THE FEDERAL REPUBLIC OF NIGERIA

REPORT ON THE NEW OCEAN TERMINAL PROJECT, LAGOS (PHASE - II)

- SUBSOIL INVESTIGATION -

MARCH, 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

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CONTENTS

CHAPTER 1: OBJECTIVE AND PROCEDURE

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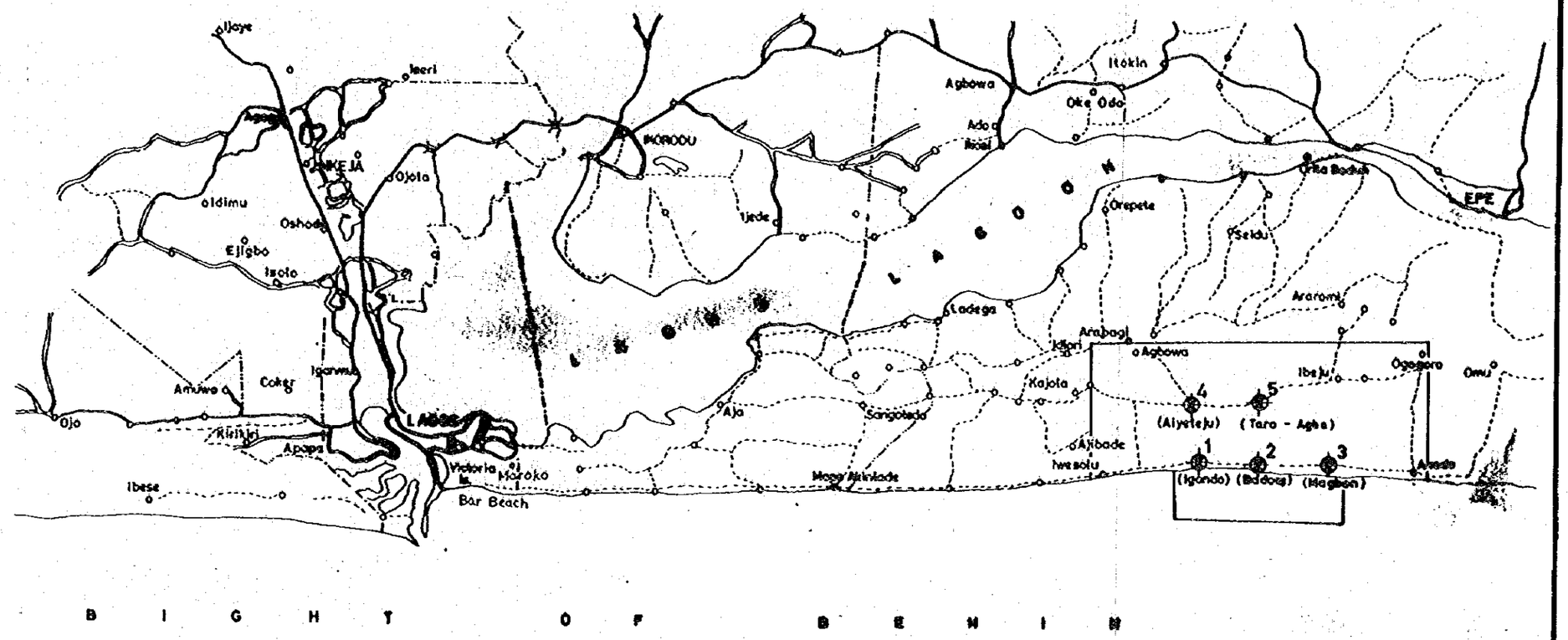
The objective of this investigation is to furnish subsoil data for preliminary evaluation of the site proposed for the new ocean terminal in the "Report on the New Ocean Terminal Project, Lagos (Phase-I), June 1978". The investigation was performed as a part of the Phase-II study for the Project.

The survey at the site was carried out by Messrs. Foundation Engineering (Nigeria) Ltd. of Lagos, Nigeria, who was recommended by Nigerian Ports Authority and approved by Japan Internationa Cooperation Agency. All the work was carried out under the direction of Messrs. Pacific Consultants International, the consultants of Japan.

The investigation comprised putting down 5 No. shell and auger boreholes in accordance with the British Standard Code of Practice 2001. Standard Penetration Tests and samples of the soil encountered were taken at regular intervals. Laboratory tests were carried out on selected samples in accordance with B.S. 1977: 1975.

The site work was performed by mobilizing three Pilcon-type boring machines between December 5th and 25th, 1978.

FIG. 1



Proposed New Ocean Terminal, Lagos.

LOCATION PLAN

Scale:- 1 : 300,000

10 0 10 20 30 Km

⊕ : Boreholes.

CHAPTER 2: SUMMARY

CHAPTER 2: SUMMARY

2-1 The Site

The site is located between 40 - 60 kilometres east of Lagos and the locations of boreholes were selected at three villages along the sandy Atlantic Ocean shoreline and two in the thickly forested inland area as shown on the attached Location Plan, Figure 1 in consideration of the draft master plan of the New Ocean Terminal. Between the two east-west rows of boreholes is an approximately 2 km wide area of mangrove swamps, containing a network of narrow creeks connecting several small villages. Near the eastern boundary of the area, these creeks become wider and converge to form a lagoon.

Borehole No. 1 was located about 10 metres north of the existing track at the eastern boundary of IGANDO village some 50 km east of Bar Beach, Lagos. The Atlantic Ocean is about 300 metres south of the borehole and the swampline about 50 metres north.

Borehole No. 2 was sited at BADORE village, about 5 km east of Igando. The borehole is behind the northside row of houses, about three-quarters of the way through the village. It is about 50 metres from the swampline and approximately a half kilometre north of the Atlantic Ocean.

Borehole No. 3 was located at the western boundary of MAGBON village, 4-1/2 km east of Badore and about 20 metres north of the existing track. The swampline is about 100 metres north of the borehole whicle the Atlantic Ocean is about three quarters of a kilometre south.

Borehole No.4 was sited at AIYETEJU village, about 50 km east of Victoria Island along the Maroki - Ibeju track. The location is behind the northside row of houses and near the eastern boundary of the village, about 25 metres north of the track. The swampline is about 2 km south of the village but there is a stream about 50 metres north of the borehole position.

Borehole No. 5 was located at TARO-AGBA village, 4 km east of Aiyeteju and just off the junction of Maroko - Ibeju track with the village foot-path. Distance of the swampline to this location was not established but a small stream crosses the Maroko - Ibeju track about 1 km east of the borehole position.

2-2 Ground Consitions

The depths of boreholes are 50.0 metres for Nos. 1, 4 and 5, 60.0 metres for No. 2 and 48.6 metres for No.3. Detailed logs of the boreholes are given in Figures 2 to 6, while very tentative subsoil profiles along the lines of the boreholes are shown on sketches given in Figures 7 to 10.

The records of the Geological Survey of Nigeria suggest that the general area of the site consists of a coastal belt of recent sands and clays formed as alluvial, littoral and lagoonal deposits. The results of the borings are in good agreement with the anticipated subsoil conditions and are discussed in detail in the following sections: -

(1) Shoreline (Boreholes 1, 2 & 4)

Sand deposits predominate from ground level to between 27 metres depth (Boreholes 2 and 3) and 30 metres depth (Borehole 1), but a stratum of firm fibrous peat approximately 2 metres thick occurs at about 4 metres depth. In-situ Standard Penetration Tests (S.P.T.'s) indicate the sand to be mainly of medium density and laboratory tests show that it is coarse to fine grained, with a varying amount of silt and generally of rather uniform grading.

At Borehole 1, a band of stiff sandy and organic clay was encountered in the sand between 21 and 27 metres depth.

Underlaying the sand, at Boreholes 1 and 2 are stiff organic/ sandy clays to about 32 metres depth, while Borehole 3 remains predominantly sandy. Laboratory tests indicate the clay to be of high plasticity and similar to that usually encountered at depth elsewhere in the Lagos area.

Underlaying the clay are compact becoming very compact sand deposits in which Boreholes 1 and 3 were terminated at 50.0 m and 48.6 m depths, respectively. However, at Borehole 2, a very stiff silty clay stratum was encountered between 48.5 m to 54 m depths, the borehole was therefore extended and terminated at 60.0 m depth in very compact sand.

The lower sand deposits generally contain occasional pieces of fine gravel and are coarser grained than the upper sand deposits.

A sketch cross-section showing a very tentative subsoil profile along the shoreline is given as Figure 7.

(2) Inland (Boreholes 4 and 5)

Medium dense sand deposits are encountered from ground level to about 13 m depth, underlain by stiff organic sandy clay to 23 m depth at Borehole 4 and 34 m depth at Borehole 5, where it is interspersed by relatively thin layers and lenses of sand.

Laboratory tests show that the sand is generally coarse to fine grained, with a low silt content and of similar grading as those obtained from the shoreline boreholes. The clays are of rather lower plasticity than those encountered on the shoreline due to the higher sand content.

The clay deposits are underlain by compact becoming very compact sand deposits to 42 m depth at Borehole 4 and 37 m depth at Borehole 5, then very stiff organic and silty clays to 40 to 43.5 m depth. Both boreholes terminated in very compact sand at 50.0 metres depth.

