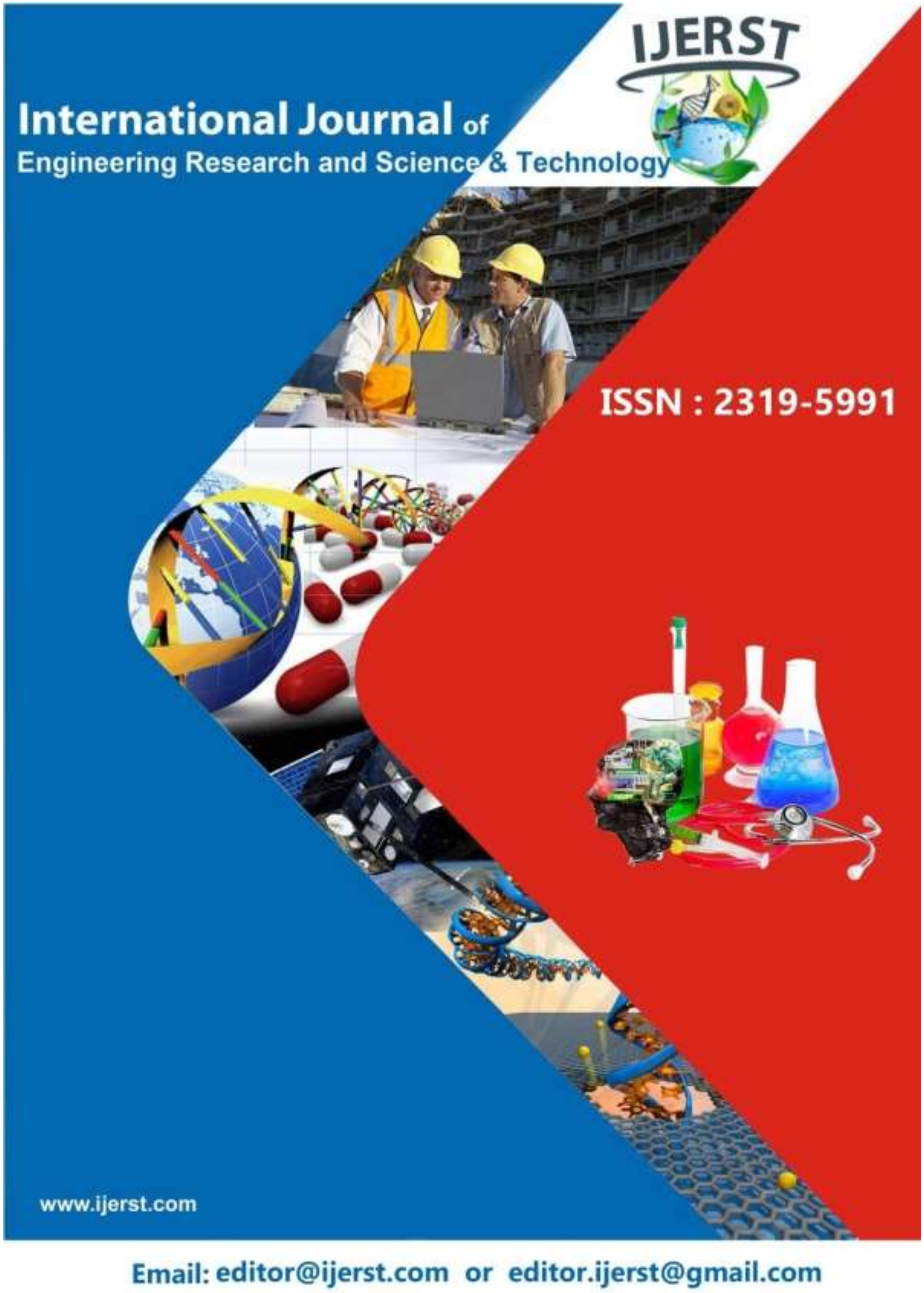

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International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com

Vol. 11, Issuse.2,April 2023

IMPROVEMENT OF THE LOAD-BEARING CAPACITY OF THE PLATFORM SOILS OF THIES REGION WITH THE ADDITION OF CEMENT RUBBLE ON THE BASIS OF THE ROAD EARTHWORKS GUIDE (GTR).

