A-８　地質調査報告書

GEOTEC AFRIQUE SENELABO

GEOTECHNICAL REPORT

A-8-1

Etude Préparatoire du Projet d'urgence de Renforcement et de Réhabilitation du réseau de transport d'énergie dans la région de Dakar

JICA PROJECT TEAM

YACHIYO ENGINEERING CO., LTD.

DAKAR - SENEGAL

SOCOCIM SUBSTATION

January 19, 2017

SENELABO
GÉOTECHNIQUE

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Mission G_2 AVP

GEOTECHNIC PRELIMINARY STUDY PROJECT

Etude Préparatoire du Projet d'urgence de Renforcement et de Réhabilitation du réseau de transport d'énergie dans la région de Dakar

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I. PRESENTATION

I.1. DEFINITION OF THE OPERATION – CONTRIBUTOR

On request and on behalf of JICA PROJECT TEAM (YACHIYO ENGINEERING CO., LTD.), GEOTEC AFRIQUE-SENELABO was commissioned to carry out geotechnical studies for **''Projet d'urgence de Renforcement et de Réhabilitation du réseau de transport d'énergie dans la région de Dakar, SENEGAL".**

I.2. MISSION

This is a mission of G2AVP type according to NF P 94-500 standard as defined in the classification of types of geotechnical tasks prepared by the geotechnical trade union and standardized AFNOR NFP 94500 in November 2013.

This mission will allow :

- To define a field geotechnical investigation campaign and make its realization by core drilling with Standard Penetration Test (SPT) as in-situ soil testing ;
- To determine the nature of soils that can be mobilized and their depth ;
- To define foundation systems adapted to soils encountered and proposed buildings ;
- To determine the bearing capacity of soil in place ;
- To define the constructive arrangements for taking into account the phenomenon of shrinkage and swelling of the existing soil ;
- Provide recommendations for earthworks.

I.3. PROJECT - RECEIVED DOCUMENTS

The project consists of reinforcement and rehabilitation of the energy transport network of Dakar, Sococim substation. Are been communicated to us the site map, finishing schedule, basement floor plan, the 1st floor plan, roof plan, the elevation of the building, sections and the fitting schedule. However it has been communicated to us the technical specifications for site investigation works.

Building have 1story and basement floor in the range of 12x24 meter and two transfers are planned outside (Total weight: 100t). Also, GIS is planned outside (Total weight: 60t).

I.4. CONVENTIONS USED

The various tests carried conform to AFNOR standards.

Recommendations and justifications were made according to the following regulations:

- XP ENV 1997-1 Eurocode 7 – geotechnical calculation - General rules;
- NF P11-300 : Earthworks ;
- AFNOR P11-211 – DTU 13.11 – shallow foundations ;
- AFNOR NF P11-711 – DTU 13.12 – Rules for the design of shallow foundations ;
- AFNOR NF P11-213-1 to 4 – DTU 13.3 – Rules for construction of pavings.

II. LOCALISATION AND GEOLOGICAL SETTINGS

II.1. SITE LOCATION

The Sococim substation site is located at Sococim as saw below (figure 1).

Figure 1 : Sococim substation location map

II.2. GEOLOGICAL SETTING OF THE SITE

Geological studies on the peninsula of Cap-Vert by (Castelain and al[1], 1965; Tessier and al[2], 1967; Lappartient 1985; Crévola and al[3], 1994 etc.) and many other authors and updated by the PASMI[4] (2009), allowed to the stratigraphic synthesis of tertiary and quaternary formations in the area of Dakar (Figure 2).

The project site relies on the old tertiary and quaternary sedimentary rock. These formations are mainly :

- Marl and clay with planktonic and benthic foraminifera ;
- Clay facies with planpronic foraminifera and Ypresian clay-marly facies ;
- Clay, limestone, marl- limestone, marl and clay with planktonic and benthic foraminifera of the Middle and Lower Eocene.

[1] CASTELAIN J. (1965) – Aperçu stratigraphique et micropaléontologique du bassin du Sénégal occidental. Historique de la découverte paléontologique. In : « Colloque International de Micropaléontologie » (Dakar). Mémoire BRGM, 32, p. 135-159.

[2] TESSIER F. & LAPPARTIENT J-R. (1967) - Observations sur la latérite récente des environs de Dakar. Bull. Soc. Géol. Fr., Paris, 9 (7), p. 455-466.

[3] G. Crevola, J.-M. Cantagrel, C. Moreau, 1994. *Le volcanisme de la presqu'île du Cap-Vert (Sénégal) : cadre chronologique et géodynamique*, Bull. Soc. géol. France, 165, 5, 437-446.

[4] PASMI : Programme d'Appui au Secteur Minier / Projet 9 ACP SE 009 - Cartographie géologique du Bassin Sédimentaire, Geoter/BRGM/Direction des Mines et de la Géologie, Dakar, 2009.

Geologically, the study area is located at the Graben of Rufisque. This graben with general orientation NNE-SSW, is limited to the East by the horst of Diass. The Rufisque graben is characterized by Campano-Maastrichtian formations, Tertiary and Quaternary formations of the Senegal-Mauritanian basin. In the sector of Rufisque-Bargny and Diamniadio, in favor of several quarries, essentially four lithological ensembles are noted. This is the limestone unit ("Bargny limestone"), marly units ("marl with narrow clayey limestone beds with Frondicularia", "marl with clayey limestone beds" and "gray marl with Radiolarians"). This area is cut by sub-meridian faults which delimit the horst and the grabens. These faults are sometimes associated with volcanic events between the Upper Eocene and the Quaternary (Crevola et al., 1994).

Figure 2: Geological map of the peninsula of Cap-Vert and the plateau of Thiès

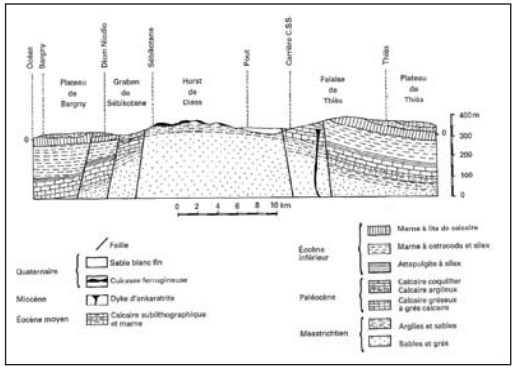

Figure 3: Geological cross-section of Diass Horst, plateau of Thiès and Bargny

III. PROGRAM AND RESULTS OF INVESTIGATION

III.1. PROGRAM OF INVESTIGATION

For this studies GEOTEC AFRIQUE - SENELABO realized on the site :

- One (01) borehole at 20m depth of investigation with SPT (in-situ soil testing) were carried out in order to take samples for laboratory tests and to define detailed log of the lithology of the site;
- Laboratory tests to identify and characterize the soil, we have done the following tests :
  - Moisture content tests [NF P 94-050]
  - Grain size analysis [NF P 94-056]
  - Specific Weight [NF P 94-053]
  - Apparent and absolute density [NF P 94-053, 94-064]
  - Atterberg limits [NF P 94-051]
  - VBS (Blue Methylen value) [NF P 94-068]
  - Direct linear shear test [NF P 94-071-1]
  - Standard oedometer test [NF P 94-090-1]
  - Compressive strength tests on rock [NF P 94-420]

III.2. DESCRIPTION OF THE CORES SAMPLES

At the location of the project, we conducted core drilling with SPT to identify and characterize the ground. The observations carried out allowed us to establish the log below.

Hole ID	Depth from (m)	Depth to (m)	Lithological description of cores
SC4/Sococim substation	0	0,1	Limestone gravel (embankment)
	0,1	2,5	Greenish marl, tender
	2,5	7,6	Greenish marl, tender to compact
	7,6	14,10	Whitish marl-limestone (alternation of marl and narrow limestone beds)
	14,10	14,95	Greenish tender marl
	14,95	20	Greenish gray clayey marl, compact

NB : All the above depths are given at our Borehole and the reference level of depth are the existing ground level.

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III.3. RESULTS OF STANDARDS PENETRATION TEST (SPT)

The project site relies on a tender to compact marl and alternation of compact marl and limestones. However we have carried out SPT tests and the results are summarized below.

Hole ID	Depth	Number of blows			
		Start of test	Test		N
		N0	N1	N2	
SC4/Sococim substation	1 to 1,3 m	6	50	> 50 (without penetration)	> 100
	up to 20 m	> 50 (without penetration)	-	-	> 100
NB : The tests are carried out at intervals of 1m					

III.4. RESULTS OF THE LABORATORY TESTS AND SOIL CARACTERISATION

The results of laboratory tests conducted on soil samples collected from core samples are summarized on the table below.

CUSTOMER		JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.						
Project		ETUDE PREPARATOIRE DU PROJET D'URGENCE, DE RENFORCEMENT ET DE REHABILITATION DU RESEAU DE TRANSPORT D'ENERGIE DANS LA REGION DE DAKAR						
Borehole Number		SC4/Sococim substation						
Depth (m)		0,1m à 1,00m	1,00m à 2,00m	2,00m à 2,50m	3,00m à 4,00m	4,00m à 5,00m	5,00m à 7,00m	14,20m à 14,90m
Lithological nature of soil		Greenish marl, tender	Greenish marl, tender	Greenish marl, tender	Greenish marl, tender to compact	Greenish marl, tender to compact	Greenish marl, tender to compact	Greenish tender marl
Water content	W%	7,2	4,52	5,82	5,33	5,92	14,89	9,28
Wet density (t/m3)	γ_h	1,472	1,722	1,597	1,722	1,722	1,569	1,666
Dry density (t/m3)	γ_d	1,374	1,648	1,509	1,635	1,626	1,366	1,525
Specific density	γs	2,284	2,268	2,265	2,269	2,264	2,271	2,229
Grain size analysis	Dmax(mm)	0,125	0,125	0,080	0,125	0,080	0,500	0,500
	0.5mm	100,0	100,0	100,0	100,0	100,0	99,5	98,4
	0.125mm	99,5	99,8		99,8	100,0	99,2	98,2
	0.08mm	99,3	99,5	99,8	99,6	99,7	98,7	97,4
Atterberg limits (%)	WL	172,81	153,53	167,10	191,90	165,02	159,01	198,93
	WP	57,22	52,86	55,07	57,13	59,73	50,91	68,27
	IP	115,59	100,67	112,03	134,77	105,28	108,10	130,66
	Ic	1,433	1,480	1,440	1,384	1,511	1,333	1,451
Cohésion (kPa)	C	23,936	35,551	46,118	24,688	41,895	41,65	66,914
Internal friction angle (°)	φ	30,46	28,7	17,14	24,59	26,28	28,16	26,58
Preconsolidation pressure (kPa)	σ'p	190	185	250	350	290	190	210
Compressibility index	Cc	0,292	0,315	0,357	0,397	0,426	0,272	0,307
Classification GTR		A4	A4	A4	A4	A4	A4	A4

On some core samples, Compressive strength tests are been carried out ant the results are summarized on the table below.

CUSTOMER		JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.						
Project		ETUDE PREPARATOIRE DU PROJET D'URGENCE, DE RENFORCEMENT ET DE REHABILITATION DU RESEAU DE TRANSPORT D'ENERGIE DANS LA REGION DE DAKAR						
Borehole Number		SC4/Sococim substation						
Depth (m)		2,70m	9,50m	12,15m	16,62	17	18,67	19,62
Lithological nature of soil		Greenish marl, tender to compact	Whitish marl-limestone	Whitish marl-limestone	Greenish gray clayey marl, compact	Greenish gray clayey marl, compact	Greenish gray clayey marl, compact	Greenish gray clayey marl, compact
Compressive strength (MPa)	Rc	54,6	45,34	58,13	44,18	65,11	37,2	39,44
Description		Moderately strong	Moderately strong	Moderately strong	Moderately strong	Highly strong	Moderately strong	Moderately strong

III.5. HYDROGEOLOGY OF THE SITE

The ground water was not encountered during drilling. However, we can not exclude the presence of anarchic water circulations on preferential flow channels. The hydrological regime can vary depending on the season and rainfall.

III.6. NATURAL AND ANTHROPIC RISKS

The marl-limestone substratum is a sedimentary environment and likely to have lateral variations in bedding thickness.

The ground water was not encountered during drilling. This could reduce the risk of increase of the ground water level.

The soils encountered in the project area can present localy a risk of shrinkage and swelling. Since variations in the water conditions of the environment may be accentuated by anthropogenic channels, plantations and runoff of rainwater, information on the risk of flooding in the lower areas of the project should be obtained.

We can also note the existence of underground electric cable and foundation of existing equipment in Sococim.

III.7. SEISMICITY OF THE SITE

The project site is located at the plateau of Bargny tectonically stable and therefore deemed non-seismic.

III.8. DEFINITION OF ZONE OF INFLUENCE AND GEOTECHNICAL MODEL

The Geotechnical Influence Zone (GIZ) is not restricted to the parcel interested in the project. It also concerns the immediate environment (interfaces related to temporary earthworks) with the presence of roads, habitations and Fence near the project.

Aerial view of the site

view of existing equipment

According to the results of the laboratory tests, the geotechnical model can be defined in this version of the report (See table below).

Selected geotechnical characteristics									
Lithological nature of soil	Depth (m/GL)	Wet density (t/m3)	Specific density (t/m3)	Atterberg limits (Ip) %	Cohésion (kPa)	Internal friction angle (°)	Classification according to the GTR	Compressive strength (MPa)	SPT N-value
Limestone gravel (Embankment)	0,1	-	-	-	-	-	-	-	-
Greenish marl, tender to compact	7,6	1,63	2,27	112,74	35,64	25,9	A4	54,6	> 100
Whitish marl-limestone (alternation of marl and narrow limestone beds)	14,1	-	-	-	-	-	R2	51,74	> 100
Greenish gray clayey marl, compact	> 20	1,67	2,23	130,66	66,914	26,58	A4 to R2	46,5	> 100

IV. RECOMMENDATIONS

IV.1. JUSTIFICATION OF SHALLOW FOUNDATIONS

- **Definition of fondations :**

Considering the observations of the field investigation and foundation elements that have been transmitted to us, we check here a rectangular foundation raft for shallow foundation.

- **Strength limits of soil :**

The Geofond software was used to evaluate the bearing capacity of the soil. The calculation is done using the method of Meyerhoff which involves the calculation of an average value Nm of N by the relation:

$$N_m = \frac{1}{2B - 0{,}5B} \int_{D+0{,}5B}^{D+2B} N(z)dz$$

The breaking stress q'u under the base of foundation raft is given by the equation:

$$q'_u = \frac{3 \cdot N}{0{,}08} \cdot \left(1 + \frac{D}{3 \cdot B}\right) \cdot \left(\frac{B + 0{,}3}{B}\right)^2$$

With D = anchoring depth and B = Width of the foundation raft.

The bearing capacity at SLS and ULS are given respectively by $q'_u / 3$ and $q'_u / 2$ and the table below gives the results of this calculation.

Structures	Dimensions of the foundation raft	Anchoring depth (m) / GL	Applied load (kN)	Breaking stress q'_u (MPa)	Bearing capacity (MPa)		Settlements Sf (cm)
					SLS	ULS	
Transfer	***5 m x 8 m***	*1*	*500*	4,49	**1,5**	**2,25**	**< 0,05**
GIS for Switching	***8 m x 15 m***	*1*	*600*	4,2	**1,4**	**2,1**	**< 0,05**
Building (Isolated fottings)	***1,5 m x 2 m***	*1,2*	-	6,84	**2,28**	**3,42**	**-**
Building (Raft under the cable room)	***5 m x 8 m***	*2,35*	-	5,11	**1,7**	**2,55**	**-**

- **Settlements deformations**

Considering loads that communicated to us, estimated settlements for this foundations raft are less than 0,05 cm.

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IV.2. REALIZATION OF GROUND SLAB

Considering the characteristics of the materials that will be present at the bottom of the excavation, a sub-base will be realized according to the following recommendations :

- Flushing out any mediocre layers and those damaged by earth-moving equipment ;
- Recompact the bottom of excavation thus obtained ;
- Make a sub-base in materials, of a thickness to be defined by the prime contractor of the project. It can be realized in gravel, grave-cement, compacted sand, laterite, all coming from quarry etc.

To check the quality of the sub-base thus obtained, for this type of structure, KW> 50MPa / m and EV2 / EV1 <2 must be used according to the rules of DTU 13.3.

IV.3. EARTHWORKS REALISATION

- **Earthworks :**

If the foundations are shallow, will have to be envisaged a provisional supporting. It is excluded to carry out the earthworks without ensuring the stability of the excavations by an adapted supporting prohibiting any displacement in provisional and final phase.

- **Water Conditions**

Any water inflows in the excavations (runoff of rainwater) during earthworks will be evacuated.

IV.4. SPECIAL PRECAUTIONS FOR DESIGN AND EXECUTION

- **Constructives dispositions**

Foundations :

Structural adaptation of reference documents (Fascicule 62 and DTU) are to be considered.

IV.5. GEOTECHNICAL ALEAS AND CONTRACTUAL CONDITIONS

1. This report and its annexes constitute an inseparable whole. Misuse that could be made following a partial disclosure or reproduction does not engage GEOTEC AFRIQUE-SENELABO.
2. Changes in the location, design or importance of buildings as well as the assumptions used in particular in the indications of the "presentation" of this report can lead to challenges to the regulations. A new mission will then be entrusted to GEOTEC AFRIQUE-SENELABO to rehabilitate or validate these findings in writing the new project.

3. Similarly, new evidence revealed during the execution of the foundations and could not be detected in the soil reconnaissance (eg localized heterogeneity, water inflows, dissolution cavity, etc.) can render obsolete some of the recommendations contained in the report.

4. The ground reconnaissance proceed by ad hoc surveys, the results are not strictly extrapolated to the entire site. It persists hazards (eg local heterogeneity) that can lead to adaptations to the design of performance that can not be borne by the geotechnician.

5. At the time of the opening of the excavations, it is advisable to conduct a site visit by a geotechnician to GEOTEC AFRIQUE-SENELABO. This visit gives rise to a written notice on the verification of soil type and level seat of shallow foundations. This tour is subject to prior specific command.

A Dakar, 19/01/2017

Engineer in charge of the study

N. L. BADJI

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ANNEX

Annex 1 : Log of the exploratory hole

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Borehole Number	PROJECT : ETUDE PREPARATOIRE DU PROJET D'URGENCE ET DE RENFORCEMENT ET DE REHABILITATION DU RESEAU DE TRANSPORT D'ENERGIE DANS LA REGION DE DAKAR		
	Custumer : JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.		
SC4/Sococim substation	FOLDER : GT/2016-484		
	TYPE OF SAMPLING : Core drilling		
	DEPTH : 20,10 m Below existing ground level		
Localisation	Coordonnées UTM _ zone 28P	X= 257934	Y=1627554

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Ground water level	Depth (m) / existing ground level	Stratigraphic column	Lithological description	% of Recovery	SPT	Ø Drilling	Ø Tubing (mm)	Tool
	0,1		limestone gravel (Embankment)	100				
	2,5		Greenish marl, tender	85	SPT (1 à 1,3 m) N = 6-50-R			
	7,6		Greenish marl, tender to compact	76,67				
	14,10		Whitish marl-limestone (alternation of marl and narrow limestone beds)	95,38				
	14,95		Greenish tender marl	100				
	20		Greenish gray, clayey marl	94,06				
Not met								Carottier double T6 116 à couronne

COMMENTS

PHOTOGRAPHIC DOCUMENTS

0 - 4 m

4 - 8,90 m

8,90 - 13 m

13 - 17,40 m

17,40 - 20 m

Annex 2 : Sheet of laboratory tests

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GEOTEC SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

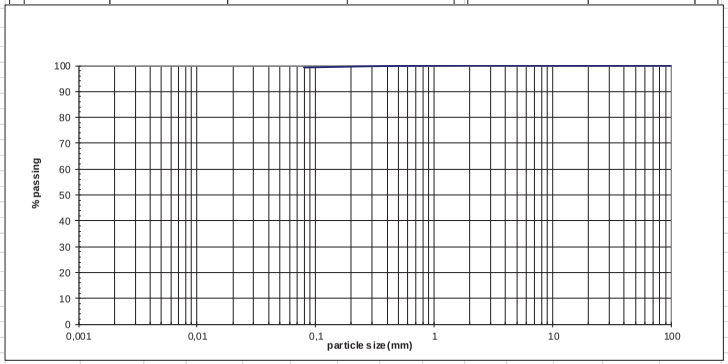
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	/ SOCOCIM SUBSTAT	1	0,10m à 1,00m	Greenish marl, tender	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				NFP 11-300	ASTM D2937		ASTM D854
7,2			172,81	57,22	115,59	1,43	A4	1,472	1,374	2,284

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay | silt | fine sand | coarse sand | gravel | cobble



Sieve mesh size (mm)	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	99,5	99,3

Sieve mesh size (mm)												
Passing (%)												

OBSERVATIONS

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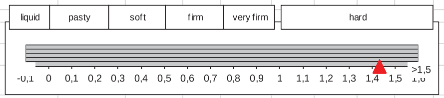
The engineer responsible of the tests

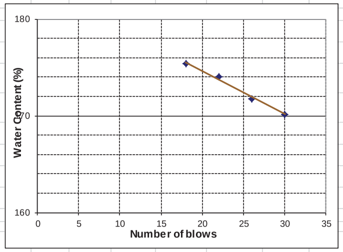
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SOCOCIM SUBSTA	1	0,10m à 1,00m	Greenish marl, tender	SIDY

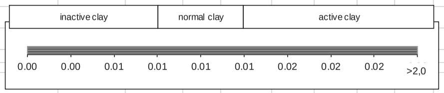
	1- Liquid Limit						2- Plasticy Limit		
Number of blows	18	22	26	30					
Tare N°	M	B2	BB	G9			G7	X12	
Total wet weight	91,17	87,88	116,6	112,76			35,7	33,46	
Total dry weight	64,78	61,9	92,77	90,86			29,33	27,31	
Total weight of tares	49,73	46,97	78,91	77,99			18,31	16,45	
Net weight of water	26,39	25,98	23,8	21,9			6,37	6,15	
Weight of dry material	15,05	14,93	13,86	12,87			11,02	10,86	
Water content (%)	175,35	174,01	171,7	170,16			57,804	56,62983	
Limits and indices	W_L = 172,81		W_P = 57,217		I_P = 115,6		I_c = 1,43	A =	

3- Scale of Consistency (Ic)

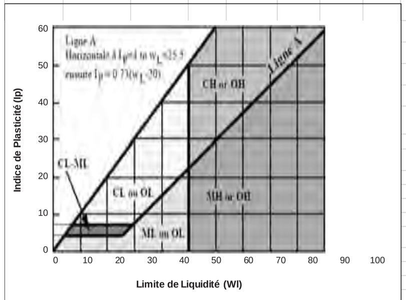




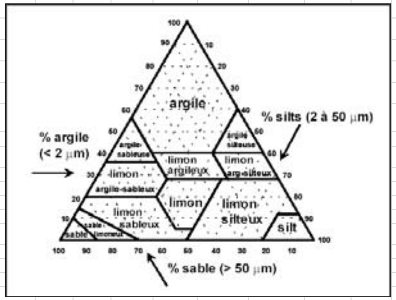
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		CH: Muddy, gravelly and/or sandy clay
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	MH: Gravelly and/or sandy silt of high plasticity

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : YACHIYO ENGINEERING CO., LTD.

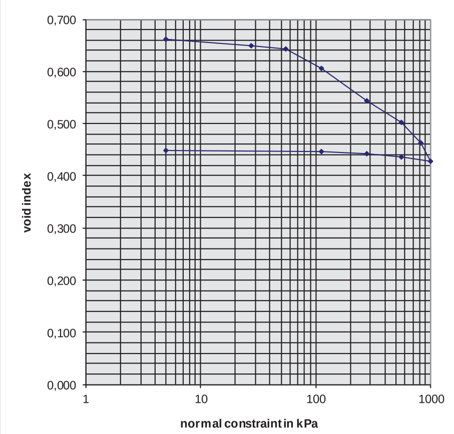
SITE : SOCOCIM SUBSTATION

summery description :	Greenish marl, tender	Register N° :
date of arrival at the laboratory :		Borehole N° : SC4 / SOCOCIM SUBSTATION
date of tests :	11/01/2017	

characteristic of the test-tube or core		Before test		After test		Sample N° : 1
Diameter : D	in mm	D_0 =	50,47			Depht of test-tube or core (m) =
Height : H	in mm	Hi =	20			0,10m à 1,00m
dry formerly densité	in Mg/m^3	γ_{di} =	1,37	γ_{df} =		Experimenter :
Unit weight	in MG/m^3	γ_s =	2,28			
Water content	in %	Wi =	7,20	Wf =		Frame N° :
Saturation degree	in %	Sri =	24,83	Srf =		2

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,691	0,662
		2	28	16,0	0,677	0,649
		3	56	24,0	0,671	0,643
		4	111	69,0	0,634	0,606
		5	277	145,0	0,572	0,543
		6	555	195,0	0,531	0,502
		7	830	242,0	0,492	0,464
		8	1000	286,0	0,456	0,428
		9	555	276,0	0,464	0,436
		10	277	268,0	0,471	0,442
		11	111	263,0	0,475	0,446
		12	5	260,0	0,477	0,449

oedometer curve



Results

Characteristics of compressibility

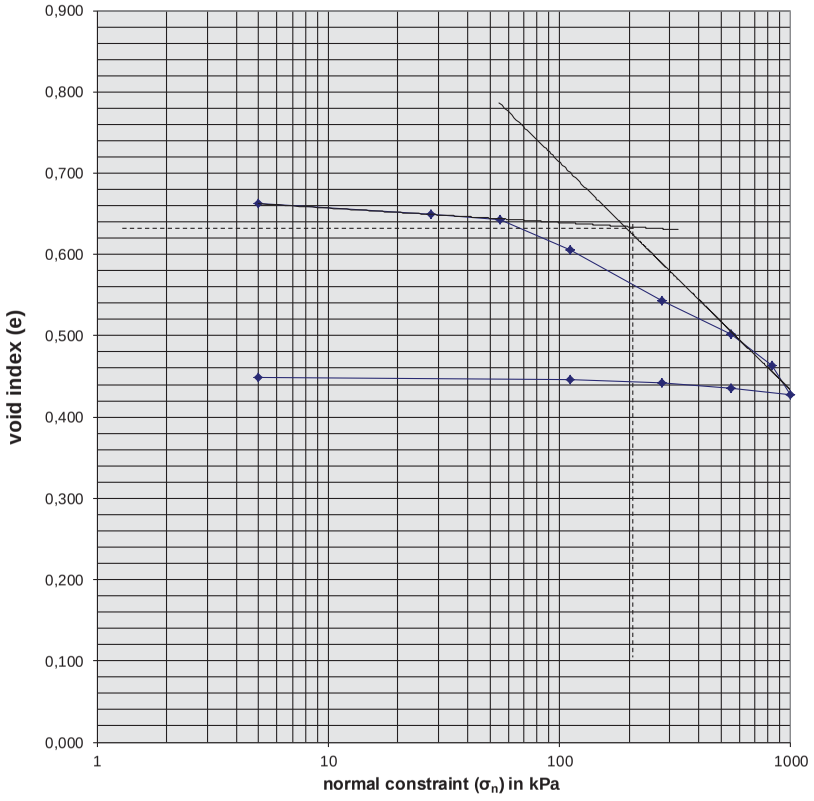
void index		e_i= 0,662
		e_0= 0,63
Vertical effective constraint	(kPa)	σ'_{V0}= 7,557
Constraint of preconsolidation	(kPa)	$\sigma'p$= 190
Index of compression		Cc= 0,292
Pressure of swelling	(kPa)	Pg=
Swelling Index		Cs=

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

	Report of test with the oedometer (consolidation test)			
GEOTEC SENELABO	Compression test on fine grained soils saturated with loading by stages Test carried out in accordance with standard ASTM D2435			
PROJECT or BUILDING SITE :	**summery description :**	Greenish marl, tender		Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.				
SITE :	date of arrival at the laboratory :			Borehole N° :
SOCOCIM SUBSTATION	date of tests :		11/01/2017	
	sampling depht.	=	0,10m à 1,00m	Sample N° :
	test-tube (core)			1

oedometer curve



A-8-11

Direct linear shear test

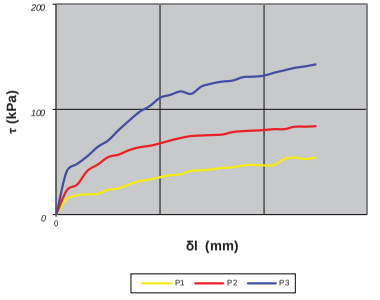
(réalisé conformément à la norme NF P 94-071-1)

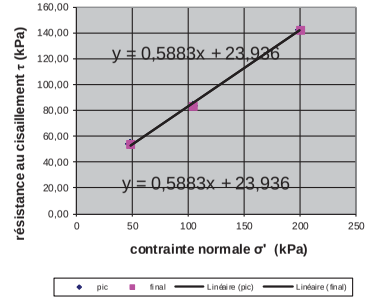
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar		**CLIENT**	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	
Site:	Sococim Substation		**Date essai:**	29/12/2016	
N° Sondage:	SC4	**Prof. :** 0,1m à 1m	**Nature sol**	Greenish marl, tender	**Vitesse de cis. =** 0.5 mm/mn

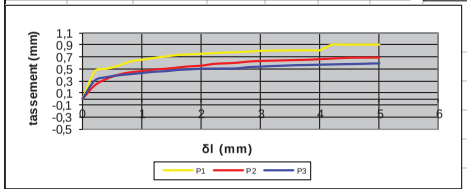
Caractéristiques de l'éprouvette — ρ_s

Hauteur =	20 mm	Largeur, diamètre =	60 mm	mesuré = 2,700 T/m3	estimé =

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,44	1,347	7,2	1,0044					48,61	53,635	5	53,635	5
2	1,44	1,347	7,2	1,0044					104,18	83,484	3,2	83,484	5
3	1,44	1,347	7,2	1,0044					200,02	142,25	2,6	142,25	5
4													







Results	cohésion (kPa)		Internal friction angle Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	23,936	23,936	30,46	30,46

Observations:

L'ingénieur responsable des essais:

GEOTEC afrique SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

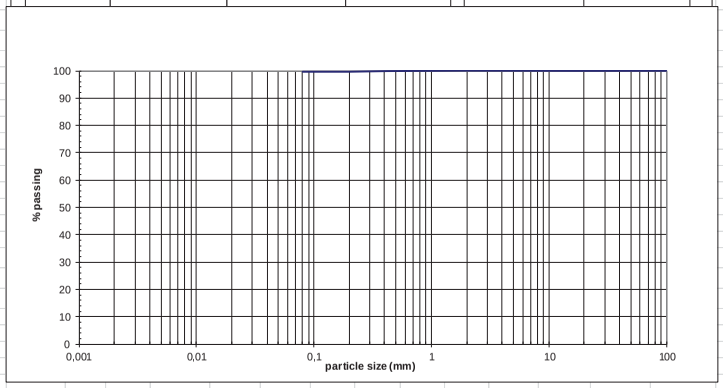
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC4 / SOCOCIM SUBSTATION	2	1,00 à 2,00m	Greenish marl, tender	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_c		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
4,52			153,53	52,86	100,67	1,48	A4	1,722	1,648	2,268

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay | silt | fine sand | coarse sand | gravel | cobble



Sieve mesh size (mm)	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	99,8	99,5

Sieve mesh size (mm)											
Passing (%)											

OBSERVATIONS

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The engineer responsible of the tests

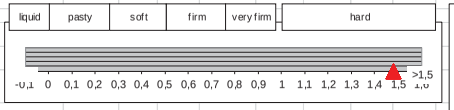
A-8-12

CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.,	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

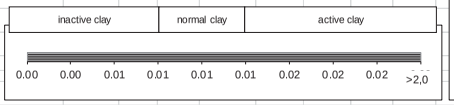
REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SOCOCIM SUBSTA	2	1,00 à 2,00m	Greenish marl, tender	SIDY

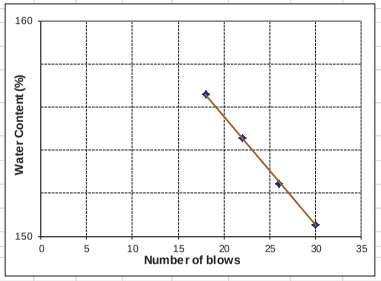
	1- Liquid Limit						2- Plasticy Limit			
Number of blows	18	22	26	30						
Tare N°	B2	M	B10	B18				0	PX	
Total wet weight	66,24	86,69	78,72	85,35				53,51	53,47	
Total dry weight	54,48	64,25	64,27	63,25				49,6	49,02	
Total weight of tares	46,97	49,73	54,79	48,57				42,23	40,57	
Net weight of water	11,76	22,44	14,45	22,1				3,91	4,45	
Weight of dry material	7,51	14,52	9,48	14,68				7,37	8,45	
Water content (%)	156,59	154,55	152,4	150,54				53,0529	52,66272	
Limits and indices	W_L =	153,53	W_P =	52,858	I_P =	100,7	I_c =	1,48	A =	

3- Scale of Consistency (Ic)

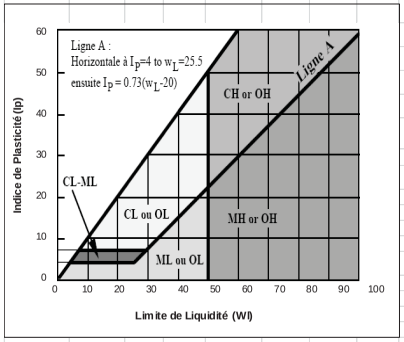


4- Scale of activity (A)

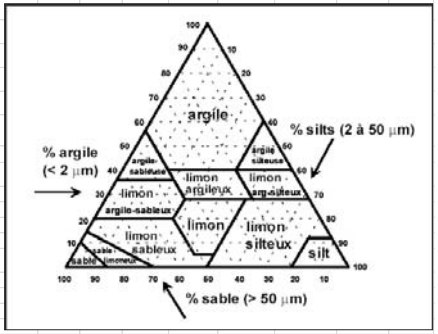




5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	CH: Muddy, gravelly and/or sandy clay
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
		MH: Gravelly and/or sandy silt of high plasticity

Report of test with the oedometer (consolidation test)

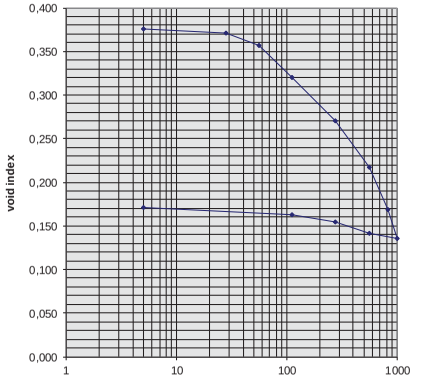
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**	Greenish marl, tender	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.			
SITE :	date of arrival at the laboratory :		Borehole N° :
SOCOCIM SUBSTATION	date of tests :	11/01/2016	**SC4/ SOCOCIM SUBSTATION**
			Sample N° :
characteristic of the test-tube or core	**Before test**	**After test**	**2**

Diameter : D	***in mm***	D_0 =	50,47		Depht of test-tube or
Height : H	***in mm***	Hi =	20		core (m) =
dry formerly densité	***in Mg/m³***	γ_{di} =	1,65	γ_{df} =	1,00m à 2,00m
Unit weight	***in MG/m³***	γ_s =	2,27		Experimenter :
Water content	***in %***	Wi =	4,52	Wf =	
Saturation degree	***in %***	Sri =	27,25	Srf =	Frame N° :
					6

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,643	0,376
		2	28	5,9	0,639	0,372
		3	56	25,0	0,623	0,356
		4	111	70,0	0,588	0,321
		5	277	133,0	0,538	0,270
		6	555	200,0	0,484	0,217
		7	830	261,0	0,436	0,169
		8	1000	303,0	0,402	0,135
		9	555	295,2	0,409	0,141
		10	277	279,0	0,422	0,154
		11	111	268,0	0,430	0,163
		12	5	258,0	0,438	0,171

oedometer curve



Results

Characteristics of compressibility

void index		e_i=	0,376
		e_0=	0,376
Vertical effective constraint	(kPa)	σ'_{V0}=	24,72
Constraint of preconsolidation	(kPa)	$\sigma'p$=	185
Index of compression		Cc=	0,315
Pressure of swelling	(kPa)	Pg=	
Swelling Index		Cs=	

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

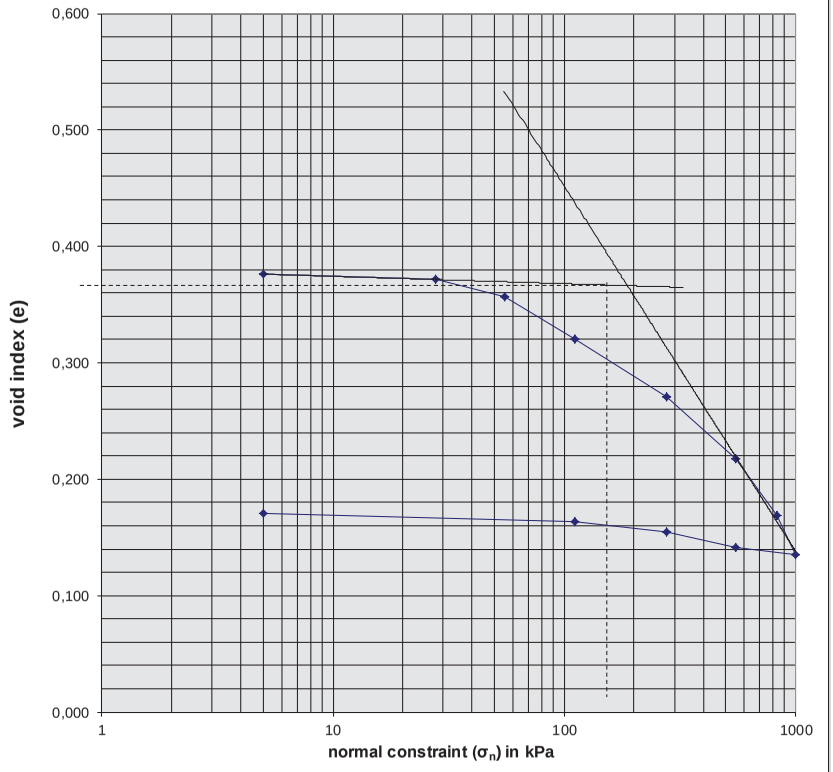
A-8-13

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**	Greenish marl, tender	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.			
SITE :	date of arrival at the laboratory :		Borehole N° :
SOCOCIM SUBSTATION	date of tests :	11/01/2016	
	sampling depht. =	1,00m à 2,00m	Sample N° :
	test-tube (core)		2

oedometer curve



Direct linear shear test

(réalisé conformément à la norme NF P 94-071-1)

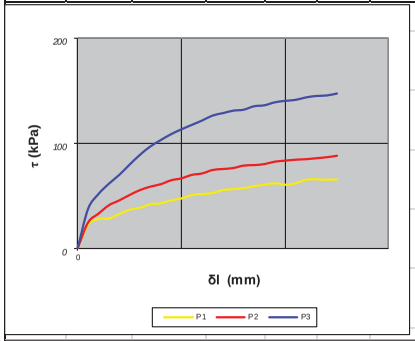
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de	**CLIENT**	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.
Site:	Sococim Substation	**Date essai:**	29/12/2016

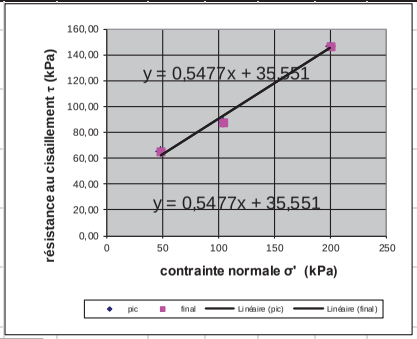
N° Sondage:	SC4	**Prof. :**	1m à 2m	**Nature sol**	Marne tendre verdeatre	**Vitesse de cis. =**	0.5 mm/mn

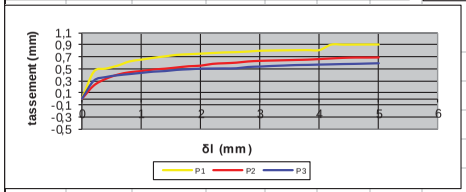
Caractéristiques de l'éprouvette — ρ_s

Hauteur =	20 mm	Largeur, diamètre =	60 mm	mesuré = 2,700 T/m3	estimé =

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,72	1,648	4,5	0,6388					48,61	65,294	5	65,294	5
2	1,72	1,648	4,5	0,6388					104,18	87,681	3,2	87,681	5
3	1,72	1,648	4,5	0,6388					200,02	146,91	2,6	146,91	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	35,551	35,551	28,7	28,7

Observations:

L'ingénieur responsable des essais:

A-8-14

GÉOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

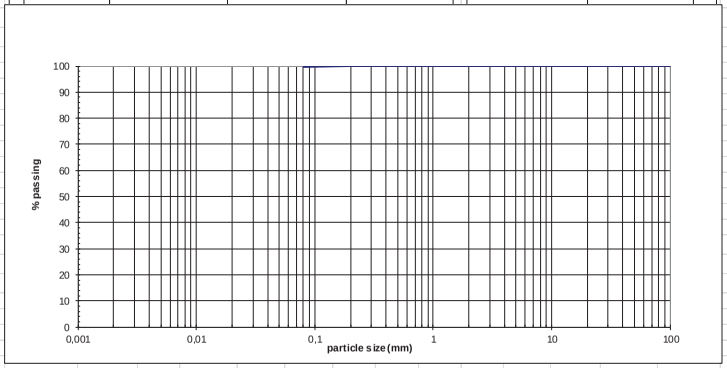
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC4 / SOCOCIM SUBSTATION	3	2,00m à 2,50m	Greenish marl, tender	SIDY

Water Content *w* (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_c		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
5,82			167,1	55,07	112,03	1,44	A4	1,597	1,509	2,265

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	*w* (%) of saturation	Swelling (%)

clay | silt | fine sand | coarse sand | gravel | cobble



Sieve mesh size (mm)	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	99,8

Sieve mesh size (mm)											
Passing (%)											

OBSERVATIONS

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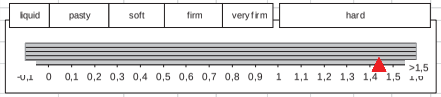
The engineer responsible of the tests

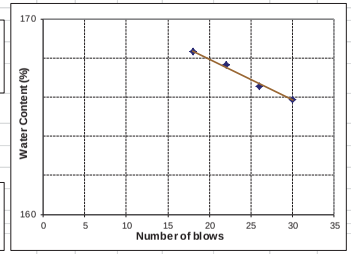
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC4 / SOCOCIM SUBSTATION	3	2,00m à 2,50m	Greenish marl, tender	SIDY

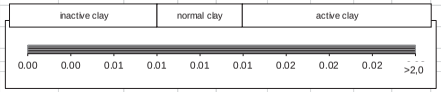
	1- Liquid Limit						2- Plasticy Limit			
Number of blows	18	22	26	30						
Tare N°	B17	P4	AB+	BN				AB1	G	
Total wet weight	73,41	76,06	115,5	116,81				27,29	27,99	
Total dry weight	55,3	59,78	91,42	95,03				20,99	21,22	
Total weight of tares	44,54	50,07	76,95	81,9				9,51	8,97	
Net weight of water	18,11	16,28	24,1	21,78				6,3	6,77	
Weight of dry material	10,76	9,71	14,47	13,13				11,48	12,25	
Water content (%)	168,31	167,66	166,6	165,88				54,878	55,26531	
Limits and indices	W_L =	167,1	W_P =	55,072	I_P =	112	I_c =	1,44	A =	

3- Scale of Consistency (Ic)

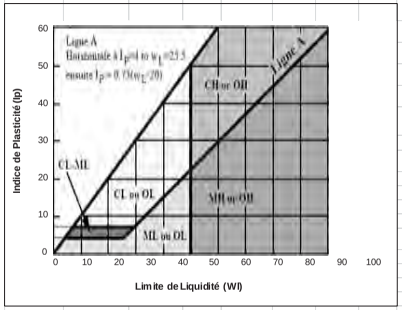




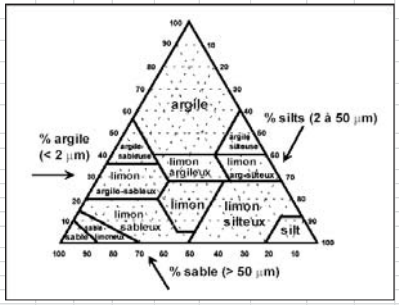
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	CH: Muddy, gravelly and/or sandy clay
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
		MH: Gravelly and/or sandy silt of high plasticity

A-8-15

GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

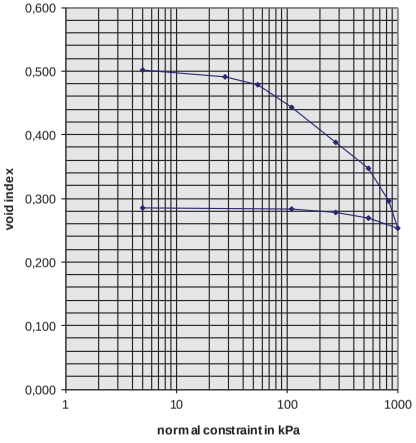
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	**summery description :**	Greenish marl, tender	Register N° :
SITE : SOCOCIM SUBSTATION	date of arrival at the laboratory :		Borehole N° : **SC4/SOCOCIM SUBSTATION**
	date of tests :	11/01/2017	

characteristic of the test-tube or core		Before test		After test		Sample N° :
Diameter : D	***in mm***	D_0 =	50,47			Depht of test-tube or
Height : H	***in mm***	Hi =	20			core (m) =
dry formerly densité	***in Mg/m³***	γ_{di} =	1,51	γ_{df} =		2,00m à 2,50m
Unit weight	***in MG/m³***	γ_s =	2,27			Experimenter :
Water content	***in %***	Wi =	5,82	Wf =		
Saturation degree	***in %***	Sri =	26,31	Srf =		Frame N° : 1

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	4,759	0,501
		2	28	12,0	4,749	0,491
		3	56	28,0	4,736	0,478
		4	111	73,0	4,700	0,442
		5	277	140,0	4,646	0,388
		6	555	192,0	4,604	0,346
		7	830	255,0	4,553	0,296
		8	1000	308,0	4,511	0,253
		9	555	289,0	4,526	0,268
		10	277	278,0	4,535	0,277
		11	111	271,0	4,541	0,283
		12	5	268,0	4,543	0,285

oedometer curve



Results

Characteristics of compressibility

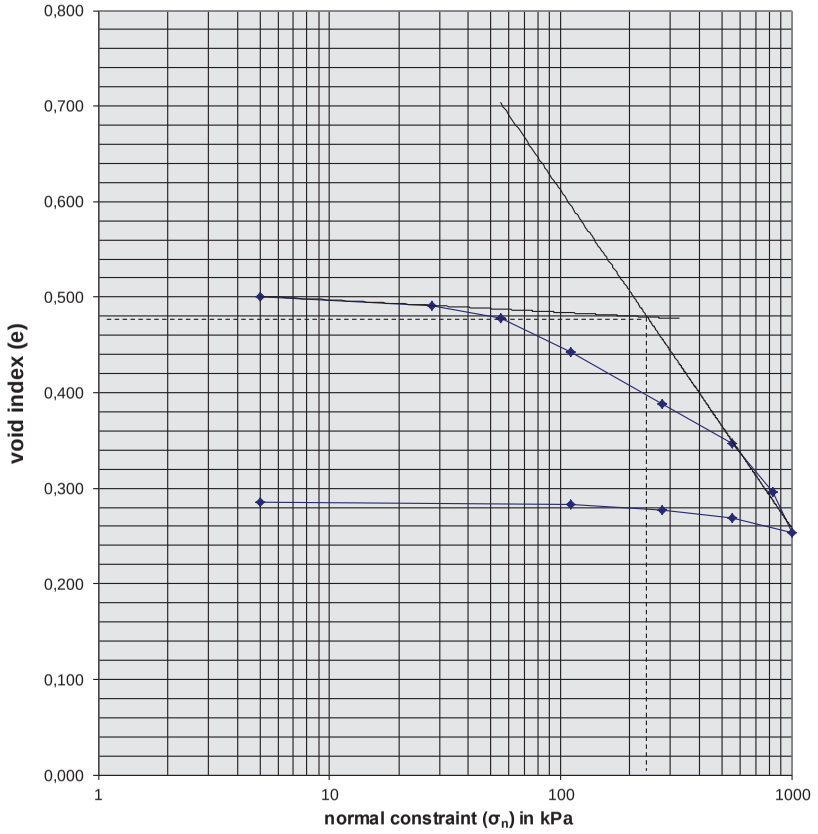
void index	e_i=	0,501
	e_0=	0,48
Vertical effective constraint	(kPa) σ'_{V0}=	33,95
Constraint of preconsolidation	(kPa) $\sigma'p$=	250
Index of compression	Cc=	0,357
Pressure of swelling	(kPa) Pg=	
Swelling Index	Cs=	