Unlike in the shoreline boreholes, the lower sand deposits here appear coarser grained than the upper sand deposits at Borehole 5 only.

A sketch cross-section showing a very tentative subsoil profile in this area is given as Figure 8. Similar very tentative north-south profiles across two rows of boreholes are shown in Figures 9 and 10.

(3) Groundwater

At the time of the investigation, ground water occured between 2.5 m and 4.5 m below ground level along the shoreline and about 1 m below ground level at the inland boreholes. Investigation showed that the groundwater levels at the inland were about 1 metre higher than those along the shoreline. It should be noted, however, that the groundwater level is likely to vary depending on the prevailing weather and tidal conditions in the nearby ocean, creeks, swamps and streams.

2-3 Discussion

Details of the development proposed for the site are not available and in view of the preliminary nature of the investigation, the following comments are given for general guidance only:

(1) Reclamation

The upper sand deposits are generally of coarse to fine rather uniform grading and could be dredged out for use as fill material. However, care should be taken, especially in the shoreline area and near swamps, to avoid using sand containing inclusions of peat and clay.

It is very likely that the peaty deposits encountered in the shoreline boreholes are of greater thickness and softer in the swamp area where reclamation will be necessary. It should be noted therefore that where fill is placed over such highly compressible deposits there will be very marked settlement of the fill. Such settlement is likely to continue for some time after placement of the fill. Great care should be taken during the filling operations to prevent shear failure of the compressible deposits.

Any structure bearing on the fill in swamp areas will, of course, settle with the fill, hence, filling should be carried out as far ahead of construction as possible. Stress increase in soft clay or peat deposits underlying fill due to structural loadings will also result in settlement.

(2) Shallow Foundation

The results of the investigation suggest that light and reasonably flexible structures can be supported on reinforced concrete strip, and or raft foundations set at about 1 metre depth in the upper sand deposits. The indications are that an allowable load of 3 to 5 ton/sq.m. may be applied. Settlement of any form of shallow foundation in these deposits will depend on its width, loading intensity and the thickness and nature of any compressible stratum beneath the superficial sand.

The sand or sand-fill at the location of structures, roads, etc. sould be compacted with a heavy vibrating roller or plate before foundation construction.

After filling, the area should be left as long as possible before development and only used for light open storage or for very light, flexible sheds. Where more permanent or heavier structures are required, the thinner areas of soft compressible swampy deposits under the area of each structure could be removed and replaced with sand fill.

(3) Pile Foundation

Loading and settlement of any shallow foundation will be influenced by the properties of the underlying peat or clay deposits. Hence, where there are concentrated loads and/or total settlements have to be minimised, piles may be used.

The Standard Penetration Test (SPT) results indicate that piles founded in the compact sand will be capable of carrying high working loads. Allowance should be made in the pile design for negative skin friction (downdrag) caused by the consolidation of compressible deposits underlying filled areas.

(4) General

Experience indicates that the superficial sand deposits are somewhat finer than sand usually used in concrete production. However, with carefully conducted laboratory studies, satisfactory mix proportions can be evolved for concrete and for sand/cement stabilisation.

2-4 Conclusions

A) The overall subsoil sequence is indicated to be similar and mainly sandy along the two lines of east-west boreholes, but lenses and layers of part and clay occur at varying levels. Groundwater was observed to be between 1 and 4 metres below ground level during drilling.

B) Between the two rows of boreholes is a large area of mangrove swamp and creeks. Subsoil conditions in this area have not been investigated, but it is considered possible that beneath perhaps a substantial thickness of soft highly compressible swampy organic deposits is encountered and that the lower subsoil sequence is similar to that encountered in the boreholes.

C) The superficial sand deposits may be dredged out and used as general fill. Care should be taken to avoid contaminating the fill with peat or clay.

D) For light and reasonably flexible structure, shallow foundations comprising reinforced concrete pad, strip or raft foundations may be used in the areas investigated.

E) The probable existence of superficial soft highly compressible peat and organic clay deposits, perhaps of substantial thickness, in the swampy areas will cause marked settlement of fill and necessitate founding all important structures on piles.

F) The presence of substantial deposits of compact sand at depth will allow piles of high load carrying capacity.

G) The superficial san deposits might be suitable for economic stabilisation with cement or concrete production. However, detailed laboratory tests should be made to select good mix proportions.

H) Because of the relatively great distances between the boreholes, comments and recommendations given in this report are essentially of very general nature. As soon as structure locations are known, a more detailed investigation is essential in order to allow more accurate estimates of soil bearing capacity and settlement. In any subsequent investigation, special attention must be paid to the swampy areas in order to formulate

satisfactory foundation solutions since it is suspected that substantial deposits of soft highly compressible peats and organic clays occue in these area.

CHAPTER 3: RESULTS

3-1 Borehole Logs

(Fig 2 - Fig 6)

Location :— PROPOSED NEW OCEAN TERMINAL, LAGOS

FIG. 2

Water level: Approx. 2·5m below ground level. Date : 8 . 12 . 78 Ground level : B.L. +3.85 Borehole Dia. : 0·25m 0·20m & 0·15m Borehole No. 1

DEPTH METRES	DEPTH FEET	SAMPLE No.	DESCRIPTION	MOISTURE CONTENT % / LIQUID LIMIT % / PLASTIC LIMIT % (25 50 75 100)	WET DENSITY Mg/m³	BLOWS FOR S.P.T. SPOON FOR 0·30m DRIVE (20 40 60)	SHEAR STRENGTH t/m²	COHESION C_u t/m²	ANGLE OF FRICTION
0	0	1				(3 blows/0·30m)			
1									
2	5	2	Medium dense brown SAND (mf) becoming coarser at depth. Very loose at top. (SP)			(4)			
3	10	3				(7)			
4	15	4	Firm dark brown fibrous PEAT with sand partings. (PT)	MC = 152%, LL = 210%, PL = 63%					
5		5							
6	20	6				(13)			
7									
8	25	7	Medium dense dark gray SAND (mf) with traces of peat to about 8·5m depth. (SP)			(12)			
9	30	8				(19)			
10									
11	35	9				(17)			
12	40	10				(19)			
13									
14	45	11				(23)			
15	50	12	Medium dense gray silty SAND (mf) (SP)			(30)			
16									
17		13				(31)			
18	60	14				(32)			
19									
20	65	15	Medium dense blue-gray silty SAND (mf) with shelly layers from 19m depth. (SP)			(36)			
21	70	16				(29)			
22									
23	75	17	Stiff dark blue gray organic silty CLAY.			(28)			
24									
25	80	18	Stiff blue-gray sandy (mf) silty CLAY.			(30)			
26									
27	85	19	Very stiff mottled blue gray and yellow sandy (mf) silty CLAY. (CH)			(44)			
28									
29	90	20				(31)			
30									
31	95	21	Medium dense dark blue-gray very silty SAND (mf).			(36)			
32	100	22				(37)			
33		23				(29)			
34	105	24	Stiff dark blue-gray organic silty CLAY. (CH)			(28)			
35									
36	110	25				(39)			
37									
38	115	26	Compact dark gray silty SAND (mf). (SP)			(48)			
39									
40	120	27				(50)			
41									
42	125	28	Very compact dark gray silty SAND (mf). (SP)			(94)			
43									
44	130	29				(93)			
45									
46	135	30				(50/0·18m)			
47									
48	140	31				(50/0·10m)			
49									
50	145	32				(50/0·15m)			
51									
52	150	33	Very compact gray SAND (mf)			(52/0·18m)			
53									
54	155	34				(50/0·13m)			
55									
56	160	35				(50/0·18m)			
57									
58	165	36	Borehole completed.						
59									
60	170								
61									
62	175								
63									
64	180								
65									
66	185								
67									
68	190								
69									
70	195								

• DISTURBED SAMPLE ‖ UNDISTURBED SAMPLE (Um) ⊕ STANDARD PENETRATION TEST

Location :— PROPOSED NEW OCEAN TERMINAL, LAGOS.