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Abstract

Having noted a lack of documentation on road earthworks, linked to a lack of national standards in Senegal that define the conditions for implementation, the aim of this document is to propose a method of development of the soils for the proper execution of the earthworks and subgrade. To this end, a study was conducted on the subgrade soils of one of the 14 regions of Senegal, namely the region of Thiès, one of the big cities of the country and which is 75 km from the Senegalese capital Dakar. Four 2.5-kilometre-long road axes have been selected for manual sampling of these platform soils in Thiès, the first axis is in the municipality of Fandène located in the North-east of the region, the second in the rural commune of Sanghé located in the south of the region, the third in the commune of Mont-Rolland located 12 km north of the study area and the last in the rural commune of Khombole located 8 km east of the study area. Following the results obtained, we will make a soil improvement with cement rubble at different percentage 2.5% and 5%. This cement rubble was collected at the waste recycling site in Thiès region.

Key words: platform; earthwork; boreholes; lift; fill; shape layer; guide; pavement, improvement.

Introduction

In Senegal, transport is dominated by a road sector that has seen many investments in recent years. The road infrastructure was developed following the implementation of the sectoral transport plans. In 1991, the Transportation Sector Adjustment Program (PAST) reformed road project planning and management. [1]
The Second Transport Sectoral Plan (PST2) came into effect in 2000 and primarily aimed at improving the efficiency of services and infrastructure. The plan is consistent with the objectives of the poverty reduction strategy and focuses on protecting the environment. In this context, to improve the overall efficiency of road management, it is necessary to:

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- On the one hand, update geotechnical studies on existing platform soils in Senegal.

- On the other hand, establish a parameter for the choice and implementation of materials encountered in earthworks.

Indeed, in the absence of a technical reference base, the sizing of pavements in Senegal is most often based on specialized works capitalizing on the experiences gone through in countries in the tropical zone. Beyond the synthesis of geotechnical conditions and the implementation of the materials represented by these experiences, it remains that they take only very partially into account the specificities of the Senegalese road context. The pavement structures which results do not always reflect the local conditions of execution of the works, much less the optimal use of locally available materials.

However, this document reflects the research conducted on platform soils in the Thiès region, but cannot answer all the questions raised by the construction of the road.

Indeed, in any road construction project, it is imperative to understand the behaviour of the soil during and after the construction of the road, hence the importance of earthworks.

We call earthworks the various movements of earth whose purpose is to dig or modify the structure of the soil. This change in ground level is carried out by cutting and filling. The objective of applying the Reference Guide to Road Earthworks to the platform floors of the Thiès region will be achieved by implementing processes that give our roads geometric characteristics (long profile, cross profile, alignment, etc.), considering the materials used for earthworks and make the most appropriate choice based on the type of project, encountered geographical and environmental site.

2. Materials and Methods: This study is centred on the Thiès region. It consists in the realization of manual boreholes, on four road routes, namely the Thiès-Fandène axis the Thiès-Sanghé axis the Thiès-Mont-Roland axis and that of Thiès-Khombole. Sampling will be based on the following assumptions:

- 100 cm depth for each manual survey;
- 500 m linear spacing between roadways
- 2.5 km travel on each axis;
- at least 25 m separate each borehole from the road layout.

This operation allows a visual description of the soil present and samples taken in the laboratory for a physical and mechanical characterization. No groundwater was encountered at any sampling point.

Cement cuttings used for soil improvement are collected at the public landfill site of Thiès Region managed by the Solid Waste Management Coordination Unit.

The sampling was carried out by visual sorting in order to obtain samples composed solely of mortar discharge from demolished building elevations.