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

GEOTEC SENELABO	Report of test with the oedometer (consolidation test)			
	Compression test on fine grained soils saturated with loading by stages			
	Test carried out in accordance with standard ASTM D2435			
PROJECT or BUILDING SITE :	**summery description :**	Greenish marl, tender		Register N° :
CT TEAM / YACHIYO ENGINEERI				
SITE :	date of arrival at the laboratory :			Borehole N° :
SOCOCIM SUBSTATION	date of tests :		11/01/2017	
	sampling depht.	=	2,00m à 2,50m	Sample N° :
	test-tube (core)			3

oedometer curve



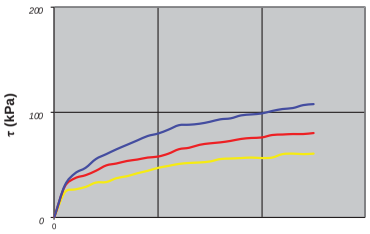
A-8-16

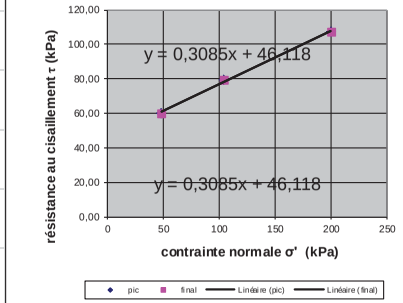
Direct linear shear test

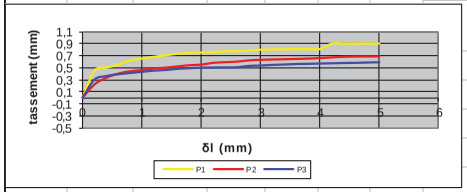
(réalisé conformément à la norme NF P 94-071-1)

Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de					**CLIENT**	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.						
Site:	Sococim Substation					**Date essai:**	29/12/2016						
N° Sondage:	SC4	**Prof. :**	2m à 2,5m	**N°Registre**				**Vitesse de cis. =**	0.5 mm/mn				
Caractéristiques de l'éprouvette										***ρ_s***			
Hauteur =	20 mm	Largeur, diamètre =	60 mm			mesuré =	2,700 T/m3	estimé =					

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m^3)	ρd (T/m^3)	w (%)	e	Sr	ρd (T/m^3)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,60	1,509	5,8	0,7891					48,61	60,164	5	60,164	5
2	1,60	1,509	5,8	0,7891					104,18	79,753	3,2	79,753	5
3	1,60	1,509	5,8	0,7891					200,02	107,27	2,6	107,27	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	46,118	46,118	17,14	17,14

Observations:

L'ingénieur responsable des essais:

GÉOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

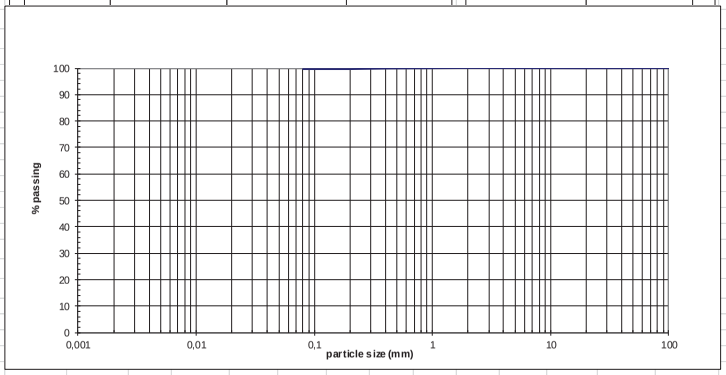
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC4 / SOCOCIM SUBSTATION	5	3,00m à 4,00m	Greenish marl, tender to compact	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
5,33			191,9	57,13	134,77	1,38	A4	1,722	1,635	2,269

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay | silt | fine sand | coarse sand | gravel | cobble



Sieve mesh size (mm)	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	99,8	99,6

Sieve mesh size (mm)											
Passing (%)											

OBSERVATIONS

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The engineer responsible of the tests

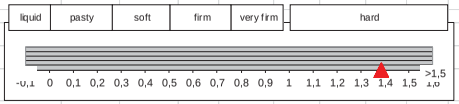
A-8-17

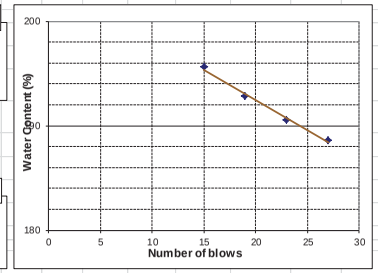
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SOCOCIM SUBSTA	5	3,00m à 4,00m	Greenish marl, tender to compact	SIDY

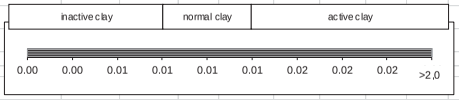
	1- Liquid Limit				2- Plasticy Limit				
Number of blows	15	19	23	27					
Tare N°	MI	G4	A2	B18			G7	X15	
Total wet weight	116,54	113,39	117,5	85,66			34,44	39,08	
Total dry weight	95,16	86,57	90,82	61,42			28,63	31,88	
Total weight of tares	84,23	72,66	76,84	48,57			18,31	19,46	
Net weight of water	21,38	26,82	26,64	24,24			5,81	7,2	
Weight of dry material	10,93	13,91	13,98	12,85			10,32	12,42	
Water content (%)	195,61	192,81	190,6	188,64			56,2984	57,97101	
Limits and indices	W_L =	191,9	W_P =	57,135	I_P =	134,8	I_C =	1,38	A =

3- Scale of Consistency (Ic)

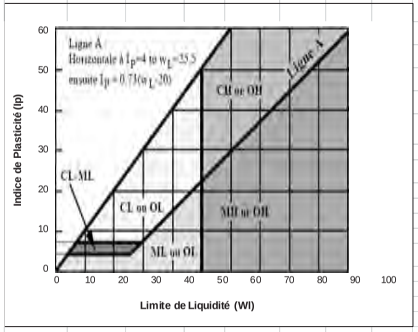




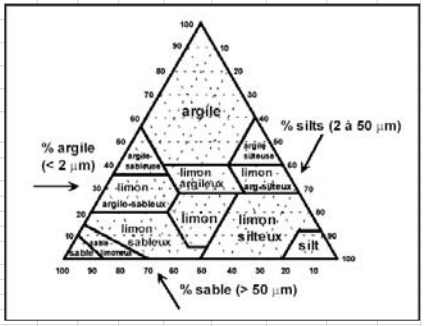
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	CH: Muddy, gravelly and/or sandy clay
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
		MH: Gravelly and/or sandy silt of high plasticity

Report of test with the oedometer (consolidation test)

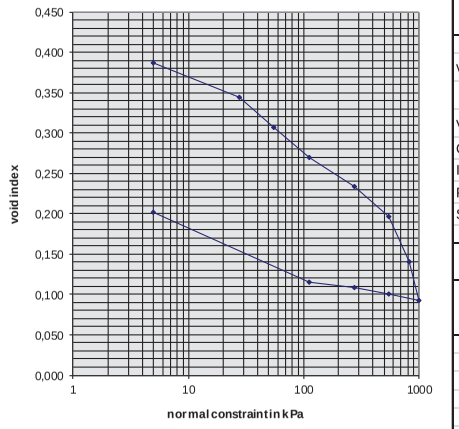
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**	Greenish marl, tender to compact	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.			
SITE :	date of arrival at the laboratory :		Borehole N° :
SOCOCIM SUBSTATION	date of tests :	11/01/2017	**SC4/SOCOCIM SUBSTATION**

characteristic of the test-tube or core		Before test		After test		Sample N° :
						5
Diameter : D	***in mm***	D_0 =	50,47			Depht of test-tube or
Height : H	***in mm***	Hi =	20			core (m) =
dry formerly densité	***in Mg/m³***	γ_{di} =	1,64	γ_{df} =		3,00m à 4,00m
Unit weight	***in MG/m³***	γ_s =	2,27			Experimenter :
Water content	***in %***	Wi =	5,33	Wf =		
Saturation degree	***in %***	Sri =	31,26	Srf =		Frame N° : 5

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	$e_{corrected}$
		1	5	0,0	-4,528	0,387
		2	28	50,1	-4,570	0,345
		3	56	95,0	-4,607	0,307
		4	111	140,0	-4,645	0,270
		5	277	182,7	-4,681	0,234
		6	555	228,0	-4,718	0,196
		7	830	295,0	-4,774	0,140
		8	1000	352,5	-4,822	0,093
		9	555	343,0	-4,814	0,100
		10	277	333,0	-4,806	0,109
		11	111	326,0	-4,800	0,115
		12	5	222,0	-4,713	0,201

oedometer curve



Results

Characteristics of compressibility

void index		e_i=	0,387
		e_0=	0,28
Vertical effective constraint	(kPa)	σ'_{V0}=	57,225
Constraint of preconsolidation	(kPa)	σ'_p=	350
Index of compression		Cc=	0,397
Pressure of swelling	(kPa)	Pg=	
Swelling Index		Cs=	

Direct shear test

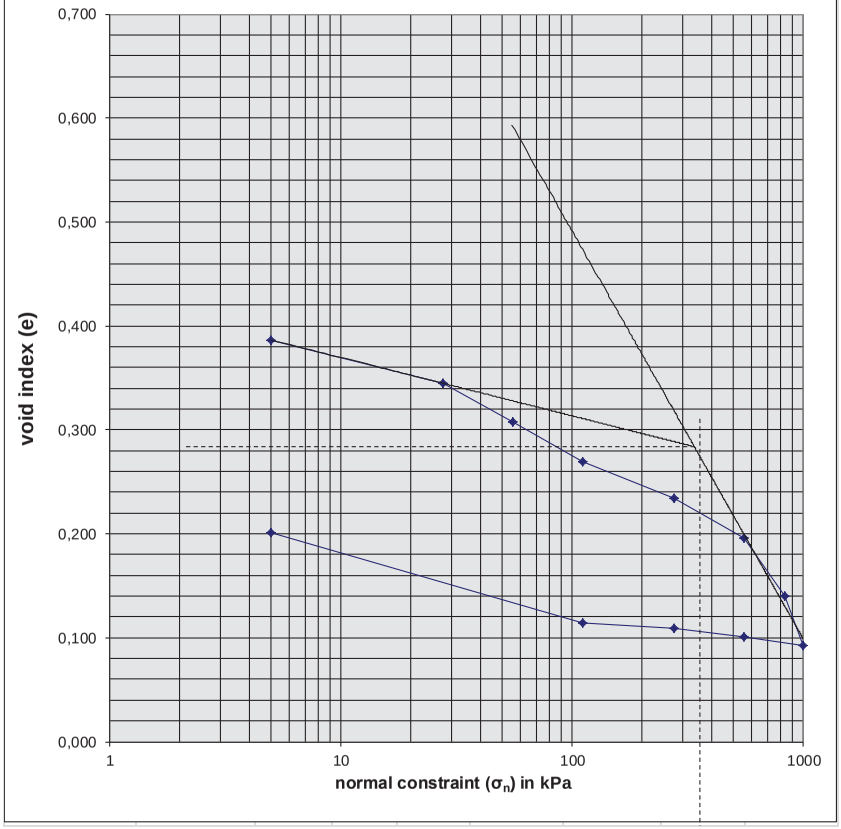
Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

A-8-18

Report of test with the oedometer (consolidation test)
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**	Greenish marl, tender to compact	Register N° :
JECT TEAM / YACHIYO ENGINEERING			
SITE :	date of arrival at the laboratory :		Borehole N° :
SOCOCIM SUBSTATION	date of tests :	11/01/2017	
	sampling depht. =	3,00m à 4,00m	Sample N° :
	test-tube (core)		5

oedometer curve



GEOTEC AFRIQUE - SENELABO _ Etude Préparatoire du Projet d'urgence de Renforcement et de Réhabilitation
du réseau de transport d'énergie dans la région de Dakar / Rapport d'études géotechniques n° GT/2016-484

Direct linear shear test

(réalisé conformément à la norme NF P 94-071-1)

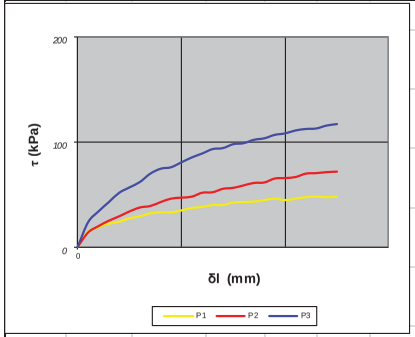
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de	**CLIENT**	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.
Site:	Sococim Substation	**Date essai:**	29/12/2016

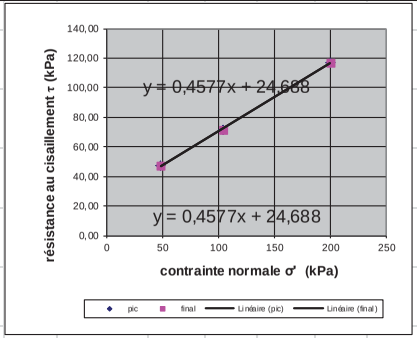
N° Sondage:	SC4	**Prof. :**	3m à 4m	**Nature sol**	Marne compacte verdeatre	**Vitesse de cis. =**	0.5 mm/mn

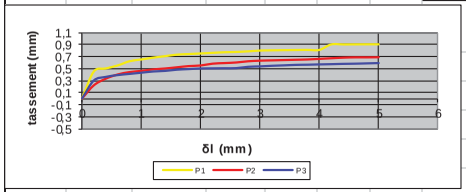
Caractéristiques de l'éprouvette — ρ_s

Hauteur =	20 mm	Largeur, diamètre =	60 mm	mesuré =	2,700 T/m3	estimé =	

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,72	1,635	5,3	0,6515					48,61	47,572	5	47,572	5
2	1,72	1,635	5,3	0,6515					104,18	71,358	3,2	71,358	5
3	1,72	1,635	5,3	0,6515					200,02	116,6	2,6	116,6	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	24,688	24,688	24,59	24,59

Observations:

L'ingénieur responsable des essais:

A-8-19

REPORT OF TESTS ON SAMPLE OF SOIL

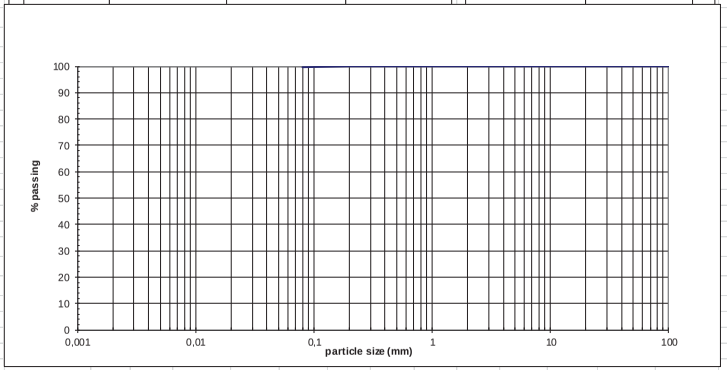
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC4 / SOCOCIM SUBSTATION	6	4,00m à 5,00m	Greenish marl, tender to compact	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
5,92			165,02	59,73	105,28	1,51	A4	1,722	1,626	2,264

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm)	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	99,7

Sieve mesh size (mm)											
Passing (%)											

OBSERVATIONS

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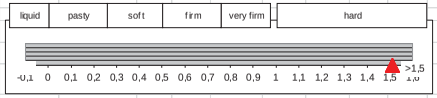
The engineer responsible of the tests

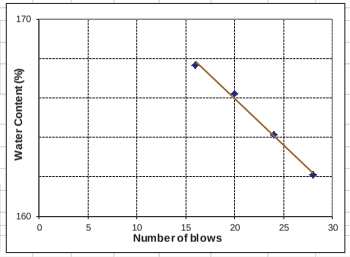
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC4 / SOCOCIM SUBSTATION	6	4,00m à 5,00m	Greenish marl, tender to compact	SIDY

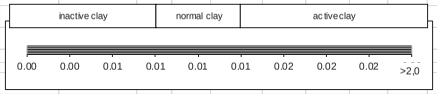
	1- Liquid Limit						2- Plasticy Limit			
Number of blows	16	20	24	28						
Tare N°	P4	B3	E2	B				G7	Z7	
Total wet weight	83,1	82,07	86,7	88,04				37,7	35,59	
Total dry weight	62,41	62,99	64,38	62,22				30,5	29,68	
Total weight of tares	50,07	51,51	50,78	46,29				18,38	19,84	
Net weight of water	20,69	19,08	22,32	25,82				7,2	5,91	
Weight of dry material	12,34	11,48	13,6	15,93				12,12	9,84	
Water content (%)	167,67	166,2	164,1	162,08				59,4059	60,06098	
Limits and indices	W_L =	165,02	W_P =	59,733	I_P =	105,3	I_C =	1,51	A =	

3- Scale of Consistency (Ic)

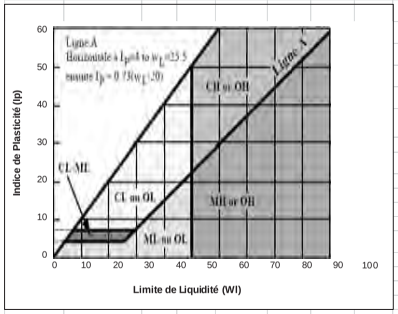




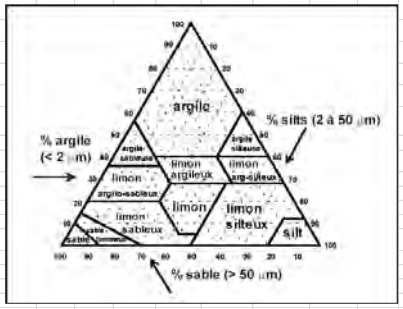
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	MH: Gravelly and/or sandy silt of high plasticity
		CH: Muddy, gravelly and/or sandy clay

A-8-20

Report of test with the oedometer (consolidation test)

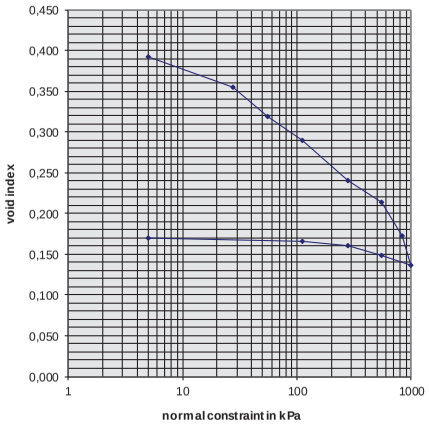
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : YACHIYO ENGINEERING CO., LTD.	summery description :	Greenish marl, tender to compact	Register N° :
SITE : SOCOCIM SUBSTATION	date of arrival at the laboratory :		Borehole N° :
	date of tests :	09/01/2017	**SC4/SUBSTATION**

characteristic of the test-tube or core		Before test		After test		Sample N° :
Diameter : D	***in mm***	D_0 =	50,47			Depht of test-tube or
Height : H	***in mm***	Hi =	20			core (m) =
dry formerly densité	***in Mg/m ^{3}***	γ_{di} =	1,63	γ_{df} =		4,00m à 5,00m
Unit weight	***in MG/m ^{3}***	γ_s =	2,26			Experimenter :
Water content	***in %***	Wi =	5,92	Wf =		
Saturation degree	***in %***	Sri =	34,16	Srf =		Frame N° : 3

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,686	0,392
		2	28	46,0	0,649	0,355
		3	56	90,0	0,613	0,319
		4	111	125,0	0,584	0,290
		5	277	186,0	0,534	0,240
		6	555	218,0	0,508	0,214
		7	830	270,0	0,466	0,172
		8	1000	313,0	0,430	0,137
		9	555	298,0	0,443	0,149
		10	277	284,0	0,454	0,160
		11	111	278,0	0,459	0,165
		12	5	273,0	0,463	0,169

oedometer curve



Results

Characteristics of compressibility

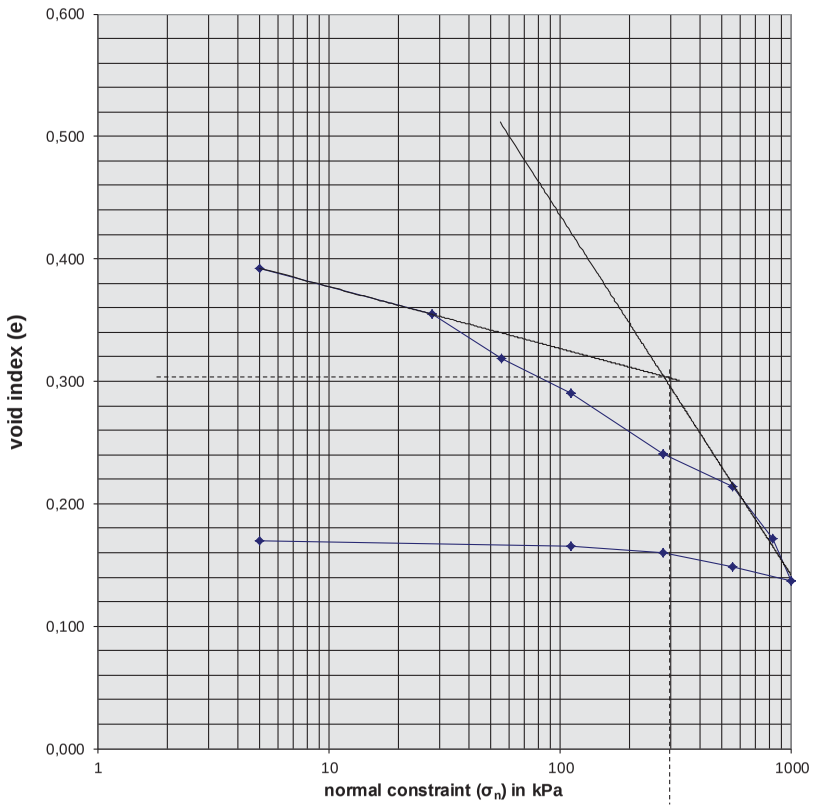
void index		e_i= 0,392
		e_0= 0,3
Vertical effective constraint	(kPa)	σ'_{V0}= 73,17
Constraint of preconsolidation	(kPa)	σ'_p= 290
Index of compression		Cc= 0,426
Pressure of swelling	(kPa)	Pg=
Swelling Index		Cs=

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

		Report of test with the oedometer (consolidation test)		
		Compression test on fine grained soils saturated with loading by stages		
		Test carried out in accordance with standard ASTM D2435		
PROJECT or BUILDING SITE :	**summery description :**	Greenish marl, tender to compact		Register N° :
ECT TEAM / YACHIYO ENGINEERING				
SITE :	date of arrival at the laboratory :			Borehole N° :
SOCOCIM SUBSTATION	date of tests :		09/01/2017	
	sampling depht.	=	4,00m à 5,00m	Sample N° :
	test-tube (core)			

oedometer curve



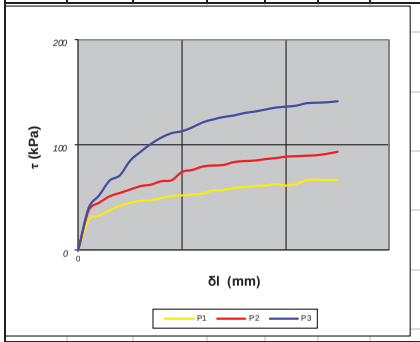
A-8-21

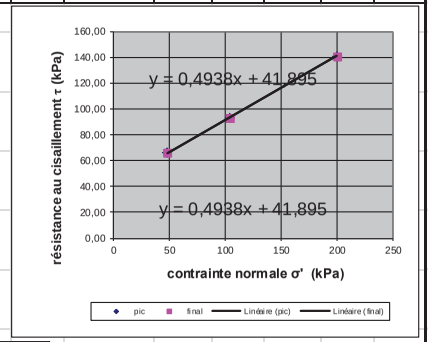
Direct linear shear test

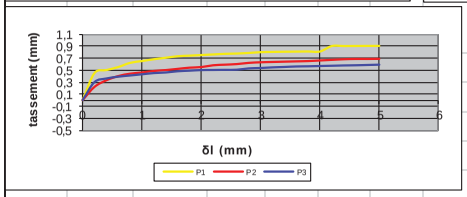
(réalisé conformément à la norme NF P 94-071-1)

Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'energie dans la région de Dakar				**CLIENT**	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	
Site:	Sococim Substation				**Date essai:**	29/12/2016	
N° Mélange:	SC4	**Prof. :**	4m à 5m	**Nature sol**	Greenish marl, tender to compact	**Vitesse de cis. =**	0.5 mm/mn
Caractéristiques de l'éprouvette						ρ_s	
Hauteur =	20 mm	Largeur, diamètre =	60 mm		mesuré =	2,700 T/m3	estimé =

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m^3)	ρd (T/m^3)	w (%)	e	Sr	ρd (T/m^3)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,72	1,626	5,9	0,6608					48,61	66,227	5	66,227	5
2	1,72	1,626	5,9	0,6608					104,18	92,811	3,2	92,811	5
3	1,72	1,626	5,9	0,6608					200,02	140,85	2,6	140,85	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	41,895	41,895	26,28	26,28

Observations:

L'ingénieur responsable des essais:

GEOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

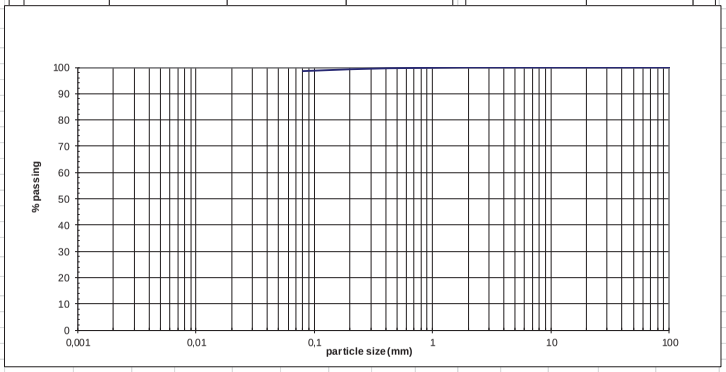
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC4 / SOCOCIM SUBSTATION	7	5,00m à 7,00m	Greenish marl, tender to compact	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
14,89			159,01	50,91	108,1	1,33	A4	1,569	1,366	2,271

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay | silt | fine sand | coarse sand | gravel | cobble



Sieve mesh size (mm)	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	99,5	99,2	98,7

Sieve mesh size (mm)											
Passing (%)											

OBSERVATIONS

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The engineer responsible of the tests

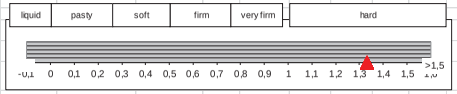
A-8-22

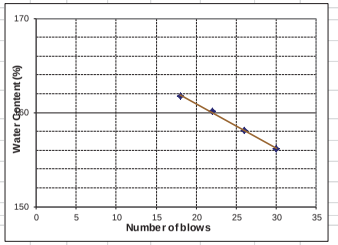
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC4 / SOCOCIM SUBSTATION	7	5,00m à 7,00m	Greenish marl, tender to compact	SIDY

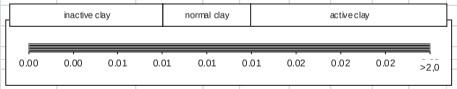
	1- Liquid Limit						2- Plasticy Limit			
Number of blows	18	22	26	30						
Tare N°	B3	B	M17	F+				X5	Z3	
Total wet weight	80,93	75,24	110,9	111,7				23,64	24,99	
Total dry weight	62,75	57,42	91,14	91,28				18,79	20,12	
Total weight of tares	51,51	46,29	78,62	78,2				9,43	10,38	
Net weight of water	18,18	17,82	19,79	20,42				4,85	4,87	
Weight of dry material	11,24	11,13	12,52	13,08				9,36	9,74	
Water content (%)	161,74	160,11	158,1	156,12				51,8162	50	
Limits and indices	W_L =	159,01	W_P =	50,908	I_P =	108,1	I_C =	1,33	A =	

3- Scale of Consistency (Ic)

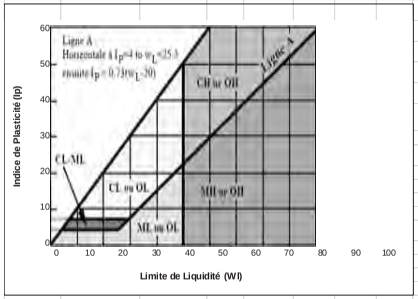




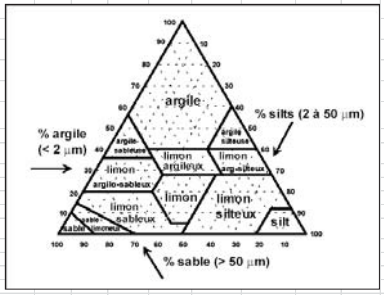
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	CH: Muddy, gravelly and/or sandy clay
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
		MH: Gravelly and/or sandy silt of high plasticity

Report of test with the oedometer (consolidation test)

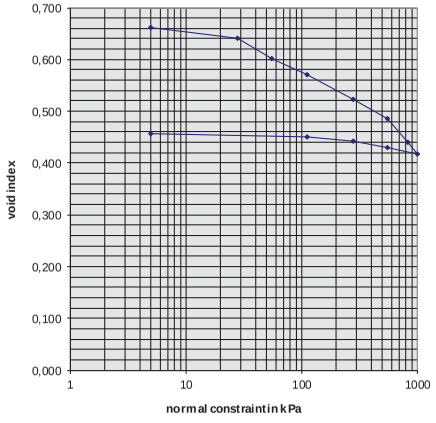
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**	Greenish marl, tender to compact	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.			
SITE :	date of arrival at the laboratory :		Borehole N° :
SOCOCIM SUBSTATION	date of tests :	09/01/2017	**SC4/SOCOCIM SUBSTATION**

characteristic of the test-tube or core		Before test		After test		Sample N° :
						7
Diameter : D	***in mm***	D_0 =	50,47			Depht of test-tube or
Height : H	***in mm***	Hi =	20			core (m) =
dry formerly densité	***in Mg/m³***	γ_{di} =	1,37	γ_{df} =		5,00m à 7,00m
Unit weight	***in MG/m³***	γ_s =	2,27			Experimenter :
Water content	***in %***	Wi =	14,89	Wf =		
Saturation degree	***in %***	Sri =	51,04	Srf =		Frame N° : 5

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,694	0,663
		2	28	28,0	0,671	0,640
		3	56	76,0	0,633	0,601
		4	111	115,0	0,601	0,570
		5	277	173,0	0,555	0,524
		6	555	219,0	0,518	0,487
		7	830	276,0	0,472	0,441
		8	1000	305,0	0,449	0,418
		9	555	289,0	0,462	0,430
		10	277	275,0	0,473	0,442
		11	111	264,0	0,482	0,451
		12	5	257,0	0,487	0,456

oedometer curve



Results

Characteristics of compressibility

void index		e_i=	0,663
		e_0=	0,61
Vertical effective constraint	(kPa)	σ'_{V0}=	81,96
Constraint of preconsolidation	(kPa)	$\sigma'p$=	190
Index of compression		Cc=	0,272
Pressure of swelling	(kPa)	Pg=	
Swelling Index		Cs=	

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

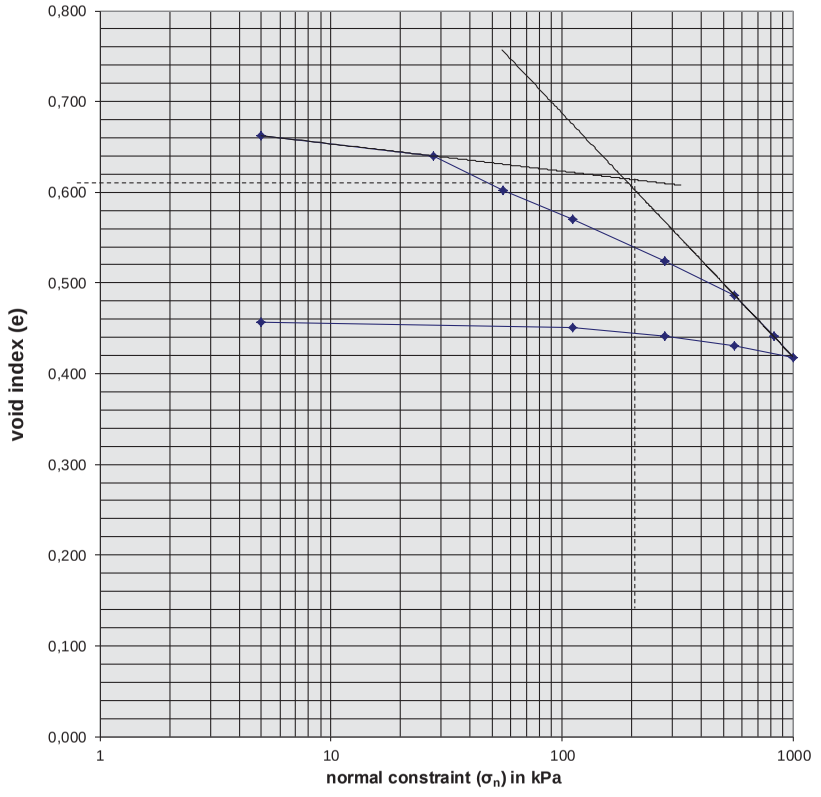
A-8-23

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**	Greenish marl, tender to compact	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.			
SITE :	date of arrival at the laboratory :		Borehole N° :
SOCOCIM SUBSTATION	date of tests :	09/01/2017	
	sampling depht. =	5,00m à 7,00m	Sample N° :
	test-tube (core)		7

oedometer curve



GEOTEC AFRIQUE - SENELABO _ Etude Préparatoire du Projet d'urgence de Renforcement et de Réhabilitation du réseau de transport d'énergie dans la région de Dakar / Rapport d'études géotechniques n° GT/2016-484

Direct linear shear test

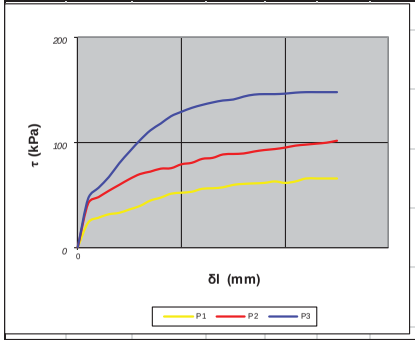
(réalisé conformément à la norme NF P 94-071-1)

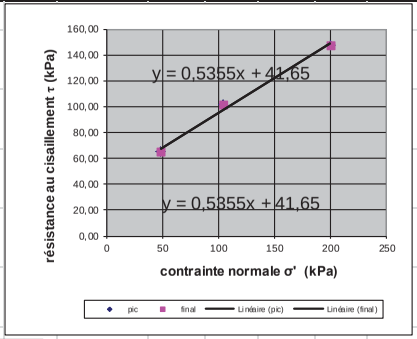
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'energie dans la région de Dakar	**CLIENT**	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.
Site:	Sococim Substation	**Date essai:**	29/12/2016

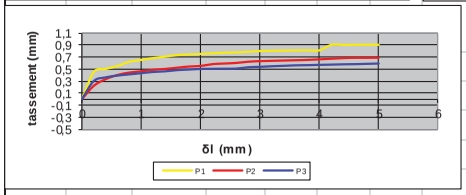
N° Sondage:	SC4	**Prof. :**	5m à 7m	**Nature sol**	Greenish marl, tender to compact	**Vitesse de cis. =**	0.5 mm/mn

Caractéristiques de l'éprouvette				ρ_s	
Hauteur =	20 mm	Largeur, diamètre =	60 mm	mesuré =	2,700 T/m3	estimé =	

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m^3)	ρd (T/m^3)	w (%)	e	Sr	ρd (T/m^3)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,57	1,366	14,9	0,9771					48,61	65,294	5	65,294	5
2	1,57	1,366	14,9	0,9771					104,18	101,21	3,2	101,21	5
3	1,57	1,366	14,9	0,9771					200,02	147,38	2,6	147,38	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	41,65	41,65	28,16	28,16

Observations:

L'ingénieur responsable des essais:

A-8-24

REPORT OF TESTS ON SAMPLE OF SOIL

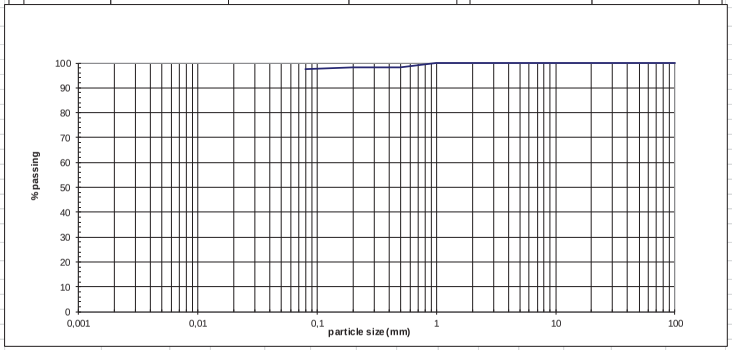
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC4 / SOCOCM SUBSTATION	10	14,20m à 14,90m	Greenish marl, tender	SIDY

Water Content *w* (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m^3)		Unit weight
			W_L	W_P	I_P	I_c		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
9,28			198,93	68,27	130,66	1,45		1,666	1,525	2,229

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m^3)	Optimal Moisture Content (%)	CBR(95% OPM)	*w* (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm)	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	98,4	98,2	97,4

Sieve mesh size (mm)										
Passing (%)										

OBSERVATIONS

.....
.....
.....
.....
.....

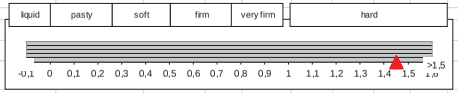
The engineer responsible of the tests

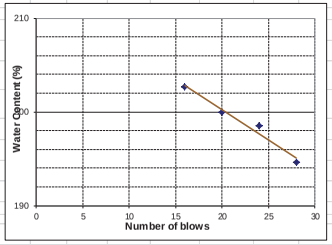
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SOCOCIM SUBSTA	10	14,20m à 14,90m	Greenish marl, tender	SIDY

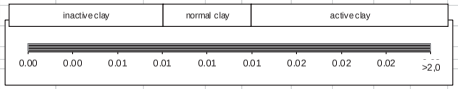
	1- Liquid Limit						2- Plasticy Limit		
Number of blows	16	20	24	28					
Tare N°	B10	B6	F24	E2			0	K1	
Total wet weight	79,79	76,26	79,81	77,5			61,57	62,01	
Total dry weight	63,05	59,76	61,55	59,85			53,68	53,63	
Total weight of tares	54,79	51,51	52,35	50,78			42,23	41,24	
Net weight of water	16,74	16,5	18,26	17,65			7,89	8,38	
Weight of dry material	8,26	8,25	9,2	9,07			11,45	12,39	
Water content (%)	202,66	200	198,5	194,6			68,9083	67,63519	
Limits and indices	W_L =	198,93	W_P =	68,272	I_P =	130,7	I_c =	1,45	A =

3- Scale of Consistency (Ic)

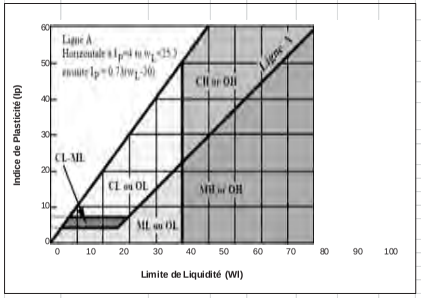




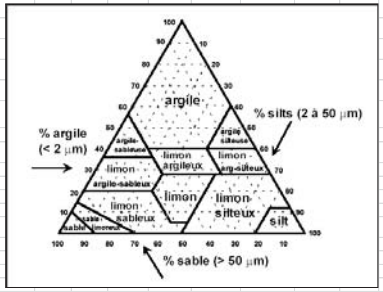
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	CH: Muddy, gravelly and/or sandy clay
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
		MH: Gravelly and/or sandy silt of high plasticity

A-8-25

Report of test with the oedometer (consolidation test)

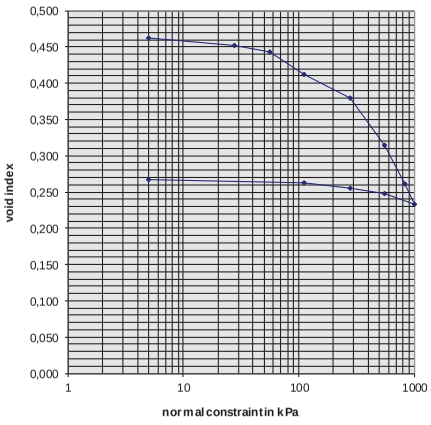
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	summery description :	Greenish marl, tender	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.			
SITE :	date of arrival at the laboratory :		Borehole N° :
SOCOCIM SUBSTATION	date of tests :	09/01/2017	SC4/SOCOCIM SUBSTATION

characteristic of the test-tube or core		Before test		After test		Sample N° :
Diameter : D	*in mm*	D_0 =	50,47			Depht of test-tube or
Height : H	*in mm*	Hi =	20			core (m) =
dry formerly densité	*in Mg/m³*	γ_{di} =	1,53	γ_{df} =		14,20m à 14,90m
Unit weight	*in MG/m³*	γ_s =	2,23			Experimenter :
Water content	*in %*	Wi =	9,28	Wf =		
Saturation degree	*in %*	Sri =	44,81	Srf =		Frame N° : 4

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,674	0,462
		2	28	11,5	0,665	0,453
		3	56	23,0	0,656	0,444
		4	111	64,0	0,624	0,411
		5	277	105,0	0,591	0,379
		6	555	188,0	0,526	0,314
		7	830	255,0	0,474	0,261
		8	1000	291,0	0,445	0,233
		9	555	273,0	0,460	0,247
		10	277	263,0	0,467	0,255
		11	111	254,0	0,475	0,262
		12	5	248,0	0,479	0,267

oedometer curve



Results

Characteristics of compressibility

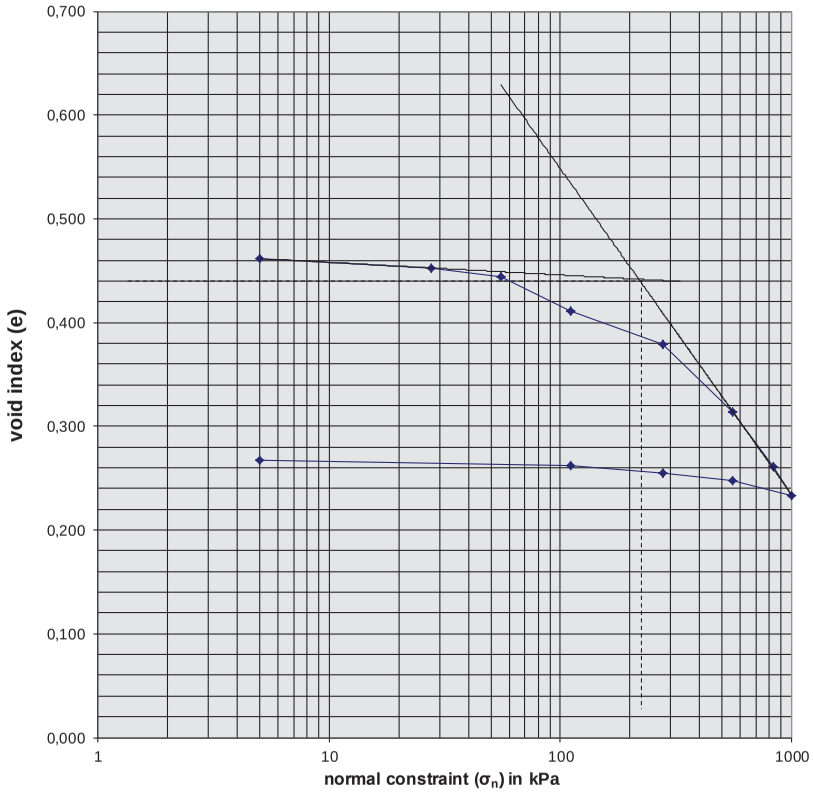
void index	e_i=	0,462
	e_0=	0,44
Vertical effective constraint	(kPa) σ'_{V0}=	221,9
Constraint of preconsolidation	(kPa) σ'_p=	210
Index of compression	C_c=	0,307
Pressure of swelling	(kPa) Pg=	
Swelling Index	C_s=	

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

GEOTEC SENELABO	**Report of test with the oedometer (consolidation test)**		
	Compression test on fine grained soils saturated with loading by stages		
	Test carried out in accordance with standard ASTM D2435		
PROJECT or BUILDING SITE :	**summery description :**	Greenish marl, tender	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.			
SITE :	date of arrival at the laboratory :		Borehole N° :
SOCOCIM SUBSTATION	date of tests :	09/01/2017	
	sampling depht. =	14,20m à 14,90m	Sample N° :
	test-tube (core)		10

oedometer curve



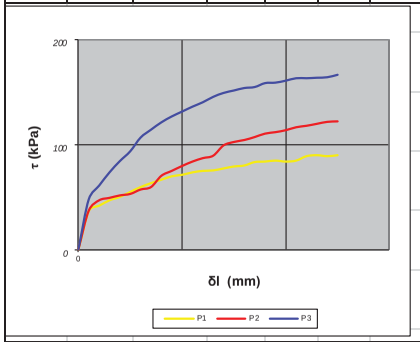
A-8-26

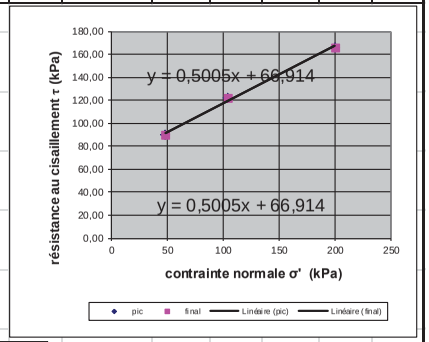
Direct linear shear test

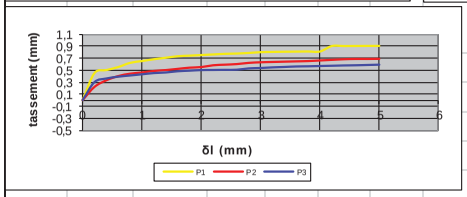
(réalisé conformément à la norme NF P 94-071-1)

Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'energie dans la région de Dakar				**CLIENT**	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	
Site:	Sococim Substation				**Date essai:**	29/12/2016	
N° Mélange:	SC4	**Prof. :**	14,2m à 14,9m	**Nature sol**	Greenish marl, tender	**Vitesse de cis. =**	0.5 mm/mn
Caractéristiques de l'éprouvette						ρ_s	
Hauteur =	20 mm	Largeur, diamètre =	60 mm		mesuré =	2,700 T/m3	estimé =

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m^3)	ρd (T/m^3)	w (%)	e	Sr	ρd (T/m^3)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,67	1,525	9,3	0,771					48,61	89,547	5	89,547	5
2	1,67	1,525	9,3	0,771					104,18	121,73	3,2	121,73	5
3	1,67	1,525	9,3	0,771					200,02	166,03	2,6	166,03	5
4													







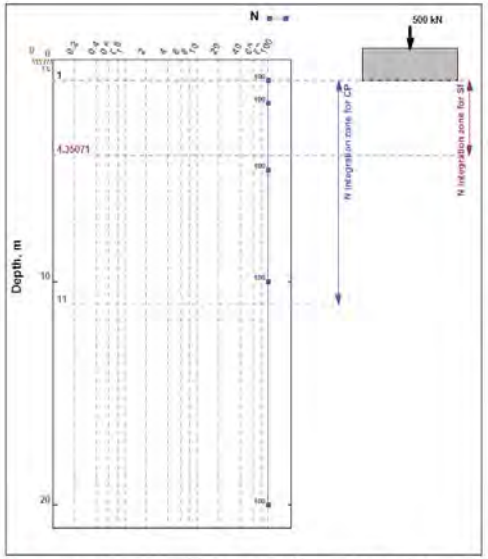
Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	66,914	66,914	26,58	26,58

Observations:

L'ingénieur responsable des essais:

Annex 3 : Sheet of geofond calculation

A-8-27



Foundation
Rectangular spread footing
Width : 5 m, Length : 8 m
area : 40 m²
Embeddment : 1 m
Foundation: 1 m

Soils parameters

Soils weight above the foundation :

Soils weight above the foundation :
Final vertical stress q'0: 14 kPa (calculated)
Initial vertical stress σ'v0: 14 kPa (calculated)

Time considered
10 year(s)

File : SOCOCIM SUBSTATION

GEOFOND® V1.19 of 08/06/2015 developed par GEOS
site web : http://www.geos.fr e-mail : logiciels@geos.fr

GEOS Ingénieurs Conseils, 310 Avenue Marie Curie
Bât. Europa 2, Archamps Technopole, F-74160 ARCHAMPS

Tél : + 33 (0)4 50 95 38 14
Fax : + 33 (0)4 50 95 99 36

Datas :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	500	0	0	0	500	0
2	ELU	750	0	0	0	750	0

Bearings capacityby the method of Meyerhoff (sand only):

				For the shallow foundation		For riffles	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'_u (MPa)	C.P. (MPa)	q'_u (MPa)	C.P. (MPa)
1	12.5	12.5	12.5	6.4	2.13 checked	4.49	1.5 checked
2	18.8	18.8	18.8	6.4	3.2 checked	4.49	2.25 checked

Settlement

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'_{v0} (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N*	S_f (cm)	S_f (cm)
1	12.5	100	0.014	1.17	1.5	1.4	0.00858	1	0.95	0.0315	0.557	65.7	0.0326	-0.0029
2	18.8	Non Calculé (ELU)												

GT/2016-484 _ NLB 19/01/2017 16:33	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 1	FIGURE
	Sococim substation	Transfer

SENELABO.BTP - 82368389461944000 1

Detailed results : bearing capacity

Load case No : 1

ELS, F = 500 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 500 kN, MB = 0 kN.m

With the Meyerhoff method

qmin = Hd/A * (1-6*e/B) = 0.0125 MPa ; qmax = Hd/A * (1+6*e/B) = 0.0125 MPa

qref(SLS) = (3.qmax(SLS) + qmin(SLS)) / 4 = 0.0125 MPa

q'0 = γ.D - γe.Ze = 14 kPa

$$Nm = 1/(2B - 0.5B)\int_{D+0.5B}^{D+2B} N(z).dz = 100$$

for the footings (B < 1.20 m)

3N/0.05 (1 + D/3B) = 6.4 MPa

Bearing capacity (SLS) = q'u / 3 = 2.13 MPa

for the base slabs (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 4.49 MPa

Bearing capacity (SLS) = q'u / 3 = 1.5 MPa

Detailes results : settlements

Load case No : 1

ELS, F = 500 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 500 kN, MB = 0 kN.m