FIG. 3

Water level: Approximately 3.0m below ground level. Date : 14 : 12 : 78 Ground level EL. +5.65 Borehole Dia. : 0.25, 0.20 & 0.15m Borehole No. 2

DEPTH METRES	DEPTH FEET	SAMPLE No	DESCRIPTION
0	0	+ 1	
1	5	+ 2	Loose dark brown silty SAND (surf) with roots at top.
2	10	+ 3	
3	15	+ 4	Medium dense grey brown SAND (surf).
4	20	+ 5	Firm dark brown fibrous PEAT.
5	25	+ 6	Loose dark grey silty SAND (surf). (SP)
6	30	+ 7	
7	35	+ 8	Loose becoming medium dense dark grey-brown slightly silty SAND (surf) with traces of peat at top.
8	40	+ 9	
9	45	+ 10	
10	50	+ 11	
11	55	+ 12	
12	60	+ 13	Medium dense dark grey brown SAND (surf). (SP)
13	65	+ 14	
14	70	+ 15	Medium dense grey SAND (surf).
15	75	+ 16	
16	80	+ 17	
17	85	+ 18	Very compact dark grey-brown SAND (sur) (SP)
18	90	+ 19	
19	95	+ 20	Stiff dark blue-grey organic silty CLAY becoming sandy at depth. (CH)
20	100	+ 21	
21	105	+ 22	
22	110	+ 23	Compact dark grey-grey slightly silty SAND (surf) (SP)
23	115	+ 24	
24	120	+ 25	
25	125	+ 26	
26	130	+ 27	Compact becoming very compact grey slightly silty SAND (surf)
27	135	+ 28	
28	140	+ 29	
29	145	+ 30	Very compact grey SAND (surf).
30	150	+ 31	
31	155	+ 32	Very compact dark grey slightly silty SAND (surf) with cemented band at 48·7m depth.
32	160	+ 33	
33	165	+ 34	Very stiff dark grey organic silty CLAY with thin layers of sand.
34	170	+ 35	Stiff dark grey organic silty CLAY.
35	175	+ 36	
36	180	+ 37	Compact grey silty SAND (surf).
37	185	+ 38	Very compact grey SAND (surf) with occasional gravel (f).
38	190	+ 39	
39	195	+ 40	
40			Borehole completed.

MOISTURE CONTENT ● %
LIQUID LIMIT %
PLASTIC LIMIT %
25 50 75 100

WET DENSITY Mg/m³
1·0 1·5 2·0

BLOWS FOR S.P.T. SPOON FOR 0.30m DRIVE.
20 40 60

SHEAR STRENGTH t/m²
5 10 15

COHESION C_u t/m²

ANGLE OF FRICTION

(10 blows/0·10m)
(8)
(20)
(7)
(8)
(6)
(7)
(7)
(13)
(9)
(14)
(14)
(16)
(19)
(18)
(50/0·15m)
(50/0·15m)
(18)
(18)
(19)
(29)
(25)
(50/0·15m)
(14)
(27)
(34)
(50/0·10m)
(50/0·10m)
(50/0·10m)
(50/0·10m)
(50/0·15m)
(50/0·15m)
(50/0·15m)
(37)
(27)
(32)
(31)
(28)
(24)
(32)

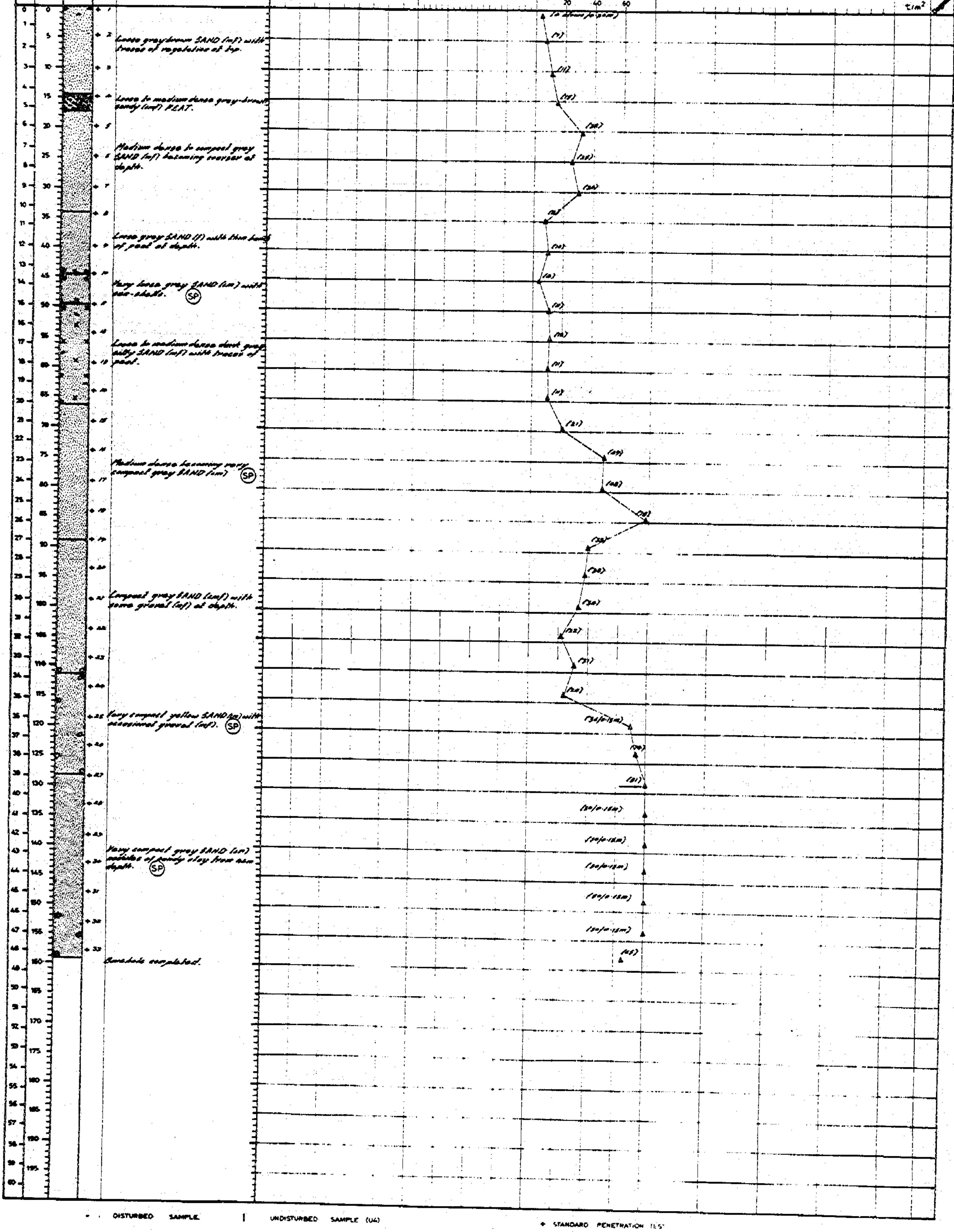
• DISTURBED SAMPLE | UNDISTURBED SAMPLE (U4) + STANDARD PENETRATION TEST

Location :— PROPOSED NEW OCEAN TERMINAL LAGOS.

FIG. 4

Water level: Approx. 4·5m below ground level. Date: 10 . 12 . 78. Ground level: EL. +4.58 Borehole Dia.: 0.20m & 0.15m Borehole No. 3

DEPTH (METRES / FEET)		SAMPLE No.	DESCRIPTION	MOISTURE CONTENT — % / LIQUID LIMIT — % / PLASTIC LIMIT — %	WET DENSITY Mg/m³	BLOWS FOR S.P.T. SPOON FOR 0·30m DRIVE	SHEAR STRENGTH T/m²	COHESION C_u T/m²	ANGLE OF FRICTION



· DISTURBED SAMPLE | UNDISTURBED SAMPLE (U4) ◆ STANDARD PENETRATION TEST

Location :— PROPOSED NEW OCEAN TERMINAL LAGOS.

FIG. 5

Water level: Approx. 0·3m. below ground level. Date : 9 : 12 : 78 Ground level: EL. +3.57 Borehole Dia. : 0·25m 0·20m & 0·15m Borehole No. 4

DEPTH METRES	DEPTH FEET	SAMPLE No.	DESCRIPTION
0	0	1	
1	5	2	Medium dense grey SAND (mf) with some vegetation. Very loose at top.
2	10	3	
3	15	4	Medium dense grey SAND (mf).
5	20	5	
6	25	6	Medium dense light grey brown SAND (mf) (SP).
8	30	7	
9	35	8	Medium dense light grey brown slightly silty SAND (f).
10		9	
11	40	10	Very loose grey SAND (mf) with a few band of dark blue-grey organic silty CLAY at this depth.
12	45	11	
13	50	12	
14		13	Firm to stiff dark blue grey very sandy inorganic silty CLAY, becoming more sandy at depth. (CL) - (CH)
15	55	14	
16	60	15	
17		16	
18	65	17	Stiff blue-grey with brown streaks silty CLAY.
20	70	18	
21		19	Stiff blue-grey very sandy (f) silty CLAY.
22	75	20	
23	80	21	Compact blue grey slightly clayey very silty SAND (mf).
24		22	
25	85	23	
26	90	24	Compact grey SAND (mf).
27		25	
28	95	26	
29		27	
30	100	28	Very compact grey SAND (mf).
31	105	29	
32		30	Medium dense light blue grey very silty SAND (mf).
33	110	31	
34		32	
35	115	33	Very compact grey slightly silty SAND (mf) (SP).
36		34	
37	120	35	
38		36	Compact light blue grey clayey silty SAND (mf). (SC) - (CL)
39	125	37	
40		38	
41	130	39	
42		40	
43	135	41	Very stiff light yellow silty CLAY.
44		42	
45	140	43	Medium dense grey SAND (mf).
46		44	
47	145	45	
48		46	Very compact grey SAND (fm). (SP)
49	150	47	
50		48	Borehole completed.
51	155		
52			
53	160		
54			
55	165		
56			
57	170		
58			
59	175		
60			
	180		
	185		
	190		
	195		

MOISTURE CONTENT + %
LIQUID LIMIT —— %
PLASTIC LIMIT —— %

WET DENSITY Mg/m³

BLOWS FOR S.P.T. SPOON FOR 0·30m DRIVE

SHEAR STRENGTH τ/m²

COHESION C_u τ/m²

ANGLE OF FRICTION

• DISTURBED SAMPLE | UNDISTURBED SAMPLE (U4) ⊕ STANDARD PENETRATION TEST

Location :— PROPOSED NEW OCEAN TERMINAL, LAGOS.