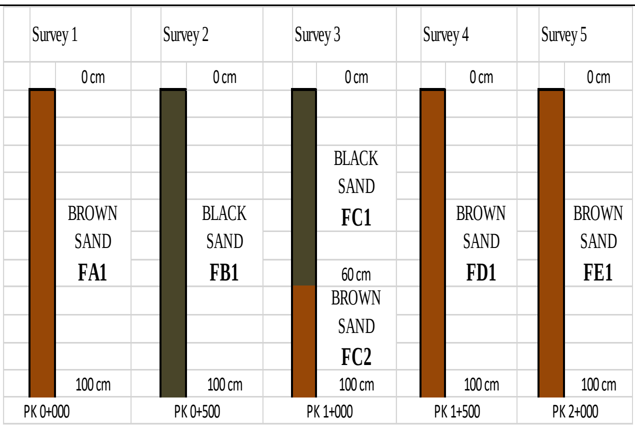

Figure 1: Section of the polls on the Thiès-Fandène axis

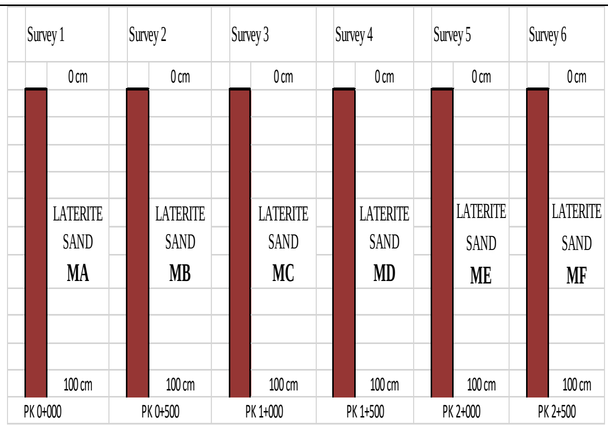

Figure 2. Section of the polls on the Thiès-Sanghé axis

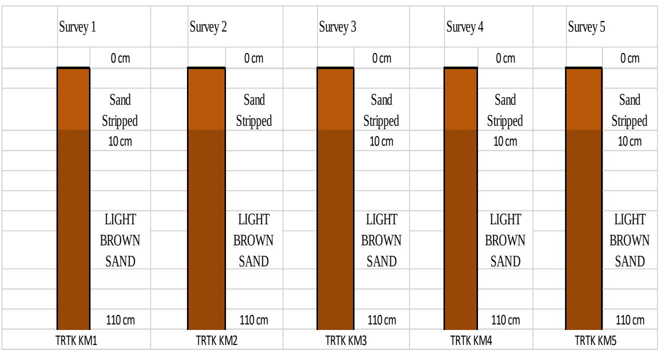

Figure 3: Section of the holes on the Thiès-Khombole axis.

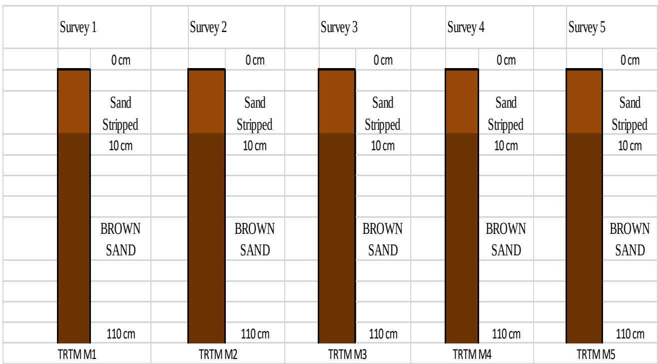

Figure 4: Section of the holes on the Thiès-Montroland axis.

The samples collected were composed of loose soils and were analyzed using the following laboratory test procedures: natural water content, Atterberg limits or sand equivalent depending on the nature of the soil, sieve size, blue value, Proctor compaction test and CBR punching test. [7-8-9-10-11-12-13-14].

3. Results and Discussion:

3.1. Mechanical Characterization

-Results Water Content

Samples taken on the Thies-Fandène and Thies-Khombole axes have low water levels due to the absence of fines. On the other hand, the lateritic sands of the axis Thiès-Sanghé so the sands the axis Thiès-Montroland have much higher water contents because contain a fairly high rate of fines, this was also observed during the particle size test in Table 1.