Zi = 10 ^ (0.7606 * log(B) - 0.0065) = 3.35

$$Nm = 1/Zi\int_{D}^{D+Zi} N(z).dz = 100$$

With the BURLAND method

f1 = ((1.25 L/B) / (L/B + 0.25))² = 1.17

f2 = 1.5

f3 = 1.3 + 0.2 log(t/3) = 1.4

Sf = (1.71 B^0.7 / N^1.4) f1 f2 f3 (Δp/3) = 0.00858 cm

With the TERZAGHI & PECK method

Cw = σv / σv = 1 (at the D + B/2 level)

Cd = 1 - D/(4B) = 0.95

Sf = 0.000723 qref / (N - 3) (2B / (B + 0.3048))²Cw Cd = 0.0315 cm

With the PECK & BAZARAA method

Cn = 0.77 log (100 / σ'v0) = 0.657

N° = Cn.N = 65.7

Sf = 0.000508 qref / N° (2B / (B + 0.3048))²Cw Cd = 0.0326 cm

With the Alpan method

α0 = 4.98054 N^(-1.18020) = 0.0217

Sf = (L/B)^0.39 * (2B / (B + 0.3048))² * α0/12 * (qref - σ'v0)/95.76052 * 24/100 = -0.0029 cm

GT/2016-484 _ NLB 19/01/2017 16:33	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 2	FIGURE
	Sococim substation	Transfer

SENELABO.BTP - 82368389461944001

A-8-28

Detailed results : bearing capacity

Load case No : 2

ELU, F = 750 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 750 kN, MB = 0 kN.m

With the Meyerhoff method

qmin = Hd/A * (1-6*e/B) = 0.0187 MPa ; qmax = Hd/A * (1+6*e/B) = 0.0187 MPa

qref(SLS) = (3.qmax(SLS) + qmin(SLS)) / 4 = 0.0187 MPa

q'0 = γ.D - γe.Ze = 14 kPa

$$Nm = 1/(2B - 0.5B)\int_{D+0.5B}^{D+2B} N(z).dz = 100$$

for the footings (B < 1.20 m)

3N/0.05 (1 + D/3B) = 6.4 MPa

Bearing capacity (ULS) = q'u / 2 = 3.2 MPa

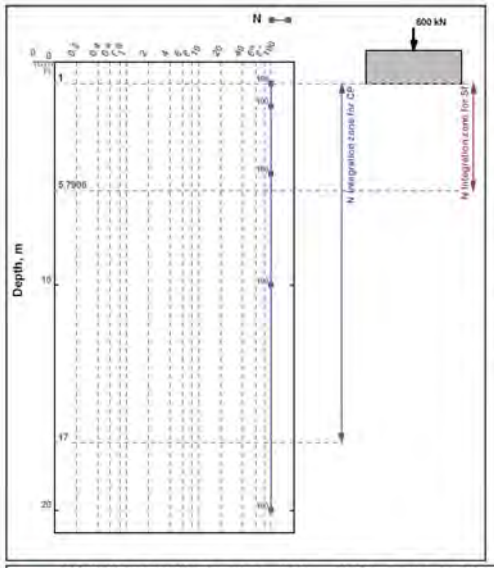
for the base slabs (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 4.49 MPa

Bearing capacity (ULS) = q'u / 2 = 2.25 MPa

GT/2016-484 _ NLB 19/01/2017 16:33	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 3	FIGURE
	Sococim substation	Transfer

SENELABO.BTP - 82368389461944001



Foundation
Rectangular spread footing
Width : 8 m, Length : 15 m
area : 120 m²
Embeddment : 1 m
Foundation: 1 m

Soils parameters

Soils weight above the foundation :

Soils weight above the foundation :
Final vertical stress q'0: 14 kPa (calculated)
Initial vertical stress σ'v0: 14 kPa (calculated)

Time considered
10 year(s)

File : SOCOCIM SUBSTATION

GEOFOND® V1.19 of 08/06/2015 developed par GEOS
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Tél : + 33 (0)4 50 95 38 14
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Datas :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	600	0	0	0	600	0
2	ELU	900	0	0	0	900	0

Bearings capacityby the method of Meyerhoff (sand only):

				For the shallow foundation		For riffles	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'u (MPa)	C.P. (MPa)	q'u (MPa)	C.P. (MPa)
1	5	5	5	6.25	2.08 checked	4.2	1.4 checked
2	7.5	7.5	7.5	6.25	3.13 checked	4.2	2.1 checked

Settlement

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'v0 (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N*	S_f (cm)	S_f (cm)
1	5	100	0.014	1.22	1.5	1.4	0.00496	1	0.969	0.0134	0.657	65.7	0.0139	-0.0194
2	7.5	Non Calculé (ELU)												

Detailed results : bearing capacity
Load case No : 1

ELS, F = 600 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 600 kN, MB = 0 kN.m

With the Meyerhoff method

qmin = Hd/A * (1-6*e/B) = 0.005 MPa ; qmax = Hd/A * (1+6*e/B) = 0.005 MPa

qref(SLS) = (3.qmax(SLS) + qmin(SLS)) / 4 = 0.005 MPa

q'0 = γ_1.D - γ_e.Ze = 14 kPa

$$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 100$$

for the footings (B < 1.20 m)

3N/0.05 (1 + D/3B) = 6.25 MPa

Bearing capacity (SLS) = q'u / 3 = 2.08 MPa

for the base slabs (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 4.2 MPa

Bearing capacity (SLS) = q'u / 3 = 1.4 MPa

Detailes results : settlements
Load case No : 1

ELS, F = 600 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 600 kN, MB = 0 kN.m

Zi = 10 ^ (0.7606 * log(B) - 0.0065) = 4.79

$$Nm = 1/Zi \int_{D}^{D+Zi} N(z).dz = 100$$

With the BURLAND method

f1 = ((1.25 L/B) / (L/B + 0.25))² = 1.22

f2 = 1.5

f3 = 1.3 + 0.2 log(t/3) = 1.4

Sf = (1.71 B^0.7 / N^1.4) f1 f2 f3 (Δp/3) = 0.00496 cm

With the TERZAGHI & PECK method

Cw = σv / σv = 1 (at the D + B/2 level)

Cd = 1 - D/(4B) = 0.969

Sf = 0.000723 qref / (N - 3) (2B / (B + 0.3048))²Cw Cd = 0.0134 cm

With the PECK & BAZARAA method

Cn = 0.77 log (100 / σ'v0) = 0.657

N* = Cn.N = 65.7

Sf = 0.000508 qref / N* (2B / (B + 0.3048))²Cw Cd = 0.0139 cm

With the Alpan method

α0 = 4.98054 N^(-1.18020) = 0.0217

Sf = (L/B)^0.39 * (2B / (B + 0.3048))² * α0/12 * (qref - σ'v0)/95.76052 * 24/100 = -0.0194 cm

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Detailed results : bearing capacity

Load case No : 2

ELU, F = 900 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 900 kN, MB = 0 kN.m

With the Meyerhoff method

qmin = Hd/A * (1-6*e/B) = 0.0075 MPa ; qmax = Hd/A * (1+6*e/B) = 0.0075 MPa

qref(SLS) = (3.qmax(SLS) + qmin(SLS)) / 4 = 0.0075 MPa

$q'0 = \gamma.D - \gamma e.Ze = 14$ kPa

$$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 100$$

for the footings (B < 1.20 m)

3N/0.05 (1 + D/3B) = 6.25 MPa

Bearing capacity (ULS) = q'u / 2 = 3.13 MPa

for the base slabs (B > 1.20 m)

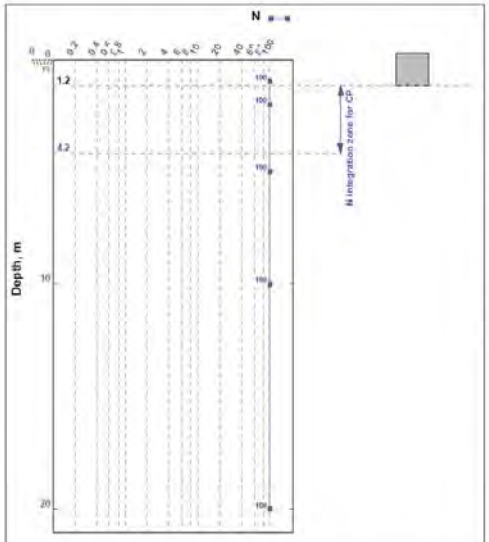
3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 4.2 MPa

Bearing capacity (ULS) = q'u / 2 = 2.1 MPa

GT/2016-484 _ NLB 19/01/2017 16:31	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 3	FIGURE
	Sococim substation	GIS Switchin

SENELABO.BTP - 8236838946194400O1

A-8-30



Foundation
Rectangular spread footing
Width : 1.5 m, Length : 2 m
area : 3 m²
Embeddment : 1.2 m
Foundation: 1.2 m

Soils parameters

Soils weight above the foundation :

Soils weight above the foundation :
Final vertical stress q'0: 16.8 kPa (calculated)
Initial vertical stress σ'v0: 16.8 kPa (calculated)

Time considered
10 year(s)

File : SOCOCIM SUBSTATION

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Fax :+ 33 (0)4 50 95 99 36

Calculation results: Bearing capacity

With the Meyerhoff method
(Sand only)
N = 100

For the base slabs
q'u = 6.84 MPa
Bearing capacity = 2.28 MPa
Bearing capacity = 3.42 MPa

GT/2016-484 _ NLB 19/01/2017 16:22	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 1	FIGURE
	Sococim substation	Building

SENELABO.BTP - 8236838946194400O1

Detailed results : bearing capacity

With the Meyerhoff method

$q'0 = \gamma_1 D - \gamma_e Ze = 16.8$ kPa

$$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 100$$

for the footings (B < 1.20 m)

3N/0.05 (1 + D/3B) = 7.6 MPa

Bearing capacity (SLS) = q'u / 3 = 2.53 MPa

Bearing capacity (ULS) = q'u / 2 = 3.8 MPa

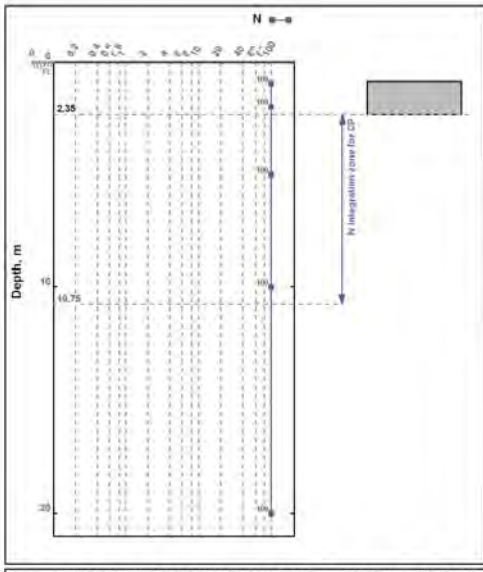
for the base slabs (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 6.84 MPa

Bearing capacity (SLS) = q'u / 3 = 2.28 MPa

Bearing capacity (ULS) = q'u / 2 = 3.42 MPa

A-8-31



Foundation
Rectangular spread footing
Width : 4.2 m, Length : 14.5 m
area : 60.9 m²
Embeddment : 2.35 m
Foundation: 2.35 m

Soils parameters

Soils weight above the foundation :

Soils weight above the foundation :
Final vertical stress q'0: 32.9 kPa (calculated)
Initial vertical stress σ'v0: 32.9 kPa (calculated)

Time considered
10 year(s)

File : SOCOCIM SUBSTATION

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Calculation results: Bearing capacity

With the Meyerhoff method
(Sand only)
N = 100

For the base slabs
q'u = 5.11 MPa
Bearing capacity = 1.7 MPa
Bearing capacity = 2.55 MPa

GT/2016-484 _ NLB 19/01/2017 16:17	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 1	FIGURE
	Sococim substation	Building Cable r

SENELABO.BTP - 8236838946194400001

Detailed results : bearing capacity

With the Meyerhoff method

$q'0 = \gamma_1 D - \gamma_e . Ze = 32.9$ kPa

$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 100$

for the footings (B < 1.20 m)

$3N/0.05\ (1 + D/3B) = 7.12$ MPa

Bearing capacity (SLS) = q'u / 3 = 2.37 MPa

Bearing capacity (ULS) = q'u / 2 = 3.56 MPa

for the base slabs (B > 1.20 m)

$3N/0.08\ (1 + D/3B)\ ((B + 0.3) / B)^2 = 5.11$ MPa

Bearing capacity (SLS) = q'u / 3 = 1.7 MPa

Bearing capacity (ULS) = q'u / 2 = 2.55 MPa

A-8-32

GEOTEC AFRIQUE SENELABO

GEOTECHNICAL REPORT

Etude Préparatoire du Projet d'urgence de Renforcement et de Réhabilitation du réseau de transport d'énergie dans la région de Dakar

JICA PROJECT TEAM

YACHIYO ENGINEERING CO., LTD.

DAKAR - SENEGAL

KEUR DAOUDA SARR SUBSTATION

January 27, 2017

SENELABO GÉOTECHNIQUE

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Mission G_2 AVP

GEOTECHNIC PRELIMINARY STUDY PROJECT

Etude Préparatoire du Projet d'urgence de Renforcement et de Réhabilitation du réseau de transport d'énergie dans la région de Dakar

JICA PROJECT TEAM

YACHIYO ENGINEERING CO., LTD.

DAKAR - SENEGAL

KEUR DAOUDA SARR SUBSTATION

January 27, 2017

A-8-33

N° FOLDER		GT/2016-484			GT	MISSION : G2AVP	
Index	Date	Number of pages		Emetted by	Verified by	Modifications Observations	Approved by
		Text	Annex				
0	07/01/2017	10	2	N. L. BADJI		First release	
A	27/01/2017	13	49	N. L. BADJI		Integration of laboratory test and foundation recommendation	
B							
C							

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I. PRESENTATION

I.1. DEFINITION OF THE OPERATION – CONTRIBUTOR

On request and on behalf of JICA PROJECT TEAM (YACHIYO ENGINEERING CO., LTD.), GEOTEC AFRIQUE-SENELABO was commissioned to carry out geotechnical studies for **"Projet d'urgence de Renforcement et de Réhabilitation du réseau de transport d'énergie dans la région de Dakar, SENEGAL".**

I.2. MISSION

This is a mission of G2AVP type according to NF P 94-500 standard as defined in the classification of types of geotechnical tasks prepared by the geotechnical trade union and standardized AFNOR NFP 94500 in November 2013.

This mission will allow :

- To define a field geotechnical investigation campaign and make its realization by core drilling with Standard Penetration Test (SPT) as in-situ soil testing ;
- To determine the nature of soils that can be mobilized and their depth ;
- To define foundation systems adapted to soils encountered and proposed buildings ;
- To determine the bearing capacity of soil in place ;
- To define the constructive arrangements for taking into account the phenomenon of shrinkage and swelling of the existing soil ;
- Provide recommendations for earthworks.

I.3. PROJECT - RECEIVED DOCUMENTS

The project consists of reinforcement and rehabilitation of the energy transport network of Dakar ; Keur daouda sarr substation. The features and details of the work are not been communicated to us. However it has been communicated to us the technical specifications for site investigation works.

I.4. CONVENTIONS USED

The various tests carried conform to AFNOR standards.

Recommendations and justifications were made according to the following regulations:

- XP ENV 1997-1 Eurocode 7 – geotechnical calculation - General rules;
- NF P11-300 : Earthworks ;
- AFNOR P11-211 – DTU 13.11 – shallow foundations ;
- AFNOR P11-711 – DTU 13.12 – Rules for the design of shallow foundations ;
- AFNOR NF P11-213-1 to 4 – DTU 13.3 – Rules for construction of pavings.

II. LOCALISATION AND GEOLOGICAL SETTINGS

II.1. SITE LOCATION

The Keur daouda Sarr substation site is located in the municipality of Keur Ndiaye LO near the rufisque-sangalkam road as saw below (figure 1).

Figure 1 : Keur daouda Sarr substation location map

II.2. GEOLOGICAL SETTING OF THE SITE

Geological studies on the peninsula of Cap-Vert by (Castelain and al[1], 1965; Tessier and al[2], 1967; Lappartient 1985; Crévola and al[3], 1994 etc.) and many other authors and updated by the PASMI[4] (2009), allowed to the stratigraphic synthesis of tertiary and quaternary formations in the area of Dakar (Figure 2).

The project site relies on the old tertiary and quaternary sedimentary rock. These formations are mainly :

- Marl and clay with planktonic and benthic foraminifera ;
- Clay facies with planpronic foraminifera and Ypresian clay-marly facies ;
- Clay, limestone, marl- limestone, marl and clay with planktonic and benthic foraminifera of the Middle and Lower Eocene.

[1] CASTELAIN J. (1965) – Aperçu stratigraphique et micropaléontologique du bassin du Sénégal occidental. Historique de la découverte paléontologique. In : « Colloque International de Micropaléontologie » (Dakar). Mémoire BRGM, 32, p. 135-159.

[2] TESSIER F. & LAPPARTIENT J-R. (1967) - Observations sur la latérite récente des environs de Dakar. Bull. Soc. Géol. Fr., Paris, 9 (7), p. 455-466.

[3] G. Crevola, J.-M. Cantagrel, C. Moreau, 1994. *Le volcanisme de la presqu'île du Cap-Vert (Sénégal) : cadre chronologique et géodynamique*, Bull. Soc. géol. France, 165, 5, 437-446.

[4] PASMI : Programme d'Appui au Secteur Minier / Projet 9 ACP SE 009 - Cartographie géologique du Bassin Sédimentaire, Geoter/BRGM/Direction des Mines et de la Géologie, Dakar, 2009.

Geologically, the study area is located at the Graben of Rufisque. This graben with general orientation NNE-SSW, is limited to the East by the horst of Diass. The Rufisque graben is characterized by Campano-Maastrichtian formations, Tertiary and Quaternary formations of the Senegal-Mauritanian basin. In the sector of Rufisque-Bargny and Diamniadio, in favor of several quarries, essentially four lithological ensembles are noted. This is the limestone unit ("Bargny limestone"), marly units ("marl with narrow clayey limestone beds with Frondicularia", "marl with clayey limestone beds" and "gray marl with Radiolarians"). This area is cut by sub-meridian faults which delimit the horst and the grabens. These faults are sometimes associated with volcanic events between the Upper Eocene and the Quaternary (Crevola et al., 1994).

These marly units are covered by the quaternary sands of the sangalkam erg on this area.

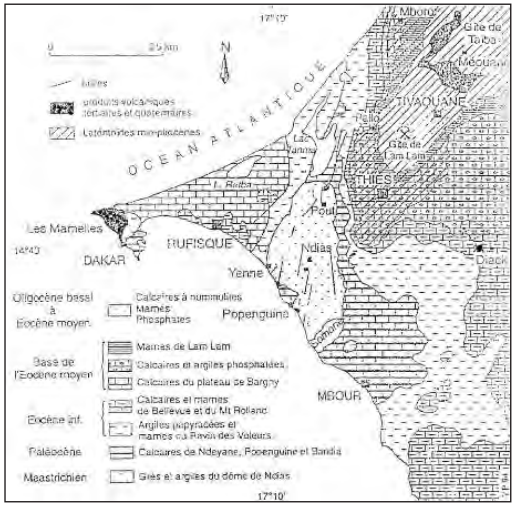

Figure 2: Geological map of the peninsula of Cap-Vert and the plateau of Thiès

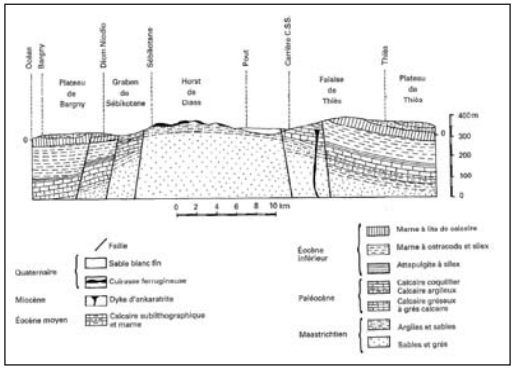

Figure 3: Geological cross-section of Diass Horst, plateau of Thiès and Bargny

III. PROGRAM AND RESULTS OF INVESTIGATION

III.1. PROGRAM OF INVESTIGATION

For this studies GEOTEC AFRIQUE - SENELABO realized on the site :

- One (01) borehole at 20m depth of investigation with SPT (in-situ soil testing) were carried out in order to take samples for laboratory tests and to define detailed log of the lithology of the site;
- Laboratory tests to identify and characterize the soil, we have done the following tests :
  - Moisture content tests [NF P 94-050]
  - Grain size analysis [NF P 94-056]
  - Specific Weight [NF P 94-053]
  - Apparent and absolute density [NF P 94-053, 94-064]
  - Atterberg limits [NF P 94-051]
  - VBS (Blue Methylen value) [NF P 94-068]
  - Direct linear shear test [NF P 94-071-1]
  - Standard oedometer test [NF P 94-090-1]
  - Compressive strength tests on rock [NF P 94-420]

III.2. DESCRIPTION OF THE CORES SAMPLES

At the location of the project, we conducted core drilling with SPT to identify and characterize the ground. The observations carried out allowed us to establish the log below.

Hole ID	Depth from (m)	Depth to (m)	Lithological description of cores
SC2/Keur Daouda Sarr Substation	0	0,5	Reddish sandy clay with calcareous concretions and lateritic gravel
	0,5	3,15	Brown yellowish sand
	3,15	3,45	Black compact sandy clay
	3,45	20,3	Greenish gray marl, tender to compact

NB : All the above depths are given at our Borehole and the reference level of depth are the existing ground level.

III.3. RESULTS OF STANDARDS PENETRATION TEST (SPT)

The project site relies on a tender to compact marl and covered by the quaternary sands. However we have carried out SPT tests and the results are summarized below.

Hole ID	Depth	Number of blows			
		Start of test	Test		N
		N0	N1	N2	
SC2/Keur Daouda Sarr Substation	1,5 to 1,95 m	2	3	4	7
	3,45 to 3,90 m	5	8	11	19
	up to 8 m	> 50 (without penetration)	-	-	> 100
	8 to 8,3 m	11	20	> 50 (without penetration)	> 100
	up to 20 m	> 50 (without penetration)	-	-	> 100
NB : The tests are carried out at intervals of 1m					

III.4. RESULTS OF THE LABORATORY TESTS AND SOIL CARACTERISATION

The results of laboratory tests conducted on soil samples collected from core samples are summarized on the table below.

CUSTOMER		JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.						
Project		ETUDE PREPARATOIRE DU PROJET D'URGENCE, DE RENFORCEMENT ET DE REHABILITATION DU RESEAU DE TRANSPORT D'ENERGIE DANS LA REGION DE DAKAR						
Borehole Number		SC2/Keur daouda Sarr substation						
Depth (m)		0,20m à 0,50m	0,50m à 1,50m	1,95m à 3,15m	3,15m à 3,45m	3,90m à 4,80m	6,50m à 6,90m	8,30m à 8,70m
Lithological nature of soil		Reddish sandy clay with calcareous concretions and lateritic gravel	Brown yellowish sand	Brown yellowish sand	Black compact sandy clay	Greenish gray marl, tender to compact	Greenish gray marl, tender to compact with clast	Greenish gray marl, tender to compact
Water content	W%	9,16	4,57	6,28	8,63	11,09	10,32	11,39
Wet density (t/m3)	γ_h	1,900	1,965	1,875	1,703	1,511	1,534	1,465
Dry density (t/m3)	γ_d	1,741	1,879	1,764	1,568	1,360	1,391	1,315
Specific density	γ_s	2,600	2,610	2,623	2,480	2,300	2,280	2,280
Grain size analysis	Dmax(mm)	5,0	2,0	1,0	2,0	0,5	5,0	0,5
	5mm	97,7	100,0	100,0	100,0	100,0	99,3	100,0
	2mm	95,2	99,8	100,0	97,5	100,0	98,1	100,0
	1mm	92,9	99,5	99,9	95,8	100,0	97,4	100,0
	0.5mm	90,4	98,8	99,5	93,5	99,4	97,0	99,8
	0.125mm	15,6	12,4	12,2	57,7	95,2	96,3	98,2
	0.08mm	13,1	9,0	9,3	54,7	94,4	95,9	98,0
Atterberg limits (%)	WL	-	-	-	52,86	153,21	208,25	222,08
	WP	-	-	-	15,11	49,88	67,37	58,79
	IP	-	-	-	37,75	103,33	140,88	163,30
	Ic	-	-	-	1,172	1,375	1,405	1,290
VBS		0,660	0,660	0,830	-	-	-	-
Cohésion (kPa)	C	20,833	12,123	14,065	22,408	75,503	50,433	60,185
Internal friction angle (°)	φ	31,68	35,21	34,83	15,01	16,16	20,01	15,22
Preconsolidation pressure (kPa)	σ'p	210	210	150	130	300	200	210
Compressibility index	Cc	0,157	0,108	0,135	0,240	0,234	0,368	0,291
Pressure of swelling (kPa)	Pg ≤					111	111	111
Classification GTR		B5	B2	B2	A3	A4	A4	A4

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On some core samples, Compressive strength tests are been carried out ant the results are summarized on the table below.

CUSTOMER		JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.
Project		ETUDE PREPARATOIRE DU PROJET D'URGENCE, DE RENFORCEMENT ET DE REHABILITATION DU RESEAU DE TRANSPORT D'ENERGIE DANS LA REGION DE DAKAR
Borehole Number		SC2/Keur daouda Sarr substation
Depth (m)		18,09m
Lithological nature of soil		Greenish gray marl, tender to compact
Compressive strength (MPa)	Rc	10,46
Description		Very weakly resistant

III.5. HYDROGEOLOGY OF THE SITE

The ground water was encountered at 3.10m during drilling. However, we can not exclude the presence of anarchic water circulations on preferential flow channels. The hydrological regime can vary depending on the season and rainfall.

III.6. NATURAL AND ANTHROPIC RISKS

The marl-limestone substratum is a sedimentary environment as well as sand and likely to have lateral variations in bedding thickness.

The ground water was encountered at 3.10m during drilling. This could have an impact on the foundation with the increase of the ground water level. It will be necessary to determine the level of the highest waters.

The soils encountered in the project area present a risk of shrinkage and swelling. Since variations in the water conditions of the environment may be accentuated by anthropogenic channels, plantations and runoff of rainwater, information on the risk of flooding in the lower areas of the project should be obtained.

We can also note the existence of underground electric cable and foundation of existing equipment in bargny substation.

III.7. SEISMICITY OF THE SITE

The project site is located at the plateau of Bargny tectonically stable and therefore deemed non-seismic.

III.8. DEFINITION OF ZONE OF INFLUENCE AND GEOTECHNICAL MODEL

The Geotechnical Influence Zone (GIZ) is not restricted to the parcel interested in the project. It also concerns the immediate environment (interfaces related to temporary earthworks) with the presence of roads and habitations near the project.

Aerial view of the site

According to the results of the laboratory tests, the geotechnical model can be defined in this version of the report (See table below).

Selected geotechnical characteristics										
Lithological nature of soil	Depth (m/GL)	Wet density (t/m3)	Specific density (t/m3)	VBS / Atterberg limits (Ip) %	Pressure of swelling Pg (kPa)	Cohésion (kPa)	Internal friction angle (°)	Classification according to the GTR	Compressive strength (MPa)	SPT N-value
Filling depot (sand and sandy clay with calcareous concretions and lateritic gravel)	3,45	1,86	2,6	0,7 / 37,7	-	17,4	29	B2 / A3	-	7
Greenish gray marl, tender to compact	> 20	1,50	2,3	134	≤ 111	62	17	A4 to R2	10,46	> 19

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IV. RECOMMENDATIONS

IV.1. JUSTIFICATION OF SHALLOW FOUNDATIONS

- **Definition of fondations :**

Considering the observations of the field investigation and foundation elements that have been transmitted to us, we check here a rectangular foundation raft for shallow foundation.

- **Strength limits of soil :**

The Geofond software was used to evaluate the bearing capacity of the soil. The calculation is done using the method of Meyerhoff which involves the calculation of an average value Nm of N by the relation:

$$N_m = \frac{1}{2B - 0{,}5B} \int_{D-0{,}5B}^{D+2B} N(z)dz$$

The breaking stress q'u under the base of foundation raft is given by the equation:

$$q'_u = \frac{3 \cdot N}{0{,}08} \cdot \left(1 + \frac{D}{3 \cdot B}\right) \cdot \left(\frac{B + 0{,}3}{B}\right)^2$$

With D = anchoring depth and B = Width of the foundation raft.

The bearing capacity at SLS and ULS are given respectively by $q'_u / 3$ and $q'_u / 2$ and the table below gives the results of this calculation.

Structures	Dimensions of the foundation raft	Anchoring depth (m) / GL	Applied load (kN)	Breaking stress q'_u (MPa)	Bearing capacity (MPa)		Settlements Sf (cm)
					SLS	ULS	
Container building	*2 m x 3 m*	*1,5*	*170*	3,25	1,08	1,63	≤ 0,66
	2 m x 3 m	*1,5*	*200*	3,25	1,08	1,63	≤ 0,78
	3 m x 4 m	*1,5*	*170*	4,08	1,36	2,04	≤ 0,32
	3 m x 4 m	*1,5*	*200*	4,08	1,36	2,04	≤ 0,37

- **Settlements deformations**

Considering loads that communicated to us, estimated settlements for this foundations raft are less than 1 cm.

IV.2. REALIZATION OF GROUND SLAB

Considering the characteristics of the materials that will be present at the bottom of the excavation, a sub-base will be realized according to the following recommendations :

- Flushing out any mediocre layers and those damaged by earth-moving equipment ;
- Recompact the bottom of excavation thus obtained ;
- Make a sub-base in materials, of a thickness to be defined by the prime contractor of the project. It can be realized in gravel, grave-cement, compacted sand, laterite, all coming from quarry etc.

To check the quality of the sub-base thus obtained, for this type of structure, KW> 50MPa / m and EV2 / EV1 <2 must be used according to the rules of DTU 13.3.

IV.3. EARTHWORKS REALISATION

- **Earthworks :**

If the foundations are shallow, will have to be envisaged a provisional supporting. It is excluded to carry out the earthworks without ensuring the stability of the excavations by an adapted supporting prohibiting any displacement in provisional and final phase.

- **Water Conditions**

Any water inflows in the excavations (runoff of rainwater) during earthworks will be evacuated.

IV.4. SPECIAL PRECAUTIONS FOR DESIGN AND EXECUTION

- **Constructives dispositions**

<u>Foundations</u> :

Structural adaptation of reference documents (Fascicule 62 and DTU) are to be considered.

IV.5. GEOTECHNICAL ALEAS AND CONTRACTUAL CONDITIONS

1. This report and its annexes constitute an inseparable whole. Misuse that could be made following a partial disclosure or reproduction does not engage GEOTEC AFRIQUE-SENELABO.
2. Changes in the location, design or importance of buildings as well as the assumptions used in particular in the indications of the "presentation" of this report can lead to challenges to the regulations. A new mission will then be entrusted to GEOTEC AFRIQUE-SENELABO to rehabilitate or validate these findings in writing the new project.

3. Similarly, new evidence revealed during the execution of the foundations and could not be detected in the soil reconnaissance (eg localized heterogeneity, water inflows, dissolution cavity, etc.) can render obsolete some of the recommendations contained in the report.
4. The ground reconnaissance proceed by ad hoc surveys, the results are not strictly extrapolated to the entire site. It persists hazards (eg local heterogeneity) that can lead to adaptations to the design of performance that can not be borne by the geotechnician.
5. At the time of the opening of the excavations, it is advisable to conduct a site visit by a geotechnician to GEOTEC AFRIQUE-SENELABO. This visit gives rise to a written notice on the verification of soil type and level seat of shallow foundations. This tour is subject to prior specific command.

A Dakar, 27/01/2017

Engineer in charge of the study

N. L. BADJI

ANNEX

A-8-39

Annex 1 : Log of the exploratory hole

Borehole Number	PROJECT : ETUDE PREPARATOIRE DU PROJET D'URGENCE ET DE RENFORCEMENT ET DE REHABILITATION DU RESEAU DE TRANSPORT D'ENERGIE DANS LA REGION DE DAKAR		
	Custumer : JICA STUDY TEAM		
SC2/Keur Daouda Sarr Substation	FOLDER : GT/2016-484		
	TYPE OF SAMPLING : Core drilling		
	DEPTH : 20,30 m Below existing ground level		
LOCALISATION: Keur Daouda Sarr	Coordonnées UTM _ zone 28P	X= 258057	Y=1630920

Ground water level	Description of cores									COMMENTS
	Depth (m) / existing ground level	Stratigraphic column	Lithological description	% of Recovery	SPT	Ø Drilling	Ø Tubing (mm)	Tool		PHOTOGRAPHIC DOCUMENTS
3,1m	0,5		Reddish sandy clay with calcareous concretions and lateritic gravel	100						
	3,15		Brown yellowish sand	45,28	SPT (1,5 à 1,95 m) N = 2 - 3 - 4					
	3,45		Black compact sandy clay	100	SPT (3,45 à 3,90 m) N = 5 - 8 - 11					0 à 5,70 m
										5,70 à 9,70 m
					SPT (8 à 8,30 m) N = 11 - 20 - R					
			Greenish gray marl, tender to compact	99,7				Double crown barrel T6 116 with crown		9,70 à 13,70 m
										13,70 à 17,30 m
	20,3									17,30 à 20,30 m

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Annex 2 : Sheet of laboratory tests

GEOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

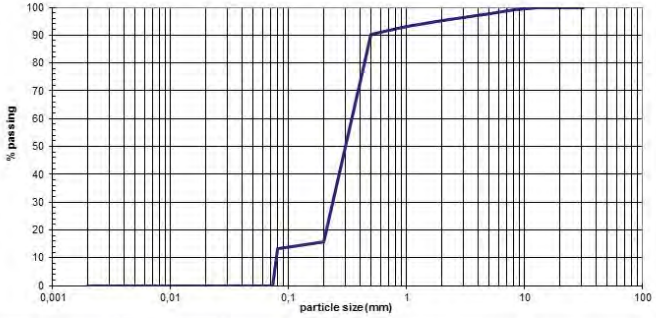
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC2 / KEUR DAOUDA SARR SUBSTATION	1	0,20m à 0,50m	Reddish sandy clay with calcareous concretions and lateritic gravel	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
9,16		0,66					B5	1,900	1,741	2,600

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm)	31,5	25	20	16	12,5	8	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	99,0	97,7	95,2	92,9	90,4	15,6	13,1

Sieve mesh size (mm)	0,073	0,053	0,039	0,025	0,018	0,013	0,009	0,006	0,004	0,002
Passing (%)										

OBSERVATIONS

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The engineer responsible of the tests

GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

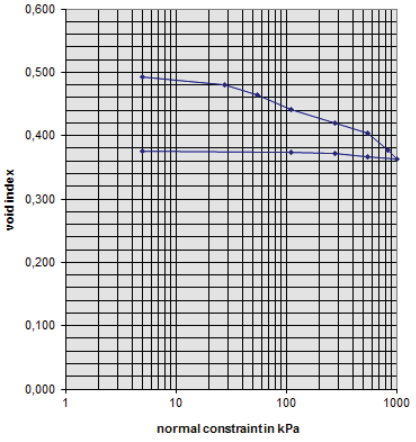
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	summery description :	Reddish sandy clay with calcareous concretions and lateritic gravel	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.			
SITE :	date of arrival at the laboratory :		Borehole N° :
Keur Daouda Sarr	date of tests :	09/01/2016	SC2

characteristic of the test-tube or core		Before test		After test		Sample N° :
Diameter : D	in mm	D_0 =	50,47			Depht of test-tube or core (m) =
Height : H	in mm	Hi =	20			0,20m à 0,50m
dry formerly densité	in Mg/m³	γ_{di} =	1,74	γ_{df} =		Experimenter :
Unit weight	in MG/m³	γ_s =	2,60			
Water content	in %	Wi =	9,16	Wf =		Frame N° :
Saturation degree	in %	Sri =	48,27	Srf =		

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,448	0,493
		2	28	20,0	0,435	0,480
		3	56	44,0	0,418	0,464
		4	111	76,0	0,397	0,442
		5	277	108,0	0,375	0,420
		6	555	131,0	0,359	0,405
		7	830	172,0	0,332	0,377
		8	1000	192,0	0,318	0,363
		9	555	186,0	0,322	0,367
		10	277	180,0	0,326	0,371
		11	111	177,0	0,328	0,373
		12	5	174,2	0,330	0,375

oedometer curve



Results

Characteristics of compressibility

void index	e_i =	0,493
	e_0 =	0,46
Vertical effective constraint	(kPa) σ'_{V0} =	5,999
Constraint of preconsolidation	(kPa) σ'_p =	210
Index of compression	C_c =	0,157
Pressure of swelling	(kPa) P_g =	
Swelling index	C_s =	

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

A-8-41

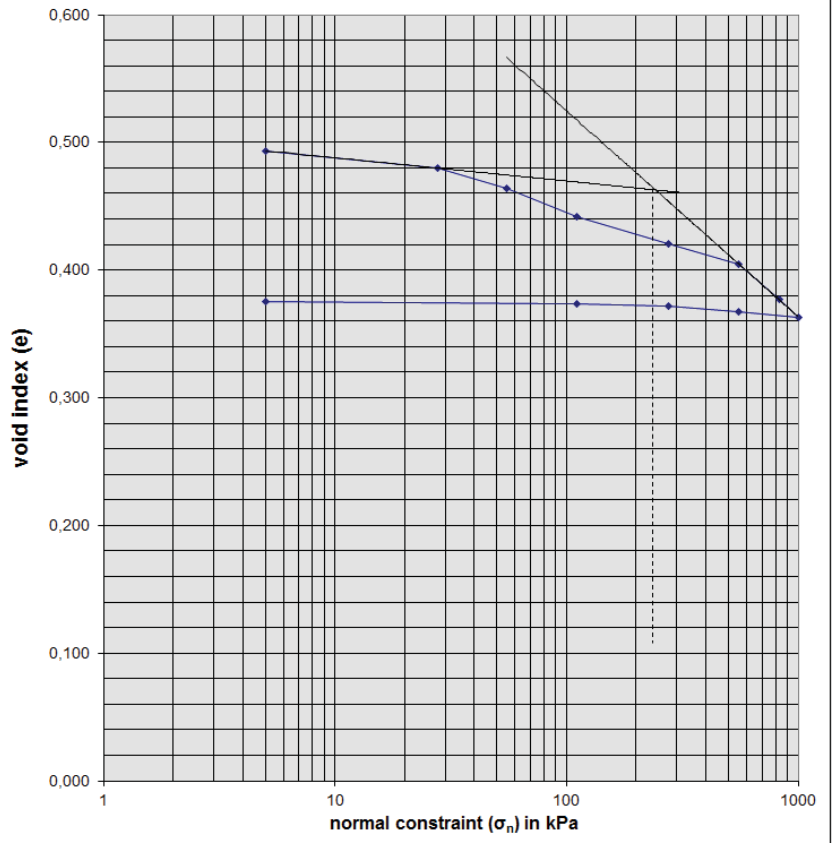
GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**	dy clay with calcareous concretions and la	Register N° :
CT TEAM / YACHIYO ENGINEERI			
SITE :	date of arrival at the laboratory :		Borehole N° :
Keur Daouda Sarr	date of tests :	09/01/2016	
	sampling depht. =	0,20m à 0,50m	Sample N° :
	test-tube (core)		

oedometer curve



A-8-42

Direct linear shear test

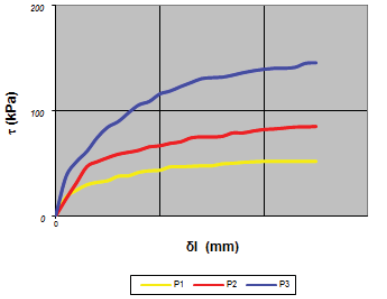
(réalisé conformément à la norme NF P 94-071-1)

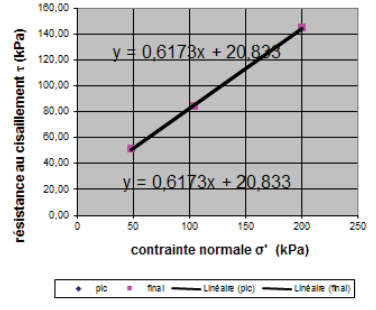
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar				**CLIENT**	JICA	
Site:	KEUR DAOUDA SARR				**Date essai:**	30/12/2016	
N° Sondage:	SC2	**Prof. :**	0,20m à 0,50m	**Nature sol**	Reddish sandy clay with calcareous concretions and lateritic gravel	**Vitesse de cis. =**	0.5 mm/mn

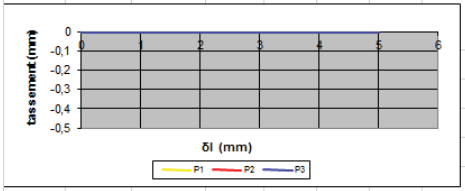
Caractéristiques de l'éprouvette — ρ_s

Hauteur = 20 mm | Largeur, diamètre = 60 mm | mesuré = 2,700 T/m3 | estimé =

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,90	1,741	9,16	0,5512				0	48,61	51,303	5	51,303	5
2	1,90	1,741	9,16	0,5512				0	104,18	84,416	3,2	84,416	5
3	1,90	1,741	9,16	0,5512				0	200,02	144,58	2,6	144,58	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	20,833	20,833	31,68	31,68

Observations:

L'ingénieur responsable des essais:

GÉOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

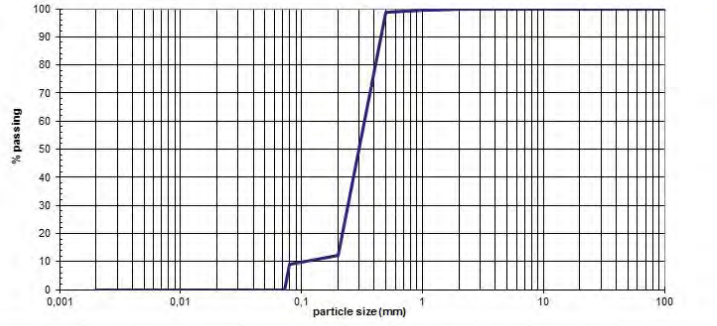
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC2/ BARGNY SUBSTATION	2	0,50m à 1,50m	Brown yellowish sand	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
4,57		0,66					B2	1,965	1,879	2,610

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm)	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	99,8	99,5	98,8	12,4	9,0

Sieve mesh size (mm)	0,073	0,053	0,039	0,025	0,018	0,013	0,009	0,006	0,004	0,002
Passing (%)										

OBSERVATIONS

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The engineer responsible of the tests

A-8-43

GÉOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

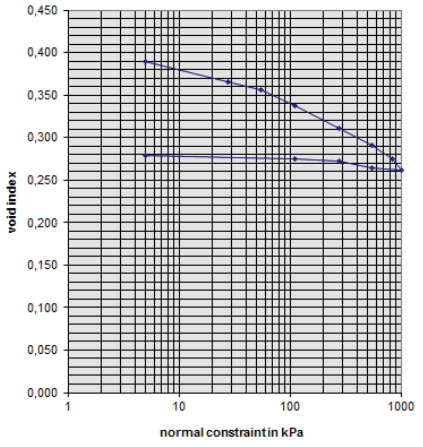
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	summery description :	Brown yellowish sand	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING			
SITE :	date of arrival at the laboratory :		Borehole N° :
Keur Daouda Sarr	date of tests :	09/01/2017	SC2

characteristic of the test-tube or core		Before test		After test		Sample N° :
Diameter : D	in mm	D_0 =	50,47			Depht of test-tube or core (m) =
Height : H	in mm	Hi =	20			0,50m à 1,50m
dry formerly densité	in Mg/m³	γ_{di} =	1,88	γ_{df} =		Experimenter :
Unit weight	in MG/m³	γ_s =	2,61			
Water content	in %	Wi =	4,57	Wf =	25,00	
Saturation degree	in %	Sri =	30,66	Srf =	167,72	Frame N° :

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	1,032	0,389
		2	28	26,0	1,008	0,365
		3	56	36,0	0,998	0,356
		4	111	55,0	0,981	0,338
		5	277	83,8	0,954	0,311
		6	555	106,0	0,933	0,290
		7	830	123,0	0,917	0,275
		8	1000	137,0	0,904	0,262
		9	555	134,0	0,907	0,264
		10	277	126,0	0,914	0,272
		11	111	122,0	0,918	0,276
		12	5	118,3	0,922	0,279

oedometer curve



Results

Characteristics of compressibility

void index	e_i=	0,389
	e_0=	0,335
Vertical effective constraint	(kPa) σ'_{V0}=	18,7
Constraint of preconsolidation	(kPa) σ'_p=	210
Index of compression	C_c=	0,108
Pressure of swelling	(kPa) P_g=	
Swelling index	C_S=	

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

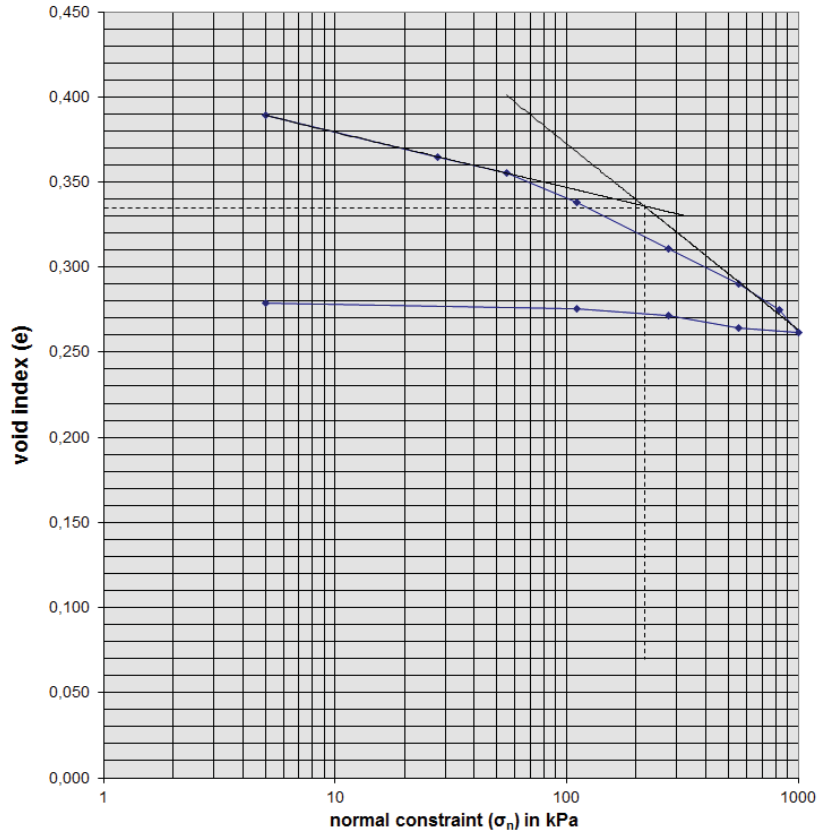
GÉOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**		Brown yellowish sand	Register N° :
CT TEAM / YACHIYO ENGINEERI				
SITE :	date of arrival at the laboratory :			Borehole N° :
Keur Daouda Sarr	date of tests :		09/01/2017	
	sampling depht.	=	0,50m à 1,50m	Sample N° :
	test-tube (core)			

oedometer curve



Direct linear shear test

(réalisé conformément à la norme NF P 94-071-1)

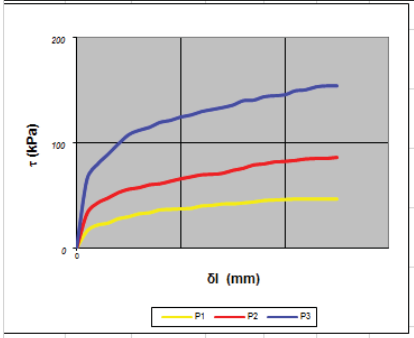
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'energie dans la région de Dakar			**CLIENT**	JICA
Site:	KEUR DAOUDA SARR			**Date essai:**	30/12/2016
N° Sondage:	SC2	**Prof. :**	0,50m à 1,50m	**Nature sol**	Brown yellowish sand

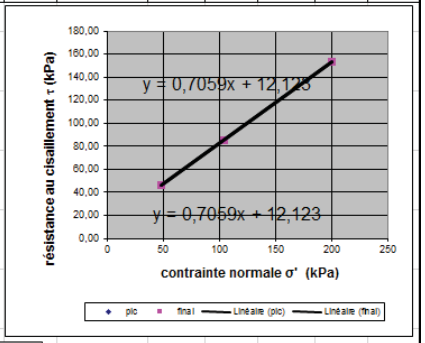
Vitesse de cis. = 0.5 mm/mn

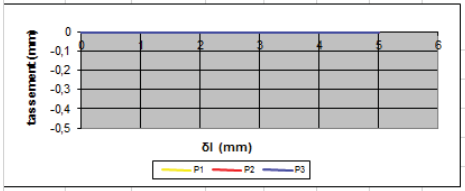
Caractéristiques de l'éprouvette — ρ_s

Hauteur = 20 mm | Largeur, diamètre = 60 mm | mesuré = 2,700 T/m3 | estimé =

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,97	1,879	4,57	0,4368				0	48,61	46,639	5	46,639	5
2	1,97	1,879	4,57	0,4368				0	104,18	85,349	3,2	85,349	5
3	1,97	1,879	4,57	0,4368				0	200,02	153,44	2,6	153,44	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	12,123	12,123	35,21	35,21

Observations:

L'ingénieur responsable des essais:

A-8-44

GEOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

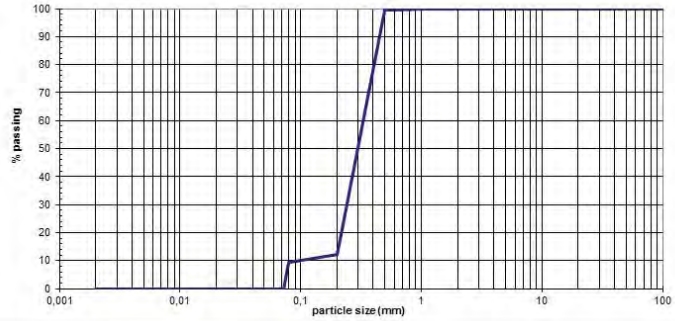
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	2 /KEUR DAOUDA SA	3	1,95m à 3,15m	Brown yellowish sand	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D221	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
6,28		0,83					B2	1,875	1,764	2,623

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm)	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	99,9	99,5	12,2	9,3

Sieve mesh size (mm)	0,073	0,053	0,039	0,025	0,018	0,013	0,009	0,006	0,004	0,002
Passing (%)										

OBSERVATIONS

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The engineer responsible of the tests

A-8-45

GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

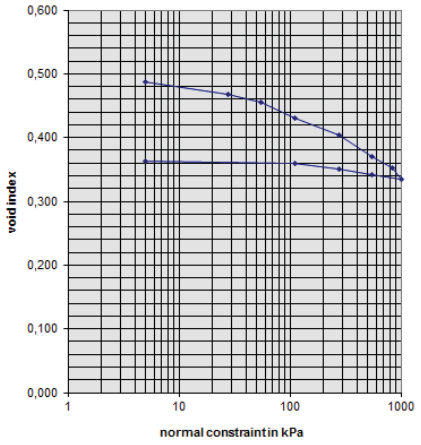
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	summery description :	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING		
SITE :	date of arrival at the laboratory :	Borehole N° :
Keur Daouda Sarr	date of tests : 09/01/2017	SC2

characteristic of the test-tube or core		Before test		After test		Sample N° :
						3
Diameter : D	in mm	D_0 =	50,47			Depht of test-tube or core (m) =
Height : H	in mm	Hi =	20			1,95m à 3,15m
dry formerly densité	in Mg/m³	γ_{di} =	1,76	γ_{df} =		Experimenter :
Unit weight	in MG/m³	γ_s =	2,62			
Water content	in %	Wi =	6,28	Wf =	18,01	Frame N° :
Saturation degree	in %	Sri =	33,83	Srf =	97,02	

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,943	0,487
		2	28	22,0	0,923	0,467
		3	56	34,2	0,912	0,456
		4	111	62,9	0,886	0,430
		5	277	92,0	0,860	0,404
		6	555	129,0	0,826	0,370
		7	830	149,0	0,808	0,352
		8	1000	168,0	0,791	0,335
		9	555	160,0	0,798	0,342
		10	277	151,0	0,806	0,350
		11	111	140,0	0,816	0,360
		12	5	137,0	0,819	0,363

oedometer curve



Results

Characteristics of compressibility

void index	e_i=	0,487
	e_0=	0,45
Vertical effective constraint	(kPa) σ'_{V0}=	38,808
Constraint of preconsolidation	(kPa) $\sigma'p$=	150
Index of compression	Cc=	0,135
Pressure of swelling	(kPa) Pg=	
Swelling index	Cs=	

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

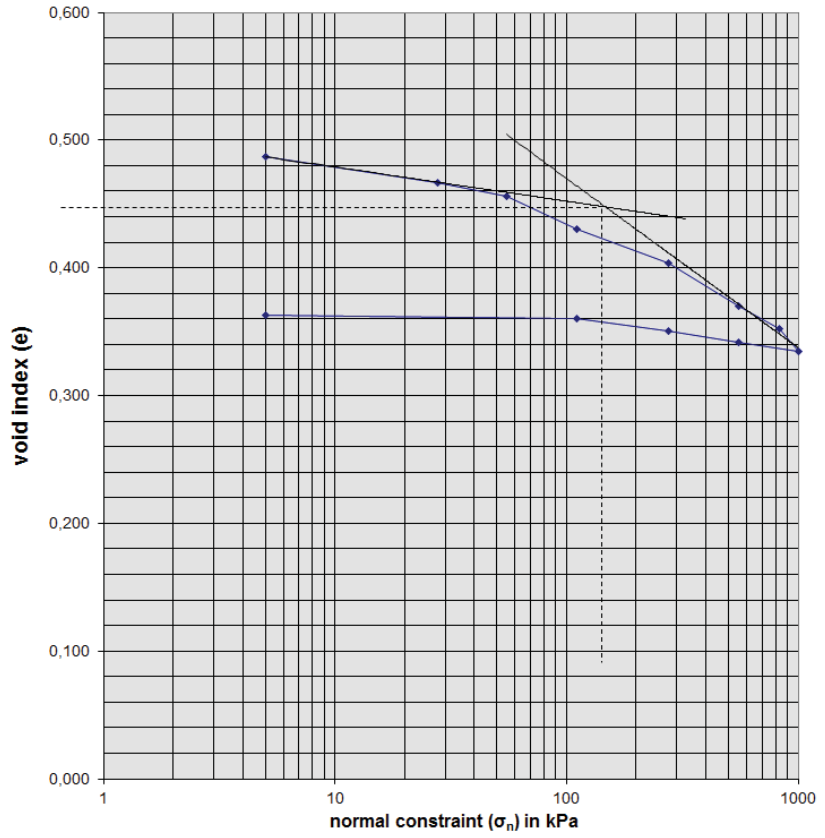
GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**			Register N° :
CT TEAM / YACHIYO ENGINEERI				
SITE :	date of arrival at the laboratory :			Borehole N° :
Keur Daouda Sarr	date of tests :		09/01/2017	
	sampling depht.	=	1,95m à 3,15m	Sample N° :
	test-tube (core)			3

oedometer curve



A-8-46

GEOTEC AFRIQUE SENELABO

Direct linear shear test

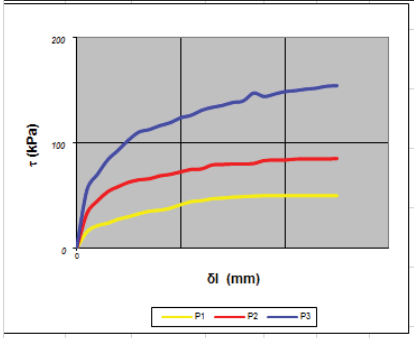
(réalisé conformément à la norme NF P 94-071-1)

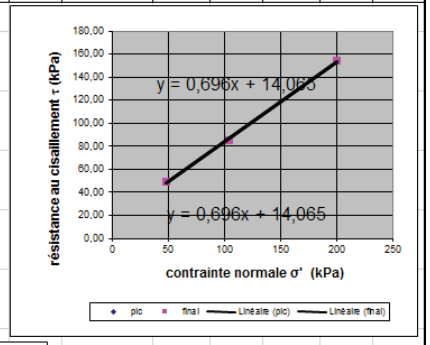
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'energie dans la région de Dakar			**CLIENT**	JICA
Site:	KEUR DAOUDA SARR			**Date essai:**	30/12/2016
N° Sondage:	SC2	**Prof. :**	1,95m à 3,15m	**Nature sol**	Brown yellowish sand
Vitesse de cis. =	0.5 mm/mn				

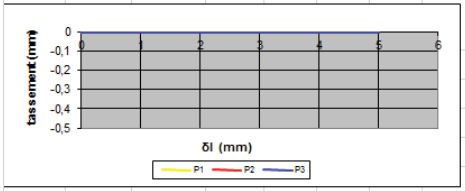
Caractéristiques de l'éprouvette — ρ_s

Hauteur = 20 mm | Largeur, diamètre = 60 mm | mesuré = 2,700 T/m3 | estimé =

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,88	1,764	6,28	0,5304				0	48,61	48,971	5	48,971	5
2	1,88	1,764	6,28	0,5304				0	104,18	84,883	3,2	84,883	5
3	1,88	1,764	6,28	0,5304				0	200,02	153,91	2,6	153,91	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	14,065	14,065	34,83	34,83

Observations:

L'ingénieur responsable des essais:

GEOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

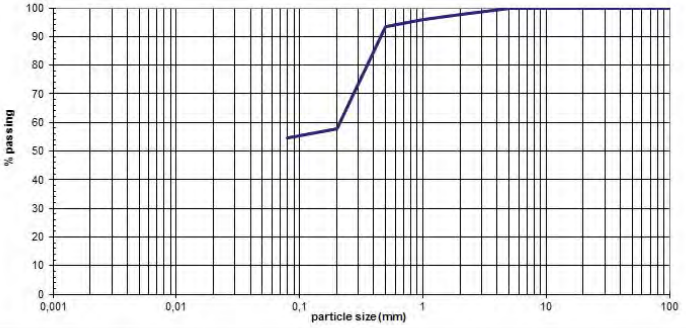
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	/ BARGNY SUBSTAT	4	3,15m à 3,45m	Black compact sandy clay	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D221	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
8,63			52,863	15,11	37,751	1,17	A3	1,703	1,568	2,480

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	97,5	95,8	93,5	57,7	54,7

Sieve mesh size (mm)												
Passing (%)												

OBSERVATIONS

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The engineer responsible of the tests

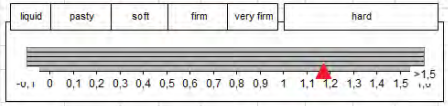
A-8-47

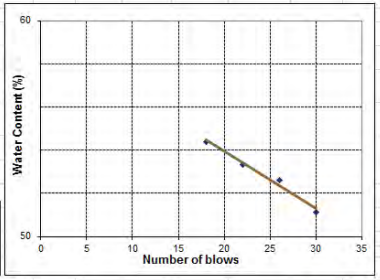
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.,	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	/ BARGNY SUBSTA	4	3,15m à 3,45m	Black compact sandy clay	SIDY

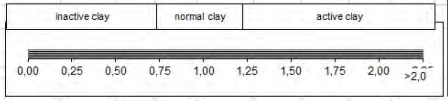
	1- Liquid Limit						2- Plasticy Limit		
Number of blows	18	22	26	30					
Tare N°	ZB	R	7	G			B2	P4	
Total wet weight	84,01	84,64	83,39	94,51			70,98	71,75	
Total dry weight	71,02	71,13	72,23	81,31			67,81	68,92	
Total weight of tares	47,14	45,8	51,02	55,48			46,97	50,07	
Net weight of water	12,99	13,51	11,16	13,2			3,17	2,83	
Weight of dry material	23,88	25,33	21,21	25,83			20,84	18,85	
Water content (%)	54,397	53,336	52,62	51,103			15,2111	15,01326	
Limits and indices	W_L =	52,863	W_P =	15,112	I_P =	37,75	I_C =	1,17	A =

3- Scale of Consistency (Ic)

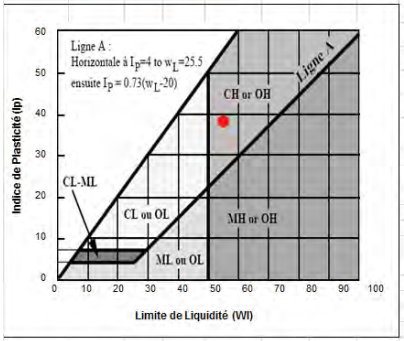




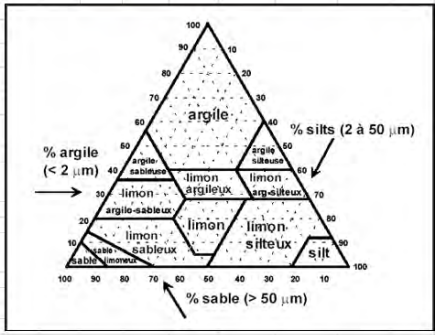
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	CH: Muddy, gravelly and/or sandy clay
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
		MH: Gravelly and/or sandy silt of high plasticity

Report of test with the oedometer (consolidation test)

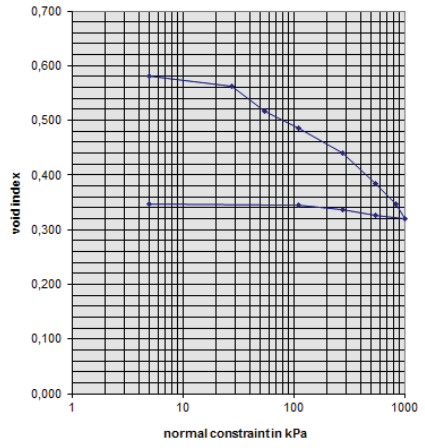
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**	Register N° :
T TEAM / YACHIYO ENGINEER		
SITE :	date of arrival at the laboratory :	Borehole N° :
KEUR DAOUDA SARR	date of tests : 03/12/2016	SC2

characteristic of the test-tube or core		Before test		After test		Sample N° :
						4
Diameter : D	*in mm*	D_0 =	50,47			Depht of test-tube or
Height : H	*in mm*	Hi =	20			core (m) =
dry formerly densité	*in Mg/m³*	γ_{di} =	1,57	γ_{df} =		3,15m à 3,45m
Unit weight	*in MG/m³*	γ_s =	2,48			Experimenter :
Water content	*in %*	Wi =	8,63	Wf =		
Saturation degree	*in %*	Sri =	36,80	Srf =		Frame N° : 1

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,622	0,582
		2	28	25,0	0,604	0,563
		3	56	88,0	0,558	0,517
		4	111	131,0	0,526	0,486
		5	277	192,0	0,482	0,441
		6	555	270,0	0,424	0,384
		7	830	319,0	0,388	0,348
		8	1000	356,0	0,361	0,320
		9	555	347,0	0,368	0,327
		10	277	334,0	0,377	0,337
		11	111	324,0	0,385	0,344
		12	5	319,0	0,388	0,348

oedometer curve



Results

Characteristics of compressibility

void index		e_i=	0,582
		e_0=	0,5
Vertical effective constraint	(kPa)	σ'_{V0}=	51,74
Constraint of preconsolidation	(kPa)	σ'_p=	130
Index of compression		Cc=	0,24
Pressure of swelling	(kPa)	Pg=	
Swelling index		Cs=	

Direct shear test

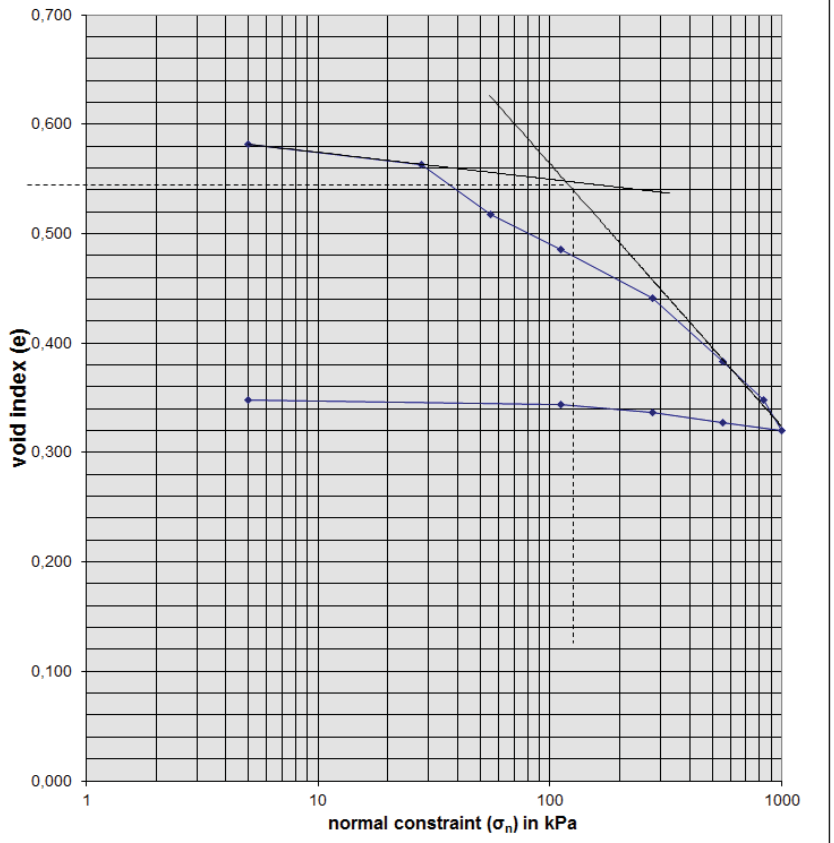
Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**			Register N° :
CT TEAM / YACHIYO ENGINEERI				
SITE :	date of arrival at the laboratory :			Borehole N° :
KEUR DAOUDA SARR	date of tests :		03/12/2016	
	sampling depht.	=	3,15m à 3,45m	Sample N° :
	test-tube (core)			4

oedometer curve



A-8-48

Direct linear shear test

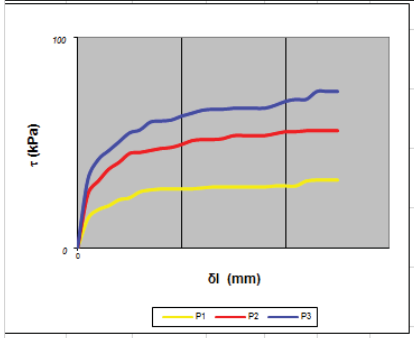
(réalisé conformément à la norme NF P 94-071-1)

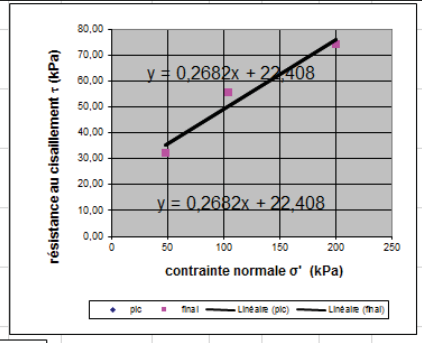
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'energie dans la région de Dakar	**CLIENT**	JICA
Site:	KEUR DAOUDA SARR	**Date essai:**	30/12/2016
N° Sondage: SC2	**Prof. :** 3,15m à 3,45m	**Nature sol**	Black compact sandy clay
Vitesse de cis. =	0.5 mm/mn		

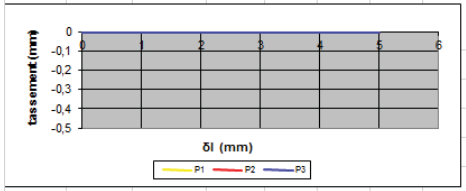
Caractéristiques de l'éprouvette — ρ_s

Hauteur = 20 mm — Largeur, diamètre = 60 mm — mesuré = 2,700 T/m3 — estimé =

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,70	1,568	8,63	0,7223				0	48,61	32,181	5	32,181	5
2	1,70	1,568	8,63	0,7223				0	104,18	55,5	3,2	55,5	5
3	1,70	1,568	8,63	0,7223				0	200,02	74,156	2,6	74,156	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	22,408	22,408	15,01	15,01

Observations:

L'ingénieur responsable des essais:

GEOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

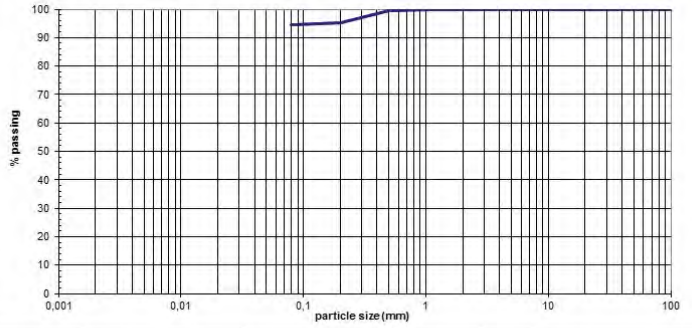
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.,	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC2 /KEUR DAOUDA SARR SUBSTATION	5	3,90m à 4,80m	Greenish gray marl, tender to compact	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
11,09			153,21	49,88	103,33	1,38	A4	1,511	1,360	2,300

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	99,4	95,2	94,4

Sieve mesh size (mm)											
Passing (%)											

OBSERVATIONS

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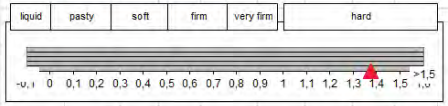
The engineer responsible of the tests

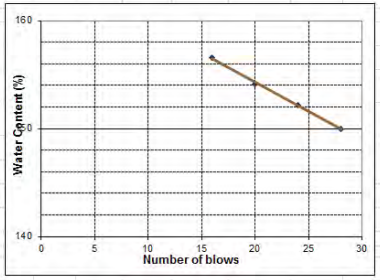
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS:
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	DAOUDA SARR SU	5	3,90m à 4,80m	Greenish gray marl, tender to compact	SIDY

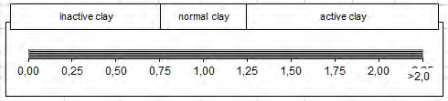
	1- Liquid Limit				2- Plasticy Limit	
Number of blows	16	20	24	28		
Tare N°	XD	M17	105	A8+	FII	XE
Total wet weight	99,35	125,89	130	106,95	80,11	80,79
Total dry weight	73,3	97,27	102,3	88,92	71,14	71,32
Total weight of tares	56,66	78,7	84,11	76,9	53,48	51,98
Net weight of water	26,05	28,62	27,71	18,03	8,97	9,47
Weight of dry material	16,64	18,57	18,21	12,02	17,66	19,34
Water content (%)	156,55	154,12	152,2	150	50,7928	48,96587
Limits and indices	W_L =	153,21	W_P =	49,879	I_P =	103,3	I_c =	1,38	A =

3- Scale of Consistency (Ic)

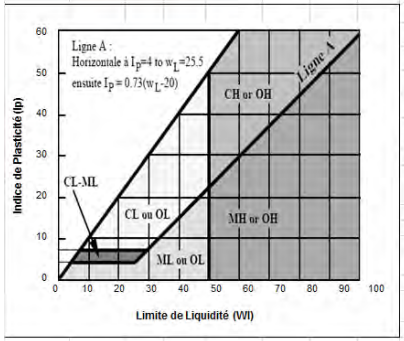




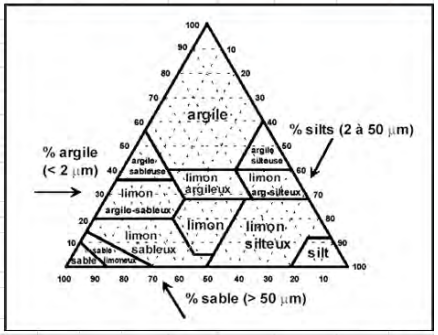
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	CH: Muddy, gravelly and/or sandy clay
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
		MH: Gravelly and/or sandy silt of high plasticity

A-8-50

Report of test with the oedometer (consolidation test)

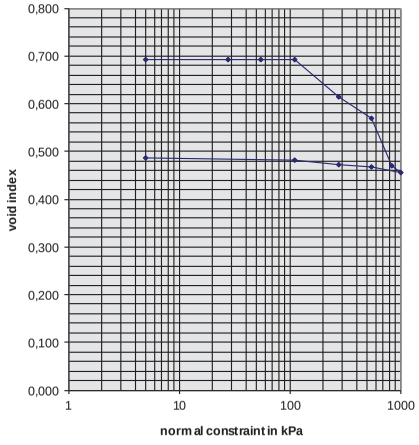
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : TEAM / YACHIYO ENGINEER	**summery description :**	Greenish gray marl, tender to compact	Register N° :
SITE : Keur Daouda Sarr	date of arrival at the laboratory :		Borehole N° :
	date of tests :	28/12/2016	**SC2**

characteristic of the test-tube or core		Before test		After test		Sample N° : **5**
Diameter : D	*in mm*	D_0 =	50,47			Depht of test-tube or core (m) =
Height : H	*in mm*	Hi =	20			3,90m à 4,80m
dry formerly densité	*in Mg/m³*	γ_{di} =	1,36	γ_{df} =		Experimenter :
Unit weight	*in MG/m³*	γ_s =	2,30			
Water content	*in %*	Wi =	11,09	Wf =		Frame N° : 5
Saturation degree	*in %*	Sri =	36,90	Srf =		

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	1,048	0,691
		2	28	0,0	1,048	0,691
		3	56	0,0	1,048	0,691
		4	111	0,0	1,048	0,691
		5	277	87,0	0,972	0,615
		6	555	139,0	0,926	0,570
		7	830	252,0	0,827	0,471
		8	1000	268,0	0,813	0,457
		9	555	257,0	0,823	0,466
		10	277	250,0	0,829	0,473
		11	111	240,0	0,838	0,481
		12	5	233,0	0,844	0,487

oedometer curve



Results

Characteristics of compressibility

void index		e_i=	0,691
		e_0=	0,691
Vertical effective constraint	(kPa)	σ'_{V0}=	59,16
Constraint of preconsolidation	(kPa)	$\sigma'p$=	300
Index of compression		Cc=	0,234
Pressure of swelling	(kPa)	Pg=	111
Swelling index		Cs=	

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

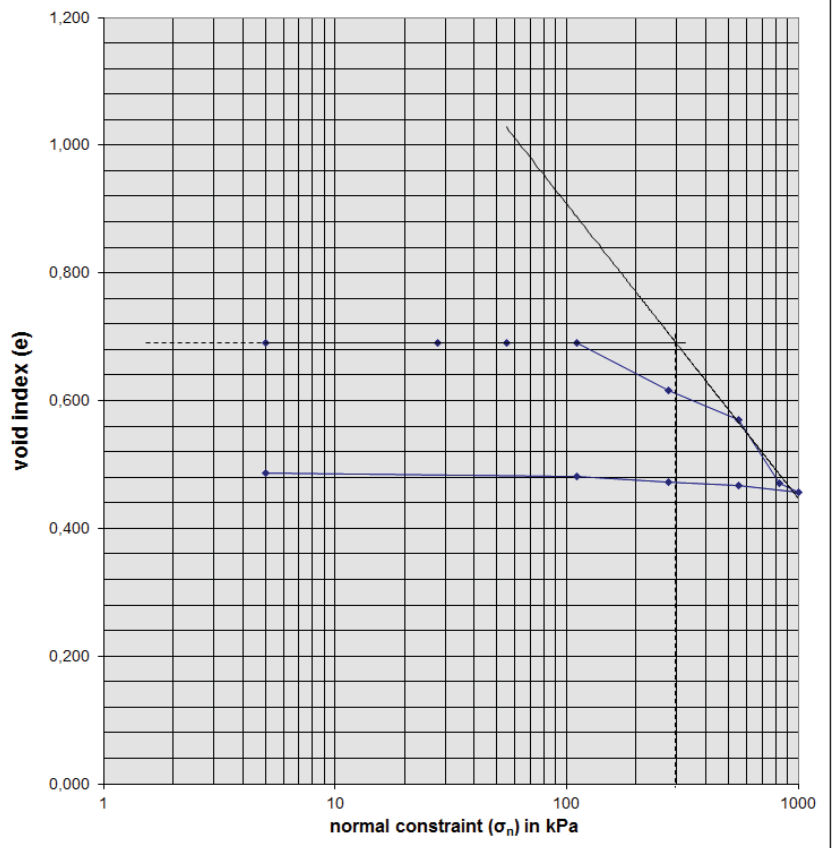
GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : YACHIYO ENGINEERING CO., LTD.	**summery description :**	Greenish gray marl, tender to compact	Register N° :
SITE : Keur Daouda Sarr	date of arrival at the laboratory :		Borehole N° :
	date of tests :	28/12/2016	
	sampling depht. =	3,90m à 4,80m	Sample N° :
	test-tube (core)		5

oedometer curve



A-8-51

GEOTEC AFRIQUE SENELABO

Direct linear shear test

(réalisé conformément à la norme NF P 94-071-1)

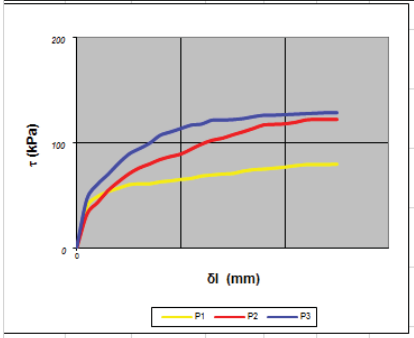
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'energie dans la région de Dakar			**CLIENT**	JICA
Site:	KEUR DAOUDA SARR			**Date essai:**	30/12/2016
N° Sondage:	SC2	**Prof. :**	3,90m à 4,80m	**Nature sol**	Marne tendre à compacte verdatre

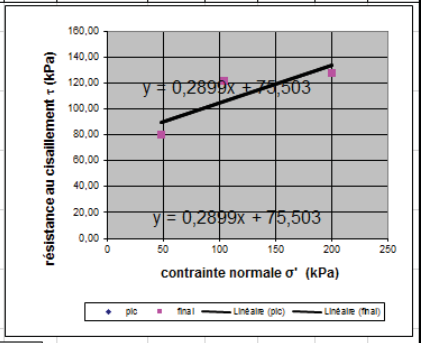
Vitesse de cis. = 0.5 mm/mn

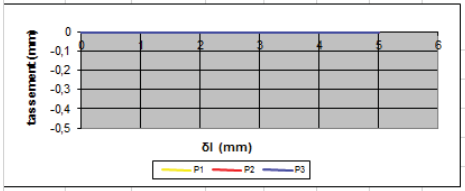
Caractéristiques de l'éprouvette — ρ_s

Hauteur = 20 mm | Largeur, diamètre = 60 mm | mesuré = 2,700 T/m3 | estimé =

N°	*Avant essai* ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	*Après consolid* ρd (T/m³)	t_{100} (mn)	*Après cisaillement* w (%)	σ' (kPa)	*Paramètres de résistance au cisaillement* $\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,51	1,360	11,09	0,9851				0	48,61	79,753	5	79,753	5
2	1,51	1,360	11,09	0,9851				0	104,18	121,26	3,2	121,26	5
3	1,51	1,360	11,09	0,9851				0	200,02	127,79	2,6	127,79	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	75,503	75,503	16,16	16,16

Observations:

L'ingénieur responsable des essais:

GEOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

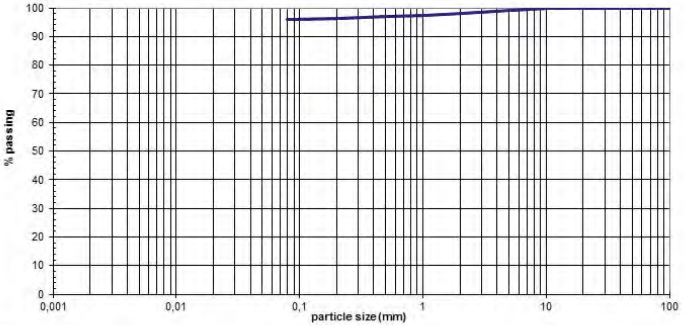
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	2 / KEUR DAOUDA SA	6	6,50m à 6,90m	Greenish gray marl, tender to compact	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D221	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
10,32			208,25	67,37	140,88	1,40	A4	1,535	1,391	2,280

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	99,3	98,1	97,4	97,0	96,3	95,9

Sieve mesh size (mm)												
Passing (%)												

OBSERVATIONS

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The engineer responsible of the tests

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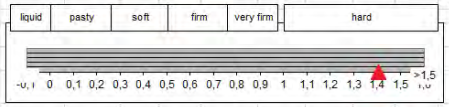
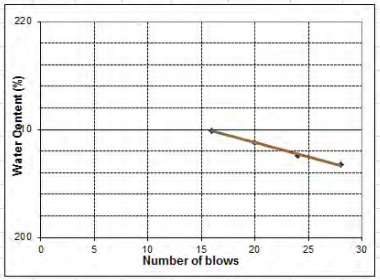
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.,	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC2 / KEUR DAOUDA SARR	6	6,50m à 6,90m	Greenish gray marl, tender to compact	SIDY

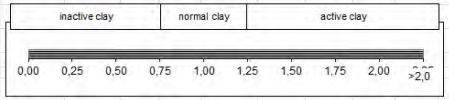
	1- Liquid Limit						2- Plastiey Limit		
Number of blows	16	20	24	28					
Tare N°	X0	BN	F+	A33			XA	AR	
Total wet weight	89,91	120,26	116,8	121,9			78,72	76,69	
Total dry weight	63,84	94,35	90,75	91,84			66,98	65,5	
Total weight of tares	51,42	81,94	78,21	77,3			49,69	48,76	
Net weight of water	26,07	25,91	26,03	30,06			11,74	11,19	
Weight of dry material	12,42	12,41	12,54	14,54			17,29	16,74	
Water content (%)	209,9	208,78	207,6	206,74			67,9005	66,84588	
Limits and indices	W_L =	208,25	W_P =	67,373	I_P =	140,9	I_C =	1,40	A =

3- Scale of Consistency (Ic)

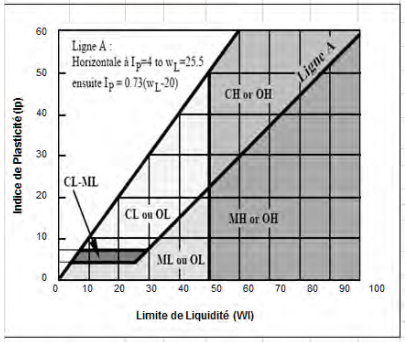




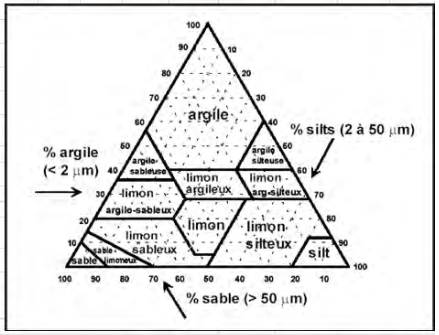
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	CH: Muddy, gravelly and/or sandy clay
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
		MH: Gravelly and/or sandy silt of high plasticity

Report of test with the oedometer (consolidation test)

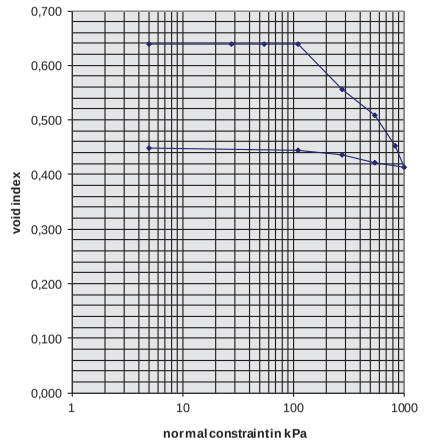
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : JICA PROJECT TEAM / YACHIYO ENGINEERING	**summery description :**	Greenish gray marl, tender to compact	Register N° :
SITE : Keur Daouda Sarr	date of arrival at the laboratory :		Borehole N° :
	date of tests :	28/12/2016	**SC2**

characteristic of the test-tube or core		Before test		After test		Sample N° : **6**
Diameter : D	***in mm***	D_0 =	50,47			Depht of test-tube or
Height : H	***in mm***	Hi =	20			core (m) =
dry formerly densité	***in Mg/m³***	γ_{di} =	1,39	γ_{df} =		6,50m à 6,90m
Unit weight	***in MG/m³***	γ_s =	2,28			Experimenter :
Water content	***in %***	Wi =	10,32	Wf =		
Saturation degree	***in %***	Sri =	36,82	Srf =		Frame N° : 6

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	$e_{corrected}$
		1	5	0,0	0,940	0,639
		2	28	0,0	0,940	0,639
		3	56	0,0	0,940	0,639
		4	111	0,0	0,940	0,639
		5	277	100,0	0,856	0,555
		6	555	156,0	0,809	0,508
		7	830	222,0	0,753	0,453
		8	1000	270,0	0,713	0,412
		9	555	260,0	0,721	0,421
		10	277	243,0	0,736	0,435
		11	111	231,0	0,746	0,445
		12	5	227,5	0,749	0,448

oedometer curve



Results

Characteristics of compressibility

void index		e_i=	0,639
		e_0=	0,67
Vertical effective constraint	(kPa)	σ'_{V0}=	93,197
Constraint of preconsolidation	(kPa)	σ'_p=	200
Index of compression		Cc=	0,368
Pressure of swelling	(kPa)	Pg=	111
Indice de gonfl Swelling index		Cs=	

Direct shear test

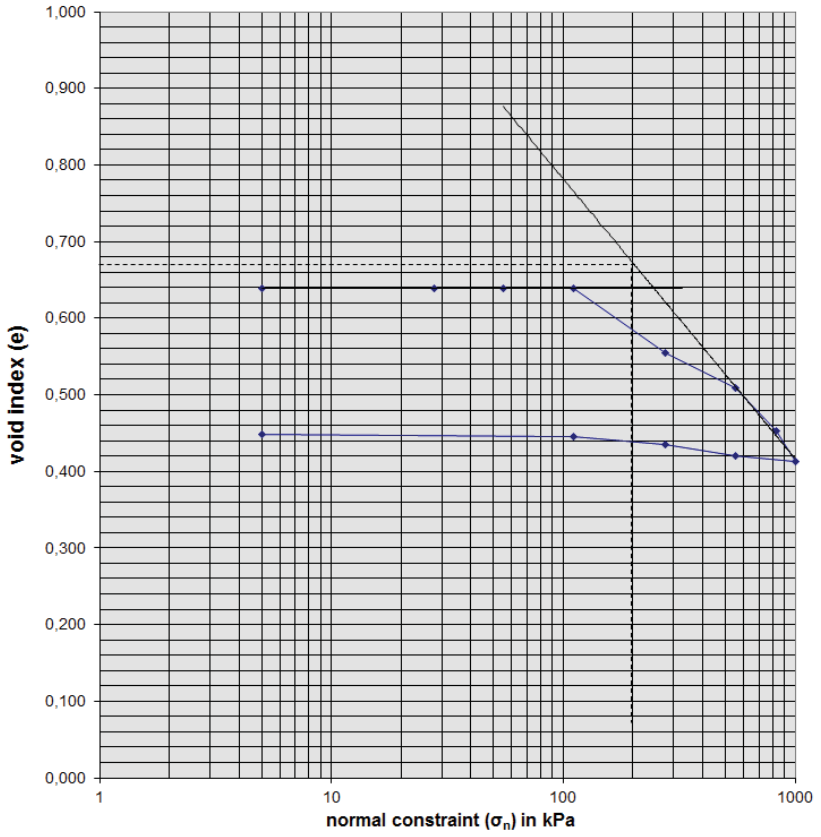
Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : CT TEAM / YACHIYO ENGINEERI	**summery description :**	Greenish gray marl, tender to compact	Register N° :
SITE : Keur Daouda Sarr	date of arrival at the laboratory :		Borehole N° :
	date of tests :	28/12/2016	
	sampling depht. =	6,50m à 6,90m	Sample N° :
	test-tube (core)		6

oedometer curve



A-8-53

Direct linear shear test

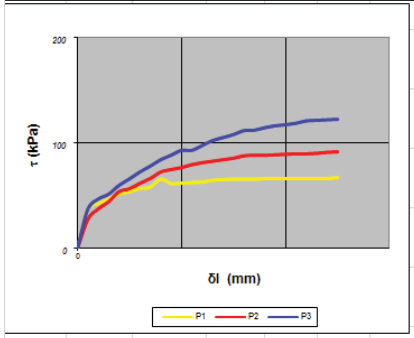
(réalisé conformément à la norme NF P 94-071-1)

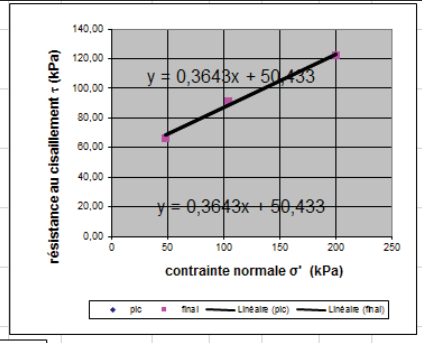
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'energie dans la région de Dakar			**CLIENT**	JICA
Site:	KEUR DAOUDA SARR			**Date essai:**	30/12/2016
N° Sondage:	SC2	**Prof. :**	6,50m à 6,90m	**Nature sol**	Greenish gray marl, tender to compact
Vitesse de cis. =	0.5 mm/mn				

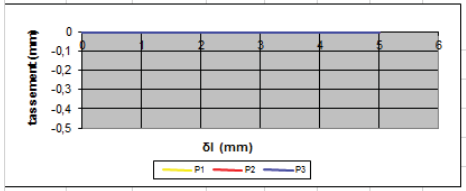
Caractéristiques de l'éprouvette — ρ_s

Hauteur = 20 mm — Largeur, diamètre = 60 mm — mesuré = 2,700 T/m3 — estimé =

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,53	1,391	10,32	0,9417				0	48,61	66,227	5	66,227	5
2	1,53	1,391	10,32	0,9417				0	104,18	91,412	3,2	91,412	5
3	1,53	1,391	10,32	0,9417				0	200,02	122,19	2,6	122,19	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	50,433	50,433	20,01	20,01

Observations:

L'ingénieur responsable des essais:

A-8-54

GEOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

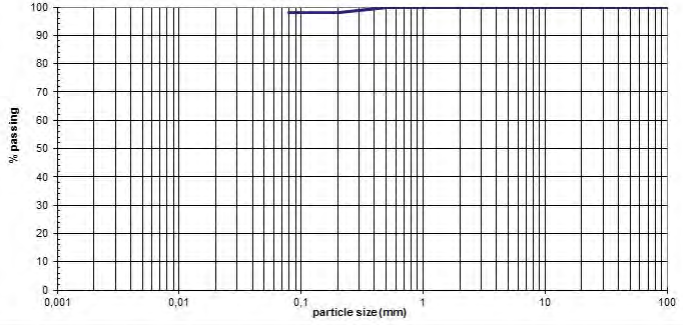
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC2 / KEUR DAOUDA SARR	7	8,30m à 8,70m	Greenish gray marl, tender to compact	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
11,39			222,08	58,79	163,3	1,29	A4	1,465	1,315	2,280

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm)	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	99,8	98,2	98,0

Sieve mesh size (mm)											
Passing (%)											

OBSERVATIONS

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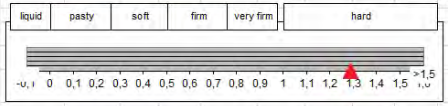
The engineer responsible of the tests

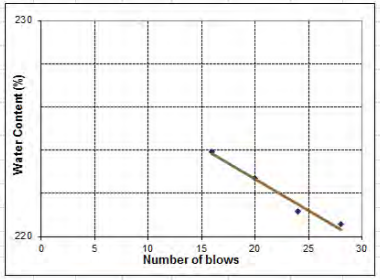
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	/ KEUR DAOUDA S	7	8,30m à 8,70m	Greenish gray marl, tender to compact	SIDY

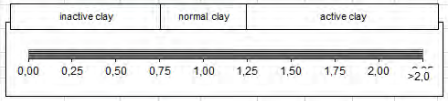
	1- Liquid Limit				2- Plasticy Limit			
Number of blows	16	20	24	28				
Tare N°	FII	G	105	A8		G7	0M	
Total wet weight	76,35	79,74	117,6	106,06		33,83	30,88	
Total dry weight	60,54	62,95	94,5	84,93		28,21	25,59	
Total weight of tares	53,48	55,41	84,05	75,35		18,31	16,89	
Net weight of water	15,81	16,79	23,11	21,13		5,62	5,29	
Weight of dry material	7,06	7,54	10,45	9,58		9,9	8,7	
Water content (%)	223,94	222,68	221,1	220,56		56,7677	60,8046	
Limits and indices	W_L =	222,08	W_P =	58,786	I_P =	163,3	I_c =	1,29	A =

3- Scale of Consistency (Ic)

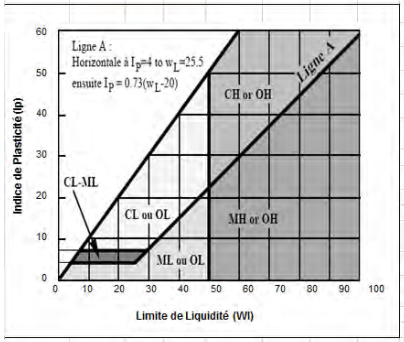




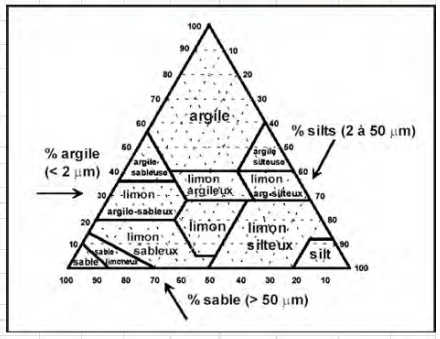
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)	
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt
CH: Muddy, gravelly and/or sandy clay	
OH: Organic, gravelly and/or sandy clay muddy	
MH: Gravelly and/or sandy silt of high plasticity	

A-8-55

GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

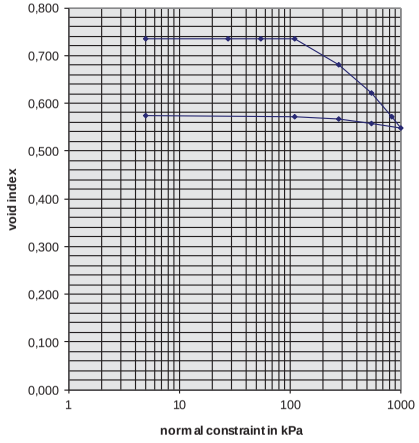
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	summery description :	Greenish gray marl, tender to compact	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.			
SITE :	date of arrival at the laboratory :		Borehole N° :
Keur Daouda Sarr	date of tests :	28/12/2016	**SC2**

characteristic of the test-tube or core		Before test		After test		Sample N° :
						7
Diameter : D	***in mm***	D_0 =	50,47			Depht of test-tube or
Height : H	***in mm***	Hi =	20			core (m) =
dry formerly densité	***in Mg/m³***	γ_{di} =	1,32	γ_{df} =		8,30m à 8,70m
Unit weight	***in MG/m³***	γ_s =	2,28			Experimenter :
Water content	***in %***	Wi =	11,39	Wf =		
Saturation degree	***in %***	Sri =	35,39	Srf =		Frame N° :
						3

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,715	0,734
		2	28	0,0	0,715	0,734
		3	56	0,0	0,715	0,734
		4	111	0,0	0,715	0,734
		5	277	70,0	0,661	0,680
		6	555	145,0	0,603	0,622
		7	830	209,0	0,554	0,573
		8	1000	240,0	0,530	0,549
		9	555	229,0	0,538	0,557
		10	277	218,0	0,547	0,566
		11	111	212,0	0,551	0,570
		12	5	208,5	0,554	0,573

oedometer curve



Results

Characteristics of compressibility

void index		e_i= 0,734
		e_0= 0,734
Vertical effective constraint	(kPa)	σ'_{V0}= 111,78
Constraint of preconsolidation	(kPa)	$\sigma'p$= 210
Index of compression		Cc= 0,291
Pressure of swelling	(kPa)	Pg= 111
Swelling index		Cs=

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

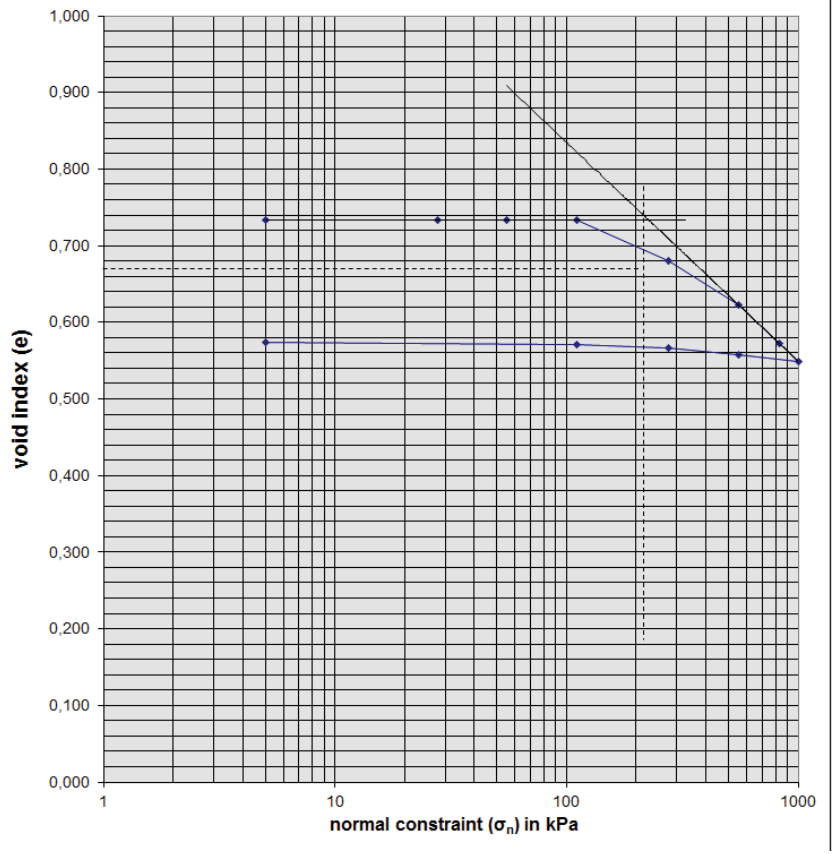
GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**	Greenish gray marl, tender to compact	Register N° :
YACHIYO ENGINEERING CO., LTD.			
SITE :	date of arrival at the laboratory :		Borehole N° :
Keur Daouda Sarr	date of tests :	28/12/2016	
	sampling depht. =	8,30m à 8,70m	Sample N° :
	test-tube (core)		7

oedometer curve



A-8-56

Direct linear shear test

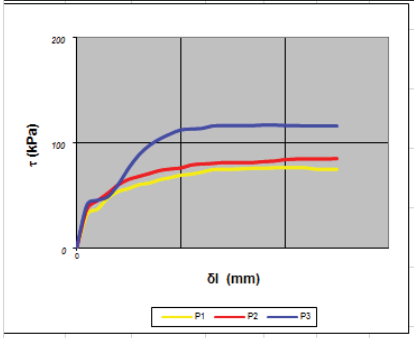
(réalisé conformément à la norme NF P 94-071-1)