FIG. 6

Water level: Approx. 1·2m below ground level. Date : 17 . 12 . 76 Ground level: EL. +3.20 Borehole Dia. : 0.25m, 0.20m & 0.15m Borehole No. 5

DEPTH METRES	DEPTH FEET	SAMPLE No.	DESCRIPTION
0	0	+ 1	Very loose grey-brown silty SAND (sm) with some roots.
1	5	+ 2	
2	10	+ 3	Medium dense light grey-brown SAND (sw) with occasional gravel. (f) (SP)
3	15	+ 4	
4	20	+ 5	
5	25	+ 6	
6	30	+ 7	Medium dense grey slightly silty SAND (sf)
7	35	+ 8	
8	40	+ 9	Stiff dark blue-grey organic silty CLAY with thin sand layers.
9	45	+ 10	Very loose dark grey very silty SAND (sf)
10	50	+ 11	
11	55	+ 12	Firm to stiff dark blue-grey (slightly sandy (sf)) organic silty CLAY. (CH)
12	60	+ 13	
13	65	+ 14	Medium dense dark blue-grey silty SAND (sm) with clay pockets at top
14	70	+ 15	Hard dark blue-grey sandy (f) silty CLAY.
15	75	+ 16	Dark grey slightly silty SAND (sw)
16	80	+ 17	
17	85	+ 18	
18	90	+ 19	Very stiff dark blue-grey organic silty CLAY with thin layers and pockets of sand (sf) (CL)
19	95	+ 20	
20	100	+ 21	
21	105	+ 22	
22	110	+ 23	
23	115	+ 24	
24	120	+ 25	Compact dark blue-grey slightly clayey silty SAND (sm).
25	125	+ 26	Very stiff to hard dark blue-grey organic silty CLAY.
26	130	+ 27	
27	135	+ 28	Very compact dark blue-grey very silty SAND (sm)
28	140	+ 29	
29	145	+ 30	Very compact grey slightly silty SAND (sw) with some gravel (f)
30	150	+ 31	
31	155	+ 32	Very compact grey SAND (sw) with occasional gravel (f)
32	160	+ 33	
33	165	+ 34	Borehole completed.
34	170		
35	175		
36	180		
37	185		
38	190		
39	195		
40	200		

MOISTURE CONTENT = %
LIQUID LIMIT —|— %
PLASTIC LIMIT |— %

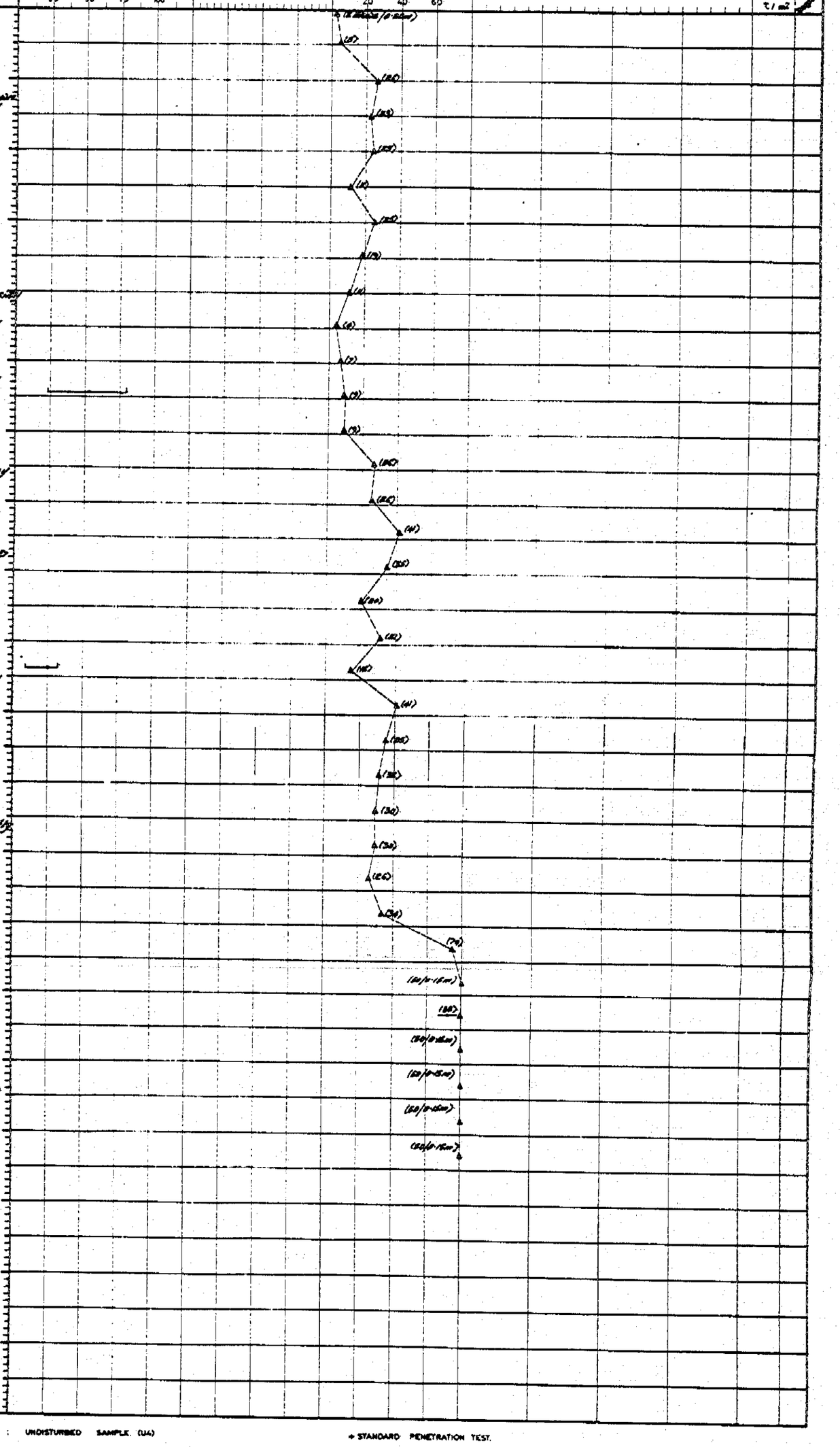
WET DENSITY Mg / m³

BLOWS FOR S.P.T. SPOON FOR 0.30m DRIVE

SHEAR STRENGTH τ / m²

COHESION C_u τ / m²

ANGLE OF SHEARING RESISTANCE



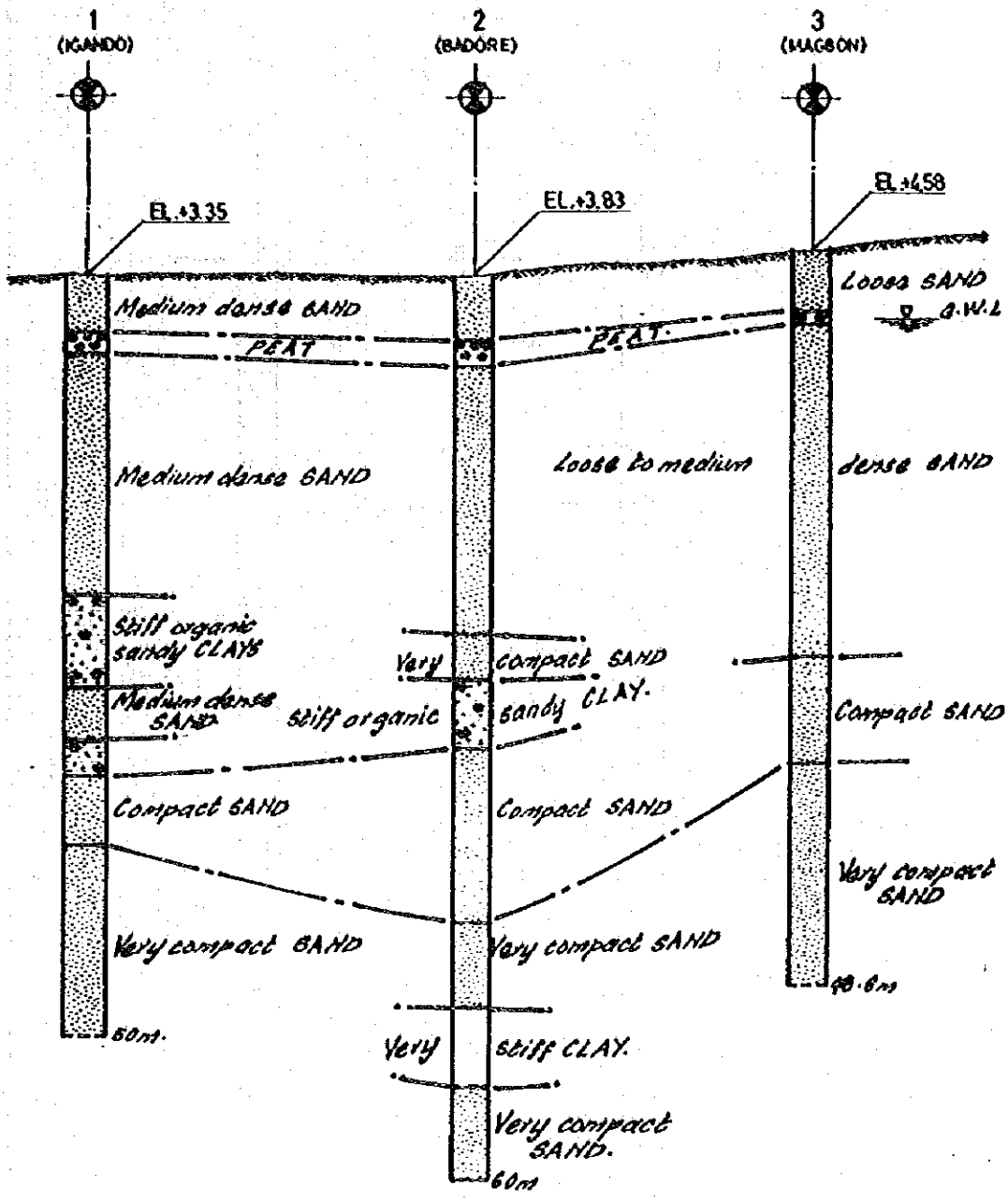
• : DISTURBED SAMPLE. | : UNDISTURBED SAMPLE. (U4)