Table1: *Water Content Results*

FANDENE						
Samples	FA1	FB1	FC1	FC2	FD1	FE1
Wn (%)	2,39	2,09	0,74	3,31	1,04	2,72

SANGHE						
Samples	MA	MB	MC	MD	ME	MF
Wn (%)	8,29	7,40	8,55	9,26	10,35	7,34

KHOMBOLE					
Samples	KM1	KM2	KM3	KM4	KM5
Wn (%)	1,10	1,13	0,99	1,07	0,96

MONTROLAND					
Samples	M1	M2	M3	M4	M5
Wn (%)	6,51	8,09	4,68	5,93	6,51

- Atterberg Results

The results of the plasticity index of the sands of both Mont-Rolland and Sanghé areas are shown in Table 2 below.

Table2: *Atterberg Limit Test Results*

SANGHE						
Samples	MA	MB	MC	MD	ME	MF
IP(%)	8,6	14,4	12,9	11,4	12,6	10,1

MONTROLAND					
Samples	M1	M2	M3	M4	M5
IP(%)	13,2	12,9	12,5	13,7	12,9

According to the GTR, the results obtained for the lateritic sands of the Thiès-Sanghé axis and the Thiès- Mont-Rolland axis have given us a fairly low argilosity since their plasticity index varies around 12.

-Resultats Equivalent Sable

According to the GTR, the results obtained for the sands the axis Thiès-Fandène and the axis Thiès-Khombole we have soils of average plasticity since their values of ES are between 20 and 40 represented in Table 3.

Table 3: *Equivalent sand test results.*

FANDENE						
Samples	FA1	FB1	FC1	FC2	FD1	FE1
ES(%)	31,4	27,9	41,1	30,05	35,25	25,9

KHOMBOLE					
Samples	KM1	KM2	KM3	KM4	KM5
ES(%)	26,6	28,9	28,1	27,05	28,58

- Granulometric Results

Figures 5, 6, 7 and 8 show all the curves obtained during the particle size tests of the soil samples respectively on the four lines of research.

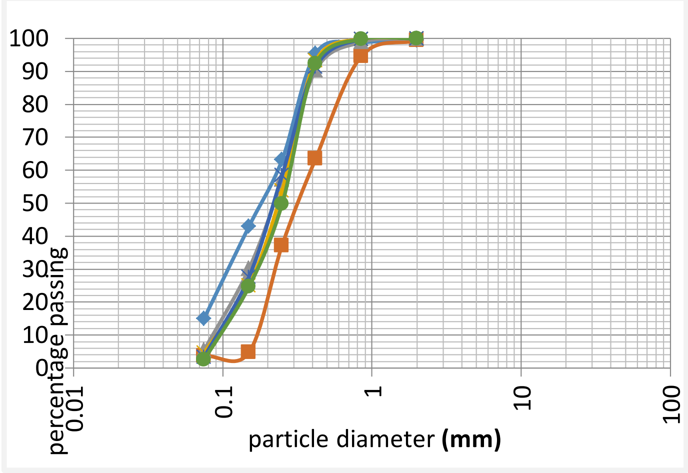

Figure 5 : Particle size analysis curve after sieving samples from the Thiès-Fandène axis

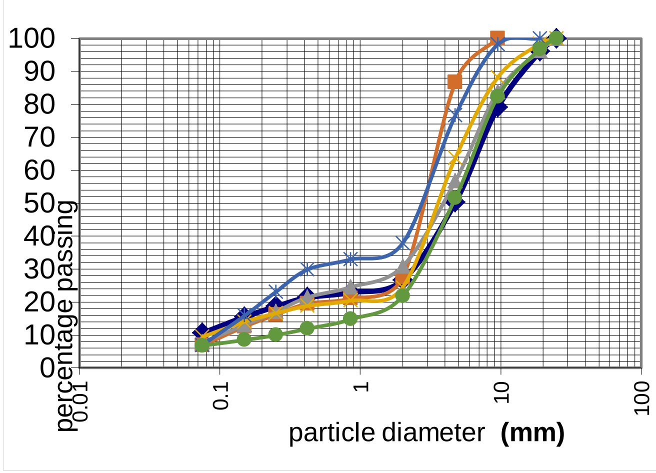

Figure 6 : Particle size analysis curve after sieving samples from the Thiès-Sanghé axis