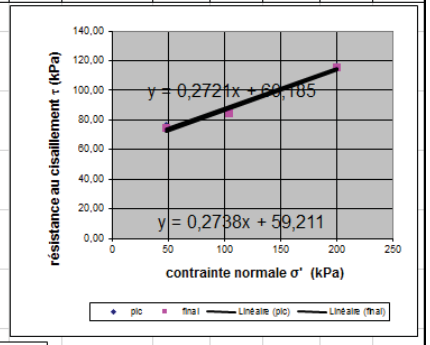
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'energie dans la région de Dakar			**CLIENT**	JICA
Site:	KEUR DAOUDA SARR			**Date essai:**	31/12/2016
N° Sondage:	SC2	**Prof. :**	8,30m à 8,70m	**Nature sol**	Greenish gray marl, tender to compact
Vitesse de cis. =	0.5 mm/mn				

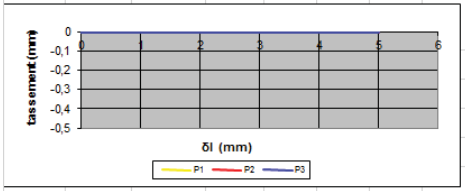
Caractéristiques de l'éprouvette — ρ_s

Hauteur =	20 mm	Largeur, diamètre =	60 mm	mesuré =	2,700 T/m3
estimé =					

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,47	1,315	11,39	1,0529				0	48,61	76,021	5	74,622	5
2	1,47	1,315	11,39	1,0529				0	104,18	84,416	3,2	84,416	5
3	1,47	1,315	11,39	1,0529				0	200,02	116,13	2,6	115,2	5
4													







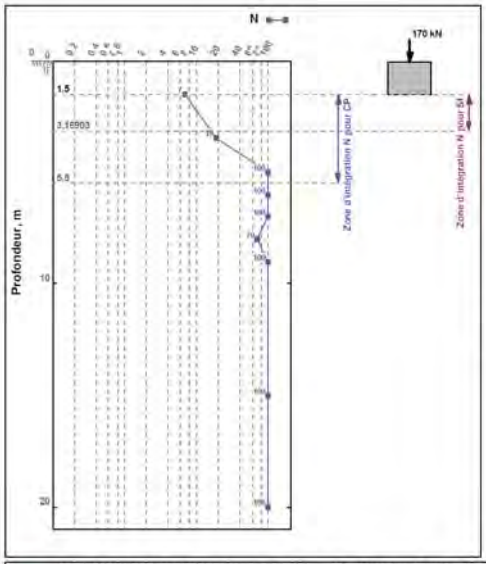
Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	60,185	59,211	15,22	15,31

Observations:

L'ingénieur responsable des essais:

Annex 3 : Sheet of geofond calculation

A-8-57



Fondation
Semelle rectangulaire
Largeur : 2 m, Longueur : 3 m
Aire : 6 m²
Encastrement : 1.5 m
Base de la fondation : 1.5 m

Paramètres des sols

Poids des terres au-dessus de la fondation :
après travaux = 18 kN/m³
avant travaux = 18.6 kN/m³
Contrainte verticale finale q'0 : 27 kPa (calculée)
Contrainte verticale initiale σ'v0 : 27.9 kPa (calculée)

Temps considéré
10 année(s)

Fichier : KDS SUBSTATION

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site web : http://www.geos.fr e-mail : logiciels@geos.fr — Bât. Europa 2, Archamps Technopole, 74160 ARCHAMPS — Fax :04 50 95 99 36

Données :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	170	0	0	0	170	0
2	ELU	255	0	0	0	255	0

Capacité portante par la méthode de Meyerhoff (sable uniquement) :

				Pour les semelles		Pour les radiers	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'_u (MPa)	C.P. (MPa)	q'_u (MPa)	C.P. (MPa)
1	28.3	28.3	28.3	3.94	1.31 vérifié	3.25	1.08 vérifié
2	42.5	42.5	42.5	3.94	1.97 vérifié	3.25	1.63 vérifié

Tassements

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'_{v0} (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N'	S_f (cm)	S_f (cm)
1	28.3	12.1	0.0279	1.15	1.5	1.4	0.199	1	0.813	0.549	0.438	5.31	0.663	0.00836
2	42.5	Non Calculé (ELU)												

GT/2016-484 _ NLB 27/01/2017 09:16	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 1	FIGURE
	Keur daouda Sarr substation	Container build

SENELABO.BTP - 8236838946194400001

Résultats détaillés : capacité portante

Cas de charge N° : 1

ELS, F = 170 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 170 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.0283 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0283 MPa

qref = (3.qmax + qmin) / 4 = 0.0283 MPa

q'0 = γ_1.D - γ_e.Ze = 27 kPa

$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 52.5$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 3.94 MPa

Capa. Port. (ELS) = q'u / 3 = 1.31 MPa

pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 3.25 MPa

Capa. Port. (ELS) = q'u / 3 = 1.08 MPa

Résultats détaillés : tassement

Cas de charge N° : 1

ELS, F = 170 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 170 kN, MB = 0 kN.m

Zi = 10 ^ (0.7606 * log(B) - 0.0065) = 1.67

$Nm = 1/Zi \int_{D}^{D+Zi} N(z).dz = 12.1$

Par la méthode de BURLAND

f1 = ((1.25 L/B) / (L/B + 0.25))² = 1.15

f2 = 1.5

f3 = 1.3 + 0.2 log(t/3) = 1.4

Sf = (1.71 B^0.7 / N^1.4) f1 f2 f3 (σ'v0/3 + Δσ - σ'v0) = 0.199 cm

Par la méthode de TERZAGHI & PECK

Cw = σv / σ'v = 1 (au niveau D + B/2)

Cd = 1 - D/(4B) = 0.813

Sf = 0.000723 qref / (N - 3) (2B / (B + 0.3048))²Cw Cd = 0.549 cm

Par la méthode de PECK & BAZARAA

Cn = 0.77 log (100 / σ'v0) = 0.438

N* = Cn.N = 5.31

Sf = 0.000508 qref / N* (2B / (B + 0.3048))²Cw Cd = 0.663 cm

Par la méthode Alpan

α0 = 4.98054 N^(-1.18020) = 0.262

Sf = (L/B)^0.39 * (2B / (B + 0.3048))² * α0/12 * (qref - σ'v0)/95.76052 * 24/100 = 0.00836 cm

GT/2016-484 _ NLB 27/01/2017 09:16	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 2	FIGURE
	Keur daouda Sarr substation	Container build

SENELABO.BTP - 82368389461944000 1

A-8-58

Résultats détaillés : capacité portante

Cas de charge N° : 2

ELU, F = 255 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 255 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.0425 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0425 MPa

qref = (3.qmax + qmin) / 4 = 0.0425 MPa

q'0 = γ_1.D - γ_e.Ze = 27 kPa

$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 52.5$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 3.94 MPa

Capa. Port. (ELU) = q'u / 2 = 1.97 MPa

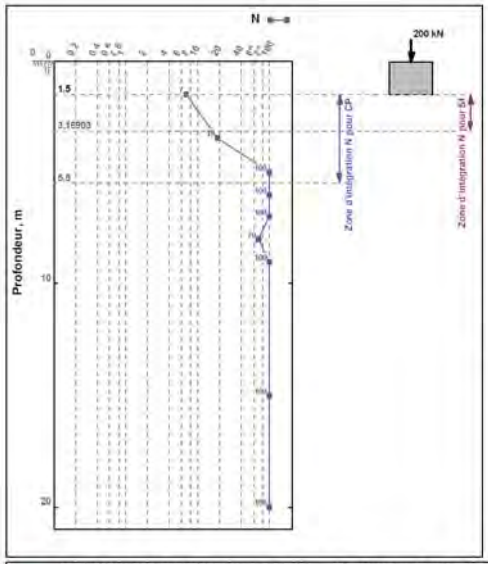
pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 3.25 MPa

Capa. Port. (ELU) = q'u / 2 = 1.63 MPa

GT/2016-484 _ NLB 27/01/2017 09:16	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 3	FIGURE
	Keur daouda Sarr substation	Container build

SENELABO.BTP - 82368389461944000 1



Fondation
Semelle rectangulaire
Largeur : 2 m, Longueur : 3 m
Aire : 6 m²
Encastrement : 1.5 m
Base de la fondation : 1.5 m

Paramètres des sols

Poids des terres au-dessus de la fondation :
après travaux = 18 kN/m³
avant travaux = 18.6 kN/m³
Contrainte verticale finale q'0 : 27 kPa (calculée)
Contrainte verticale initiale σ'v0 : 27.9 kPa (calculée)

Temps considéré
10 année(s)

Fichier : KDS SUBSTATION

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Bât. Europa 2, Archamps Technopole, 74160 ARCHAMPS
Tél : 04 50 95 38 14
Fax :04 50 95 99 36

Données :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	200	0	0	0	200	0
2	ELU	300	0	0	0	300	0

Capacité portante par la méthode de Meyerhoff (sable uniquement) :

				Pour les semelles		Pour les radiers	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'u (MPa)	C.P. (MPa)	q'u (MPa)	C.P. (MPa)
1	33.3	33.3	33.3	3.94	1.31 vérifié	3.25	1.08 vérifié
2	50	50	50	3.94	1.97 vérifié	3.25	1.63 vérifié

Tassements

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'v0 (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N*	S_f (cm)	S_f (cm)
1	33.3	12.1	0.0279	1.15	1.5	1.4	0.301	1	0.813	0.646	0.438	5.31	0.78	0.105
2	50	Non Calculé (ELU)												

GT/2016-484 _ NLB 27/01/2017 09:20	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 1	FIGURE
	Keur daouda Sarr substation	Container build

SENELABO.BTP - 8236838946194400001

Résultats détaillés : capacité portante
Cas de charge N° : 1
ELS, F = 200 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 200 kN, MB = 0 kN.m

Par la méthode de Meyerhoff
qmin = Vd/A * (1-6*e/B) = 0.0333 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0333 MPa
qref = (3.qmax + qmin) / 4 = 0.0333 MPa
q'0 = γ.D - γe.Ze = 27 kPa

$$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 52.5$$

pour les semelles (B < 1.20 m)
3N/0.05 (1 + D/3B) = 3.94 MPa
Capa. Port. (ELS) = q'u / 3 = 1.31 MPa

pour les radiers (B > 1.20 m)
3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 3.25 MPa
Capa. Port. (ELS) = q'u / 3 = 1.08 MPa

Résultats détaillés : tassement
Cas de charge N° : 1
ELS, F = 200 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 200 kN, MB = 0 kN.m

Zi = 10 ^ (0.7606 * log(B) - 0.0065) = 1.67

$$Nm = 1/Zi \int_{D}^{D+Zi} N(z).dz = 12.1$$

Par la méthode de BURLAND
f1 = ((1.25 L/B) / (L/B + 0.25))² = 1.15
f2 = 1.5
f3 = 1.3 + 0.2 log(t/3) = 1.4
Sf = (1.71 B^0.7 / N^1.4) f1 f2 f3 (σ'v0/3 + Δσ - σ'v0) = 0.301 cm

Par la méthode de TERZAGHI & PECK
Cw = σv / σ'v = 1 (au niveau D + B/2)
Cd = 1 - D/(4B) = 0.813
Sf = 0.000723 qref / (N - 3) (2B / (B + 0.3048))²Cw Cd = 0.646 cm

Par la méthode de PECK & BAZARAA
Cn = 0.77 log (100 / σ'v0) = 0.438
N* = Cn.N = 5.31
Sf = 0.000508 qref / N* (2B / (B + 0.3048))²Cw Cd = 0.78 cm

Par la méthode Alpan
α0 = 4.98054 N^(-1.18020) = 0.262
Sf = (L/B)^0.39 * (2B / (B + 0.3048))² * α0/12 * (qref - σ'v0)/95.76052 * 24/100 = 0.105 cm

GT/2016-484 _ NLB 27/01/2017 09:20	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 2	FIGURE
	Keur daouda Sarr substation	Container build

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A-8-59

Résultats détaillés : capacité portante

Cas de charge N° : 2

ELU, F = 300 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 300 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.05 MPa ; qmax = Vd/A * (1+6*e/B) = 0.05 MPa

qref = (3.qmax + qmin) / 4 = 0.05 MPa

q'0 = γ_1.D - γ_e.Ze = 27 kPa

$$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 52.5$$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 3.94 MPa

Capa. Port. (ELU) = q'u / 2 = 1.97 MPa

pour les radiers (B > 1.20 m)

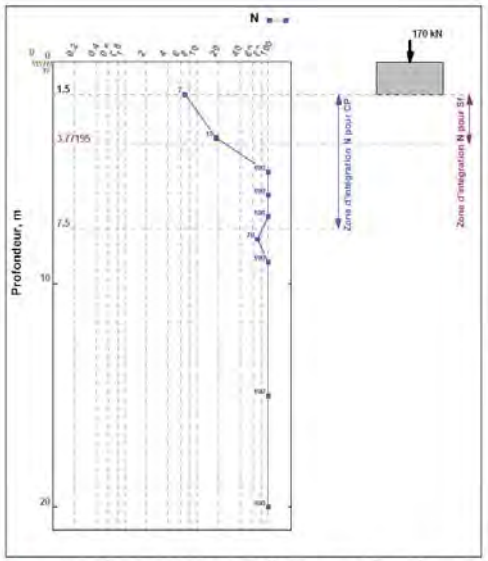
3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 3.25 MPa

Capa. Port. (ELU) = q'u / 2 = 1.63 MPa

GT/2016-484 _ NLB 27/01/2017 09:20	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 3	FIGURE
	Keur daouda Sarr substation	Container build

SENELABO.BTP - 8236838946194400001

A-8-60



Fondation
Semelle rectangulaire
Largeur : 3 m, Longueur : 4 m
Aire : 12 m²
Encastrement : 1.5 m
Base de la fondation : 1.5 m

Paramètres des sols

Poids des terres au-dessus de la fondation :
après travaux = 18 kN/m³
avant travaux = 18.6 kN/m³
Contrainte verticale finale q'0 : 27 kPa (calculée)
Contrainte verticale initiale σ'v0 : 27.9 kPa (calculée)

Temps considéré
10 année(s)

Fichier : KDS SUBSTATION

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Tél : 04 50 95 38 14
Fax :04 50 95 99 36

Données :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	170	0	0	0	170	0
2	ELU	255	0	0	0	255	0

Capacité portante par la méthode de Meyerhoff (sable uniquement) :

				Pour les semelles		Pour les radiers	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'_u (MPa)	C.P. (MPa)	q'_u (MPa)	C.P. (MPa)
1	14.2	14.2	14.2	5.39	1.8 vérifié	4.08	1.36 vérifié
2	21.3	21.3	21.3	5.39	2.69 vérifié	4.08	2.04 vérifié

Tassements

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'_{v0} (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N*	S_f (cm)	S_f (cm)
1	14.2	15	0.0279	1.11	1.5	1.4	0.0914	1	0.875	0.245	0.438	6.59	0.315	-0.215
2	21.3	Non Calculé (ELU)												

GT/2016-484 _ NLB 27/01/2017 09:23	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 1	FIGURE
	Keur daouda Sarr substation	Container build

SENELABO.BTP - 8236838946194400001

Résultats détaillés : capacité portante
Cas de charge N° : 1

ELS, F = 170 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 170 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.0142 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0142 MPa

qref = (3.qmax + qmin) / 4 = 0.0142 MPa

q'0 = γ_1D - γe.Ze = 27 kPa

$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 77$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 5.39 MPa

Capa. Port. (ELS) = q'u / 3 = 1.8 MPa

pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 4.08 MPa

Capa. Port. (ELS) = q'u / 3 = 1.36 MPa

Résultats détaillés : tassement
Cas de charge N° : 1

ELS, F = 170 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 170 kN, MB = 0 kN.m

Zi = 10 ^ (0.7606 * log(B) - 0.0065) = 2.27

$Nm = 1/Zi \int_{D}^{D+Zi} N(z).dz = 15$

Par la méthode de BURLAND

f1 = ((1.25 L/B) / (L/B + 0.25))² = 1.11

f2 = 1.5

f3 = 1.3 + 0.2 log(t/3) = 1.4

Sf = (1.71 B^0.7 / N^1.4) f1 f2 f3 (Δp/3) = 0.0914 cm

Par la méthode de TERZAGHI & PECK

Cw = σ'v / σ'v = 1 (au niveau D + B/2)

Cd = 1 - D/(4B) = 0.875

Sf = 0.000723 qref / (N - 3) (2B / (B + 0.3048))²Cw Cd = 0.245 cm

Par la méthode de PECK & BAZARAA

Cn = 0.77 log (100 / σ'v0) = 0.438

N' = Cn.N = 6.59

Sf = 0.000508 qref / N' (2B / (B + 0.3048))²Cw Cd = 0.315 cm

Par la méthode Alpan

α0 = 4.98054 N^(-1.18020) = 0.203

Sf = (L/B)^0.39 * (2B / (B + 0.3048))² * α0/12 * (qref - σ'v0)/95.76052 * 24/100 = -0.215 cm

GT/2016-484 _ NLB 27/01/2017 09:23	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 2	FIGURE
	Kéur daouda Sarr substation	Container build

SENELABO.BTP - 82368389461944001

A-8-61

Résultats détaillés : capacité portante
Cas de charge N° : 2

ELU, F = 255 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 255 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.0213 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0213 MPa

qref = (3.qmax + qmin) / 4 = 0.0213 MPa

q'0 = γ_1D - γe.Ze = 27 kPa

$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 77$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 5.39 MPa

Capa. Port. (ELU) = q'u / 2 = 2.69 MPa

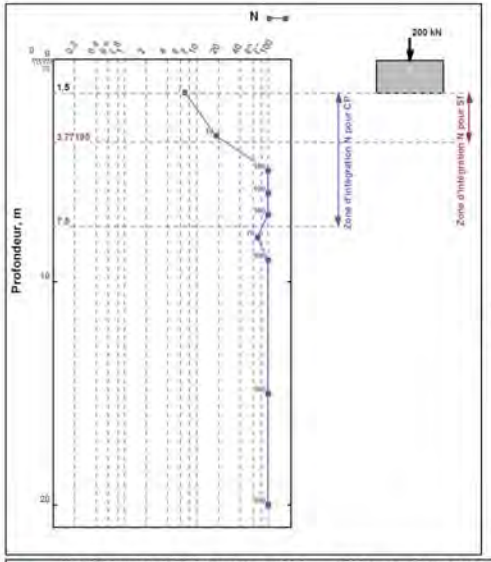
pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 4.08 MPa

Capa. Port. (ELU) = q'u / 2 = 2.04 MPa

GT/2016-484 _ NLB 27/01/2017 09:23	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 3	FIGURE
	Kéur daouda Sarr substation	Container build

SENELABO.BTP - 82368389461944001



Fondation
Semelle rectangulaire
Largeur : 3 m, Longueur : 4 m
Aire : 12 m²
Encastrement : 1.5 m
Base de la fondation : 1.5 m

Paramètres des sols

Poids des terres au-dessus de la fondation :
après travaux = 18 kN/m³
avant travaux = 18.6 kN/m³
Contrainte verticale finale q'0 : 27 kPa (calculée)
Contrainte verticale initiale σ'v0 : 27.9 kPa (calculée)

Temps considéré
10 année(s)

Fichier : KDS SUBSTATION

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site web : http://www.geos.fr e-mail : logiciels@geos.fr — Bât. Europa 2, Archamps Technopole, 74160 ARCHAMPS — Fax :04 50 95 99 36

Données :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	200	0	0	0	200	0
2	ELU	300	0	0	0	300	0

Capacité portante par la méthode de Meyerhoff (sable uniquement) :

				Pour les semelles		Pour les radiers	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'_u (MPa)	C.P. (MPa)	q'_u (MPa)	C.P. (MPa)
1	16.7	16.7	16.7	5.39	1.8 vérifié	4.08	1.36 vérifié
2	25	25	25	5.39	2.69 vérifié	4.08	2.04 vérifié

Tassements

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'_{v0} (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N*	S_f (cm)	S_f (cm)
1	16.7	15	0.0279	1.11	1.5	1.4	0.108	1	0.875	0.289	0.438	6.59	0.371	-0.176
2	25	Non Calculé (ELU)												

GT/2016-484 _ NLB 27/01/2017 09:22	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 1	FIGURE
	Keur daouda Sarr substation	Container build

SENELABO.BTP - 82368389461944000 1

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Résultats détaillés : capacité portante
Cas de charge N° : 1
ELS, F = 200 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 200 kN, MB = 0 kN.m
Par la méthode de Meyerhoff
qmin = Vd/A * (1-6*e/B) = 0.0167 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0167 MPa
qref = (3.qmax + qmin) / 4 = 0.0167 MPa
q'0 = γ.D - γe.Ze = 27 kPa
$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 77$

pour les semelles (B < 1.20 m)
3N/0.05 (1 + D/3B) = 5.39 MPa
Capa. Port. (ELS) = q'u / 3 = 1.8 MPa

pour les radiers (B > 1.20 m)
3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 4.08 MPa
Capa. Port. (ELS) = q'u / 3 = 1.36 MPa

Résultats détaillés : tassement
Cas de charge N° : 1
ELS, F = 200 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 200 kN, MB = 0 kN.m
Zi = 10 ^ (0.7606 * log(B) - 0.0065) = 2.27
$Nm = 1/Zi \int_{D}^{D+Zi} N(z).dz = 15$

Par la méthode de BURLAND
f1 = ((1.25 L/B) / (L/B + 0.25))² = 1.11
f2 = 1.5
f3 = 1.3 + 0.2 log(t/3) = 1.4
Sf = (1.71 B^0.7 / N^1.4) f1 f2 f3 (Δp/3) = 0.108 cm

Par la méthode de TERZAGHI & PECK
Cw = σv / σ'v = 1 (au niveau D + B/2)
Cd = 1 - D/(4B) = 0.875
Sf = 0.000723 qref / (N - 3) (2B / (B + 0.3048))²Cw Cd = 0.289 cm

Par la méthode de PECK & BAZARAA
Cn = 0.77 log (100 / σ'v0) = 0.438
N* = Cn.N = 6.59
Sf = 0.000508 qref / N* (2B / (B + 0.3048))²Cw Cd = 0.371 cm

Par la méthode Alpan
α0 = 4.98054 N^(-1.18020) = 0.203
Sf = (L/B)^0.39 * (2B / (B + 0.3048))² * α0/12 * (qref - σ'v0)/95.76052 * 24/100 = -0.176 cm

GT/2016-484 _ NLB 27/01/2017 09:22	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 2	FIGURE
	Keur daouda Sarr substation	Container build

SENELABO.BTP - 82368389461944000 1

Résultats détaillés : capacité portante

Cas de charge N° : 2

ELU, F = 300 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 300 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.025 MPa ; qmax = Vd/A * (1+6*e/B) = 0.025 MPa

qref = (3.qmax + qmin) / 4 = 0.025 MPa

q'0 = γ.D - γ.Ze = 27 kPa

$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 77$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 5.39 MPa

Capa. Port. (ELU) = q'u / 2 = 2.69 MPa

pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 4.08 MPa

Capa. Port. (ELU) = q'u / 2 = 2.04 MPa

GT/2016-484 _ NLB : 27/01/2017 09:22	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	Page 3	FIGURE
	Keur daouda Sarr substation		Container build

SENELABO BTP - 8236838948194400001

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GÉOTEC AFRIQUE SENELABO

GEOTECHNICAL REPORT

Etude Préparatoire du Projet d'urgence de Renforcement et de Réhabilitation du réseau de transport d'énergie dans la région de Dakar

JICA PROJECT TEAM

YACHIYO ENGINEERING CO., LTD.

DAKAR - SENEGAL

KEY ROAD SUBSTATION

January 27, 2017

SENELABO GÉOTECHNIQUE

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Mission G_2 AVP

GEOTECHNIC PRELIMINARY STUDY PROJECT

Etude Préparatoire du Projet d'urgence de Renforcement et de Réhabilitation du réseau de transport d'énergie dans la région de Dakar

JICA PROJECT TEAM

YACHIYO ENGINEERING CO., LTD.

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January 27, 2017

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N° FOLDER		GT/2016-484			GT	MISSION : G2AVP	
Index	Date	Number of pages		Emetted by	Verified by	Modifications Observations	Approved by
		Text	Annex				
0	09/01/2017	9	2	N. L. BADJI		First release	
A	27/01/2017	13	37	N. L. BADJI		Integration of laboratory test and foundation recommendation	
B							
C							

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I. PRESENTATION

I.1. DEFINITION OF THE OPERATION – CONTRIBUTOR

On request and on behalf of JICA PROJECT TEAM (YACHIYO ENGINEERING CO., LTD.), GEOTEC AFRIQUE-SENELABO was commissioned to carry out geotechnical studies for **"Projet d'urgence de Renforcement et de Réhabilitation du réseau de transport d'énergie dans la région de Dakar, SENEGAL".**

I.2. MISSION

This is a mission of G2AVP type according to NF P 94-500 standard as defined in the classification of types of geotechnical tasks prepared by the geotechnical trade union and standardized AFNOR NFP 94500 in November 2013.

This mission will allow :

- To define a field geotechnical investigation campaign and make its realization by core drilling with Standard Penetration Test (SPT) as in-situ soil testing ;
- To determine the nature of soils that can be mobilized and their depth ;
- To define foundation systems adapted to soils encountered and proposed buildings ;
- To determine the bearing capacity of soil in place ;
- To define the constructive arrangements for taking into account the phenomenon of shrinkage and swelling of the existing soil ;
- Provide recommendations for earthworks.

I.3. PROJECT - RECEIVED DOCUMENTS

The project consists of reinforcement and rehabilitation of the energy transport network of Dakar ; Key road substation. The features and details of the work are not been communicated to us. However it has been communicated to us the technical specifications for site investigation works.

I.4. CONVENTIONS USED

The various tests carried conform to AFNOR standards.

Recommendations and justifications were made according to the following regulations:

- XP ENV 1997-1 Eurocode 7 – geotechnical calculation - General rules;
- NF P11-300 : Earthworks ;
- AFNOR P11-211 – DTU 13.11 – shallow foundations ;
- AFNOR P11-711 – DTU 13.12 – Rules for the design of shallow foundations ;
- AFNOR NF P11-213-1 to 4 – DTU 13.3 – Rules for construction of pavings.

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II. LOCALISATION AND GEOLOGICAL SETTINGS

II.1. SITE LOCATION

The Key road substation site is located in the area of the urbanization project of diamniadio as saw below (figure 1).

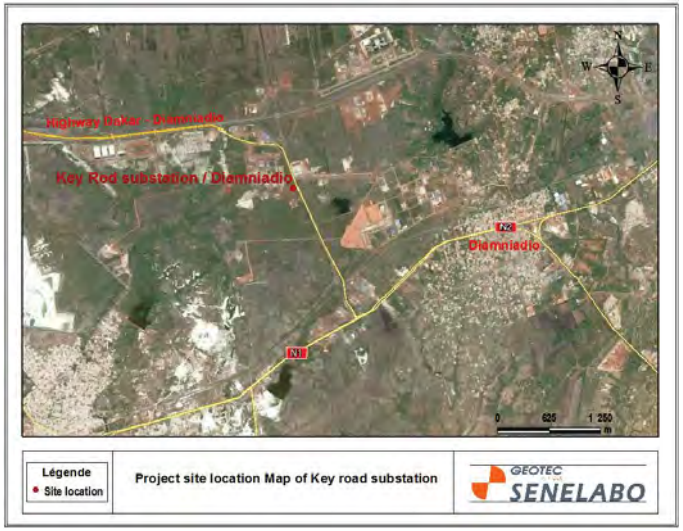

Figure 1 : Key road substation location map

II.2. GEOLOGICAL SETTING OF THE SITE

Geological studies on the peninsula of Cap-Vert by (Castelain and al[1], 1965; Tessier and al[2], 1967; Lappartient 1985; Crévola and al[3], 1994 etc.) and many other authors and updated by the PASMI[4] (2009), allowed to the stratigraphic synthesis of tertiary and quaternary formations in the area of Dakar (Figure 2).

The project site relies on the old tertiary and quaternary sedimentary rock. These formations are mainly :

- Marl and clay with planktonic and benthic foraminifera ;
- Clay facies with planpronic foraminifera and Ypresian clay-marly facies ;
- Clay, limestone, marl- limestone, marl and clay with planktonic and benthic foraminifera of the Middle and Lower Eocene.

[1] CASTELAIN J. (1965) – Aperçu stratigraphique et micropaléontologique du bassin du Sénégal occidental. Historique de la découverte paléontologique. In : « Colloque International de Micropaléontologie » (Dakar). Mémoire BRGM, 32, p. 135-159.

[2] TESSIER F. & LAPPARTIENT J-R. (1967) - Observations sur la latérite récente des environs de Dakar. Bull. Soc. Géol. Fr., Paris, 9 (7), p. 455-466.

[3] G. Crevola, J.-M. Cantagrel, C. Moreau, 1994. *Le volcanisme de la presqu'île du Cap-Vert (Sénégal) : cadre chronologique et géodynamique*, Bull. Soc. géol. France, 165, 5, 437-446.

[4] PASMI : Programme d'Appui au Secteur Minier / Projet 9 ACP SE 009 - Cartographie géologique du Bassin Sédimentaire, Geoter/BRGM/Direction des Mines et de la Géologie, Dakar, 2009.

Geologically, the study area is located at the Graben of Rufisque. This graben with general orientation NNE-SSW, is limited to the East by the horst of Diass. The Rufisque graben is characterized by Campano-Maastrichtian formations, Tertiary and Quaternary formations of the Senegal-Mauritanian basin. In the sector of Rufisque-Bargny and Diamniadio, in favor of several quarries, essentially four lithological ensembles are noted. This is the limestone unit ("Bargny limestone"), marly units ("marl with narrow clayey limestone beds with Frondicularia", "marl with clayey limestone beds" and "gray marl with Radiolarians"). This area is cut by sub-meridian faults which delimit the horst and the grabens. These faults are sometimes associated with volcanic events between the Upper Eocene and the Quaternary (Crevola et al., 1994).

These marly units are covered by the quaternary sands of the sangalkam erg on this area.

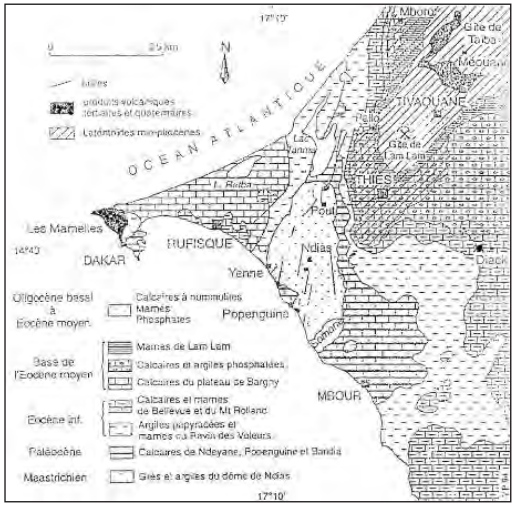

Figure 2: Geological map of the peninsula of Cap-Vert and the plateau of Thiès

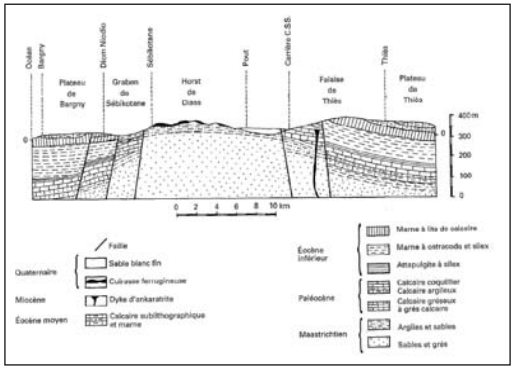

Figure 3: Geological cross-section of Diass Horst, plateau of Thiès and Bargny

III. PROGRAM AND RESULTS OF INVESTIGATION

III.1. PROGRAM OF INVESTIGATION

For this studies GEOTEC AFRIQUE - SENELABO realized on the site :

- One (01) borehole at 20m depth of investigation with SPT (in-situ soil testing) were carried out in order to take samples for laboratory tests and to define detailed log of the lithology of the site;
- Laboratory tests to identify and characterize the soil, we have done the following tests :
  - Moisture content tests [NF P 94-050]
  - Grain size analysis [NF P 94-056]
  - Specific Weight [NF P 94-053]
  - Apparent and absolute density [NF P 94-053, 94-064]
  - Atterberg limits [NF P 94-051]
  - VBS (Blue Methylen value) [NF P 94-068]
  - Direct linear shear test [NF P 94-071-1]
  - Standard oedometer test [NF P 94-090-1]
  - Compressive strength tests on rock [NF P 94-420]

III.2. DESCRIPTION OF THE CORES SAMPLES

At the location of the project, we conducted core drilling with SPT to identify and characterize the ground. The observations carried out allowed us to establish the log below.

Hole ID	Depth from (m)	Depth to (m)	Lithological description of cores
SC3/Key road Substation	0	3,8	Black sandy clay with calcareous concretions
	3,8	11,9	Whitish yellow marl-limestone (alternation of marl and narrow limestone beds)
	11,9	20,1	Greyish marl-limestone (alternation of marl and narrow limestone beds)

NB : All the above depths are given at our Borehole and the reference level of depth are the existing ground level.

III.3. RESULTS OF STANDARDS PENETRATION TEST (SPT)

The project site relies on a tender to compact marl and covered by the quaternary sands. However we have carried out SPT tests and we got refusal up to the end of the hole.

III.4. RESULTS OF THE LABORATORY TESTS AND SOIL CARACTERISATION

The results of laboratory tests conducted on soil samples collected from core samples are summarized on the table below.

CUSTOMER		JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.			
Project		PREPARATOIRE DU PROJET D'URGENCE, DE RENFORCEMENT ET DE REHABILITATION DU RESEAU DE TRANSPORT D'ENERGIE DANS LA REGION DE D			
Borehole Number		SC3/Key road substation			
Depth (m)		0,20m à 1,00m	1,50m à 2,00m	2,50m à 3,00m	4,50m à 5,50m
Lithological nature of soil		Black sandy clay with calcareous concretions	Black sandy clay with calcareous concretions	Whitish yellow marl-limestone (alternation of marl and narrow limestone beds)	Whitish yellow marl-limestone (alternation of marl and narrow limestone beds)
Water content	W%	8,22	7,94	8,28	9,63
Wet density (t/m3)	γ_h	1,847	1,750	1,534	1,416
Dry density (t/m3)	γ_d	1,707	1,621	1,417	1,292
Specific density	γs	2,512	2,515	2,440	2,314
Grain size analysis	Dmax(mm)	2,0	5,0	12,5	2,0
	5mm	100,0	99,4	95,5	100,0
	2mm	98,1	96,2	93,2	95,8
	1mm	96,6	94,0	91,9	95,3
	0.5mm	94,0	91,4	91,3	94,5
	0.125mm	64,6	61,8	87,4	93,0
	0.08mm	61,3	59,2	86,6	92,2
Atterberg limits (%)	WL	60,44	61,72	158,18	216,43
	WP	18,63	21,55	47,55	58,79
	IP	41,81	40,17	110,63	157,64
	Ic	1,25	1,34	1,35	1,312
Cohésion (kPa)	C	55,164	31,684	30,366	25,352
Internal friction angle (°)	φ	10,05	23,13	18,8	25,07
Preconsolidation pressure (kPa)	σ'p	100	130	300	250
Compressibility index	Cc	0,227	0,205	0,596	0,137
Pressure of swelling (kPa)	Pg ≤			111	111
Classification GTR		A4	A4	A4	A4

On some core samples, Compressive strength tests are been carried out ant the results are summarized on the table below.

CUSTOMER		JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.			
Project		ETUDE PREPARATOIRE DU PROJET D'URGENCE, DE RENFORCEMENT ET DE REHABILITATION DU RESEAU DE TRANSPORT D'ENERGIE DANS LA REGION DE DAKAR			
Borehole Number		SC3/Key road substation			
Depth (m)		12,80m	13,30m	16,75m	19,00m
Lithological nature of soil		Greyish marl-limestone (alternation of marl and narrow limestone beds)	Greyish marl-limestone (alternation of marl and narrow limestone beds)	Greyish marl-limestone (alternation of marl and narrow limestone beds)	Greyish marl-limestone (alternation of marl and narrow limestone beds)
Compressive strength (MPa)	Rc	11,600	9,3	10,460	11,600
Description		Very weakly resistant	Very weakly resistant	Very weakly resistant	Very weakly resistant

III.5. HYDROGEOLOGY OF THE SITE

The ground water was encountered at 1.55m during drilling. However, we can not exclude the presence of anarchic water circulations on preferential flow channels. The hydrological regime can vary depending on the season and rainfall.

III.6. NATURAL AND ANTHROPIC RISKS

The marl-limestone substratum is a sedimentary environment as well as sandy clay and likely to have lateral variations in bedding thickness.

The ground water was encountered at 1.55m during drilling. This could have an impact on the foundation with the increase of the ground water level. It will be necessary to determine the level of the highest waters.

The soils encountered in the project area present a risk of shrinkage and swelling. Since variations in the water conditions of the environment may be accentuated by anthropogenic channels, plantations and runoff of rainwater, information on the risk of flooding in the lower areas of the project should be obtained.

III.7. SEISMICITY OF THE SITE

The project site is located at the plateau of Bargny tectonically stable and therefore deemed non-seismic.

III.8. DEFINITION OF ZONE OF INFLUENCE AND GEOTECHNICAL MODEL

The Geotechnical Influence Zone (GIZ) is not restricted to the parcel interested in the project. It also concerns the immediate environment (interfaces related to temporary earthworks). However the project site is an area without significant constructions. The distance between the construction site and the existing road is approximately 60m.

Aerial view of the site

According to the results of the laboratory tests, the geotechnical model can be defined in this version of the report (See table below).

Selected geotechnical characteristics										
Lithological nature of soil	Depth (m/GL)	Wet density (t/m3)	Specific density (t/m3)	Atterberg limits (Ip) %	Pressure of swelling Pg (kPa)	Cohésion (kPa)	Internal friction angle (°)	Classification according to the GTR	Compressive strength (MPa)	SPT N-value
Filling depot (Black sandy clay with calcareous concretions)	2,3	1,8	2,5	41	-	43,4	16,6	A4	-	50
Whitish yellow marl-limestone (alternation of marl and narrow limestone beds)	11,9	1,5	2,4	134	≤ 111	28	22	A4	-	> 100
Greyish marl-limestone (alternation of marl and narrow limestone beds)	> 20	-	-	-	-	-	-	R2	10,74	> 100

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IV. RECOMMENDATIONS

IV.1. JUSTIFICATION OF SHALLOW FOUNDATIONS

- **Definition of fondations :**

Considering the observations of the field investigation and foundation elements that have been transmitted to us, we check here a rectangular foundation raft for shallow foundation.

- **Strength limits of soil :**

The Geofond software was used to evaluate the bearing capacity of the soil. The calculation is done using the method of Meyerhoff which involves the calculation of an average value Nm of N by the relation:

$$N_m = \frac{1}{2B - 0{,}5B} \int_{D+0{,}5B}^{D+3B} N(z)dz$$

The breaking stress q'u under the base of foundation raft is given by the equation:

$$q'_u = \frac{3 \cdot N}{0{,}08} \cdot \left(1 + \frac{D}{3 \cdot B}\right) \cdot \left(\frac{B + 0{,}3}{B}\right)^2$$

With D = anchoring depth and B = Width of the foundation raft.

The bearing capacity at SLS and ULS are given respectively by $q'_u / 3$ and $q'_u / 2$ and the table below gives the results of this calculation.

Structures	Dimensions of the foundation raft	Anchoring depth (m) / GL	Applied load (kN)	Breaking stress q'_u (MPa)	Bearing capacity (MPa)		Settlements Sf (cm)
					SLS	ULS	
Container building	*2 m x 3 m*	*1,5*	*170*	6,11	2,04	3,06	≤ 0,104
	2 m x 3 m	*1,5*	*200*	6,11	2,04	3,06	≤ 0,122
	3 m x 4 m	*1,5*	*170*	5,29	1,76	2,65	≤ 0,057
	3 m x 4 m	*1,5*	*200*	5,29	1,76	2,65	≤ 0,067

- **Settlements deformations**

Considering loads that communicated to us, estimated settlements for this foundations raft are less than 0,2 cm.

IV.2. REALIZATION OF GROUND SLAB

Considering the characteristics of the materials that will be present at the bottom of the excavation, a sub-base will be realized according to the following recommendations :

- Flushing out any mediocre layers and those damaged by earth-moving equipment ;
- Recompact the bottom of excavation thus obtained ;
- Make a sub-base in materials, of a thickness to be defined by the prime contractor of the project. It can be realized in gravel, grave-cement, compacted sand, laterite, all coming from quarry etc.

To check the quality of the sub-base thus obtained, for this type of structure, KW> 50MPa / m and EV2 / EV1 <2 must be used according to the rules of DTU 13.3.

IV.3. EARTHWORKS REALISATION

- **Earthworks :**

If the foundations are shallow, will have to be envisaged a provisional supporting. It is excluded to carry out the earthworks without ensuring the stability of the excavations by an adapted supporting prohibiting any displacement in provisional and final phase.

- **Water Conditions**

Any water inflows in the excavations (runoff of rainwater) during earthworks will be evacuated.

IV.4. SPECIAL PRECAUTIONS FOR DESIGN AND EXECUTION

- **Constructives dispositions**

<u>Foundations</u> :

Structural adaptation of reference documents (Fascicule 62 and DTU) are to be considered.

IV.5. GEOTECHNICAL ALEAS AND CONTRACTUAL CONDITIONS

1. This report and its annexes constitute an inseparable whole. Misuse that could be made following a partial disclosure or reproduction does not engage GEOTEC AFRIQUE-SENELABO.
2. Changes in the location, design or importance of buildings as well as the assumptions used in particular in the indications of the "presentation" of this report can lead to challenges to the regulations. A new mission will then be entrusted to GEOTEC AFRIQUE-SENELABO to rehabilitate or validate these findings in writing the new project.

3. Similarly, new evidence revealed during the execution of the foundations and could not be detected in the soil reconnaissance (eg localized heterogeneity, water inflows, dissolution cavity, etc.) can render obsolete some of the recommendations contained in the report.
4. The ground reconnaissance proceed by ad hoc surveys, the results are not strictly extrapolated to the entire site. It persists hazards (eg local heterogeneity) that can lead to adaptations to the design of performance that can not be borne by the geotechnician.
5. At the time of the opening of the excavations, it is advisable to conduct a site visit by a geotechnician to GEOTEC AFRIQUE-SENELABO. This visit gives rise to a written notice on the verification of soil type and level seat of shallow foundations. This tour is subject to prior specific command.