+ STANDARD PENETRATION TEST.

3-2 Tentative Subsoil Profiles

(Fig 7 - Fig 10)

FIG. 2



Proposed New Ocean Terminal, Lagos.

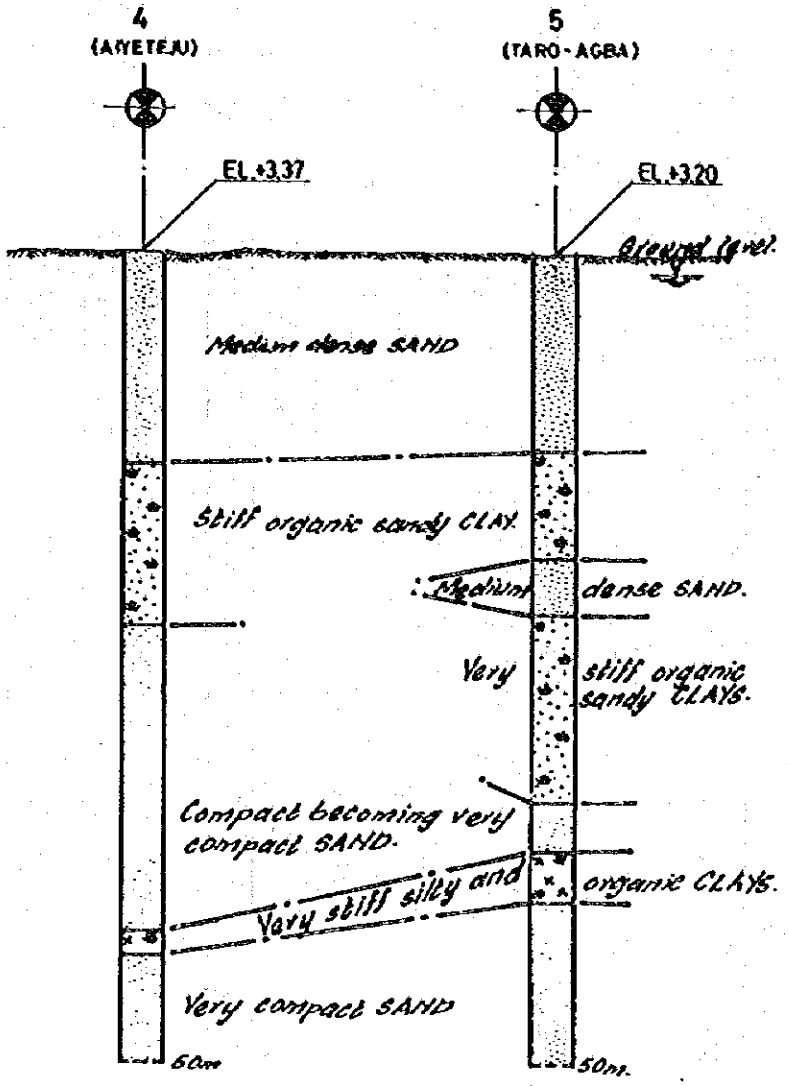
SKETCH CROSS - SECTION 'A'

SCALE:- Vertical: 1:460 approx.
Horizontal: Not to scale.

⊕ : Borehole.

NOTE: Broken lines joining strata must be regarded as very tentative.

FIG. 8



Proposed New Ocean Terminal, Lagos.

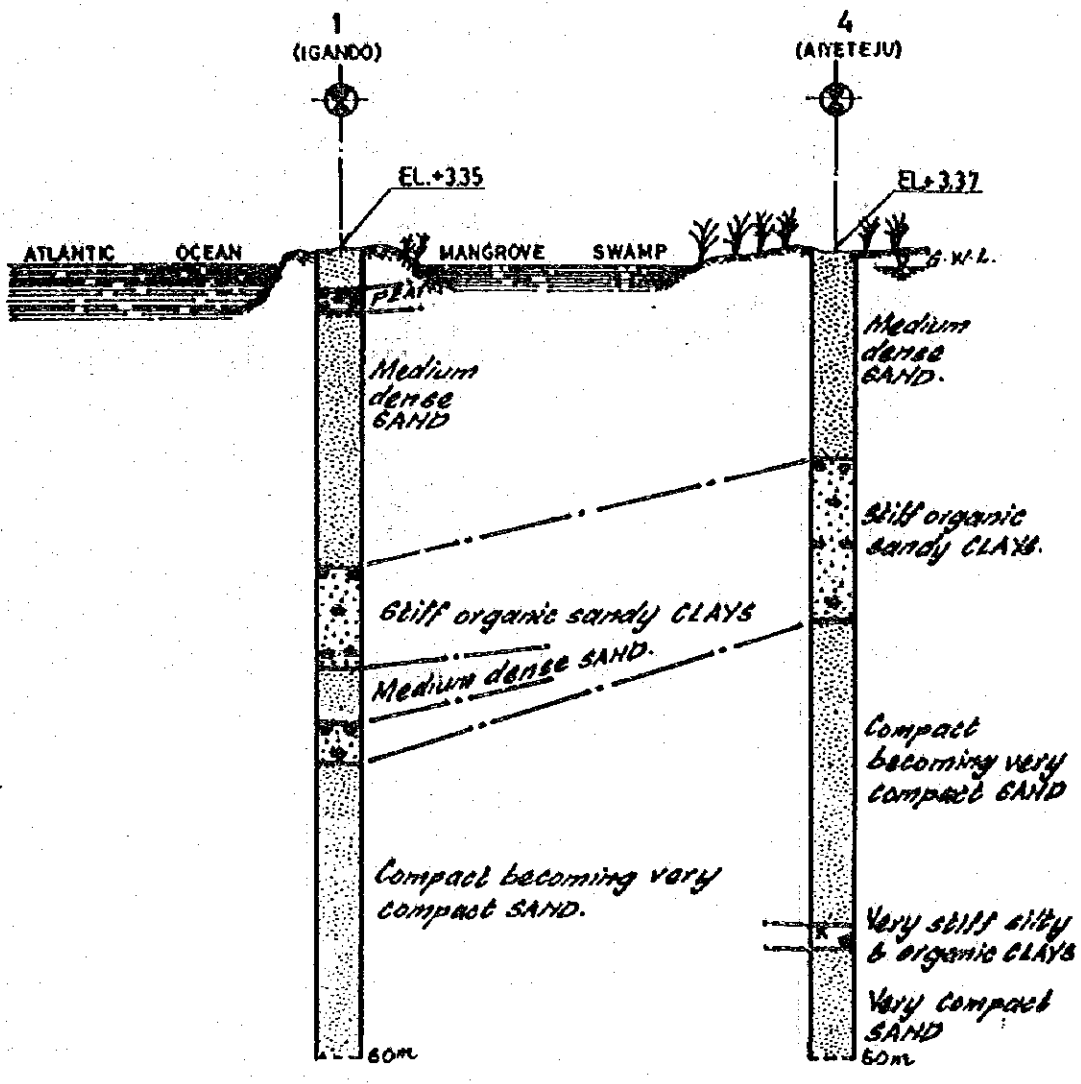
SKETCH CROSS-SECTION 'B'

SCALE:- Vertical:- 1 : 480 approx.
Horizontal:- Not to scale.

⊕ : Borehole

NOTE: Broken lines joining strata must be regarded as very tentative.