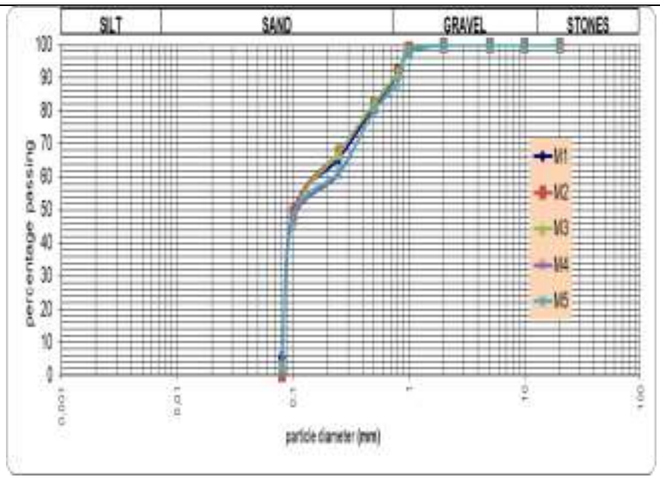

Figure 7 : Curve of the particle size analysis after sieving the samples of the Thiès-Montroland axis.

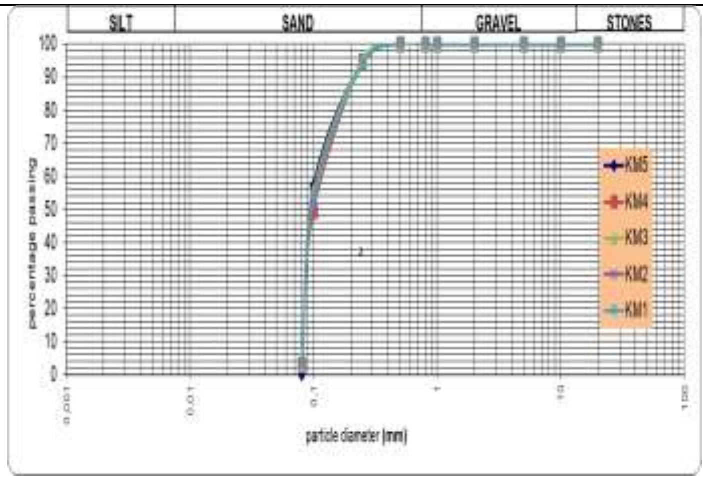

Figure 8 1: Particle size analysis curve after sieving samples from the Thiès-Khombole axis.

- *Valeur au Bleu Results*

The results obtained for the test vbs are presented in Table 4.

Table 4: *VBS test results*

FANDENE

Samples	FA1	FB1	FC1	FC2	FD1	FE1
VBS	0,60	0,40	0,40	0,40	0,40	0,40

SANGHE

Samples	MA	MB	MC	MD	ME	MF
VBS	0,20	0,17	0,23	0,25	0,15	0,21

MONTROLLAND

Samples	M1	M2	M3	M4	M5
VBS	1,33	1,49	1,50	1,50	1,42

KHOMBOLE

Samples	KM1	KM2	KM3	KM4	KM5
VBS	0,34	0,46	0,32	0,46	0,62

According to the GTR, the results obtained for the sands of the Thiès-Fandène axis and the Thiès-Mont-Rolland axis show us that we have low silt soils (low plastic and water sensitive soil) since their VBS values are between 0.4 and 1.5. For the sands of the Thiès-Sanghé axis and that of Thiès-Khombole, their VBS values are between 02 and 0.4 hence the presence of sandy soils which are insensitive to water.

- Proctor Results

The results obtained at the optimum Proctor on the original soils are given in table 5:

Table 5: *Proctor test results*

FANDENE						
Samples	FA1	FB1	FC1	FC2	FD1	FE1
w_{opt} (%)	5,7	9,4	7,62	7,6	9,9	7,2
γ_{dmax} (KN/m3)	19,3	19,2	18,8	19,3	17,8	19,3

SANGHE						
Samples	MA	MB	MC	MD	ME	MF
wopt (%)	8,20	11,3	11,6	11,6	13,8	9,2
γ_{dmax} (KN/m3)	21,4	20,0	19,0	18,7	18,4	20,3