A Dakar, 27/01/2017

Engineer in charge of the study

N. L. BADJI

ANNEX

A-8-70

Annex 1 : Log of the exploratory hole

Borehole Number	PROJECT : ETUDE PREPARATOIRE DU PROJET D'URGENCE, DE RENFORCEMENT ET DE REHABILITATION DU RESEAU DE TRANSPORT D'ENERGIE DANS LA REGION DE DAKAR		
	Custumer : JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.		
SC3/Key road Substation	FOLDER : GT/2016-484		
	TYPE OF SAMPLING : Core drilling		
	DEPTH : 20,10 m Below existing ground level		
LOCALISATION: Diamniadio	Coordonnées UTM _ zone 28P	X= 263578	Y=1629075

Ground water level	Depth (m) / existing ground level	Stratigraphic column	Lithological description	% of Recovery	SPT	Ø Drilling	Ø Tubing (mm)	Tool	COMMENTS
1,55m	2,3		Black sandy clay with calcareous concretions	47,37		Double core barrel T6 116 with crown			PHOTOGRAPHIC DOCUMENTS
	11,9		Whitish yellow marl-limestone (alternation of marl and narrow limestone beds)	95,06					
	20,1		Greyish marl-limestone (alternation of marl and narrow limestone beds)	97,56					

0 à 5,5 m

5,5 à 9,5 m

9,5 à 14,8 m

14,8 à 18,5 m

18,5 à 21,10 m

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Annex 2 : Sheet of laboratory tests

GÉOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

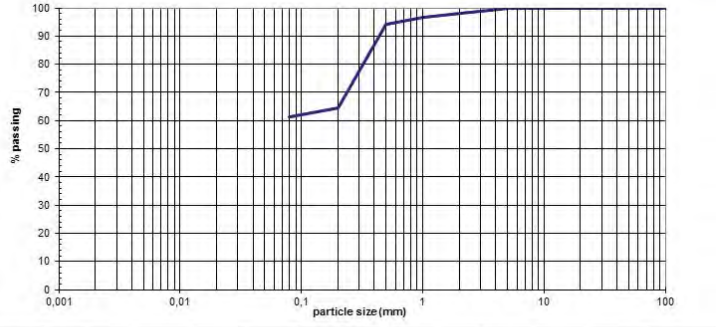
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC3 / DIAMNIADIO	1	0,20m à 1,00m	Black sandy clay with calcareous concretions	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
8,22			60,438	18,63	41,806	1,25	A4	1,847		

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm)	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	98,1	96,6	94,0	64,6	61,3

Sieve mesh size (mm)											
Passing (%)											

OBSERVATIONS

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The engineer responsible of the tests

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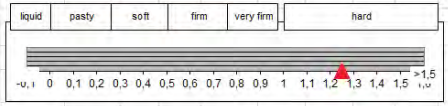
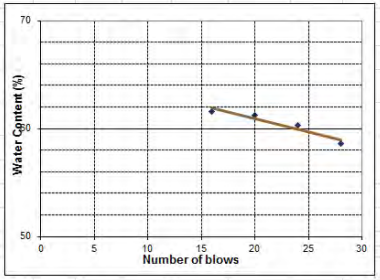
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.,	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC3 / DIAMNIADIO	1	0,20m à 1,00m	Black sandy clay with calcareous concretions	SIDY

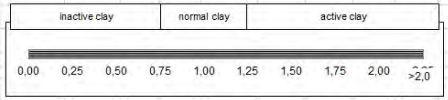
	1- Liquid Limit				2- Plasticy Limit	
Number of blows	16	20	24	28		
Tare N°	X0	XB	XA	XD	B17	B10
Total wet weight	98	94,08	98,18	101,17	70,74	80,3
Total dry weight	80,25	78,19	79,91	84,7	66,67	76,25
Total weight of tares	51,42	52,24	49,62	56,61	44,54	54,79
Net weight of water	17,75	15,89	18,27	16,47	4,07	4,05
Weight of dry material	28,83	25,95	30,29	28,09	22,13	21,46
Water content (%)	61,568	61,233	60,32	58,633	18,3913	18,87232
Limits and indices	W_L =	60,438	W_P =	18,632	I_P =	41,81	I_C =	1,25	A =	

3- Scale of Consistency (Ic)

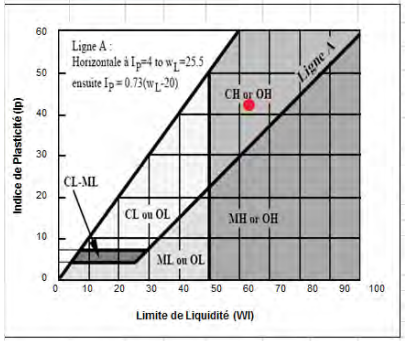




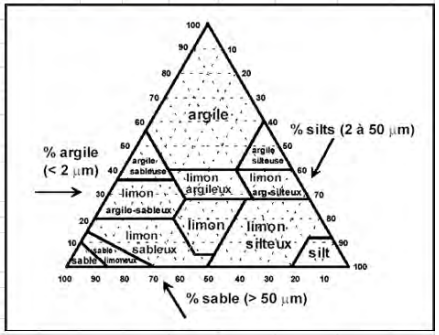
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	CH: Muddy, gravelly and/or sandy clay
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
		MH: Gravelly and/or sandy silt of high plasticity

Report of test with the oedometer (consolidation test)

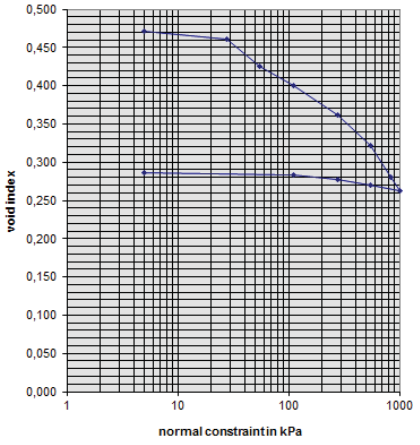
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : JICA PROJECT TEAM / YACHIYO ENGINEERING	**summery description :** Black sandy clay with calcareous concretions	Register N° :
SITE : DIAMNIADIO	date of arrival at the laboratory :	Borehole N° :
	date of tests : 03/01/2017	SC 3

characteristic of the test-tube or core		Before test		After test		Sample N° : 1
Diameter : D	*in mm*	D_0 =	50,47			Depht of test-tube or core (m) =
Height : H	*in mm*	Hi =	20			0,20m à 1,00m
dry formerly densité	*in Mg/m³*	γ_{di} =	1,71	γ_{df} =		Experimenter :
Unit weight	*in MG/m³*	γ_s =	2,51			
Water content	*in %*	Wi =	8,22	Wf =		Frame N° : 2
Saturation degree	*in %*	Sri =	43,79	Srf =		

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,601	0,472
		2	28	15,0	0,591	0,461
		3	56	66,0	0,554	0,425
		4	111	101,0	0,529	0,400
		5	277	155,0	0,491	0,361
		6	555	210,0	0,452	0,322
		7	830	268,0	0,411	0,281
		8	1000	293,0	0,393	0,263
		9	555	283,0	0,400	0,270
		10	277	274,0	0,406	0,277
		11	111	265,0	0,413	0,283
		12	5	261,0	0,416	0,286

oedometer curve



Results

Characteristics of compressibility

void index		e_i=	0,472
		e_0=	0,45
Vertical effective constraint	(kPa)	σ'_{V0}=	10,24
Constraint of preconsolidation	(kPa)	σ'_p=	100
Index of compression		Cc=	0,227
Pressure of swelling	(kPa)	Pg=	
Swelling index		Cs=	

Direct shear test

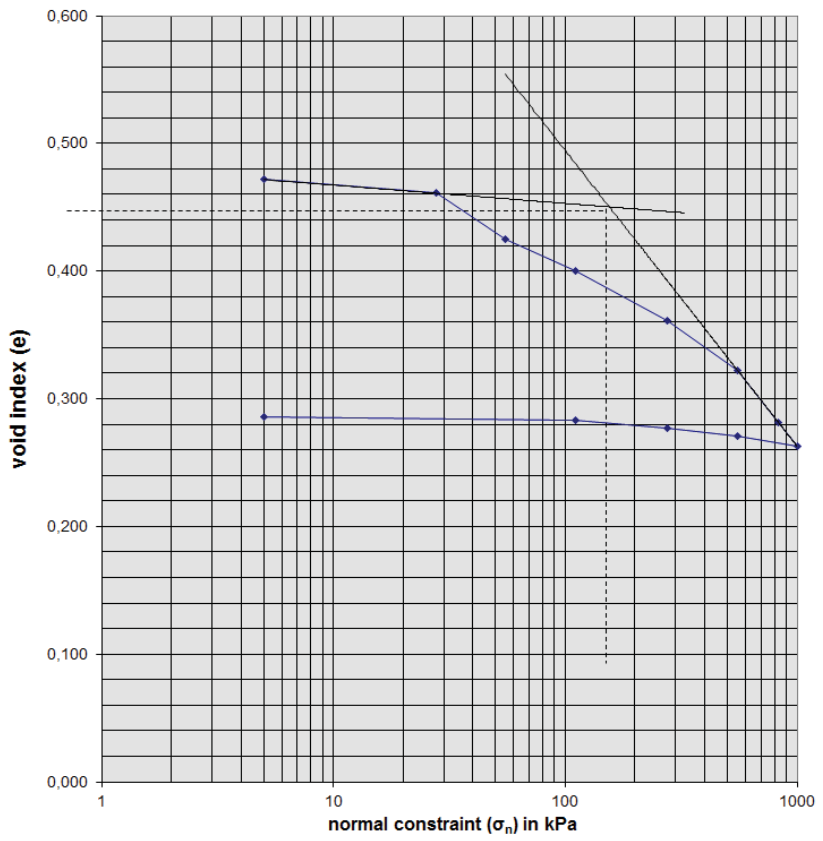
Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : CT TEAM / YACHIYO ENGINEERI	**summery description :**	lack sandy clay with calcareous concretio	Register N° :
SITE : DIAMNIADIO	date of arrival at the laboratory :		Borehole N° :
	date of tests :	03/01/2017	
	sampling depht. =	0,20m à 1,00m	Sample N° :
	test-tube (core)		1

oedometer curve



A-8-73

Direct linear shear test

(réalisé conformément à la norme NF P 94-071-1)

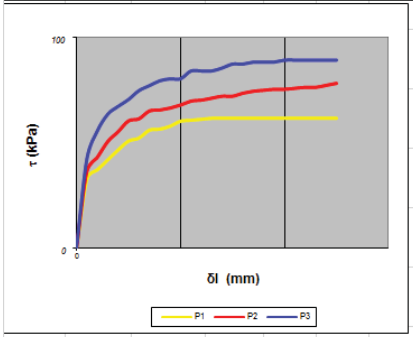
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	**CLIENT**	JICA
Site:	SC3/Diamniadio	**Date essai:**	04/02/2016

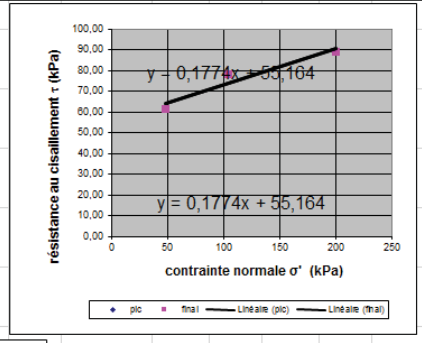
N° Sondage:	SC3	**Prof. :**	0,2m à 1m	**Nature sol**	Black sandy clay with calcareous	**Vitesse de cis. =**	0.5 mm/mn

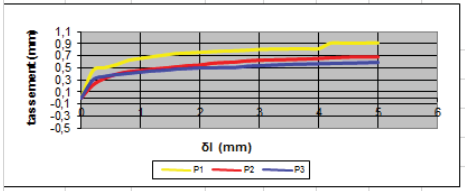
Caractéristiques de l'éprouvette — ρ_s

Hauteur =	20 mm	Largeur, diamètre =	60 mm	mesuré =	2,700 T/m3	estimé =	

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,85	1,707	8,2	0,582					48,61	61,097	5	61,097	5
2	1,85	1,707	8,2	0,582					104,18	77,887	3,2	77,887	5
3	1,85	1,707	8,2	0,582					200,02	89,08	2,6	89,08	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	55,164	55,164	10,05	10,05

Observations:

L'ingénieur responsable des essais:

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GEOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

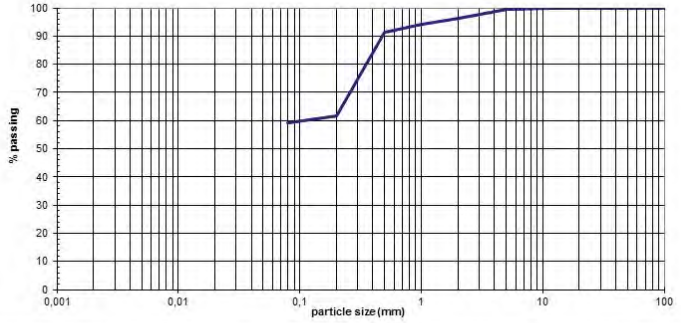
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC3 / DIAMNIADIO	2	1,50m à 2,00m	Black sandy clay with calcareous concretions	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
7,94			61,719	21,55	40,166	1,34		1,750		

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	99,4	96,2	94,0	91,4	61,8	59,2

Sieve mesh size (mm)											
Passing (%)											

OBSERVATIONS

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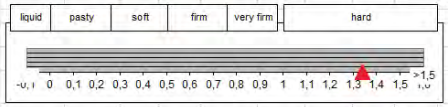
The engineer responsible of the tests

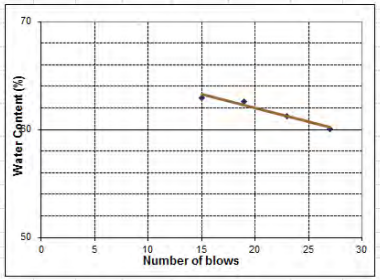
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.,	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC3 / DIAMNIADIO	2	1,50m à 2,00m	Black sandy clay with calcareous concretions	SIDY

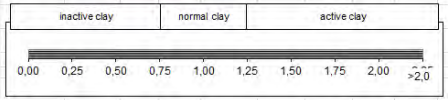
	1- Liquid Limit						2- Plasticy Limit			
Number of blows	15	19	23	27						
Tare N°	XF	Z	O	G7				B6	F24	
Total wet weight	96,48	85,7	86,97	47,3				74,57	72,71	
Total dry weight	81,08	68,87	69,98	36,42				70,47	69,11	
Total weight of tares	56,62	41,99	42,23	18,31				51,51	52,35	
Net weight of water	15,4	16,83	16,99	10,88				4,1	3,6	
Weight of dry material	24,46	26,88	27,75	18,11				18,96	16,76	
Water content (%)	62,96	62,612	61,23	60,077				21,6245	21,47971	
Limits and indices	W_L =	61,719	W_P =	21,552	I_P =	40,17	I_c =	1,34	A =	

3- Scale of Consistency (Ic)

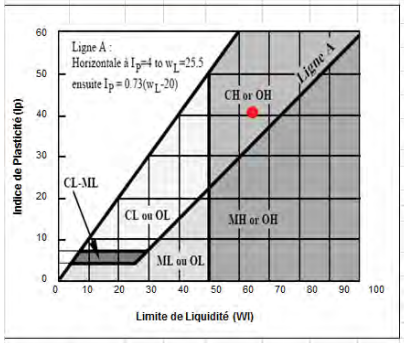




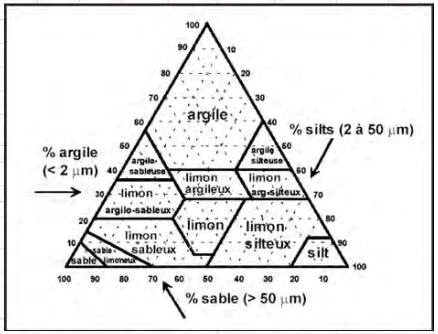
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	CH: Muddy, gravelly and/or sandy clay
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
		MH: Gravelly and/or sandy silt of high plasticity

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GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

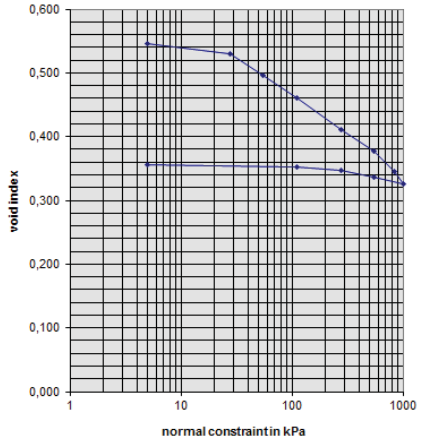
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**	Black sandy clay with calcareous concretions	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING			
SITE :	date of arrival at the laboratory :		Borehole N° :
DIAMNIADIO	date of tests :	03/01/2017	SC3

characteristic of the test-tube or core		Before test		After test		Sample N° :
						2
Diameter : D	***in mm***	D_0 =	50,47			Depht of test-tube or core (m) =
Height : H	***in mm***	Hi =	20			1,50m à 2,00m
dry formerly densité	***in Mg/m³***	γ_{di} =	1,63	γ_{df} =		Experimenter :
Unit weight	***in MG/m³***	γ_s =	2,52			
Water content	***in %***	Wi =	7,94	Wf =		Frame N° :
Saturation degree	***in %***	Sri =	36,59	Srf =		

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,842	0,546
		2	28	21,0	0,826	0,529
		3	56	62,0	0,793	0,497
		4	111	107,0	0,758	0,461
		5	277	170,0	0,708	0,412
		6	555	213,0	0,674	0,378
		7	830	255,0	0,641	0,345
		8	1000	280,0	0,621	0,325
		9	555	266,0	0,632	0,336
		10	277	253,0	0,643	0,346
		11	111	245,0	0,649	0,352
		12	5	240,0	0,653	0,356

oedometer curve



Results

Characteristics of compressibility

void index	e_i=	0,546
	e_0=	0,51
Vertical effective constraint	(kPa) σ'_{V0}=	28,47
Constraint of preconsolidation	(kPa) $\sigma'p$=	130
Index of compression	C_c=	0,205
Pressure of swelling	(kPa) Pg=	
Swelling index	C_s=	

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

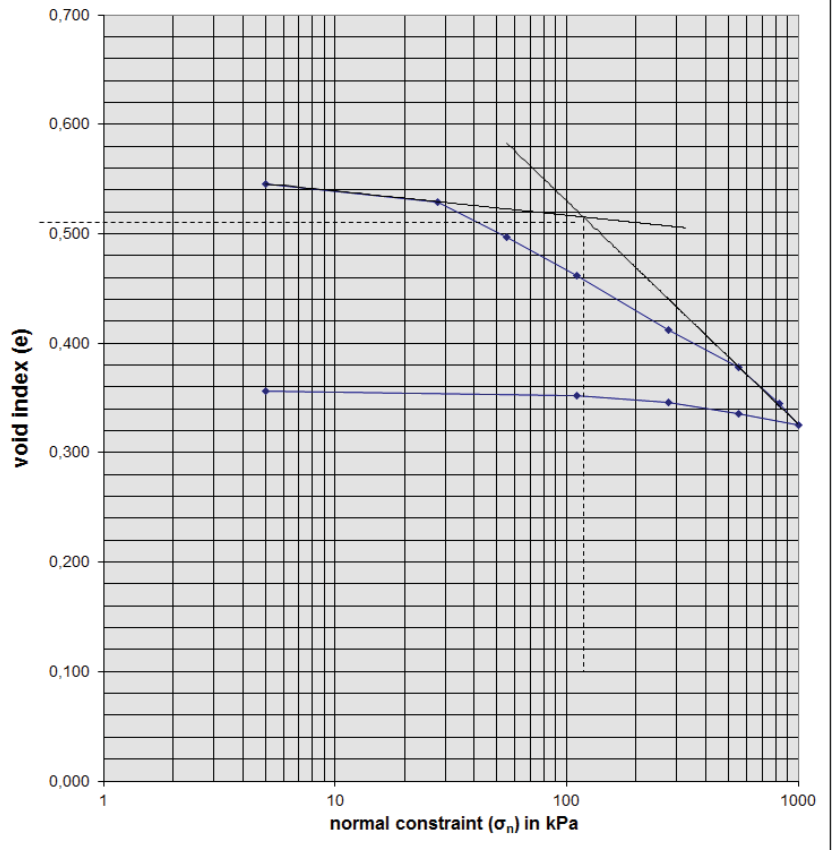
GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**	lack sandy clay with calcareous concretio		Register N° :
CT TEAM / YACHIYO ENGINEERI				
SITE :	date of arrival at the laboratory :			Borehole N° :
DIAMNIADIO	date of tests :		03/01/2017	
	sampling depht.	=	1,50m à 2,00m	Sample N° :
	test-tube (core)			2

oedometer curve



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GEOTEC AFRIQUE SENELABO

Direct linear shear test

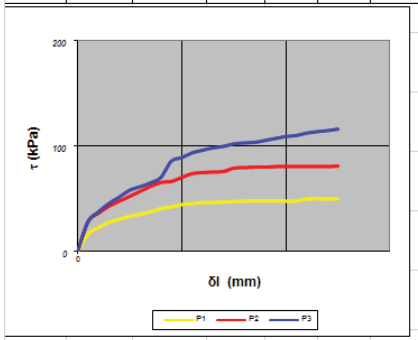
(réalisé conformément à la norme NF P 94-071-1)

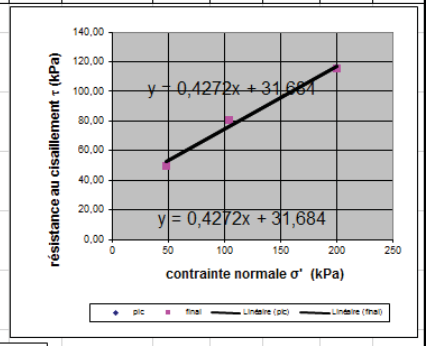
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar			**CLIENT**	JICA
Site:	Diamniadio			**Date essai:**	03/02/2016
N° Sondage:	SC3	**Prof. :**	1,5m à 2m	**Nature sol**	Black sandy clay with calcareous concretions
Vitesse de cis. =	0.5 mm/mn				

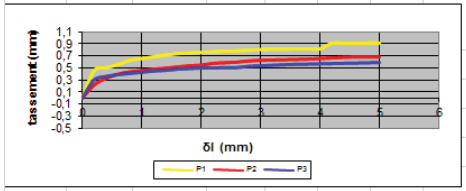
Caractéristiques de l'éprouvette — ρ_s

Hauteur =	20 mm	Largeur, diamètre =	60 mm	mesuré =	2,700 T/m3
estimé =					

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,75	1,621	7,9	0,6654					48,61	49,904	5	49,904	5
2	1,75	1,621	7,9	0,6654					104,18	80,219	3,2	80,219	5
3	1,75	1,621	7,9	0,6654					200,02	115,66	2,6	115,66	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	31,684	31,684	23,13	23,13

Observations:

L'ingénieur responsable des essais:

GEOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

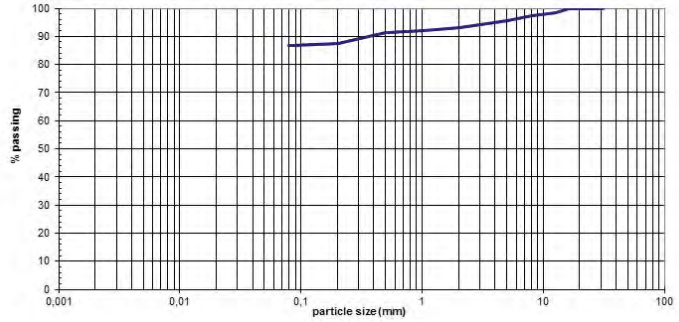
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A. ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC3 / DIAMNIADIO	3	2,50m à 3,00m	Whitish yellow marl-limestone (alternation of marl and narrow limestone beds)	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
8,28			158,18	47,55	110,63	1,35	A4	1,534		

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm	31,5	25	20	16	12,5	8	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	98,5	97,4	95,5	93,2	91,9	91,3	87,4	86,6

Sieve mesh size (mm)											
Passing (%)											

OBSERVATIONS

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The engineer responsible of the tests

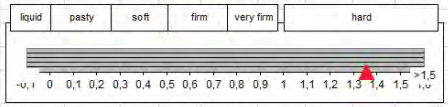
A-8-77

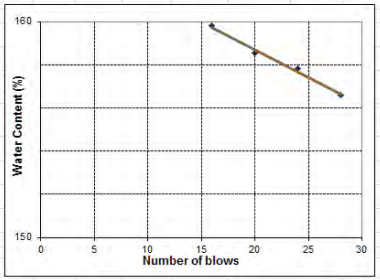
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.,	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A. ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC3 / DIAMNIADIO	3	2,50m à 3,00m	Whitish yellow marl-limestone (alternation of marl and narrow	SIDY

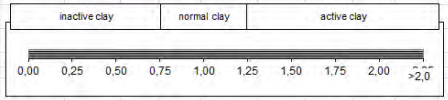
	1- Liquid Limit						2- Plastiey Limit		
Number of blows	16	20	24	28					
Tare N°	F24	B17	B6	XB			IZ	L4	
Total wet weight	85,24	76,29	86,52	87,29			64	61,42	
Total dry weight	65,01	56,82	65,09	65,9			56,85	55,41	
Total weight of tares	52,35	44,54	51,51	52,24			41,99	42,62	
Net weight of water	20,23	19,47	21,43	21,39			7,15	6,01	
Weight of dry material	12,66	12,28	13,58	13,66			14,86	12,79	
Water content (%)	159,79	158,55	157,8	156,59			48,1157	46,98984	
Limits and indices	W_L =	158,18	W_P =	47,553	I_P =	110,6	I_C =	1,35	A =

3- Scale of Consistency (Ic)

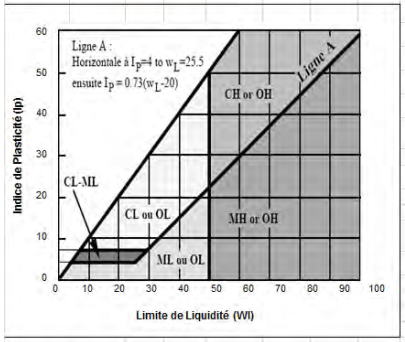




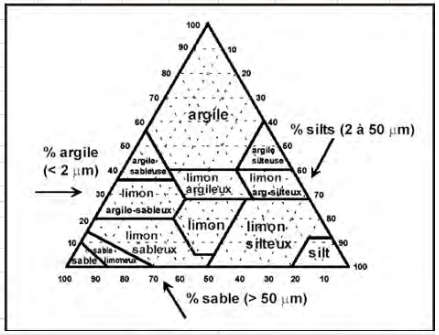
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	MH: Gravelly and/or sandy silt of high plasticity
		CH: Muddy, gravelly and/or sandy clay

Report of test with the oedometer (consolidation test)

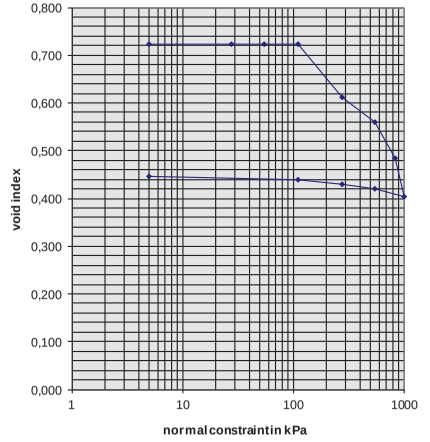
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : JICA PROJECT TEAM / YACHIYO ENGINEERING	**summery description :**	Whitish yellow marl-limestone (alternation of marl and narrow limestone beds)	Register N° :
SITE : DIAMNIADIO	date of arrival at the laboratory :		Borehole N° :
	date of tests :	28/12/2016	**SC3**

characteristic of the test-tube or core		**Before test**		**After test**		Sample N° :
						3
Diameter : D	***in mm***	D_0 =	50,47			Depht of test-tube or
Height : H	***in mm***	Hi =	20			core (m) =
dry formerly densité	***in Mg/m³***	γ_{di} =	1,42	γ_{df} =		2,50m à 3,00m
Unit weight	***in MG/m³***	γ_s =	2,44			Experimenter :
Water content	***in %***	Wi =	8,28	Wf =		
Saturation degree	***in %***	Sri =	27,98	Srf =		Frame N° : 1

Date	**hour beginning) of stage**	**stage n°**	σ_v (kPa)	Δh (10^{-2} mm)	**e**	$e_{corrected}$
		1	5	0,0	1,273	0,722
		2	28	0,0	1,273	0,722
		3	56	0,0	1,273	0,722
		4	111	0,0	1,273	0,722
		5	277	107,0	1,163	0,612
		6	555	159,0	1,110	0,559
		7	830	233,0	1,034	0,483
		8	1000	309,5	0,955	0,404
		9	555	294,0	0,971	0,420
		10	277	285,0	0,980	0,429
		11	111	275,0	0,991	0,440
		12	5	268,0	0,998	0,447

oedometer curve



Results

Characteristics of compressibility

void index		e_i=	0,722
		e_0=	0,722
Vertical effective constraint	(kPa)	σ'_{V0}=	38,97
Constraint of preconsolidation	(kPa)	σ'_p=	300
Index of compression		Cc=	0,596
Pressure of swelling	(kPa)	Pg<	111
Swelling index		Cs=	

Direct shear test

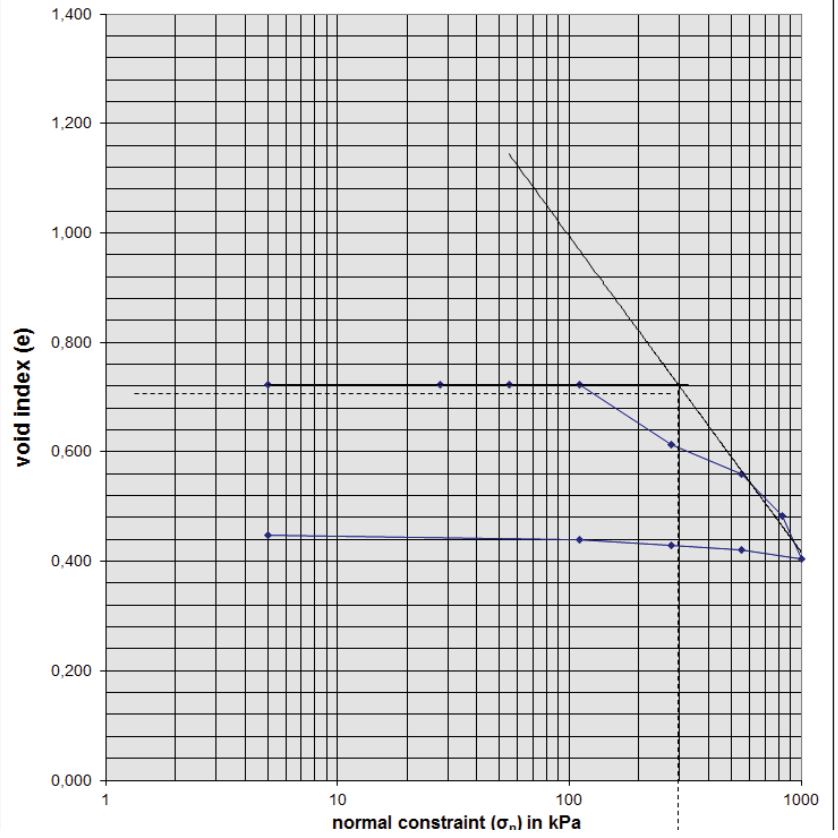
Speed of shearing	**Cohesion in kPa [c]**	**Angle of internal friction in ° [φ]**
mm/mn		

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : JICA PROJECT TEAM / YACHIYO ENGINEERING CO.,	**summery description :**	Whitish yellow marl-limestone (alternation of marl and narrow limestone beds)	Register N° :
SITE : DIAMNIADIO	date of arrival at the laboratory :		Borehole N° :
	date of tests :	28/12/2016	
	sampling depht. =	2,50m à 3,00m	Sample N° :
	test-tube (core)		3

oedometer curve



GEOTEC AFRIQUE - SENELABO _ Etude Préparatoire du Projet d'urgence de Renforcement et de Réhabilitation
du réseau de transport d'énergie dans la région de Dakar / Rapport d'études géotechniques n° GT/2016-484

Direct linear shear test

(réalisé conformément à la norme NF P 94-071-1)

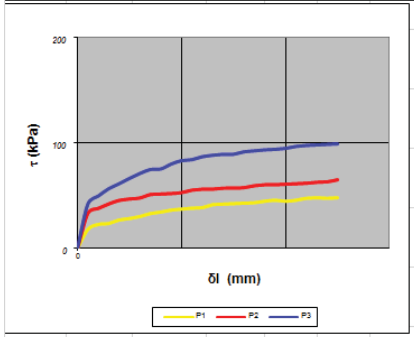
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'energie dans la région de Dakar	**CLIENT**	JICA
Site:	Diamniadio	**Date essai:**	03/02/2016

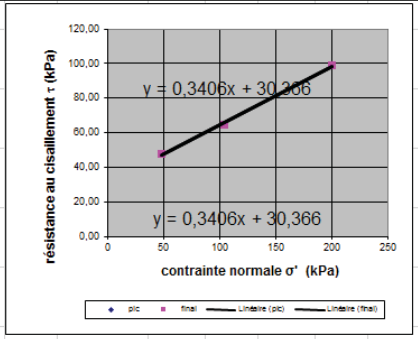
N° Sondage:	SC3	**Prof. :**	2,5m à 3m	**Nature sol**	Whitish yellow marl-limestone (alternation of marl and narrow limestone beds)	**Vitesse de cis. =**	0.5 mm/mn

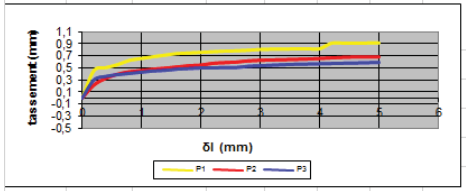
Caractéristiques de l'éprouvette — ρ_s

Hauteur = 20 mm — Largeur, diamètre = 60 mm — mesuré = 2,700 T/m3 — estimé =

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,53	1,417	8,3	0,9058					48,61	47,572	5	47,572	5
2	1,53	1,417	8,3	0,9058					104,18	64,828	3,2	64,828	5
3	1,53	1,417	8,3	0,9058					200,02	98,874	2,6	98,874	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	30,366	30,366	18,8	18,8

Observations:

L'ingénieur responsable des essais:

A-8-79

GEOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

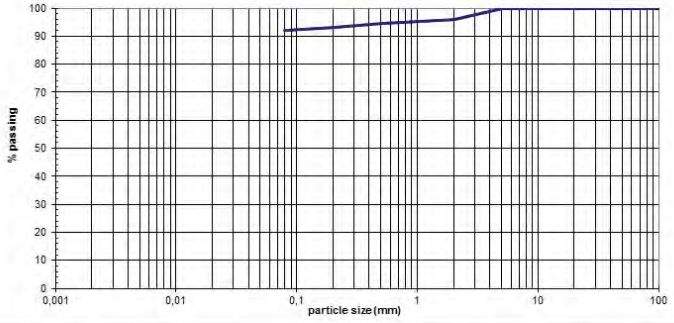
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar		29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC3 / DIAMNIADIO	4	4,50m à 5,50m	Whitish yellow marl-limestone (alternation of marl and narrow limestone beds)	

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
9,63			216,43	58,79	157,64	1,31		1,416		

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm)	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	95,8	95,3	94,5	93,0	92,2

Sieve mesh size (mm)											
Passing (%)											

OBSERVATIONS

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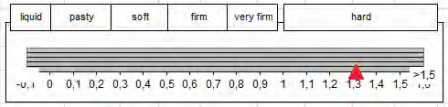
The engineer responsible of the tests

CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar		29/12/2012

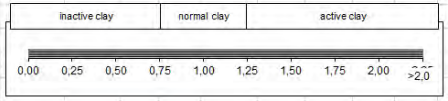
REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC3 / DIAMNIADIO	4	4,50m à 5,50m	Whitish yellow marl-limestone (alternation of marl and narrow	

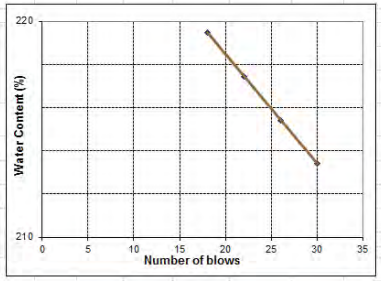
	1- Liquid Limit				2- Plasticy Limit	
Number of blows	18	22	26	30		
Tare N°	XF	A8	S3	115	7	MD
Total wet weight	85,96	129,08	101,6	126,45	75,35	75,78
Total dry weight	65,73	92,7	74,14	100,33	66,23	66,3
Total weight of tares	56,512	75,97	61,41	88,09	51	49,87
Net weight of water	20,23	36,38	27,42	26,12	9,12	9,48
Weight of dry material	9,218	16,73	12,73	12,24	15,23	16,43
Water content (%)	219,46	217,45	215,4	213,4	59,8818	57,69933
Limits and indices	W_L =	216,43	W_P =	58,791	I_P =	157,6	I_c =	1,31	A =

3- Scale of Consistency (Ic)

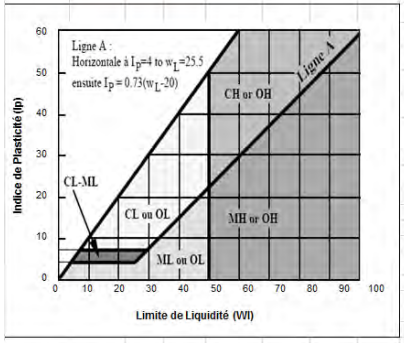


4- Scale of activity (A)

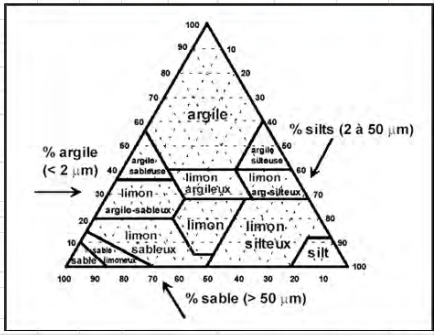




5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	MH: Gravelly and/or sandy silt of high plasticity
		CH: Muddy, gravelly and/or sandy clay

A-8-80

GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

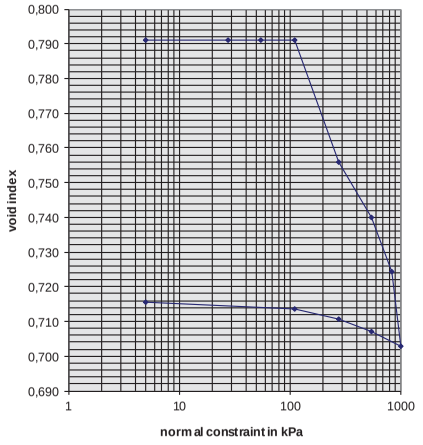
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : JICA PROJECT TEAM / YACHIYO ENGINEERING	**summery description :**	Whitish yellow marl-limestone (alternation of marl and narrow limestone beds)	Register N° :
SITE : DIAMNIADIO	date of arrival at the laboratory :		Borehole N° : **SC3**
	date of tests :	28/12/2016	Sample N° : **4**

characteristic of the test-tube or core		Before test		After test		
Diameter : D	***in mm***	D_0 =	50,47			Depht of test-tube or core (m) = 4,50m à 5,50m
Height : H	***in mm***	Hi =	20			
dry formerly densité	***in Mg/m³***	γ_{di} =	1,29	γ_{df} =		
Unit weight	***in MG/m³***	γ_s =	2,31			Experimenter :
Water content	***in %***	Wi =	9,63	Wf =		
Saturation degree	***in %***	Sri =	28,17	Srf =		Frame N° : 2

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,143	0,791
		2	28	0,0	0,143	0,791
		3	56	0,0	0,143	0,791
		4	111	0,0	0,143	0,791
		5	277	96,0	0,108	0,756
		6	555	139,0	0,092	0,740
		7	830	182,0	0,076	0,724
		8	1000	241,0	0,055	0,703
		9	555	229,0	0,059	0,707
		10	277	219,0	0,063	0,711
		11	111	211,0	0,066	0,714
		12	5	206,0	0,067	0,716

oedometer curve



Results

Characteristics of compressibility

void index		e_i= 0,791
		e_0= 0,791
Vertical effective constraint	(kPa)	σ'_{V0}= 51,68
Constraint of preconsolidation	(kPa)	$\sigma'p$= 250
Index of compression		Cc= 0,137
Pressure of swelling	(kPa)	Pg= 111
Swelling index		Cs=

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

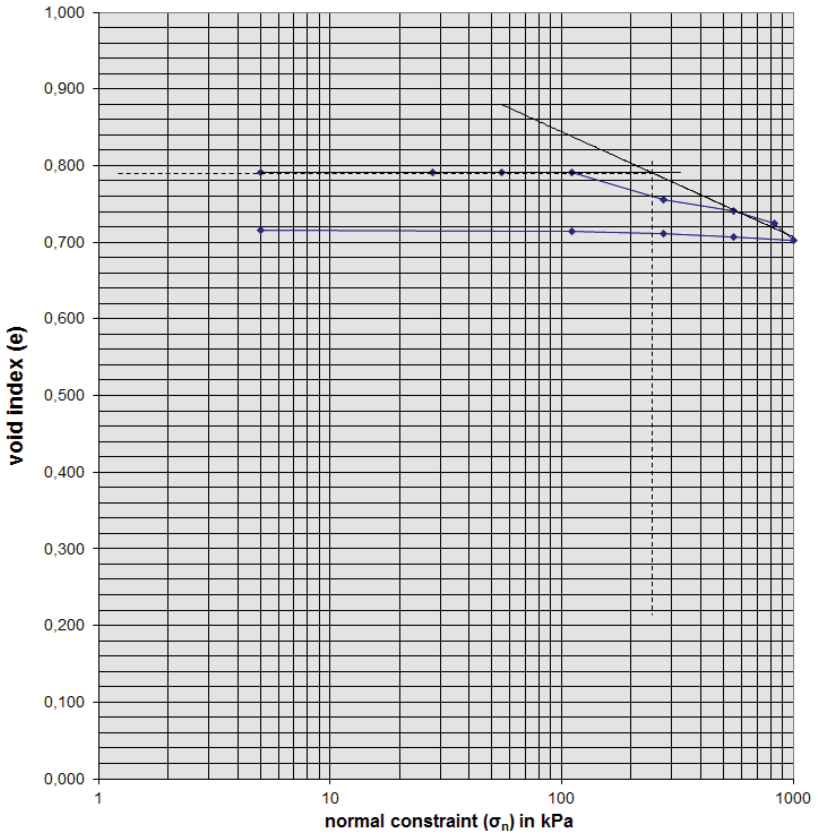
GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : JICA PROJECT TEAM / YACHIYO ENGINEERING CO.,	**summery description :**	Whitish yellow marl-limestone (alternation of marl and narrow limestone beds)	Register N° :
SITE : DIAMNIADIO	date of arrival at the laboratory :		Borehole N° :
	date of tests :	28/12/2016	
	sampling depht. =	4,50m à 5,50m	Sample N° :
	test-tube (core)		4

oedometer curve



A-8-81

GEOTEC AFRIQUE SENELABO

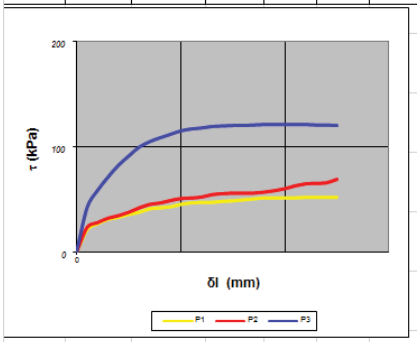
ESSAI DE CISAILLEMENT RECTILIGNE – CISAILLEMENT DIRECT

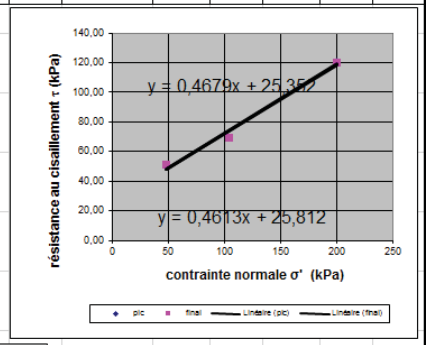
(réalisé conformément à la norme NF P 94-071-1)

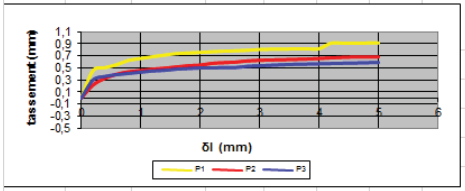
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de				**CLIENT**	JICA	
Site:	Diamniadio				**Date essai:**	03/02/2016	
N° Sondage:	SC3	**Prof. :**	4,5m à 5,5m	**Nature sol**	Whitish yellow marl-limestone (alternation of marl and narrow limestone beds)	**Vitesse de cis. =**	0.5 mm/mn

Caractéristiques de l'éprouvette				***ρ_s***		
Hauteur =	20 mm	Largeur, diamètre =	60 mm	mesuré =	2,700 T/m3	estimé =

N°	***Avant essai***					***Après consolid***		***Après cisaillement***	σ' (kPa)	***Paramètres de résistance au cisaillement***			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,42	1,292	9,6	1,0904					48,61	51,303	5	51,303	5
2	1,42	1,292	9,6	1,0904					104,18	69,026	3,2	69,026	5
3	1,42	1,292	9,6	1,0904					200,02	120,79	2,6	119,86	5
4													







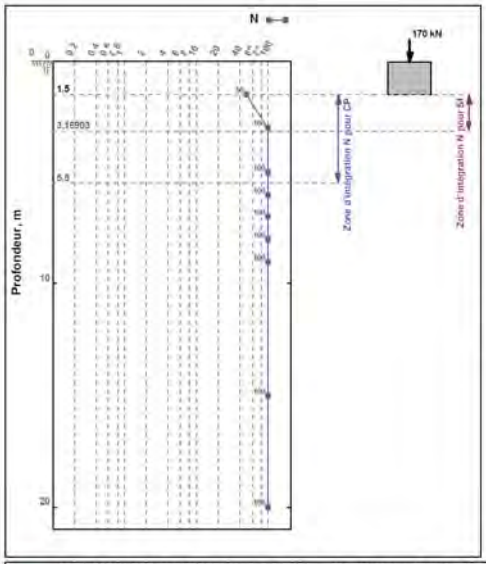
Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	25,352	25,812	25,07	24,76

Observations:

L'ingénieur responsable des essais:

Annex 3 : Sheet of geofond calculation

A-8-82



Fondation
Semelle rectangulaire
Largeur : 2 m, Longueur : 3 m
Aire : 6 m²
Encastrement : 1.5 m
Base de la fondation : 1.5 m

Paramètres des sols

Poids des terres au-dessus de la fondation :
après travaux = 18 kN/m³
avant travaux = 18.6 kN/m³
Contrainte verticale finale q'0 : 27 kPa (calculée)
Contrainte verticale initiale σ'v0 : 27.9 kPa (calculée)

Temps considéré
10 année(s)

Fichier : Key road SUBSTATION

GEOFOND® V1.19 du 08/06/2015 développé par GEOS
site web : http://www.geos.fr e-mail : logiciels@geos.fr
GEOS Ingénieurs Conseils, 310 Avenue Marie Curie
Bât. Europa 2, Archamps Technopole, 74160 ARCHAMPS
Tél : 04 50 95 38 14
Fax :04 50 95 99 36

Données :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	170	0	0	0	170	0
2	ELU	255	0	0	0	255	0

Capacité portante par la méthode de Meyerhoff (sable uniquement) :

				Pour les semelles		Pour les radiers	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'_u (MPa)	C.P. (MPa)	q'_u (MPa)	C.P. (MPa)
1	28.3	28.3	28.3	7.4	3.47 vérifié	6.11	2.04 vérifié
2	42.5	42.5	42.5	7.4	3.7 vérifié	6.11	3.06 vérifié

Tassements

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'_{v0} (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N°	S_f (cm)	S_f (cm)
1	28.3	77.5	0.0279	1.15	1.5	1.4	0.0148	1	0.813	0.0673	0.438	33.9	0.104	0.000936
2	42.5	Non Calculé (ELU)												

GT/2016-484 _ NLB 27/01/2017 10:17	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	Page 1	FIGURE
	Key road substation		Container build

SENELABO.BTP - 8236838946194400001

Résultats détaillés : capacité portante

Cas de charge N° : 1

ELS, F = 170 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 170 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.0283 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0283 MPa

qref = (3.qmax + qmin) / 4 = 0.0283 MPa

q'0 = γ_1.D - γ_e.Ze = 27 kPa

$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 98.6$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 7.4 MPa

Capa. Port. (ELS) = q'u / 3 = 2.47 MPa

pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 6.11 MPa

Capa. Port. (ELS) = q'u / 3 = 2.04 MPa

Résultats détaillés : tassement

Cas de charge N° : 1

ELS, F = 170 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 170 kN, MB = 0 kN.m

Zi = 10 ^ (0.7606 * log(B) - 0.0065) = 1.67

$Nm = 1/Zi \int_{D}^{D+Zi} N(z).dz = 77.5$

Par la méthode de BURLAND

f1 = ((1.25 L/B) / (L/B + 0.25))² = 1.15

f2 = 1.5

f3 = 1.3 + 0.2 log(t/3) = 1.4

Sf = (1.71 B^0.7 / N^1.4) f1 f2 f3 (σ'v0/3 + Δσ - σ'v0) = 0.0148 cm

Par la méthode de TERZAGHI & PECK

Cw = σv / σ'v = 1 (au niveau D + B/2)

Cd = 1 - D/(4B) = 0.813

Sf = 0.000723 qref / (N - 3) (2B / (B + 0.3048))²Cw Cd = 0.0673 cm

Par la méthode de PECK & BAZARAA

Cn = 0.77 log (100 / σ'v0) = 0.438

N* = Cn.N = 33.9

Sf = 0.000508 qref / N* (2B / (B + 0.3048))²Cw Cd = 0.104 cm

Par la méthode Alpan

α0 = 4.98054 N^(-1.18020) = 0.0293

Sf = (L/B)^0.39 * (2B / (B + 0.3048))² * α0/12 * (qref - σ'v0)/95.76052 * 24/100 = 0.000936 cm

GT/2016-484 _ NLB 27/01/2017 10:17	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 2	FIGURE
	Key road substation	Container build

SENELABO.BTP - 82368389461944000 1

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Résultats détaillés : capacité portante

Cas de charge N° : 1

ELS, F = 170 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 170 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.0283 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0283 MPa

qref = (3.qmax + qmin) / 4 = 0.0283 MPa

q'0 = γ_1.D - γ_e.Ze = 27 kPa

$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 98.6$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 7.4 MPa

Capa. Port. (ELS) = q'u / 3 = 2.47 MPa

pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 6.11 MPa

Capa. Port. (ELS) = q'u / 3 = 2.04 MPa

Résultats détaillés : tassement

Cas de charge N° : 1

ELS, F = 170 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 170 kN, MB = 0 kN.m

Zi = 10 ^ (0.7606 * log(B) - 0.0065) = 1.67

$Nm = 1/Zi \int_{D}^{D+Zi} N(z).dz = 77.5$

Par la méthode de BURLAND

f1 = ((1.25 L/B) / (L/B + 0.25))² = 1.15

f2 = 1.5

f3 = 1.3 + 0.2 log(t/3) = 1.4

Sf = (1.71 B^0.7 / N^1.4) f1 f2 f3 (σ'v0/3 + Δσ - σ'v0) = 0.0148 cm

Par la méthode de TERZAGHI & PECK

Cw = σv / σ'v = 1 (au niveau D + B/2)

Cd = 1 - D/(4B) = 0.813

Sf = 0.000723 qref / (N - 3) (2B / (B + 0.3048))²Cw Cd = 0.0673 cm

Par la méthode de PECK & BAZARAA

Cn = 0.77 log (100 / σ'v0) = 0.438

N* = Cn.N = 33.9

Sf = 0.000508 qref / N* (2B / (B + 0.3048))²Cw Cd = 0.104 cm

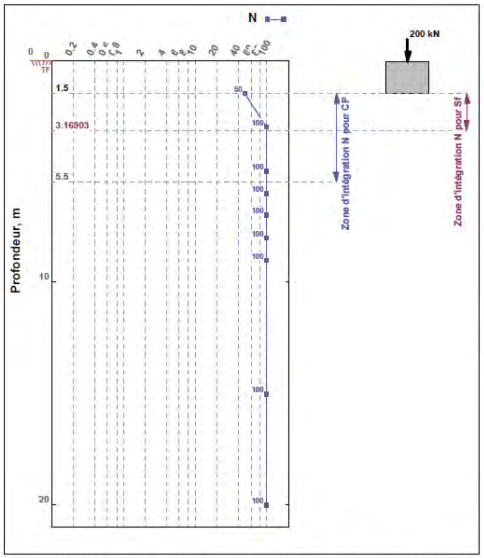
Par la méthode Alpan

α0 = 4.98054 N^(-1.18020) = 0.0293

Sf = (L/B)^0.39 * (2B / (B + 0.3048))² * α0/12 * (qref - σ'v0)/95.76052 * 24/100 = 0.000936 cm

GT/2016-484 _ NLB 27/01/2017 10:17	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 2	FIGURE
	Key road substation	Container build

SENELABO.BTP - 82368389461944000 1



Fondation
Semelle rectangulaire
Largeur : 2 m, Longueur : 3 m
Aire : 6 m²
Encastrement : 1.5 m
Base de la fondation : 1.5 m

Paramètres des sols

Poids des terres au-dessus de la fondation :
après travaux = 18 kN/m³
avant travaux = 18.6 kN/m³
Contrainte verticale finale q'0 : 27 kPa (calculée)
Contrainte verticale initiale σ'v0 : 27.9 kPa (calculée)

Temps considéré
10 année(s)

Fichier : Key road SUBSTATION

GEOFOND® V1.19 du 08/06/2015 développé par GEOS
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GEOS Ingénieurs Conseils, 310 Avenue Marie Curie
Bât. Europa 2, Archamps Technopole, 74160 ARCHAMPS
Tél : 04 50 95 38 14
Fax :04 50 95 99 36

Données :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	200	0	0	0	200	0
2	ELU	300	0	0	0	300	0

Capacité portante par la méthode de Meyerhoff (sable uniquement) :

				Pour les semelles		Pour les radiers	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'_u (MPa)	C.P. (MPa)	q'_u (MPa)	C.P. (MPa)
1	33.3	33.3	33.3	7.4	2.47 vérifié	6.11	2.04 vérifié
2	50	50	50	7.4	3.7 vérifié	6.11	3.06 vérifié

Tassements

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'_{v0} (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N*	S_f (cm)	S_f (cm)
1	33.3	77.5	0.0279	1.15	1.5	1.4	0.0224	1	0.813	0.0791	0.438	33.9	0.122	0.0117
2	50	Non Calculé (ELU)												

GT/2016-484 _ NLB 27/01/2017 10:18	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 1	FIGURE
	Key road substation	Container build

SENELABO.BTP - 82368389461944000 1

A-8-84

Résultats détaillés : capacité portante
Cas de charge N° : 1
ELS, F = 200 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 200 kN, MB = 0 kN.m

Par la méthode de Meyerhoff
qmin = Vd/A * (1-6*e/B) = 0.0333 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0333 MPa
qref = (3.qmax + qmin) / 4 = 0.0333 MPa
q'0 = γ.D - γe.Ze = 27 kPa

$$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 98.6$$

pour les semelles (B < 1.20 m)
3N/0.05 (1 + D/3B) = 7.4 MPa
Capa. Port. (ELS) = q'u / 3 = 2.47 MPa

pour les radiers (B > 1.20 m)
3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 6.11 MPa
Capa. Port. (ELS) = q'u / 3 = 2.04 MPa

Résultats détaillés : tassement
Cas de charge N° : 1
ELS, F = 200 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 200 kN, MB = 0 kN.m

Zi = 10 ^ (0.7606 * log(B) - 0.0065) = 1.67

$$Nm = 1/Zi \int_{D}^{D+Zi} N(z).dz = 77.5$$

Par la méthode de BURLAND
f1 = ((1.25 L/B) / (L/B + 0.25))² = 1.15
f2 = 1.5
f3 = 1.3 + 0.2 log(t/3) = 1.4
Sf = (1.71 B^0.7 / N^1.4) f1 f2 f3 (σ'v0/3 + Δσ - σ'v0) = 0.0224 cm

Par la méthode de TERZAGHI & PECK
Cw = σv / σ'v = 1 (au niveau D + B/2)
Cd = 1 - D/(4B) = 0.813
Sf = 0.000723 qref / (N - 3) (2B / (B + 0.3048))²Cw Cd = 0.0791 cm

Par la méthode de PECK & BAZARAA
Cn = 0.77 log (100 / σ'v0) = 0.438
N* = Cn.N = 33.9
Sf = 0.000508 qref / N* (2B / (B + 0.3048))²Cw Cd = 0.122 cm