FIG. 9



Proposed New Ocean Terminal, Lagos.

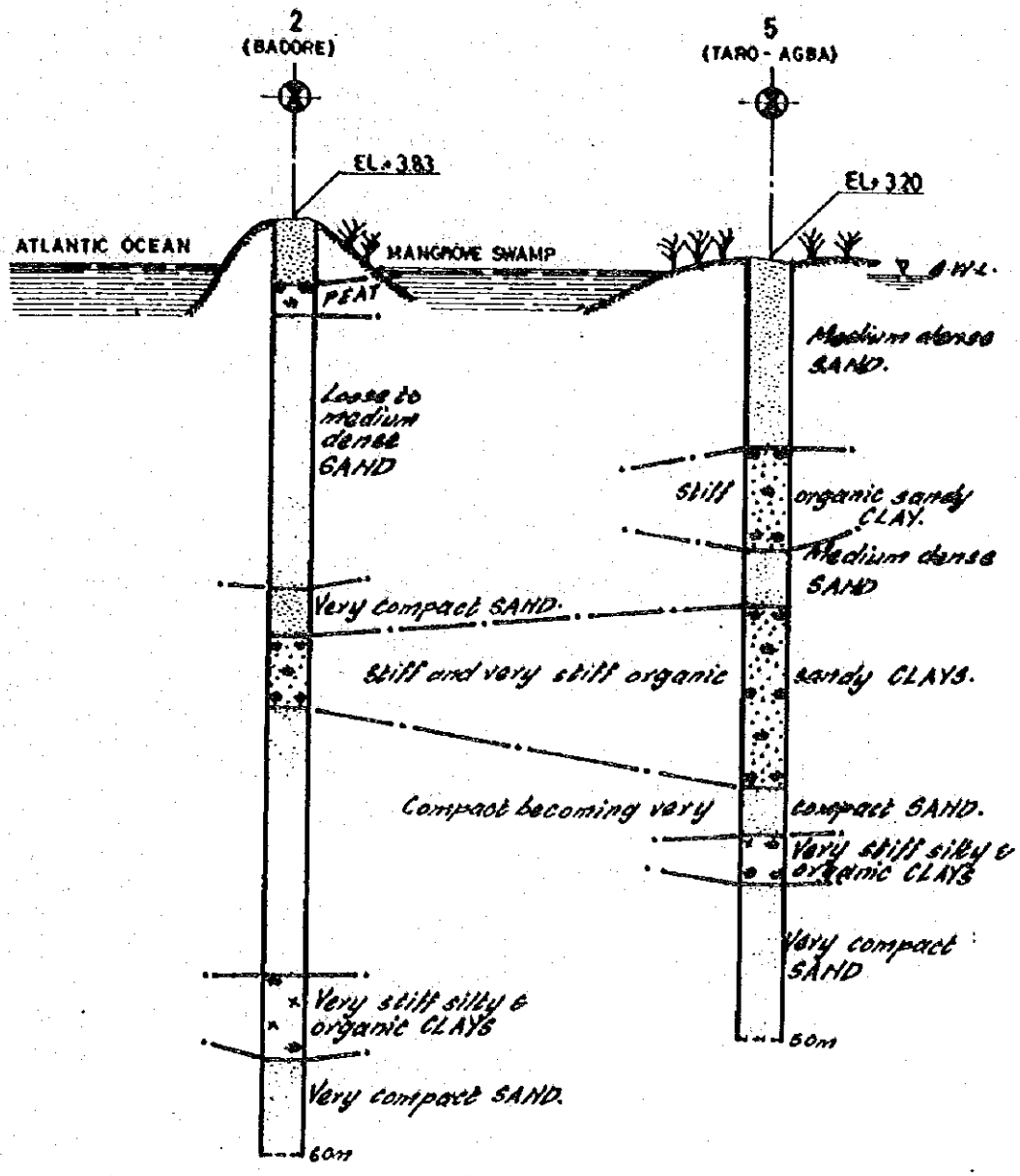
SKETCH CROSS - SECTION 'C'

SCALE:- Vertical :- 1 : 460 approx.
Horizontal:- Not to scale.

Borehole.

NOTE : Broken lines joining strata must be regarded as very tentative.

FIG. 10



Proposed New Ocean Terminal, Lagos.

SKETCH CROSS - SECTION 'D'

SCALE:- Vertical :- 1 : 460 approx.
Horizontal :- Not to scale.

: Borehole.

NOTE : Broken lines joining strata must be regarded as very tentative.

APPENDIX:

1. Results of Laboratory Tests
2. Photos of Site Work
3. Photos of Soil Samples

1. Results of Laboratory Tests

APPENDIX

NEW OCEAN TERMINAL, LAGOS

SUMMARY OF LABORATORY TEST RESULTS

1) ATTERBERG LIMITS DETERMINATION

Borehole & Sample No.	Depth (metres)	Natural Moisture Content (% dry wt.)	Liquid Limit (LL) (% dry wt.)	Plastic Limit (PL) (% dry wt.)	Plasticity Index (PI) (% dry wt.)
1/4	3.6	152	210	61	149
1/19	25.5	28	56	18	38
1/24	31.5	63	82	25	57
2/20	28.0	45	87	26	61
4/11	13.5	38	46	14	32
4/38	39.0	19	27	10	17
5/12	16.5	52	80	24	56
5/20	28.5	25	32	9	23

Note: -

The LL and PL tests were carried out on material passing 425 Micron Sieve in accordance with B.S. 1377 : 1975.

2) PARTICLE SIZE DISTRIBUTION - By Wet Sieve and Hydromerter Analyses

Borehole & Sample No.	Depth (metres)	Percentage Passing - By dry weight: 2.00mm Sieve	425 Micron Sieve	63 Micron Sieve	2 Micron from Hydrometer Analyses
1/2	1.5	100	54	3	-
1/7	7.5	99	40	3	-
1/12	15.0	100	70	8	-
1/15	19.5	99	53	5	-
1/19	25.5	100	99	68	44
1/24	31.5	100	94	82	44
1/26	34.5	100	62	6	-
1/29	39.0	99	53	5	-
2/5	6.0	100	57	5	-
2/12	16.5	100	65	4	-

Borehole & Sample No.	Depth	Percentage Passing - By dry weight 2.00mm Sieve	425 Micron Sieve	63 Micron Sieve	2 Micron from Hydrometer Analyses
2/18	25.5	99	29	4	-
2/20	28.5	100	99	91	61
2/23	33.0	96	41	5	-
3/4	4.5	99	81	43	-
3/10	13.5	99	54	2	-
3/17	24.0	100	41	1	-
3/25	36.0	100	48	2	-
3/30	43.5	99	34	2	-
4/5	6.0	100	58	3	-
4/11	13.5	100	78	43	22
4/18	24.0	100	94	20	-
4/25	34.5	99	71	6	-
4/28	39.0	100	93	25	14
4/33	46.5	99	41	3	-
5/4	4.5	98	36	1	-
5/12	16.5	99	98	86	70
5/20	28.5	100	96	49	18
5/26	36.0	100	72	15	7

Note: -

The tests were carried out in accordance with B.S. 1377 : 1975.

The grading curves are shown on Figures A1 to A11.

3) SPECIFIC GRAVITY DETERMINATION

Borehole & Sample No.	Depth (metres)	Specific Gravity
1/2	1.5	2.67
1/4	3.6	2.37
1/7	7.5	2.66
1/12	15.0	2.67
1/15	19.5	2.66
1/19	25.5	2.65

Borehole & Sample No.	Depth (metres)	Specific Gravity
1/24	31.5	2.66
1/26	34.5	2.67
1/29	39.0	2.66
2/5	6.0	2.66
2/12	16.5	2.67
2/18	25.5	2.68
2/20	28.5	2.65
3/4	4.5	2.66
3/10	13.5	2.68
4/5	6.0	2.69
4/11	13.5	2.66
4/18	24.0	2.69
4/25	34.5	2.69
4/28	39.0	2.65
4/33	46.5	2.67
5/4	4.5	2.70
5/12	16.5	2.66
5/20	28.5	2.66
5/26	36.0	2.67

Note: -

The test was carried out on material finer than 4.75 mm in accordance with B.S. 1377 : 1975.