MONTROLAND					
Samples	M1	M2	M3	M4	M5
w_{opt} (%)	8,17	8,63	8,01	7,97	8,17
γ_{dmax} (KN/m3)	21,0	19,6	21,0	20,5	20,1

KHOMBOLE					
Samples	KM1	KM2	KM3	KM4	KM5
w_{opt} (%)	8,80	9,10	8,8	7,6	8,1
γ_{dmax} (KN/m3)	19,4	19,7	19,2	19,3	19,6

The results obtained at the optimum Proctor on soils with a 5% cement rubble improvement are given in the following table 6:

Table 6: Proctor test results with 5% cement rubble

FANDENE						
Samples	FA1	FB1	FC1	FC2	FD1	FE1
w_{opt} (%)	5,80	9,60	7.40	7.40	10.10	7.60
γ_{dmax} (KN/m3)	30,2	31,0	29,8	30,2	31,0	30,2

SANGHE						
Samples	MA	MB	MC	MD	ME	MF
w_{opt} (%)	8,4	11,1	11,4	10,8	13,5	10,0
γ_{dmax} (KN/m3)	31,3	30,8	31,0	31,1	31,4	30,3

MONTROLAND					
Sampless	M1	M2	M3	M4	M5
w_{opt} (%)	10,1	11,2	11,0	9,9	10,3
γ_{dmax} (KN/m3)	32,9	33,6	33,8	32,4	31,5

KHOMBOLE					
Sampless	KM1	KM2	KM3	KM4	KM5
w_{opt} (%)	9,70	8,80	8,90	8,60	9,30
γ_{dmax} (KN/m3)	30,8	30,1	31,9	31,2	30,6

- CBR Results

The results obtained from the CBR test on the original soils without improvement are given in Table 7.

Table 7: CBR test results

FANDENE						
Samples	FA1	FB1	FC1	FC2	FD1	FE1
I.CBR	12	14	13	14	11	18

SANGHE						
Samples	MA	MB	MC	MD	ME	MF
I.CBR	22	11	14	19	12	35

MONTROLAND					
Samples	M1	M2	M3	M4	M5
I.CBR	5,2	3,1	3,2	4,7	5,0

KHOMBOLE					
Samples	KM1	KM2	KM3	KM4	KM5
I.CBR	2,4	3,1	2,1	3,7	2,6

The mean values of the CBR index in this table are greater than 5 for the two studied axes, namely Fandène and Sanghé, on the other hand for two other axes Montroland and Khombole we have a CBR between 2 and 5 which justifies that it would be necessary to purge the existing platform soil for our two study areas, and to provide a new replacement floor with an ICBR value greater than 5. [13].

The results obtained from the CBR soil test with a 5% cement improvement are given in Table 8.

Table 8: CBR test results with 5% cement rubble

FANDENE						
Samples	FA1	FB1	FC1	FC2	FD1	FE1
I.CBR	14,4	16.2	14,8	16.2	12.9	19,8

SANGHE						
Samples	MA	MB	MC	MD	ME	MF
I.CBR	23,7	13,1	15,8	20,1	13,0	35,9

MONTROLAND					
Samples	M1	M2	M3	M4	M5
I.CBR	7,2	5,2	5,1	6,1	7,0

KHOMBOLE					
Samples	KM1	KM2	KM3	KM4	KM5
I.CBR	4,8	5,8	5,1	6,1	5,0

Soil improvement with a percentage equal to 5% of cement grease gives us ICBR results that slightly exceed the original values. This shows that the presence of cement rubble gives the required qualities in terms of reinforcement of the load bearing capacity and the plasticity of the ground to be used as a layer of road form.

4. Conclusion

The results of geotechnical studies carried out along the route of each axis according to their identification and improvement with a material which constitutes a large solid waste, namely cement rubble, are presented and discussed in this document. Thus, the Platform floors of two of our axes have 95% CBR indices of the OPM between 2% and 5%, and after a reinforcement of 5% grease, the CBR index has changed to higher values for soils that had low portances, such as Khombole and Mont-Rolland. These results allowed us to classify these soils according to the French 1992 GTR Road Moving Guide and then to give a new formulation on the basis of addition of materials to meet the conditions of use in fill and subgrade as illustrated in this document.

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