Par la méthode Alpan
α0 = 4.98054 N^(-1.18020) = 0.0293
Sf = (L/B)^0.39 * (2B / (B + 0.3048))² * α0/12 * (qref - σ'v0)/95.76052 * 24/100 = 0.0117 cm

GT/2016-484 _ NLB 27/01/2017 10:18	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 2	FIGURE
	Key road substation	Container build

SENELABO.BTP - 82368389461944000 1

Résultats détaillés : capacité portante

Cas de charge N° : 2

ELU, F = 300 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 300 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.05 MPa ; qmax = Vd/A * (1+6*e/B) = 0.05 MPa

qref = (3.qmax + qmin) / 4 = 0.05 MPa

$q'0 = \gamma.D - \gamma e.Ze = 27$ kPa

$$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 98.6$$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 7.4 MPa

Capa. Port. (ELU) = q'u / 2 = 3.7 MPa

pour les radiers (B > 1.20 m)

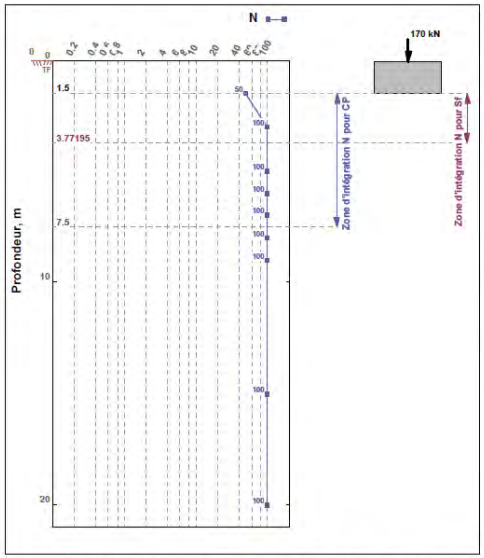
3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 6.11 MPa

Capa. Port. (ELU) = q'u / 2 = 3.06 MPa

GT/2016-484 _ NLB 27/01/2017 10:18	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 3	FIGURE
	Key road substation	Container build

SENELABO.BTP - 82368389461944O001

A-8-85



Fondation
Semelle rectangulaire
Largeur : 3 m, Longueur : 4 m
Aire : 12 m²
Encastrement : 1.5 m
Base de la fondation : 1.5 m

Paramètres des sols

Poids des terres au-dessus de la fondation :
après travaux = 18 kN/m³
avant travaux = 18.6 kN/m³
Contrainte verticale finale q'0 : 27 kPa (calculée)
Contrainte verticale initiale σ'v0 : 27.9 kPa (calculée)

Temps considéré
10 année(s)

Fichier : Key road SUBSTATION

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Bât. Europa 2, Archamps Technopole, 74160 ARCHAMPS
Tél : 04 50 95 38 14
Fax :04 50 95 99 36

Données :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	170	0	0	0	170	0
2	ELU	255	0	0	0	255	0

Capacité portante par la méthode de Meyerhoff (sable uniquement) :

				Pour les semelles		Pour les radiers	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'_u (MPa)	C.P. (MPa)	q'_u (MPa)	C.P. (MPa)
1	14.2	14.2	14.2	7	2.33 vérifié	5.29	1.76 vérifié
2	21.3	21.3	21.3	7	3.5 vérifié	5.29	2.65 vérifié

Tassements

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'_{v0} (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N°	S_f (cm)	S_f (cm)
1	14.2	83.5	0.0279	1.11	1.5	1.4	0.0083	1	0.875	0.0367	0.438	36.6	0.0568	-0.0284
2	21.3	Non Calculé (ELU)												

GT/2016-484 _ NLB 27/01/2017 10:20	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 1	FIGURE
	Key road substation	Container build

SENELABO.BTP - 82368389461944O001

Résultats détaillés : capacité portante

Cas de charge N° : 1

ELS, F = 170 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 170 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.0142 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0142 MPa

qref = (3.qmax + qmin) / 4 = 0.0142 MPa

q'0 = γ.D - γe.Ze = 27 kPa

$$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 100$$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 7 MPa

Capa. Port. (ELS) = q'u / 3 = 2.33 MPa

pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 5.29 MPa

Capa. Port. (ELS) = q'u / 3 = 1.76 MPa

Résultats détaillés : tassement

Cas de charge N° : 1

ELS, F = 170 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 170 kN, MB = 0 kN.m

Zi = 10 ^ (0.7606 * log(B) - 0.0065) = 2.27

$$Nm = 1/Zi \int_{D}^{D+Zi} N(z).dz = 83.5$$

Par la méthode de BURLAND

f1 = ((1.25 L/B) / (L/B + 0.25))² = 1.11

f2 = 1.5

f3 = 1.3 + 0.2 log(t/3) = 1.4

Sf = (1.71 B^0.7 / N^1.4) f1 f2 f3 (Δp/3) = 0.0083 cm

Par la méthode de TERZAGHI & PECK

Cw = σv / σ'v = 1 (au niveau D + B/2)

Cd = 1 - D/(4B) = 0.875

Sf = 0.000723 qref / (N - 3) (2B / (B + 0.3048))²Cw Cd = 0.0367 cm

Par la méthode de PECK & BAZARAA

Cn = 0.77 log (100 / σ'v0) = 0.438

N* = Cn.N = 36.6

Sf = 0.000508 qref / N* (2B / (B + 0.3048))²Cw Cd = 0.0568 cm

Par la méthode Alpan

α0 = 4.98054 N^(-1.18020) = 0.0269

Sf = (L/B)^0.39 * (2B / (B + 0.3048))² * α0/12 * (qref - σ'v0)/95.76052 * 24/100 = -0.0284 cm

GT/2016-484 _ NLB 27/01/2017 10:20	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	Page 2	FIGURE
	Key road substation		Container build

SENELABO.BTP - 82368389461944000 1

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Résultats détaillés : capacité portante

Cas de charge N° : 2

ELU, F = 255 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 255 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.0213 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0213 MPa

qref = (3.qmax + qmin) / 4 = 0.0213 MPa

q'0 = γ.D - γe.Ze = 27 kPa

$$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 100$$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 7 MPa

Capa. Port. (ELU) = q'u / 2 = 3.5 MPa

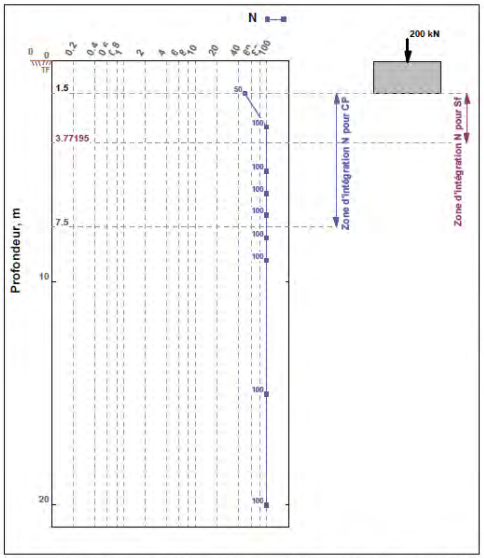
pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 5.29 MPa

Capa. Port. (ELU) = q'u / 2 = 2.65 MPa

GT/2016-484 _ NLB 27/01/2017 10:20	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	Page 3	FIGURE
	Key road substation		Container build

SENELABO.BTP - 82368389461944000 1



Fondation
Semelle rectangulaire
Largeur : 3 m, Longueur : 4 m
Aire : 12 m²
Encastrement : 1.5 m
Base de la fondation : 1.5 m

Paramètres des sols

Poids des terres au-dessus de la fondation :
après travaux = 18 kN/m³
avant travaux = 18.6 kN/m³
Contrainte verticale finale q'0 : 27 kPa (calculée)
Contrainte verticale initiale σ'v0 : 27.9 kPa (calculée)

Temps considéré
10 année(s)

Fichier : Key road SUBSTATION

GEOFOND® V1.19 du 08/06/2015 développé par GEOS
site web : http://www.geos.fr e-mail : logiciels@geos.fr
GEOS Ingénieurs Conseils, 310 Avenue Marie Curie
Bât. Europa 2, Archamps Technopole, 74160 ARCHAMPS
Tél : 04 50 95 38 14
Fax :04 50 95 99 36

Données :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	200	0	0	0	200	0
2	ELU	300	0	0	0	300	0

Capacité portante par la méthode de Meyerhoff (sable uniquement) :

				Pour les semelles		Pour les radiers	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'_u (MPa)	C.P. (MPa)	q'_u (MPa)	C.P. (MPa)
1	16.7	16.7	16.7	7	2.33 vérifié	5.29	1.76 vérifié
2	25	25	25	7	3.5 vérifié	5.29	2.65 vérifié

Tassements

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'v0 (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N*	S_f (cm)	S_f (cm)
1	16.7	83.5	0.0279	1.11	1.5	1.4	0.00976	1	0.875	0.0432	0.438	36.6	0.0668	-0.0233
2	25	Non Calculé (ELU)												

GT/2016-484 _ NLB 27/01/2017 10:19	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 1	FIGURE
	Key road substation	Container build

SENELABO.BTP - 8236838946194400001

Résultats détaillés : capacité portante
Cas de charge N° : 1
ELS, F = 200 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 200 kN, MB = 0 kN.m

Par la méthode de Meyerhoff
qmin = Vd/A * (1-6*e/B) = 0.0167 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0167 MPa
qref = (3.qmax + qmin) / 4 = 0.0167 MPa
q'0 = γ.D - γe.Ze = 27 kPa

$$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 100$$

pour les semelles (B < 1.20 m)
3N/0.05 (1 + D/3B) = 7 MPa
Capa. Port. (ELS) = q'u / 3 = 2.33 MPa

pour les radiers (B > 1.20 m)
3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 5.29 MPa
Capa. Port. (ELS) = q'u / 3 = 1.76 MPa

Résultats détaillés : tassement
Cas de charge N° : 1
ELS, F = 200 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 200 kN, MB = 0 kN.m

Zi = 10 ^ (0.7606 * log(B) - 0.0065) = 2.27

$$Nm = 1/Zi \int_{D}^{D+Zi} N(z).dz = 83.5$$

Par la méthode de BURLAND
f1 = ((1.25 L/B) / (L/B + 0.25))² = 1.11
f2 = 1.5
f3 = 1.3 + 0.2 log(t/3) = 1.4
Sf = (1.71 B^0.7 / N^1.4) f1 f2 f3 (Δp/3) = 0.00976 cm

Par la méthode de TERZAGHI & PECK
Cw = σv / σ'v = 1 (au niveau D + B/2)
Cd = 1 - D/(4B) = 0.875
Sf = 0.000723 qref / (N - 3) (2B / (B + 0.3048))²Cw Cd = 0.0432 cm

Par la méthode de PECK & BAZARAA
Cn = 0.77 log (100 / σ'v0) = 0.438
N* = Cn.N = 36.6
Sf = 0.000508 qref / N* (2B / (B + 0.3048))²Cw Cd = 0.0668 cm

Par la méthode Alpan
α0 = 4.98054 N^(-1.18020) = 0.0269
Sf = (L/B)^0.39 * (2B / (B + 0.3048))² * α0/12 * (qref - σ'v0)/95.76052 * 24/100 = -0.0233 cm

GT/2016-484 _ NLB 27/01/2017 10:19	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 2	FIGURE
	Key road substation	Container build

SENELABO.BTP - 8236838946194400001

Résultats détaillés : capacité portante

Cas de charge N° : 2

ELU, F = 300 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 300 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.025 MPa ; qmax = Vd/A * (1+6*e/B) = 0.025 MPa

qref = (3.qmax + qmin) / 4 = 0.025 MPa

$q'0 = \gamma.D - \gamma e.Ze = 27$ kPa

$$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 100$$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 7 MPa

Capa. Port. (ELU) = q'u / 2 = 3.5 MPa

pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 5.29 MPa

Capa. Port. (ELU) = q'u / 2 = 2.65 MPa

GT/2016-484 _ NLB 27/01/2017 10:19	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 3	FIGURE
	Key road substation	Container build

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GEOTEC AFRIQUE SENELABO

GEOTECHNICAL REPORT

Etude Préparatoire du Projet d'urgence de Renforcement et de Réhabilitation du réseau de transport d'énergie dans la région de Dakar

JICA PROJECT TEAM

YACHIYO ENGINEERING CO., LTD.

DAKAR - SENEGAL

BARGNY SUBSTATION

January 27, 2017

SENELABO GÉOTECHNIQUE

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Mission G_2 AVP

GEOTECHNIC PRELIMINARY STUDY PROJECT

Etude Préparatoire du Projet d'urgence de Renforcement et de Réhabilitation du réseau de transport d'énergie dans la région de Dakar

JICA PROJECT TEAM

YACHIYO ENGINEERING CO., LTD.

DAKAR - SENEGAL

BARGNY SUBSTATION

January 27, 2017

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N° FOLDER		GT/2016-484			GT	MISSION : G2AVP	
Index	Date	Number of pages		Emetted by	Verified by	Modifications Observations	Approved by
		Text	Annex				
0	07/01/2017	10	2	N. L. BADJI		First release	
A	27/01/2017	13	37	N. L. BADJI		Integration of laboratory test and foundation recommendation	
B							
C							

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I. PRESENTATION

I.1. DEFINITION OF THE OPERATION – CONTRIBUTOR

On request and on behalf of JICA PROJECT TEAM (YACHIYO ENGINEERING CO., LTD.), GEOTEC AFRIQUE-SENELABO was commissioned to carry out geotechnical studies for **"Projet d'urgence de Renforcement et de Réhabilitation du réseau de transport d'énergie dans la région de Dakar, SENEGAL".**

I.2. MISSION

This is a mission of G2AVP type according to NF P 94-500 standard as defined in the classification of types of geotechnical tasks prepared by the geotechnical trade union and standardized AFNOR NFP 94500 in November 2013.

This mission will allow :

- To define a field geotechnical investigation campaign and make its realization by core drilling with Standard Penetration Test (SPT) as in-situ soil testing ;
- To determine the nature of soils that can be mobilized and their depth ;
- To define foundation systems adapted to soils encountered and proposed buildings ;
- To determine the bearing capacity of soil in place ;
- To define the constructive arrangements for taking into account the phenomenon of shrinkage and swelling of the existing soil ;
- Provide recommendations for earthworks.

I.3. PROJECT - RECEIVED DOCUMENTS

The project consists of reinforcement and rehabilitation of the energy transport network of Dakar ; Bargny substation. The features and details of the work are not been communicated to us. However it has been communicated to us the technical specifications for site investigation works.

I.4. CONVENTIONS USED

The various tests carried conform to AFNOR standards.

Recommendations and justifications were made according to the following regulations:

- XP ENV 1997-1 Eurocode 7 – geotechnical calculation - General rules;
- NF P11-300 : Earthworks ;
- AFNOR P11-211 – DTU 13.11 – shallow foundations ;
- AFNOR P11-711 – DTU 13.12 – Rules for the design of shallow foundations ;
- AFNOR NF P11-213-1 to 4 – DTU 13.3 – Rules for construction of pavings.

II. LOCALISATION AND GEOLOGICAL SETTINGS

II.1. SITE LOCATION

The Bargny substation site is located at Bargny town near the municipal stadium as saw below (figure 1).

Figure 1 : Bargny substation location map

II.2. GEOLOGICAL SETTING OF THE SITE

Geological studies on the peninsula of Cap-Vert by (Castelain and al[1], 1965; Tessier and al[2], 1967; Lappartient 1985; Crévola and al[3], 1994 etc.) and many other authors and updated by the PASMI[4] (2009), allowed to the stratigraphic synthesis of tertiary and quaternary formations in the area of Dakar (Figure 2).

The project site relies on the old tertiary and quaternary sedimentary rock. These formations are mainly :

- Marl and clay with planktonic and benthic foraminifera ;
- Clay facies with planpronic foraminifera and Ypresian clay-marly facies ;
- Clay, limestone, marl- limestone, marl and clay with planktonic and benthic foraminifera of the Middle and Lower Eocene.

[1] CASTELAIN J. (1965) – Aperçu stratigraphique et micropaléontologique du bassin du Sénégal occidental. Historique de la découverte paléontologique. In : « Colloque International de Micropaléontologie » (Dakar). Mémoire BRGM, 32, p. 135-159.

[2] TESSIER F. & LAPPARTIENT J-R. (1967) - Observations sur la latérite récente des environs de Dakar. Bull. Soc. Géol. Fr., Paris, 9 (7), p. 455-466.

[3] G. Crevola, J.-M. Cantagrel, C. Moreau, 1994. *Le volcanisme de la presqu'île du Cap-Vert (Sénégal) : cadre chronologique et géodynamique*, Bull. Soc. géol. France, 165, 5, 437-446.

[4] PASMI : Programme d'Appui au Secteur Minier / Projet 9 ACP SE 009 - Cartographie géologique du Bassin Sédimentaire, Geoter/BRGM/Direction des Mines et de la Géologie, Dakar, 2009.

Geologically, the study area is located at the Graben of Rufisque. This graben with general orientation NNE-SSW, is limited to the East by the horst of Diass. The Rufisque graben is characterized by Campano-Maastrichtian formations, Tertiary and Quaternary formations of the Senegal-Mauritanian basin. In the sector of Rufisque-Bargny and Diamniadio, in favor of several quarries, essentially four lithological ensembles are noted. This is the limestone unit ("Bargny limestone"), marly units ("marl with narrow clayey limestone beds with Frondicularia", "marl with clayey limestone beds" and "gray marl with Radiolarians"). This area is cut by sub-meridian faults which delimit the horst and the grabens. These faults are sometimes associated with volcanic events between the Upper Eocene and the Quaternary (Crevola et al., 1994).

Figure 2: Geological map of the peninsula of Cap-Vert and the plateau of Thiès

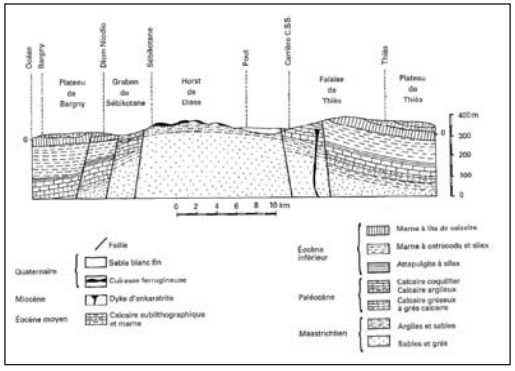

Figure 3: Geological cross-section of Diass Horst, plateau of Thiès and Bargny

III. PROGRAM AND RESULTS OF INVESTIGATION

III.1. PROGRAM OF INVESTIGATION

For this studies GEOTEC AFRIQUE - SENELABO realized on the site :

- One (01) borehole at 20m depth of investigation with SPT (in-situ soil testing) were carried out in order to take samples for laboratory tests and to define detailed log of the lithology of the site;
- Laboratory tests to identify and characterize the soil, we have done the following tests :
  - Moisture content tests [NF P 94-050]
  - Grain size analysis [NF P 94-056]
  - Specific Weight [NF P 94-053]
  - Apparent and absolute density [NF P 94-053, 94-064]
  - Atterberg limits [NF P 94-051]
  - VBS (Blue Methylen value) [NF P 94-068]
  - Direct linear shear test [NF P 94-071-1]
  - Standard oedometer test [NF P 94-090-1]
  - Compressive strength tests on rock [NF P 94-420]

III.2. DESCRIPTION OF THE CORES SAMPLES

At the location of the project, we conducted core drilling with SPT to identify and characterize the ground. The observations carried out allowed us to establish the log below.

Hole ID	Depth from (m)	Depth to (m)	Lithological description of cores
SC1/Bargny substation	0	1	Black sandy clay with calcareous concretions
	1	1,5	Clay Laterite
	1,5	5	Limestone
	5	10	Marly limestone
	10	11,45	Yellowish marl, tender
	11,45	13,5	Yellowish marl, Compact
	13,5	13,95	Greyish marl
	13,95	15,5	Greenish gray clayey marl, tender
	15,5	20,1	Greenish gray clayey marl, compact

NB : All the above depths are given at our Borehole and the reference level of depth are the existing ground level.

III.3. RESULTS OF STANDARDS PENETRATION TEST (SPT)

The project site relies on a tender to compact marl and alternation of compact marl and limestones. However we have carried out SPT tests and the results are summarized below.

Hole ID	Depth	Number of blows			
		Start of test	Test		N
		N0	N1	N2	
SC1/Bargny substation	1,5 to 1,55 m	> 50 (without penetration)	-	-	> 100
	up to 20 m	> 50 (without penetration)	-	-	> 100
NB : The tests are carried out at intervals of 1m					

III.4. RESULTS OF THE LABORATORY TESTS AND SOIL CARACTERISATION

The results of laboratory tests conducted on soil samples collected from core samples are summarized on the table below.

CUSTOMER		JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.			
Project		PREPARATOIRE DU PROJET D'URGENCE, DE RENFORCEMENT ET DE REHABILITATION DU RESEAU DE TRANSPORT D'ENERGIE DANS LA REGION DE D			
Borehole Number		SC1/Bargny substation			
Depth (m)		0,20m à 1,00m	1,00m à 1,50m	10,00m à 10,50m	13,92m à 14,80m
Lithological nature of soil		Black sandy clay with calcareous concretions	Clay Laterite	Yellowish marl, tender	Greenish gray clayey marl, tender
Water content	W%	5,22	3,98	4,61	4,35
Wet density (t/m3)	γ_h	1,680	1,993	1,611	1,666
Dry density (t/m3)	γ_d	1,597	1,917	1,540	1,597
Specific density	γs	2,520	2,650	2,200	2,200
Grain size analysis	Dmax(mm)	2,0	12,5	0,5	0,08
	5mm	100,0	88,1	100,0	100,0
	2mm	99,0	62,0	100,0	100,0
	1mm	97,7	54,5	100,0	100,0
	0.5mm	96,4	53,1	98,8	100,0
	0.125mm	56,8	41,9	98,3	100,0
	0.08mm	52,2	39,0	98,0	99,8
Atterberg limits (%)	WL	43,26	46,94	166,35	165,00
	WP	16,67	16,09	54,17	56,66
	IP	26,59	30,85	112,18	108,34
	Ic	1,43	1,39	1,44	1,483
Cohésion (kPa)	C	29,91	15,01	24,95	42,79
Internal friction angle (°)	φ	24,8	32,47	28,25	17,51
Preconsolidation pressure (kPa)	σ'p	140	210	180	310
Compressibility index	Cc	0,259	0,160	0,304	0,170
Classification GTR		A3	A3	A4	A4

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On some core samples, Compressive strength tests are been carried out ant the results are summarized on the table below.

CUSTOMER		JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.				
Project		ETUDE PREPARATOIRE DU PROJET D'URGENCE, DE RENFORCEMENT ET DE REHABILITATION DU RESEAU DE TRANSPORT D'ENERGIE DANS LA REGION DE DAKAR				
Borehole Number		SC1/Bargny substation				
Depth (m)		4,80m	6,86m	9,60m	13,60m	17,70m
Lithological nature of soil		Limestone	Marly limestone	Marly limestone	Greyish marl	Greenish gray clayey marl, compact
Compressive strength (MPa)	Rc	11,68	12,70	11,59	11,62	11,22
Description		Very weakly resistant	Very weakly resistant	Very weakly resistant	Very weakly resistant	Very weakly resistant

III.5. HYDROGEOLOGY OF THE SITE

The ground water was encountered at 2.3m during drilling. However, we can not exclude the presence of anarchic water circulations on preferential flow channels. The hydrological regime can vary depending on the season and rainfall.

III.6. NATURAL AND ANTHROPIC RISKS

The marl-limestone substratum is a sedimentary environment and likely to have lateral variations in bedding thickness.

The ground water was encountered at 2.3m during drilling. This could have an impact on the foundation with the increase of the ground water level. It will be necessary to determine the level of the highest waters.

The soils encountered in the project area present locally a risk of shrinkage and swelling. Since variations in the water conditions of the environment may be accentuated by anthropogenic channels, plantations and runoff of rainwater, information on the risk of flooding in the lower areas of the project should be obtained.

We can also note the existence of underground electric cable and foundation of existing equipment in bargny substation.

III.7. SEISMICITY OF THE SITE

The project site is located at the plateau of Bargny tectonically stable and therefore deemed non-seismic.

III.8. DEFINITION OF ZONE OF INFLUENCE AND GEOTECHNICAL MODEL

The Geotechnical Influence Zone (GIZ) is not restricted to the parcel interested in the project. It also concerns the immediate environment (interfaces related to temporary earthworks) with the presence of roads, habitations and Fence of the stadium near the project.

Aerial view of the site

According to the results of the laboratory tests, the geotechnical model can be defined in this version of the report (See table below).

Selected geotechnical characteristics									
Lithological nature of soil	Depth (m/GL)	Wet density (t/m3)	Specific density (t/m3)	Atterberg limits (Ip) %	Cohésion (kPa)	Internal friction angle (°)	Classification according to the GTR	Compressive strength (MPa)	SPT N-value
Filling depot (Black sandy clay with calcareous concretions and clay latérit)	1,5	1,84	2,6	28,7	22,5	28,6	A3	-	> 100
Calcareous formations (Limestone and Marly limestone)	10	-	-	-	-	-	R2	12	> 100
Marly formation (Yellowish marl, tender to compact)	13,95	1,61	2,20	112,18	24,95	28,25	A4 to R2	11,62	> 100
Greenish gray clayey marl, tender to compact	> 20	1,67	2,20	108,34	42,79	17,51	A4 to R2	11,22	> 100

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IV. RECOMMENDATIONS

IV.1. JUSTIFICATION OF SHALLOW FOUNDATIONS

- **Definition of fondations :**

Considering the observations of the field investigation and foundation elements that have been transmitted to us, we check here a rectangular foundation raft for shallow foundation.

- **Strength limits of soil :**

The Geofond software was used to evaluate the bearing capacity of the soil. The calculation is done using the method of Meyerhoff which involves the calculation of an average value Nm of N by the relation:

$$N_m = \frac{1}{2B - 0{,}5B} \int_{D+0{,}5B}^{D+2B} N(z)dz$$

The breaking stress q'u under the base of foundation raft is given by the equation:

$$q'_u = \frac{3 \cdot N}{0{,}08} \cdot \left(1 + \frac{D}{3 \cdot B}\right) \cdot \left(\frac{B + 0{,}3}{B}\right)^2$$

With D = anchoring depth and B = Width of the foundation raft.

The bearing capacity at SLS and ULS are given respectively by $q'_u / 3$ and $q'_u / 2$ and the table below gives the results of this calculation.

Structures	Dimensions of the foundation raft	Anchoring depth (m) / GL	Applied load (kN)	Breaking stress q'_u (MPa)	Bearing capacity (MPa)		Settlements Sf (cm)
					SLS	ULS	
Container building	*2 m x 3 m*	*1,5*	*170*	6,2	2,07	3,1	≤ 0,080
	2 m x 3 m	*1,5*	*200*	6,2	2,07	3,1	≤ 0,095
	3 m x 4 m	*1,5*	*170*	5,29	1,76	2,65	≤ 0,047
	3 m x 4 m	*1,5*	*200*	5,29	1,76	2,65	≤ 0,056

- **Settlements deformations**

Considering loads that communicated to us, estimated settlements for this foundations raft are less than 0,1 cm.

IV.2. REALIZATION OF GROUND SLAB

Considering the characteristics of the materials that will be present at the bottom of the excavation, a sub-base will be realized according to the following recommendations :

- Flushing out any mediocre layers and those damaged by earth-moving equipment ;
- Recompact the bottom of excavation thus obtained ;
- Make a sub-base in materials, of a thickness to be defined by the prime contractor of the project. It can be realized in gravel, grave-cement, compacted sand, laterite, all coming from quarry etc.

To check the quality of the sub-base thus obtained, for this type of structure, KW> 50MPa / m and EV2 / EV1 <2 must be used according to the rules of DTU 13.3.

IV.3. EARTHWORKS REALISATION

- **Earthworks :**

If the foundations are shallow, will have to be envisaged a provisional supporting. It is excluded to carry out the earthworks without ensuring the stability of the excavations by an adapted supporting prohibiting any displacement in provisional and final phase.

- **Water Conditions**

Any water inflows in the excavations (runoff of rainwater) during earthworks will be evacuated.

IV.4. SPECIAL PRECAUTIONS FOR DESIGN AND EXECUTION

- **Constructives dispositions**

<u>Foundations</u> :

Structural adaptation of reference documents (Fascicule 62 and DTU) are to be considered.

IV.5. GEOTECHNICAL ALEAS AND CONTRACTUAL CONDITIONS

1. This report and its annexes constitute an inseparable whole. Misuse that could be made following a partial disclosure or reproduction does not engage GEOTEC AFRIQUE-SENELABO.
2. Changes in the location, design or importance of buildings as well as the assumptions used in particular in the indications of the "presentation" of this report can lead to challenges to the regulations. A new mission will then be entrusted to GEOTEC AFRIQUE-SENELABO to rehabilitate or validate these findings in writing the new project.

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3. Similarly, new evidence revealed during the execution of the foundations and could not be detected in the soil reconnaissance (eg localized heterogeneity, water inflows, dissolution cavity, etc.) can render obsolete some of the recommendations contained in the report.
4. The ground reconnaissance proceed by ad hoc surveys, the results are not strictly extrapolated to the entire site. It persists hazards (eg local heterogeneity) that can lead to adaptations to the design of performance that can not be borne by the geotechnician.
5. At the time of the opening of the excavations, it is advisable to conduct a site visit by a geotechnician to GEOTEC AFRIQUE-SENELABO. This visit gives rise to a written notice on the verification of soil type and level seat of shallow foundations. This tour is subject to prior specific command.

A Dakar, 27/01/2017

Engineer in charge of the study

N. L. BADJI

ANNEX

A-8-95

Annex 1 : Log of the exploratory hole

Borehole Number	PROJECT : ETUDE PREPARATOIRE DU PROJET D'URGENCE ET DE RENFORCEMENT ET DE REHABILITATION DU RESEAU DE TRANSPORT D'ENERGIE DANS LA REGION DE DAKAR		
	Custumer : JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.		
SC1/Bargny substation	FOLDER : GT/2016-484		
	TYPE OF SAMPLING : Core drilling		
	DEPTH : 20,10 m Below existing ground level		
LOCALISATION: Bargny	Coordonnées UTM _ zone 28P	X= 259127	Y=1626784

Ground water level	Depth (m) / existing ground level	Stratigraphic column	Lithological description	% of Recovery	SPT	Ø Drilling	Ø Casing (mm)	Tool	COMMENTS / PHOTOGRAPHIC DOCUMENTS
2,3m									
	1		Black sandy clay with calcareous concretions	100					
	1,5		Clay Laterite	100	SPT (1,5 à 1,55 m)				
					N = 50-R				
	5		Limestone	71					0 à 5 m
	10		Marly limestone	79,92					5 à 9,3 m
	11,45		Yellowish marl, tender	75					
	13,5		Yellowish marl, Compact	89,19					9,3 à 13,5 m
	13,95		Greyish marl	95					
	15,5		Greenish gray clayey marl, tender	84,50					13,5 à 18,5 m
	20,1		Greenish gray clayey marl, compact	83,30				Double core barrel T6 116 with crown	18,5 à 20,1 m

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Annex 2 : Sheet of laboratory tests

GEOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

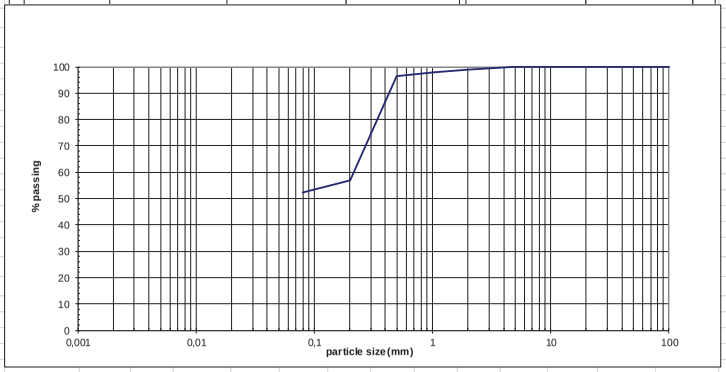
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC1 / BARGNY SUBSTATION	1	0,20m à 1,00m	Black sandy clay with calcareous concretions	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_c		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
5,22			43,262	16,67	26,594	1,43	A3	1,680	1,597	2,520

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay | silt | fine sand | coarse sand | gravel | cobble



Sieve mesh size (mm)	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	99,0	97,7	96,4	56,8	52,2

Sieve mesh size (mm)											
Passing (%)											

OBSERVATIONS

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The engineer responsible of the tests

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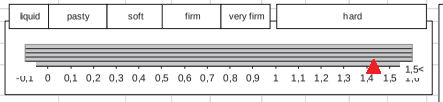
GEOTEC AFRIQUE SENELABO

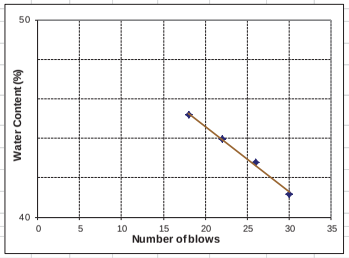
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC1 / BARGNY SUBSTATION	1	0,20m à 1,00m	Black sandy clay with calcareous concretions	SIDY

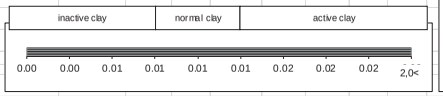
	1- Liquid Limit						2- Plasticy Limit		
Number of blows	18	22	26	30					
Tare N°	FII	W	AB	XR			B3	B	
Total wet weight	86,02	88,3	85,18	81,18			75,73	70,23	
Total dry weight	77,78	76,62	76,95	71,97			72,29	66,79	
Total weight of tares	59,54	50,04	57,71	49,59			51,51	46,29	
Net weight of water	8,24	11,68	8,23	9,21			3,44	3,44	
Weight of dry material	18,24	26,58	19,24	22,38			20,78	20,5	
Water content (%)	45,175	43,943	42,78	41,153			16,5544	16,78049	
Limits and indices	W_L =	43,262	W_P =	16,667	I_P =	26,59	I_c =	1,43	A =

3- Scale of Consistency (Ic)

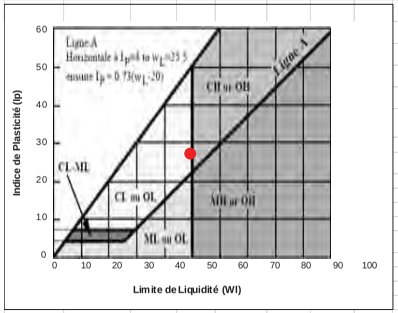




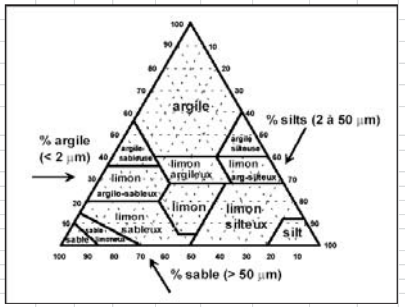
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	CH: Muddy, gravelly and/or sandy clay
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
		MH: Gravelly and/or sandy silt of high plasticity

Report of test with the oedometer (consolidation test)

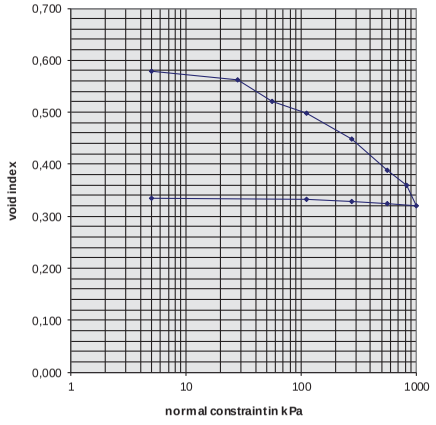
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	**summery description :**	Black sandy clay with calcareous concretions	Register N° :
SITE : BARGNY SUBSTATION	date of arrival at the laboratory :		Borehole N° :
	date of tests :	28/12/2016	**SC1**
			Sample N° : **1**

characteristic of the test-tube or core		Before test		After test		
Diameter : D	***in mm***	D_0 =	50,47			Depht of test-tube or
Height : H	***in mm***	Hi =	20			core (m) =
dry formerly densité	***in Mg/m³***	γ_{di} =	1,60	γ_{df} =		0,20m à 1,00m
Unit weight	***in MG/m³***	γ_s =	2,52			Experimenter :
Water content	***in %***	Wi =	5,22	Wf =		
Saturation degree	***in %***	Sri =	22,76	Srf =		Frame N° : 3

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	$e_{corrected}$
		1	5	0,0	0,618	0,578
		2	28	22,0	0,602	0,562
		3	56	81,0	0,560	0,520
		4	111	111,0	0,538	0,499
		5	277	181,0	0,489	0,449
		6	555	266,0	0,428	0,388
		7	830	306,0	0,399	0,360
		8	1000	361,0	0,360	0,321
		9	555	356,0	0,364	0,324
		10	277	349,0	0,369	0,329
		11	111	344,5	0,372	0,332
		12	5	341,0	0,375	0,335

oedometer curve



Results

Characteristics of compressibility

void index		e_i=	0,578
		e_0=	0,55
Vertical effective constraint	(kPa)	σ'_{V0}=	13,515
Constraint of preconsolidation	(kPa)	σ'_p=	140
Index of compression		Cc=	0,259
Pressure of swelling	(kPa)	Pg=	
Swelling Index		Cs=	

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

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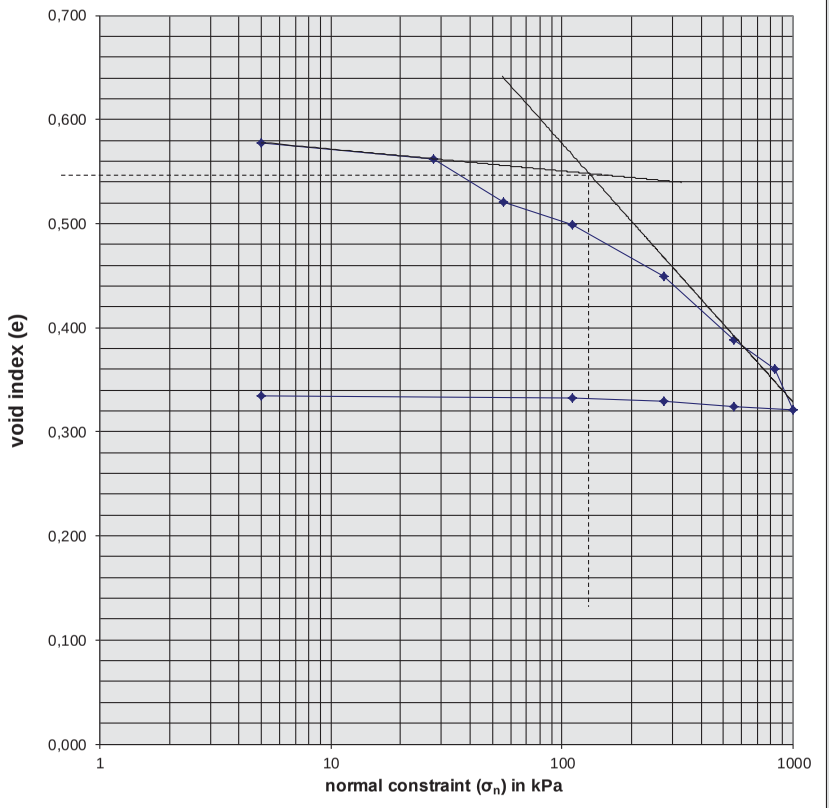
Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	**summery description :**	Black sandy clay with calcareous concretions	Register N° :
SITE : BARGNY SUBSTATION	date of arrival at the laboratory :		Borehole N° :
	date of tests :	28/12/2016	
	sampling depht. =	0,20m à 1,00m	Sample N° :
	test-tube (core)		1

oedometer curve



Direct linear shear test

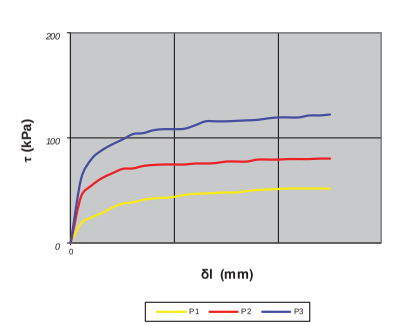
(réalisé conformément à la norme NF P 94-071-1)

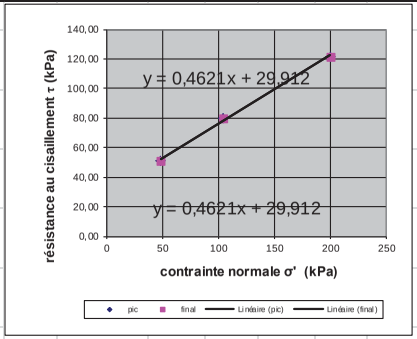
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'energie dans la région de Dakar	**CLIENT**	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.
Site:	BARGNY SUBSTATION	**Date essai:**	29/12/2016
N° Sondage: SC1	**Prof. :** 0,20m à 1,00m	**Nature sol**	Black sandy clay with calcareous concretions
Vitesse de cis. =	0.5 mm/mn		

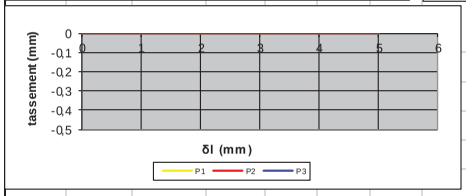
Caractéristiques de l'éprouvette — ρ_s

Hauteur = 20 mm — Largeur, diamètre = 60 mm — mesuré = 2,700 T/m3 — estimé =

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,68	1,597	5,22	0,691				0	48,61	51,303	5	51,303	5
2	1,68	1,597	5,22	0,691				0	104,18	79,753	3,2	79,753	5
3	1,68	1,597	5,22	0,691				0	200,02	121,73	2,6	121,73	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	29,912	29,912	24,8	24,8

Observations:

L'ingénieur responsable des essais:

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GEOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

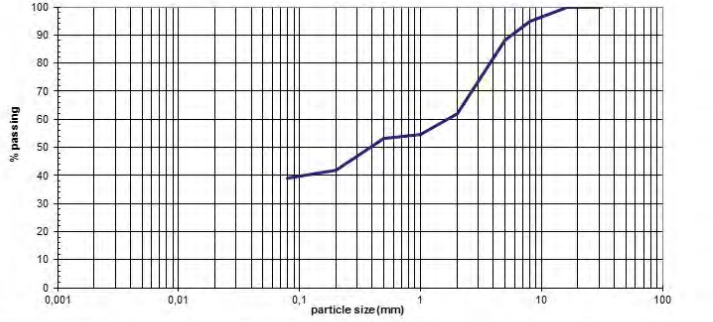
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.,		Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC1 / BARGNY	2	1,00m à 1,50m	Clay Laterite	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_c		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
3,98			46,937	16,09	30,849	1,39	A3	2,072	1,993	2,650

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm	31,5	25	20	16	12,5	8	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	98,2	95,0	88,1	62,0	54,5	53,1	41,9	39,0

Sieve mesh size (mm)										
Passing (%)										

OBSERVATIONS

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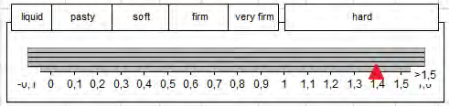
The engineer responsible of the tests

CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.,		Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

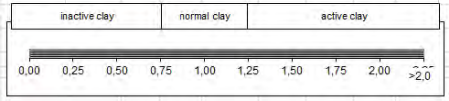
REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC1 / BARGNY	2	1,00m à 1,50m	Clay Laterite	SIDY

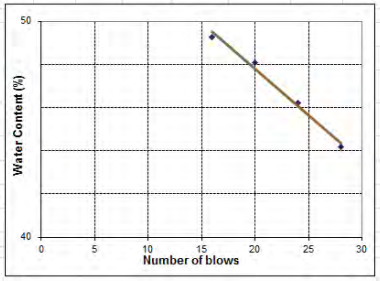
	1- Liquid Limit				2- Plasticy Limit	
Number of blows	16	20	24	28		
Tare N°	T0	10	T	2	X5	AB1
Total wet weight	74,6	81,05	75,25	74,91	26,63	25,13
Total dry weight	66,07	71,52	67,36	68,7	24,23	22,98
Total weight of tares	48,76	51,7	50,29	54,64	9,43	9,51
Net weight of water	8,53	9,53	7,89	6,21	2,4	2,15
Weight of dry material	17,31	19,82	17,07	14,06	14,8	13,47
Water content (%)	49,278	48,083	46,22	44,168	16,2162	15,9614
Limits and indices	W_L =	46,937	W_P =	16,089	I_P =	30,85	I_c =	1,39	A =

3- Scale of Consistency (Ic)

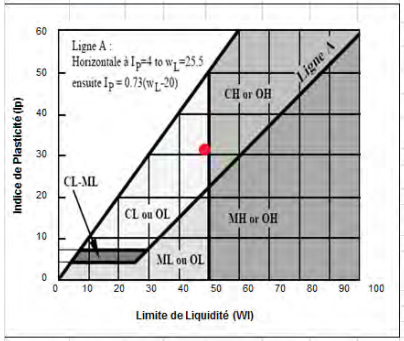


4- Scale of activity (A)

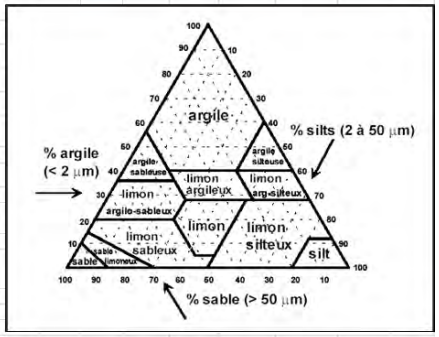




5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	CH: Muddy, gravelly and/or sandy clay
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
		MH: Gravelly and/or sandy silt of high plasticity

A-8-100

Report of test with the oedometer (consolidation test)

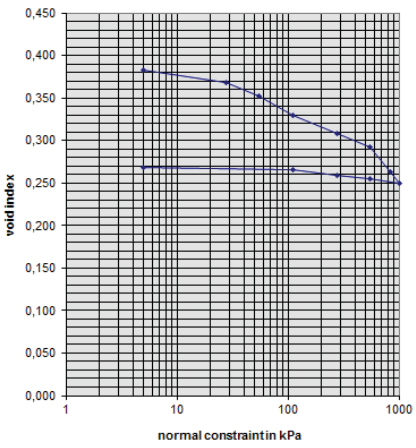
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	summery description :	Clay Laterite	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING			
SITE :	date of arrival at the laboratory :		Borehole N° :
BARGNY SUBSTATION	date of tests :	09/01/2017	SC1

characteristic of the test-tube or core		Before test		After test		Sample N° :
Diameter : D	in mm	D_0 =	50,47			Depht of test-tube or
Height : H	in mm	Hi =	20			core (m) =
dry formerly densité	in Mg/m³	γ_{di} =	1,92	γ_{df} =		1,00m à 1,50m
Unit weight	in MG/m³	γ_s =	2,65			Experimenter :
Water content	in %	Wi =	3,98	Wf =		
Saturation degree	in %	Sri =	27,58	Srf =		Frame N° :

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,451	0,382
		2	28	20,0	0,437	0,369
		3	56	44,0	0,421	0,352
		4	111	76,0	0,399	0,330
		5	277	108,0	0,377	0,308
		6	555	131,0	0,361	0,292
		7	830	172,0	0,332	0,264
		8	1000	192,0	0,319	0,250
		9	555	185,0	0,323	0,255
		10	277	178,0	0,328	0,259
		11	111	169,0	0,334	0,266
		12	5	166,0	0,336	0,268

oedometer curve



Results

Characteristics of compressibility

void index	e_i=	0,382
	e_0=	0,35
Vertical effective constraint	(kPa) σ'_{V0}=	23,96
Constraint of preconsolidation	(kPa) $\sigma'p$=	210
Index of compression	C_C=	0,16
Pressure of swelling	(kPa) Pg=	
Swelling index	C_S=	

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

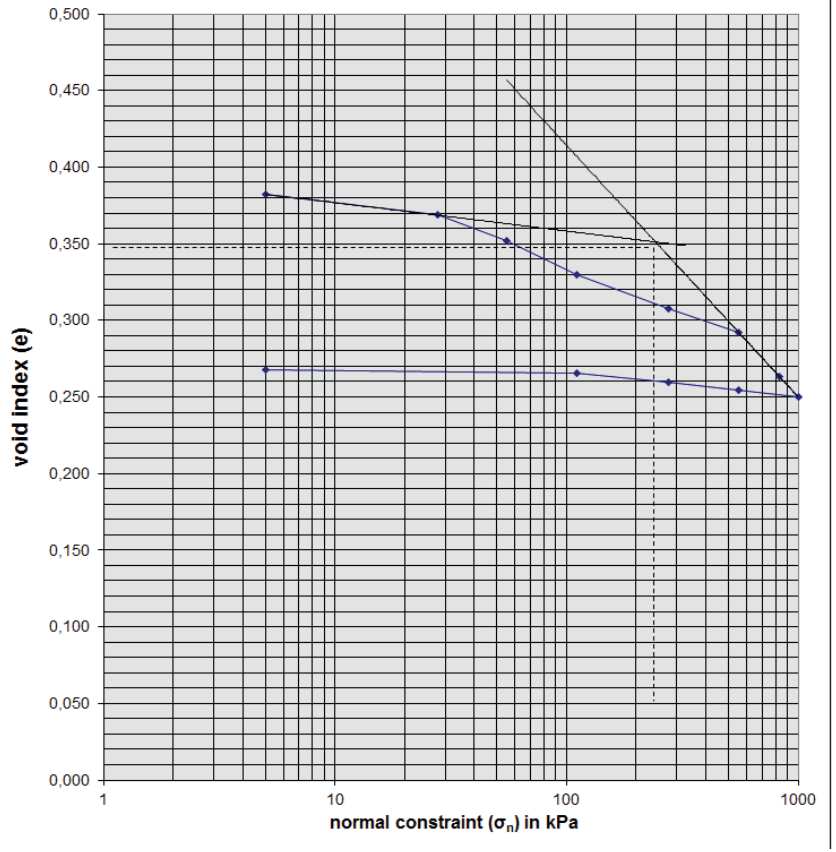
GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**	Clay Laterite	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.,			
SITE :	date of arrival at the laboratory :		Borehole N° :
BARGNY SUBSTATION	date of tests :	09/01/2017	
	sampling depht. =	1,00m à 1,50m	Sample N° :
	test-tube (core)		

oedometer curve



A-8-101

GEOTEC AFRIQUE SENELABO

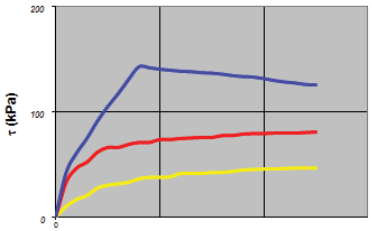
Direct linear shear test

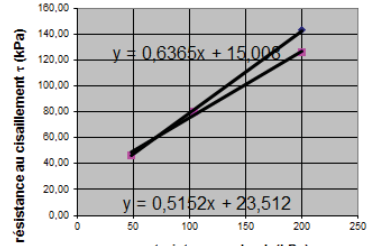
(réalisé conformément à la norme NF P 94-071-1)