4) QUICK-UNDRAINED TRIAXIAL COMPRESSION TEST

Borehole & Sample No.	Depth (metres)	Natural Moisture Content (% dry wt.)	Wet Density (Mg/m^3)	Undrained Cohesion(Cu) (ton/m^2)	Angle of Friction(Øu) (degrees)
2/20	28.0	39	1.85	10	2

Note: -

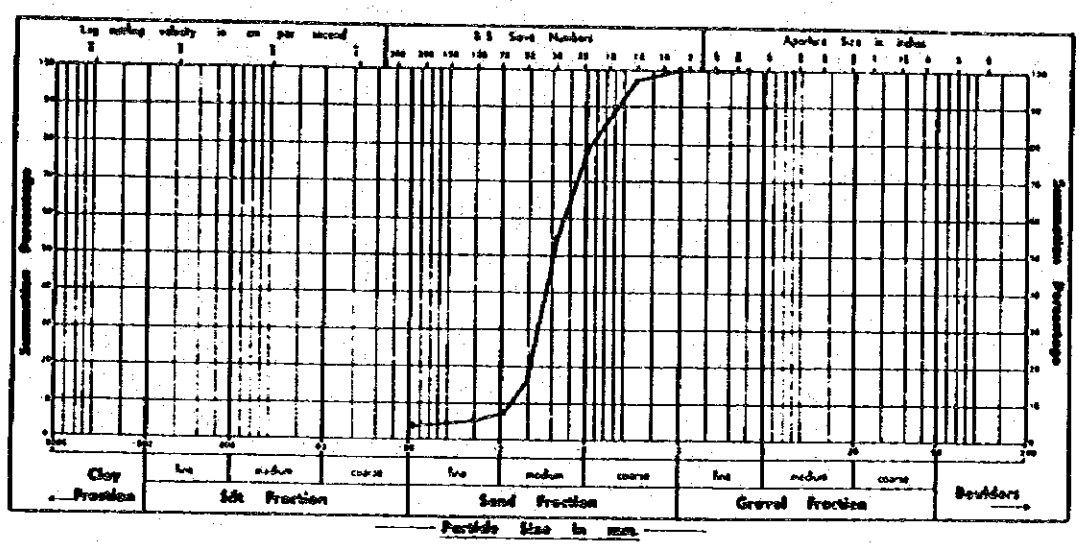
To determine the Cohesion (Cu) and Angle of Friction (Øu), three 38 mm diameter by 76 mm high specimens were prepared from the 102 mm diameter undisturbed site sample. The specimens were then tested in undrained compression using cell pressure of 20,40 & 60 ton/m^2 . Mohr Circles diagram for the sample is shown on Fig. A12.

FIG.....A.1.....

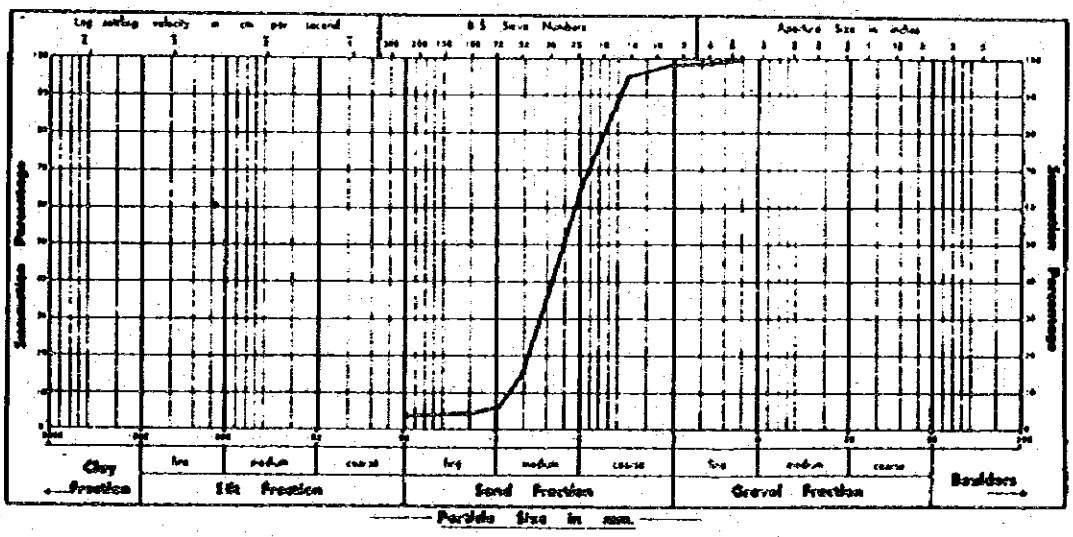
PARTICLE SIZE DISTRIBUTION

LOCATION. PROPOSED NEW OCEAN TERMINAL, LAGOS. **DATE OF TEST.** DECEMBER 1976

SAMPLE No. 1/2 **DEPTH.** 1.50m



SAMPLE No. 1/7 **DEPTH.** 7.50m



SAMPLE No. 1/12 **DEPTH.** 15.00m

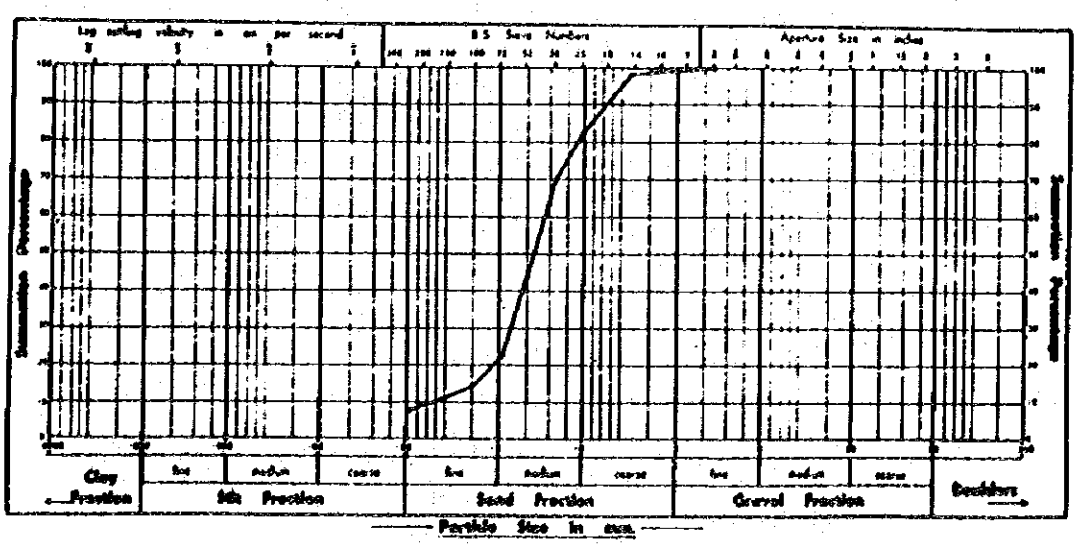
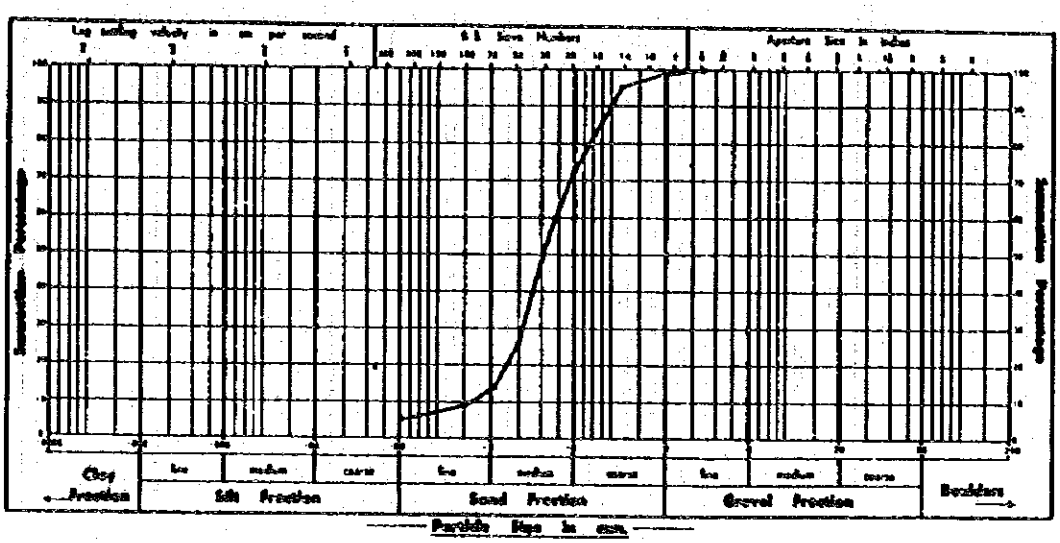


FIG.....A.2.....