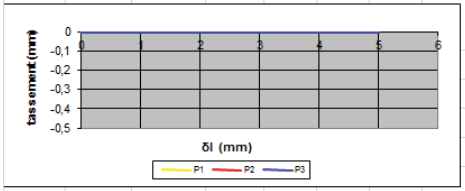
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'energie dans la région de Dakar			**CLIENT**	JICA
Site:	BARGNY			**Date essai:**	29/12/2016
N° Sondage:	SC1	**Prof. :**	1,00m à 1,50m	**Nature sol**	Clay Laterite
Vitesse de cis. =	0.5 mm/mn				

Caractéristiques de l'éprouvette				***ρ_s***	
Hauteur =	20 mm	Largeur, diamètre =	60 mm	mesuré =	2,700 T/m3
estimé =					

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,99	1,917	3,98	0,4087				0	48,61	46,639	5	46,639	5
2	1,99	1,917	3,98	0,4087				0	104,18	80,219	3,2	80,219	5
3	1,99	1,917	3,98	0,4087				0	200,02	142,72	2,6	125,46	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	15,008	23,512	32,47	27,25

Observations:

L'ingénieur responsable des essais:

GÉOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

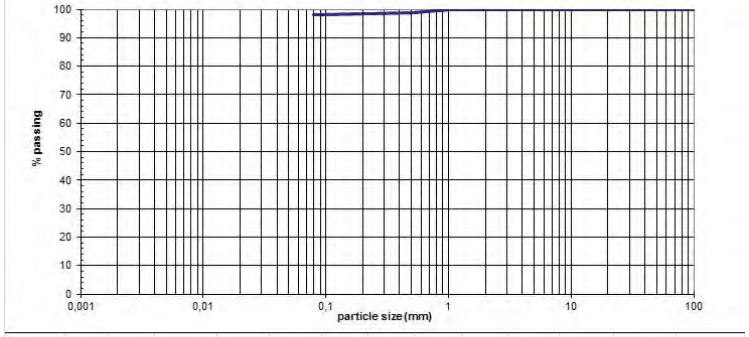
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.,	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC1 / BARGNY SUBSTATION	3	10,00m à 10,50m	Yellowish marl, tender	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_C		γ_h	γ_d	γ_s
ASTM D2216	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
4,61			166,35	54,17	112,18	1,44	A4	1,611	1,540	2,200

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	98,8	98,3	98,0

Sieve mesh size (mm)											
Passing (%)											

OBSERVATIONS

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The engineer responsible of the tests

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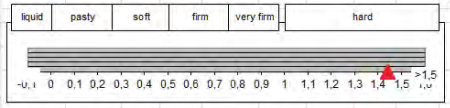
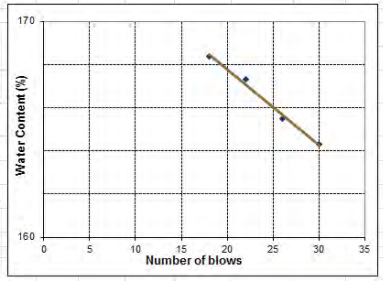
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A N D	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC1 / BARGNY SUBSTATION	3	10,00m à 10,50m	Yellowish marl, tender	SIDY

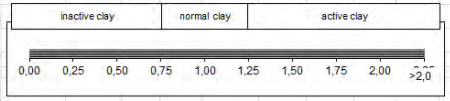
	1- Liquid Limit						2- Plasticy Limit	
Number of blows	18	22	26	30				
Tare N°	7	L	G1	YE			Z	OY
Total wet weight	76,28	91,94	106,6	110,71			63,22	59,17
Total dry weight	60,42	75,06	85,86	88,79			55,69	52,46
Total weight of tares	51	64,97	73,35	75,45			41,99	39,89
Net weight of water	15,86	16,88	20,7	21,916			7,53	6,71
Weight of dry material	9,42	10,09	12,51	13,34			13,7	12,57
Water content (%)	168,37	167,29	165,5	164,29			54,9635	53,38107
Limits and indices	W_L =	166,35	W_P =	54,172	I_P =	112,2	I_C =	1,44	A =

3- Scale of Consistency (Ic)

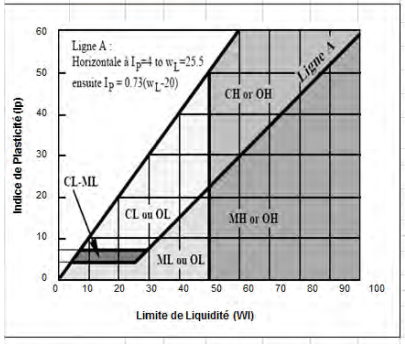




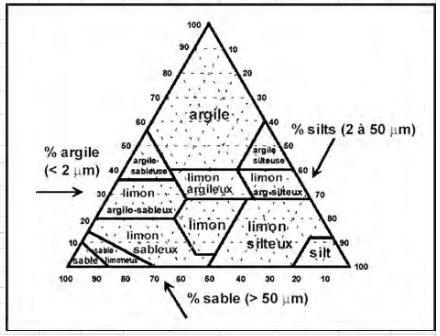
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	CH: Muddy, gravelly and/or sandy clay
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
		MH: Gravelly and/or sandy silt of high plasticity

Report of test with the oedometer (consolidation test)

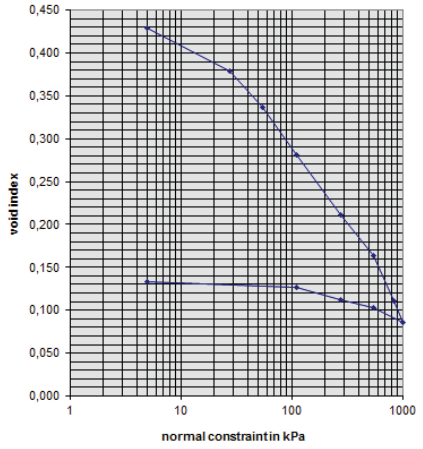
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : JICA PROJECT TEAM / YACHIYO ENGINEERING	summery description :	Marne jauneatre	Register N° :
SITE : BARGNY SUBSTATION	date of arrival at the laboratory :		Borehole N° :
	date of tests :	01/01/2017	SC1

characteristic of the test-tube or core		Before test		After test		Sample N° : 3
Diameter : D	*in mm*	D_0 =	50,47			Depht of test-tube or
Height : H	*in mm*	Hi =	20			core (m) =
dry formerly densité	*in Mg/m³*	γ_{di} =	1,54	γ_{df} =		10,00m à 10,50m
Unit weight	*in MG/m³*	γ_s =	2,20			Experimenter :
Water content	*in %*	Wi =	6,61	Wf =	24,46	
Saturation degree	*in %*	Sri =	33,93	Srf =	125,58	Frame N° :

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,775	0,429
		2	28	58,2	0,725	0,379
		3	56	108,0	0,682	0,336
		4	111	172,0	0,628	0,281
		5	277	254,0	0,557	0,211
		6	555	309,0	0,510	0,164
		7	830	371,0	0,457	0,111
		8	1000	400,0	0,432	0,086
		9	555	381,0	0,449	0,102
		10	277	369,0	0,459	0,113
		11	111	352,0	0,474	0,127
		12	5	345,0	0,480	0,133

oedometer curve



Results

Characteristics of compressibility

void index		e_i= 0,429
		e_0= 0,33
Vertical effective constraint	(kPa)	σ'_{V0}= 157,85
Constraint of preconsolidation	(kPa)	$\sigma'p$= 180
Index of compression		Cc= 0,304
Pressure of swelling	(kPa)	Pg=
Swelling index		Cs=

Direct shear test

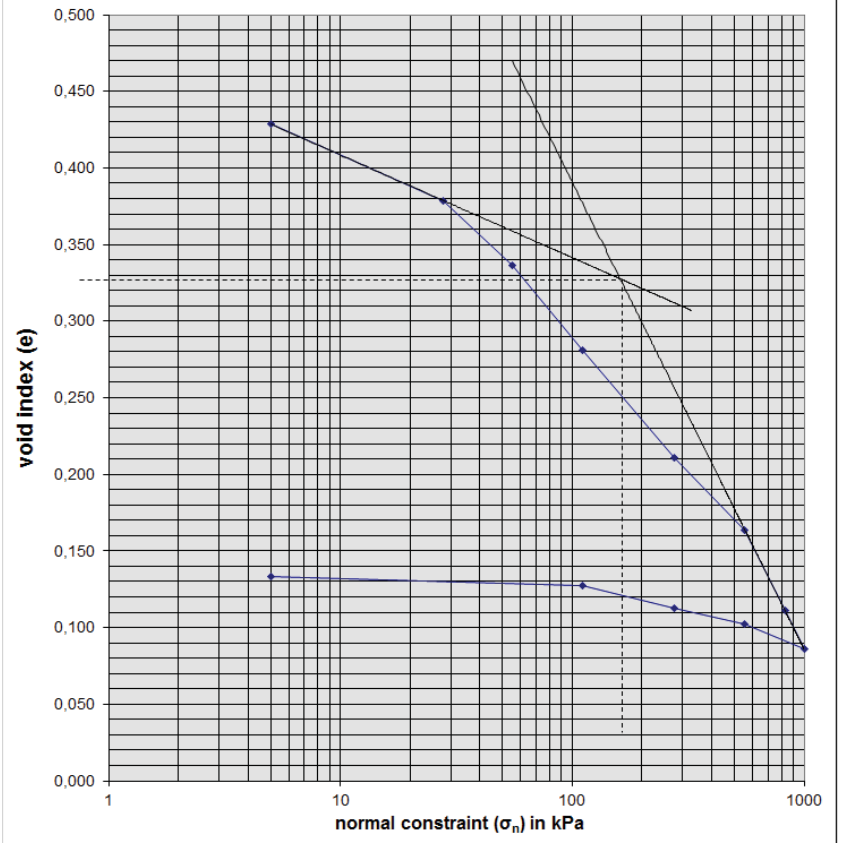
Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE : CT TEAM / YACHIYO ENGINEERI	summery description :	Marne jauneatre	Register N° :
SITE : BARGNY SUBSTATION	date of arrival at the laboratory :		Borehole N° :
	date of tests :	01/01/2017	
	sampling depht. =	10,00m à 10,50m	Sample N° :
	test-tube (core)		3

oedometer curve



A-8-103

Direct linear shear test

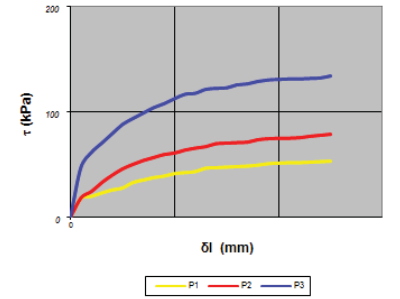
(réalisé conformément à la norme NF P 94-071-1)

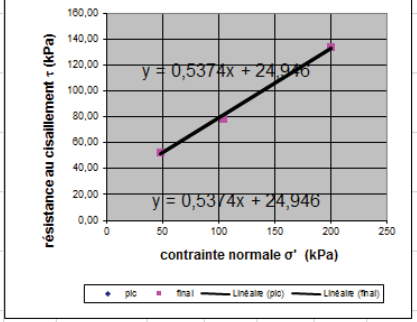
Projet / Chantier:	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'energie dans la région de Dakar	**CLIENT**	JICA
Site:	BARGNY	**Date essai:**	29/12/2016
N° Sondage: SC1	**Prof. :** 10,00m à 10,5m	**Nature sol**	Yellowish marl, tender
Vitesse de cis. =	0.5 mm/mn		

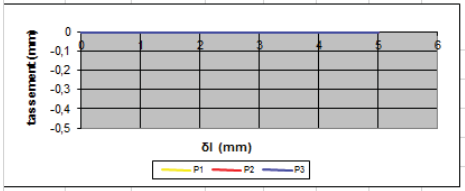
Caractéristiques de l'éprouvette — ρ_s

Hauteur = 20 mm — Largeur, diamètre = 60 mm — mesuré = 2,700 T/m3 — estimé =

N°	*Avant essai*					*Après consolid*		*Après cisaillement*	σ' (kPa)	*Paramètres de résistance au cisaillement*			
	ph (T/m³)	pd (T/m³)	w (%)	e	Sr	pd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,61	1,540	4,61	0,7532				0	48,61	52,702	5	52,702	5
2	1,61	1,540	4,61	0,7532				0	104,18	78,353	3,2	78,353	5
3	1,61	1,540	4,61	0,7532				0	200,02	133,39	2,6	133,39	5
4													







Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_f	Φuu_p	Φuu_f
	24,946	24,946	28,25	28,25

Observations:

L'ingénieur responsable des essais:

GÉOTEC AFRIQUE SENELABO

REPORT OF TESTS ON SAMPLE OF SOIL

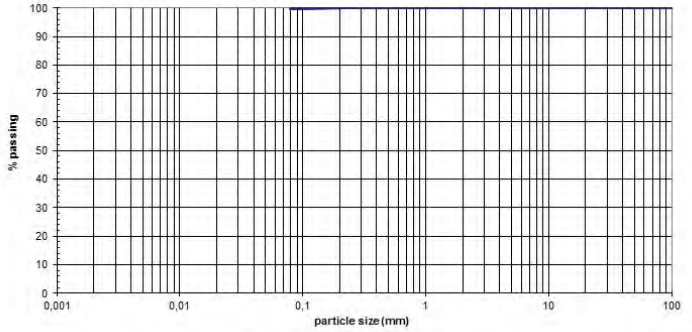
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO.,	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC1 / BARGNY SUBSTATION	4	13,92m à 14,80m	Greenish gray clayey marl, tender	SIDY

Water Content w (%)	Sand Equivalent (ES)	Methylene blue value (g/100g)	Atterberg Limits (%)				Classification of soils	Formerly Density (t/m³)		Unit weight
			W_L	W_P	I_P	I_c		γ_h	γ_d	γ_s
ASTM D221	ASTM D2419	NFP 94-068	ASTM D4318				ASTM D2487	ASTM D2937		ASTM D854
4,35			165	56,66	108,34	1,48	A4	1,666	1,597	2,200

PROCTOR TEST		CBR TEST		
Max. Dry Density (t/m³)	Optimal Moisture Content (%)	CBR(95% OPM)	w (%) of saturation	Swelling (%)

clay	silt	fine sand	coarse sand	gravel	cobble



Sieve mesh size (mm	100	80	50	31,5	20	10	5	2	1	0,5	0,2	0,08
Passing (%)	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	99,8

Sieve mesh size (mm)											
Passing (%)											

OBSERVATIONS

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The engineer responsible of the tests

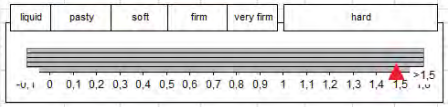
A-8-104

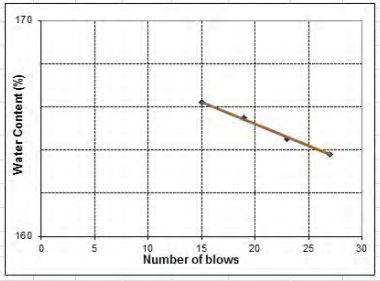
CUSTOMER	N° FILE	TITLE OF THE PROJECT OR BUILDING SITE	ING. APPROV.	DATE OF TESTS
JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	GT/2016-484	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'énergie dans la région de Dakar	A ND	29/12/2012

REGISTER N°	LOG N°	SAMPLE N°	DEPTH (m)	SUMMARY DESCRIPTION	OPERATOR
	SC1 / BARGNY SUBSTATION	4	13,92m à 14,80m	Greenish gray clayey marl, tender	SIDY

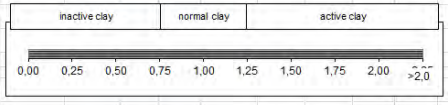
	1- Liquid Limit				2- Plasticy Limit	
Number of blows	15	19	23	27		
Tare N°	XA	XB	XD	X7	Z	X9
Total wet weight	68,67	72,15	96,87	78,18	61,38	57,66
Total dry weight	56,82	59,74	71,55	64,42	54,3	51,26
Total weight of tares	49,69	52,24	56,16	56,02	41,99	39,79
Net weight of water	11,85	12,41	25,32	13,76	7,08	6,4
Weight of dry material	7,13	7,5	15,39	8,4	12,31	11,47
Water content (%)	166,2	165,47	164,5	163,81	57,5142	55,79773
Limits and indices	W_L =	165	W_P =	56,656	I_P =	108,3	I_c =	1,48	A =

3- Scale of Consistency (Ic)

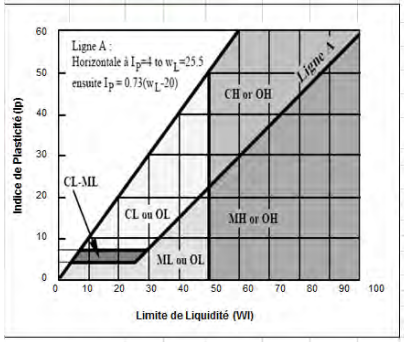




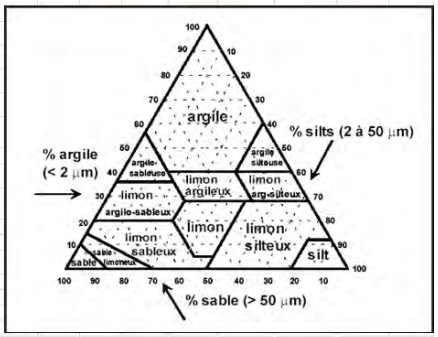
4- Scale of activity (A)



5- Plasticity Chart



6- Triangular Classification of the fine grained soils



Nomenclature of grounds according to SN 670'010a (1993)		CH: Muddy, gravelly and/or sandy clay
CL-ML: Argillaceous silt with sand and/or gravel	OL: Organic, gravelly and/or sandy silt	OH: Organic, gravelly and/or sandy clay muddy
CL: Argillaceous, gravelly and/or sandy silt	ML: Gravelly or sandy silt	MH: Gravelly and/or sandy silt of high plasticity

GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

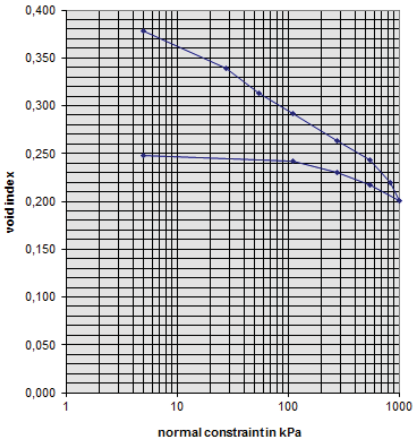
Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**	Greenish gray clayey marl, tender	Register N° :
JICA PROJECT TEAM / YACHIYO ENGINEERING			
SITE :	date of arrival at the laboratory :		Borehole N° :
BARGNY SUBSTATION	date of tests :	11/01/2017	**SC1**

characteristic of the test-tube or core		Before test		After test		Sample N° :
Diameter : D	***in mm***	D_0 =	50,47			Depht of test-tube or
Height : H	***in mm***	Hi =	20			core (m) =
dry formerly densité	***in Mg/m³***	γ_{di} =	1,60	γ_{df} =		13,92m à 14,80m
Unit weight	***in MG/m³***	γ_s =	2,20			Experimenter :
Water content	***in %***	Wi =	4,35	Wf =	24,66	
Saturation degree	***in %***	Sri =	25,35	Srf =	143,69	Frame N° : 1

Date	hour beginning) of stage	stage n°	σ_v (kPa)	Δh (10^{-2} mm)	e	e corrected
		1	5	0,0	0,550	0,378
		2	28	47,0	0,512	0,339
		3	56	78,0	0,486	0,314
		4	111	105,0	0,464	0,291
		5	277	139,0	0,436	0,263
		6	555	163,0	0,417	0,244
		7	830	192,0	0,393	0,220
		8	1000	216,0	0,373	0,200
		9	555	196,0	0,389	0,217
		10	277	179,0	0,403	0,231
		11	111	165,0	0,415	0,242
		12	5	158,5	0,420	0,247

oedometer curve



Results

Characteristics of compressibility

void index	e_i=	0,378
	e_0=	0,28
Vertical effective constraint	(kPa) σ'_{V0}=	228,324
Constraint of preconsolidation	(kPa) $\sigma'p$=	310
Index of compression	C_C=	0,17
Pressure of swelling	(kPa) Pg=	
Swelling Index	C_S=	

Direct shear test

Speed of shearing	Cohesion in kPa [c]	Angle of internal friction in ° [φ]
mm/mn		

A-8-105

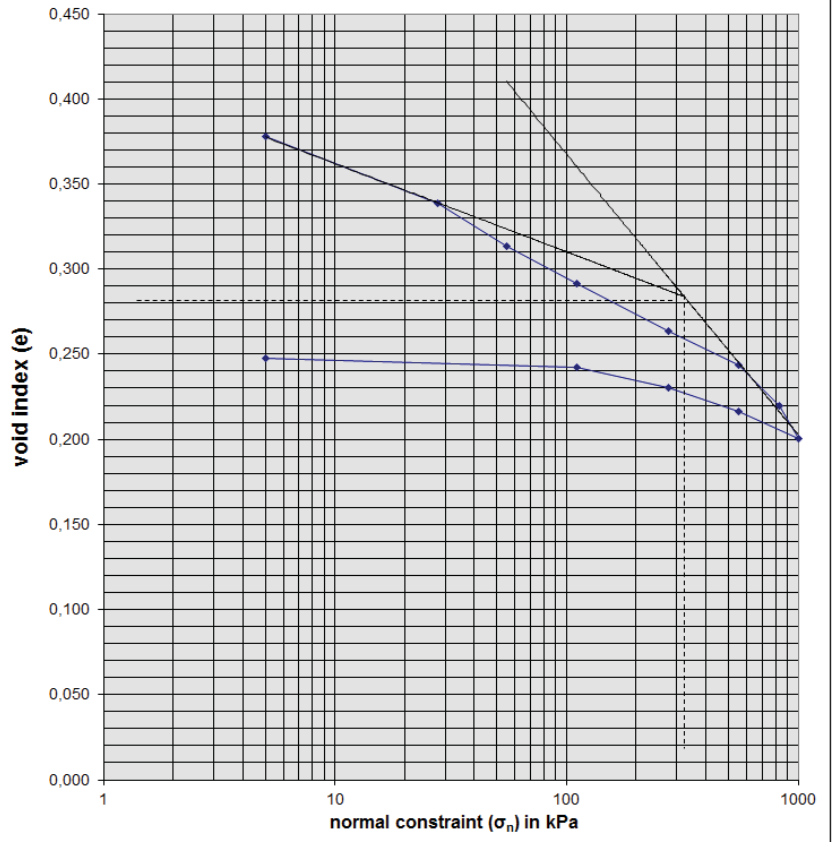
GEOTEC AFRIQUE SENELABO

Report of test with the oedometer (consolidation test)

Compression test on fine grained soils saturated with loading by stages
Test carried out in accordance with standard ASTM D2435

PROJECT or BUILDING SITE :	**summery description :**	Greenish gray clayey marl, tender	Register N° :
CT TEAM / YACHIYO ENGINEERI			
SITE :	date of arrival at the laboratory :		Borehole N° :
BARGNY SUBSTATION	date of tests :	11/01/2017	
	sampling depht. =	13,92m à 14,80m	Sample N° :
	test-tube (core)		

oedometer curve



A-8-106

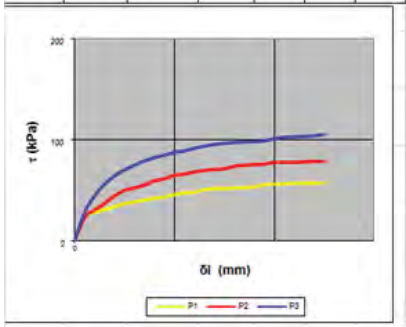
GEOTEC AFRIQUE SENELABO

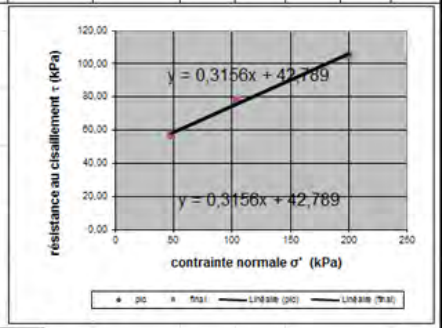
Direct linear shear test

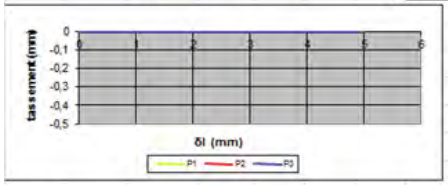
(réalisé conformément à la norme NF P 94-071-1)

Project :	Etude préparatoire du projet d'urgence de renforcement et de réhabilitation du réseau de transport d'energie dans la région de Dakar			**COSTUMER**	JICA
Site:	BARGNY			**Date essai:**	29/12/2016
Survey number	SC1	**Depth. :**	13,92m à 14,80m	**Lithological nature**	Greenish gray clayey marl, tender
Shear rate. =	0.5 mm/mn				

Characteristic of the specimen									ρ_s			
Height =	20 mm	Diameter =	60 mm					mesuré =	2,700 T/m3	estimé =		
N°	***Before test***					***After consolidation***		***After shearing***	σ' (kPa)	***Shear strength parameter***		
	ρh (T/m³)	ρd (T/m³)	w (%)	e	Sr	ρd (T/m³)	t_{100} (mn)	w (%)		$\tau_{f,p}$ (kPa)	$\delta l_{f,p}$ (mm)	$\tau_{f,f}$ (kPa)	$\delta l_{f,f}$ (mm)
1	1,60	1,530	4,35	0,7642				0	48,61	56,433	5	56,433	5
2	1,60	1,530	4,35	0,7642				0	104,18	78,353	3,2	78,353	5
3	1,60	1,530	4,35	0,7642				0	200,02	104,94	2,6	104,94	5
4													







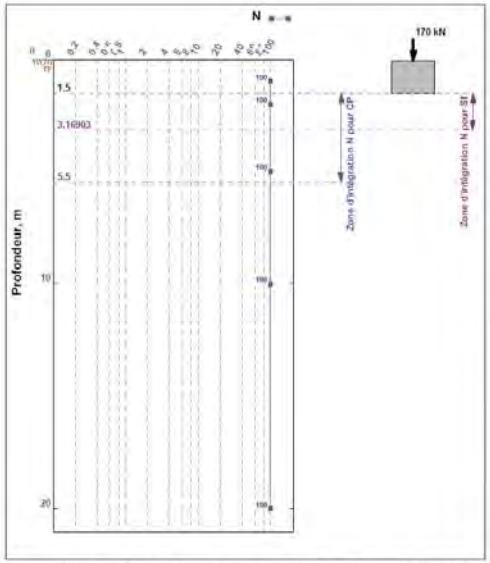
Résultats	cohésion (kPa)		angle frottement interne Φ' (°)	
	cuu_p	cuu_r	Φuu_p	Φuu_r
	42,789	42,789	17,51	17,51

Observations:

L'ingénieur responsable des essais:

Annex 3 : Sheet of geofond calculation

A-8-107



Fondation
Semelle rectangulaire
Largeur : 2 m. Longueur : 3 m
Aire : 6 m²
Encastrement : 1.5 m
Base de la fondation : 1.5 m

Paramètres des sols

Poids des terres au-dessus de la fondation :
après travaux = 18 kN/m³
avant travaux = 18 kN/m³
Contrainte verticale finale q'0 : 27 kPa (calculée)
Contrainte verticale initiale σ'v0 : 27 kPa (calculée)

Temps considéré
10 année(s)

Fichier : Bargny SUBSTATION

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GEOS Ingénieurs Conseils, 310 Avenue Marie Curie
Bât. Europa 2, Archamps Technopole, 74160 ARCHAMPS
Tél : 04 50 95 38 14
Fax :04 50 95 99 36

Données :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	170	0	0	0	170	0
2	ELU	255	0	0	0	255	0

Capacité portante par la méthode de Meyerhoff (sable uniquement) :

				Pour les semelles		Pour les radiers	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'_u (MPa)	C.P. (MPa)	q'_u (MPa)	C.P. (MPa)
1	28.3	28.3	28.3	7.5	2.5 vérifié	6.2	2.07 vérifié
2	42.5	42.5	42.5	7.5	3.75 vérifié	6.2	3.1 vérifié

Tassements

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'_{v0} (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N°	S_f (cm)	S_f (cm)
1	28.3	100	0.027	1.15	1.5	1.4	0.011	1	0.813	0.0517	0.438	43.8	0.0804	0.00213
2	42.5	Non Calculé (ELU)												

GT/2016-484 _ NLB 27/01/2017 00:28	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 1	FIGURE
	Bargny substation	Container build

SENELABO.BTP : 8236838946194400O1

Résultats détaillés : capacité portante
Cas de charge N° : 1

ELS, F = 170 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 170 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.0283 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0283 MPa

qref = (3.qmax + qmin) / 4 = 0.0283 MPa

q'0 = γ_1D - γe.Ze = 27 kPa

$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 100$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 7.5 MPa

Capa. Port. (ELS) = q'u / 3 = 2.5 MPa

pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 6.2 MPa

Capa. Port. (ELS) = q'u / 3 = 2.07 MPa

Résultats détaillés : tassement
Cas de charge N° : 1

ELS, F = 170 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 170 kN, MB = 0 kN.m

Zi = 10 ^ (0.7606 * log(B) - 0.0065) = 1.67

$Nm = 1/Zi \int_{D}^{D+Zi} N(z).dz = 100$

Par la méthode de BURLAND

f1 = ((1.25 L/B) / (L/B + 0.25))² = 1.15

f2 = 1.5

f3 = 1.3 + 0.2 log(t/3) = 1.4

Sf = (1.71 B^0.7 / N^1.4) f1 f2 f3 (σ'v0/3 + Δσ - σ'v0) = 0.011 cm

Par la méthode de TERZAGHI & PECK

Cw = σv / σ'v = 1 (au niveau D + B/2)

Cd = 1 - D/(4B) = 0.813

Sf = 0.000723 qref / (N - 3) (2B / (B + 0.3048))²Cw Cd = 0.0517 cm

Par la méthode de PECK & BAZARAA

Cn = 0.77 log (100 / σ'v0) = 0.438

N' = Cn.N = 43.8

Sf = 0.000508 qref / N' (2B / (B + 0.3048))²Cw Cd = 0.0804 cm

Par la méthode Alpan

α0 = 4.98054 N^(-1.18020) = 0.0217

Sf = (L/B)^0.39 * (2B / (B + 0.3048))² * α0/12 * (qref - σ'v0)/95.76052 * 24/100 = 0.00213 cm

GT/2016-484 _ NLB 27/01/2017 00:28	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 2	FIGURE	
	Bargny substation	Container build	

SENELABO.BTP - 8236838946194400001

A-8-108

Résultats détaillés : capacité portante
Cas de charge N° : 2

ELU, F = 255 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 255 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.0425 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0425 MPa

qref = (3.qmax + qmin) / 4 = 0.0425 MPa

q'0 = γ_1D - γe.Ze = 27 kPa

$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 100$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 7.5 MPa

Capa. Port. (ELU) = q'u / 2 = 3.75 MPa

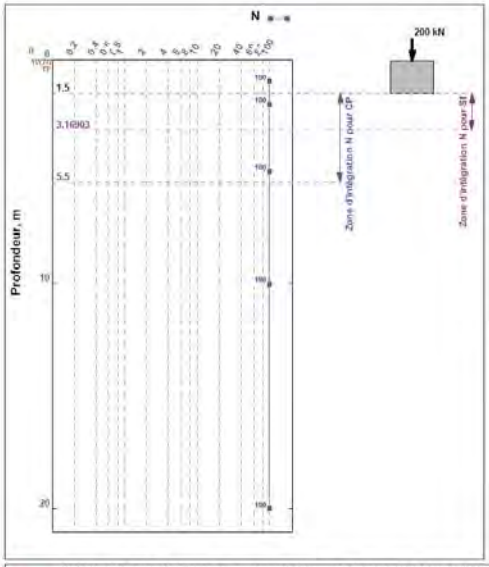
pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 6.2 MPa

Capa. Port. (ELU) = q'u / 2 = 3.1 MPa

GT/2016-484 _ NLB 27/01/2017 00:28	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 3	FIGURE	
	Bargny substation	Container build	

SENELABO.BTP - 8236838946194400001



Fondation
Semelle rectangulaire
Largeur : 2 m, Longueur : 3 m
Aire : 6 m²
Encastrement : 1.5 m
Base de la fondation : 1.5 m

Paramètres des sols

Poids des terres au-dessus de la fondation :
après travaux = 18 kN/m³
avant travaux = 18 kN/m³
Contrainte verticale finale q'0 : 27 kPa (calculée)
Contrainte verticale initiale σ'v0 : 27 kPa (calculée)

Temps considéré
10 année(s)

Fichier : Bargny SUBSTATION

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GEOS Ingénieurs Conseils, 310 Avenue Marie Curie
Bât. Europa 2, Archamps Technopole, 74160 ARCHAMPS
Tél : 04 50 95 38 14
Fax :04 50 95 99 36

Données :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	200	0	0	0	200	0
2	ELU	300	0	0	0	300	0

Capacité portante par la méthode de Meyerhoff (sable uniquement) :

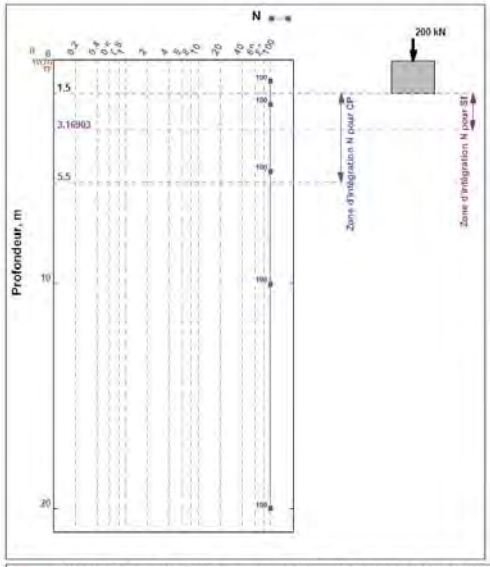
				Pour les semelles		Pour les radiers	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'_u (MPa)	C.P. (MPa)	q'_u (MPa)	C.P. (MPa)
1	33.3	33.3	33.3	7.5	2.5 vérifié	6.2	2.07 vérifié
2	50	50	50	7.5	3.75 vérifié	6.2	3.1 vérifié

Tassements

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'_{v0} (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N°	S_f (cm)	S_f (cm)
1	33.3	100	0.027	1.15	1.5	1.4	0.0163	1	0.813	0.0608	0.438	43.8	0.0946	0.0101
2	50	Non Calculé (ELU)												

GT/2016-484 _ NLB 27/01/2017 00:33	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	Page 1	FIGURE
	Bargny substation		Container build

SENELABO.BTP : 8236838946194400O1



Fondation
Semelle rectangulaire
Largeur : 2 m, Longueur : 3 m
Aire : 6 m²
Encastrement : 1.5 m
Base de la fondation : 1.5 m

Paramètres des sols

Poids des terres au-dessus de la fondation :
après travaux = 18 kN/m³
avant travaux = 18 kN/m³
Contrainte verticale finale q'0 : 27 kPa (calculée)
Contrainte verticale initiale σ'v0 : 27 kPa (calculée)

Temps considéré
10 année(s)

Fichier : Bargny SUBSTATION

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Bât. Europa 2, Archamps Technopole, 74160 ARCHAMPS
Tél : 04 50 95 38 14
Fax :04 50 95 99 36

Données :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	200	0	0	0	200	0
2	ELU	300	0	0	0	300	0

Capacité portante par la méthode de Meyerhoff (sable uniquement) :

				Pour les semelles		Pour les radiers	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'_u (MPa)	C.P. (MPa)	q'_u (MPa)	C.P. (MPa)
1	33.3	33.3	33.3	7.5	2.5 vérifié	6.2	2.07 vérifié
2	50	50	50	7.5	3.75 vérifié	6.2	3.1 vérifié

Tassements

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'_{v0} (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N°	S_f (cm)	S_f (cm)
1	33.3	100	0.027	1.15	1.5	1.4	0.0163	1	0.813	0.0608	0.438	43.8	0.0946	0.0101
2	50	Non Calculé (ELU)												

GT/2016-484 _ NLB 27/01/2017 00:33	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD.	Page 1	FIGURE
	Bargny substation		Container build

SENELABO.BTP : 8236838946194400O1

Résultats détaillés : capacité portante

Cas de charge N° : 2

ELU, F = 300 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 300 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.05 MPa ; qmax = Vd/A * (1+6*e/B) = 0.05 MPa

qref = (3.qmax + qmin) / 4 = 0.05 MPa

q'0 = γ_1D - γ_e.Ze = 27 kPa

$$Nm = 1/(2B - 0.5B)\int_{D+0.5B}^{D+2B} N(z).dz = 100$$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 7.5 MPa

Capa. Port. (ELU) = q'u / 2 = 3.75 MPa

pour les radiers (B > 1.20 m)

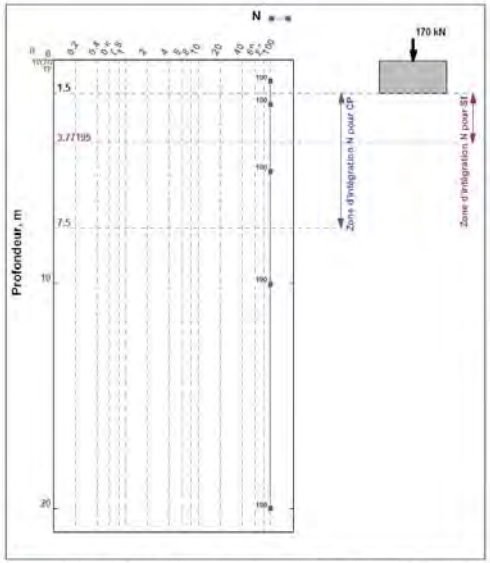
3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 6.2 MPa

Capa. Port. (ELU) = q'u / 2 = 3.1 MPa

GT/2016-484 _ NLB 27/01/2017 00:33	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 3	FIGURE
	Bargny substation	Container build

SENELABO.BTP - 823683894619440001

A-8-110



Fondation
Semelle rectangulaire
Largeur : 3 m. Longueur : 4 m
Aire : 12 m²
Encastrement : 1.5 m
Base de la fondation : 1.5 m

Paramètres des sols

Poids des terres au-dessus de la fondation :
après travaux = 18 kN/m³
avant travaux = 18 kN/m³
Contrainte verticale finale q'0 : 27 kPa (calculée)
Contrainte verticale initiale σ'v0 : 27 kPa (calculée)

Temps considéré
10 année(s)

Fichier : Bargny SUBSTATION

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Tél : 04 50 95 38 14
Fax :04 50 95 99 36

Données :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	170	0	0	0	170	0
2	ELU	255	0	0	0	255	0

Capacité portante par la méthode de Meyerhoff (sable uniquement) :

				Pour les semelles		Pour les radiers	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'_u (MPa)	C.P. (MPa)	q'_u (MPa)	C.P. (MPa)
1	14.2	14.2	14.2	7	2.33 vérifié	5.29	1.76 vérifié
2	21.3	21.3	21.3	7	3.5 vérifié	5.29	2.65 vérifié

Tassements

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'_{v0} (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N°	S_f (cm)	S_f (cm)
1	14.2	100	0.027	1.11	1.5	1.4	0.00645	1	0.875	0.0305	0.438	43.8	0.0474	-0.0215
2	21.3	Non Calculé (ELU)												

GT/2016-484 _ NLB 27/01/2017 00:41	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 1	FIGURE
	Bargny substation	Container build

SENELABO.BTP - 823683894619440001

Résultats détaillés : capacité portante
Cas de charge N° : 1

ELS, F = 170 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 170 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.0142 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0142 MPa

qref = (3.qmax + qmin) / 4 = 0.0142 MPa

$q'0 = \gamma_1 D - \gamma_2 e.Ze = 27$ kPa

$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 100$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 7 MPa

Capa. Port. (ELS) = q'u / 3 = 2.33 MPa

pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 5.29 MPa

Capa. Port. (ELS) = q'u / 3 = 1.76 MPa

Résultats détaillés : tassement
Cas de charge N° : 1

ELS, F = 170 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 170 kN, MB = 0 kN.m

Zi = 10 ^ (0.7606 * log(B) - 0.0065) = 2.27

$Nm = 1/Zi \int_{D}^{D+Zi} N(z).dz = 100$

Par la méthode de BURLAND

f1 = ((1.25 L/B) / (L/B + 0.25))² = 1.11

f2 = 1.5

f3 = 1.3 + 0.2 log(t/3) = 1.4

Sf = (1.71 B^0.7 / N^1.4) f1 f2 f3 (Δp/3) = 0.00645 cm

Par la méthode de TERZAGHI & PECK

Cw = σ'v / σ'v = 1 (au niveau D + B/2)

Cd = 1 - D/(4B) = 0.875

Sf = 0.000723 qref / (N - 3) (2B / (B + 0.3048))²Cw Cd = 0.0305 cm

Par la méthode de PECK & BAZARAA

Cn = 0.77 log (100 / σ'v0) = 0.438

N' = Cn.N = 43.8

Sf = 0.000508 qref / N' (2B / (B + 0.3048))²Cw Cd = 0.0474 cm

Par la méthode Alpan

$\alpha 0 = 4.98054\ N^{(-1.18020)} = 0.0217$

Sf = (L/B)^0.39 * (2B / (B + 0.3048))² * α0/12 * (qref - σ'v0)/95.76052 * 24/100 = -0.0215 cm

GT/2016-484 _ NLB 27/01/2017 00:41	JICA PROJECT TEAM / YACHIYO ENGINEERING CO., LTD. Page 2	FIGURE
	Bargny substation	Container build

SENELABO.BTP - 8236838946194400001

Résultats détaillés : capacité portante
Cas de charge N° : 2

ELU, F = 255 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 255 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.0213 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0213 MPa

qref = (3.qmax + qmin) / 4 = 0.0213 MPa

$q'0 = \gamma_1 D - \gamma_2 e.Ze = 27$ kPa

$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 100$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 7 MPa

Capa. Port. (ELU) = q'u / 2 = 3.5 MPa

pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 5.29 MPa

Capa. Port. (ELU) = q'u / 2 = 2.65 MPa

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	Bargny substation	Container build

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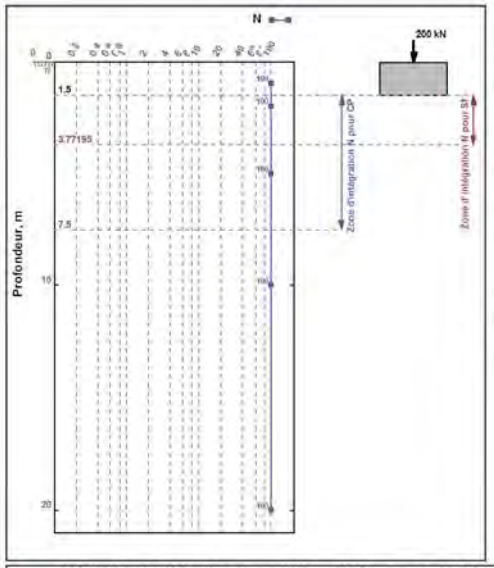

Fondation
Semelle rectangulaire
Largeur : 3 m, Longueur : 4 m
Aire : 12 m²
Encastrement : 1.5 m
Base de la fondation : 1.5 m

Paramètres des sols

Poids des terres au-dessus de la fondation :
après travaux = 18 kN/m³
avant travaux = 18 kN/m³
Contrainte verticale finale q'0 : 27 kPa (calculée)
Contrainte verticale initiale σ'v0 : 27 kPa (calculée)

Temps considéré
10 année(s)

Fichier : Bargny SUBSTATION

GEOFOND® V1.19 du 08/06/2015 développé par GEOS — GEOS Ingénieurs Conseils, 310 Avenue Marie Curie — Tél : 04 50 95 38 14
site web : http://www.geos.fr e-mail : logiciels@geos.fr — Bât. Europa 2, Archamps Technopole, 74160 ARCHAMPS — Fax :04 50 95 99 36

Données :

N°	Etat-limite	F (kN)	δ (°)	e (m)	H_d (kN)	V_d (kN)	M (kN.m)
1	ELS	200	0	0	0	200	0
2	ELU	300	0	0	0	300	0

Capacité portante par la méthode de Meyerhoff (sable uniquement) :

				Pour les semelles		Pour les radiers	
N°	q_{min} (kPa)	q_{max} (kPa)	q_{ref} (kPa)	q'_u (MPa)	C.P. (MPa)	q'_u (MPa)	C.P. (MPa)
1	16.7	16.7	16.7	7	2.33 vérifié	5.29	1.76 vérifié
2	25	25	25	7	3.5 vérifié	5.29	2.65 vérifié

Tassements

				Burland				Terzaghi & Peck			Peck & Bazaraa			Alpan
N°	q_{ref} (kPa)	N_m	σ'_{v0} (kPa)	f_1	f_2	f_3	S_f (cm)	C_w	C_d	S_f (cm)	C_n	N*	S_f (cm)	S_f (cm)
1	16.7	100	0.027	1.11	1.5	1.4	0.00758	1	0.875	0.0358	0.438	43.8	0.0558	-0.0173
2	25	Non Calculé (ELU)												

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Résultats détaillés : capacité portante
Cas de charge N° : 1
ELS, F = 200 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 200 kN, MB = 0 kN.m

Par la méthode de Meyerhoff
qmin = Vd/A * (1-6*e/B) = 0.0167 MPa ; qmax = Vd/A * (1+6*e/B) = 0.0167 MPa
qref = (3.qmax + qmin) / 4 = 0.0167 MPa
q'0 = γ_1.D - γ_e.Ze = 27 kPa

$$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 100$$

pour les semelles (B < 1.20 m)
3N/0.05 (1 + D/3B) = 7 MPa
Capa. Port. (ELS) = q'u / 3 = 2.33 MPa

pour les radiers (B > 1.20 m)
3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 5.29 MPa
Capa. Port. (ELS) = q'u / 3 = 1.76 MPa

Résultats détaillés : tassement
Cas de charge N° : 1
ELS, F = 200 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 200 kN, MB = 0 kN.m
Zi = 10 ^ (0.7606 * log(B) - 0.0065) = 2.27

$$Nm = 1/Zi \int_{D}^{D+Zi} N(z).dz = 100$$

Par la méthode de BURLAND
f1 = ((1.25 L/B) / (L/B + 0.25))² = 1.11
f2 = 1.5
f3 = 1.3 + 0.2 log(t/3) = 1.4
Sf = (1.71 B^0.7 / N^1.4) f1 f2 f3 (Δp/3) = 0.00758 cm

Par la méthode de TERZAGHI & PECK
Cw = σv / σ'v = 1 (au niveau D + B/2)
Cd = 1 - D/(4B) = 0.875
Sf = 0.000723 qref / (N - 3) (2B / (B + 0.3048))²Cw Cd = 0.0358 cm

Par la méthode de PECK & BAZARAA
Cn = 0.77 log (100 / σ'v0) = 0.438
N* = Cn.N = 43.8
Sf = 0.000508 qref / N* (2B / (B + 0.3048))²Cw Cd = 0.0558 cm

Par la méthode Alpan
α0 = 4.98054 N^(-1.18020) = 0.0217
Sf = (L/B)^0.39 * (2B / (B + 0.3048))² * α0/12 * (qref - σ'v0)/95.76052 * 24/100 = -0.0173 cm

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Résultats détaillés : capacité portante

Cas de charge N° : 2

ELU, F = 300 kN, δ = 0 °, e = 0 m, Hd = 0 kN, Vd = 300 kN, MB = 0 kN.m

Par la méthode de Meyerhoff

qmin = Vd/A * (1-6*e/B) = 0.025 MPa ; qmax = Vd/A * (1+6*e/B) = 0.025 MPa

qref = (3.qmax + qmin) / 4 = 0.025 MPa

q'0 = γ_1.D - γ_e.Ze = 27 kPa

$$Nm = 1/(2B - 0.5B) \int_{D+0.5B}^{D+2B} N(z).dz = 100$$

pour les semelles (B < 1.20 m)

3N/0.05 (1 + D/3B) = 7 MPa

Capa. Port. (ELU) = q'u / 2 = 3.5 MPa

pour les radiers (B > 1.20 m)

3N/0.08 (1 + D/3B) ((B + 0.3) / B)² = 5.29 MPa

Capa. Port. (ELU) = q'u / 2 = 2.65 MPa

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	Bargny substation	Container build

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