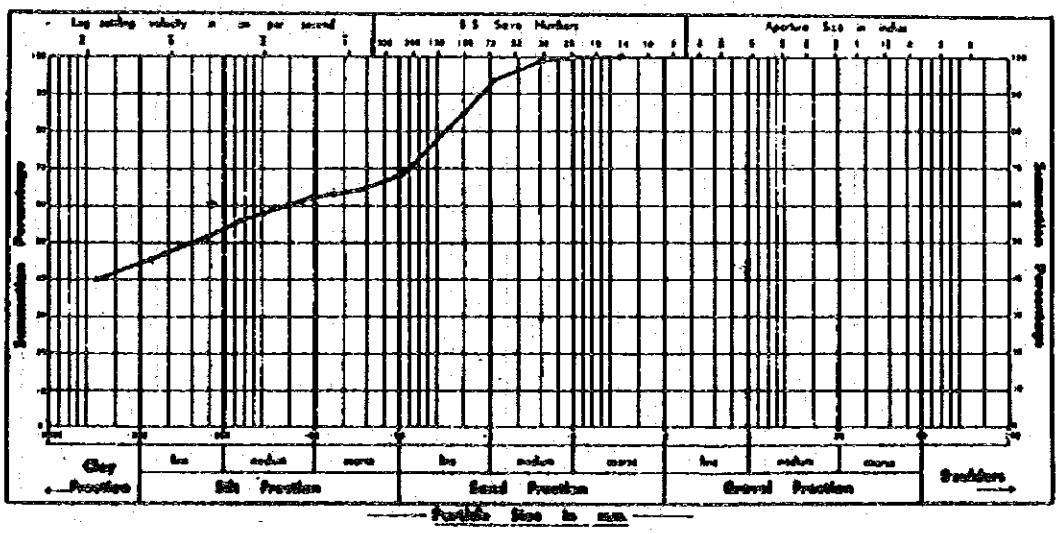
PARTICLE SIZE DISTRIBUTION

LOCATION. PROPOSED NEW OCEAN TERMINAL, LAGOS. **DATE OF TEST.** DECEMBER 1976

SAMPLE No. 1/15 **DEPTH.** 19.50m



SAMPLE No. 1/19 **DEPTH.** 25.50m



SAMPLE No. 1/24 **DEPTH.** 31.50m

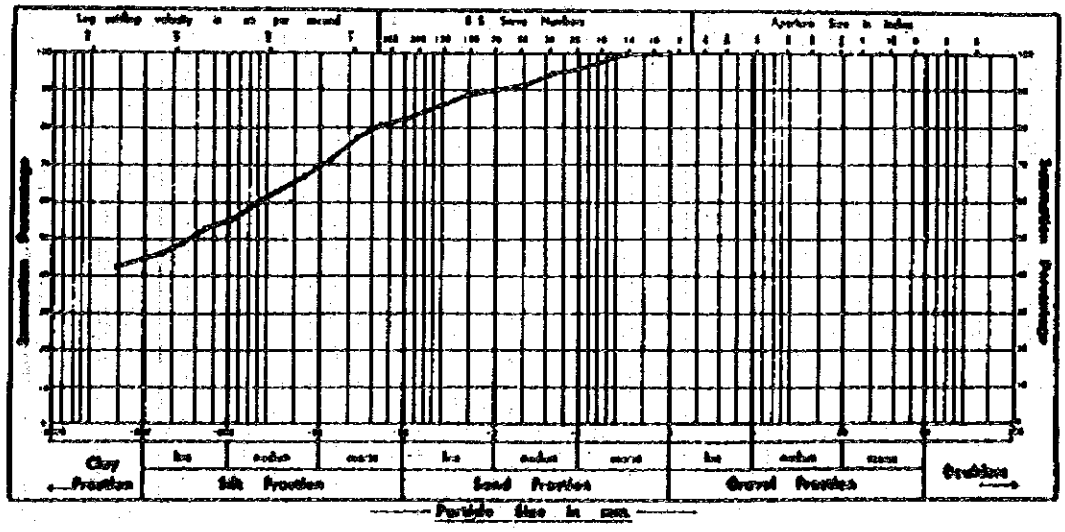
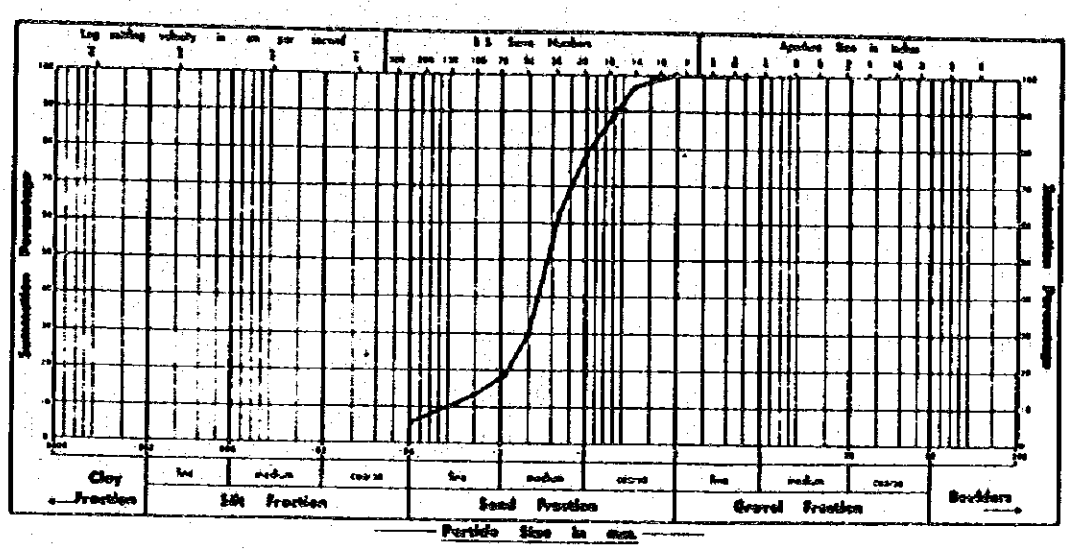


FIG.....A.3.....

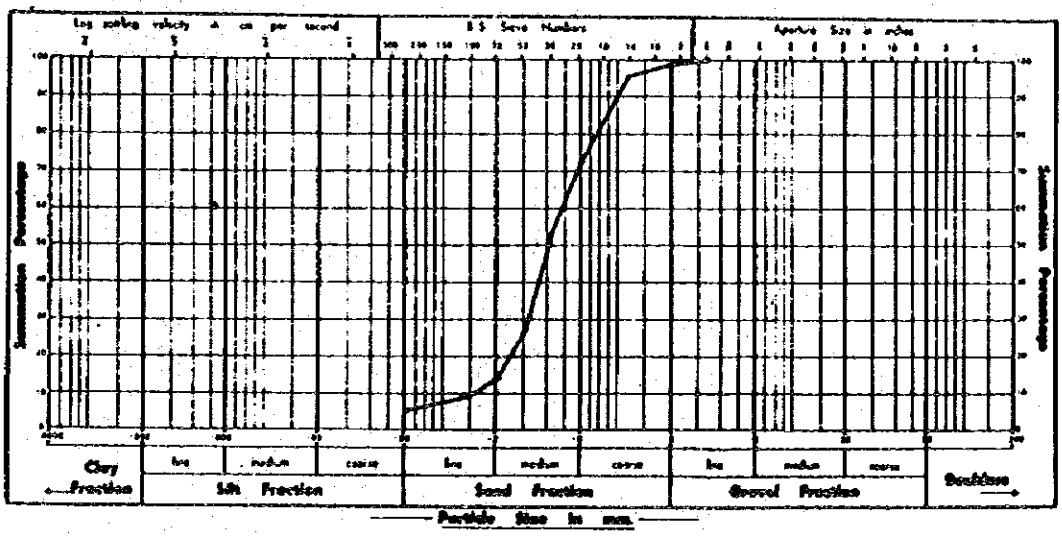
PARTICLE SIZE DISTRIBUTION

LOCATION. PROPOSED NEW OCEAN TERMINAL, LAGOS. **DATE OF TEST.** DECEMBER 1970

SAMPLE No. 1/26 **DEPTH.** 34.50m



SAMPLE No. 1/29 **DEPTH.** 39.00m



SAMPLE No. **DEPTH.**

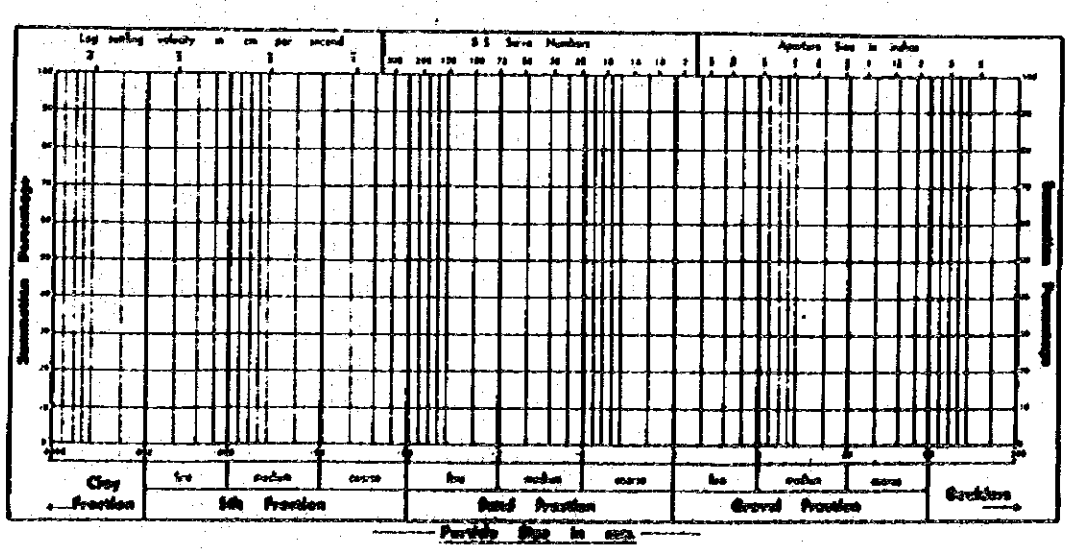
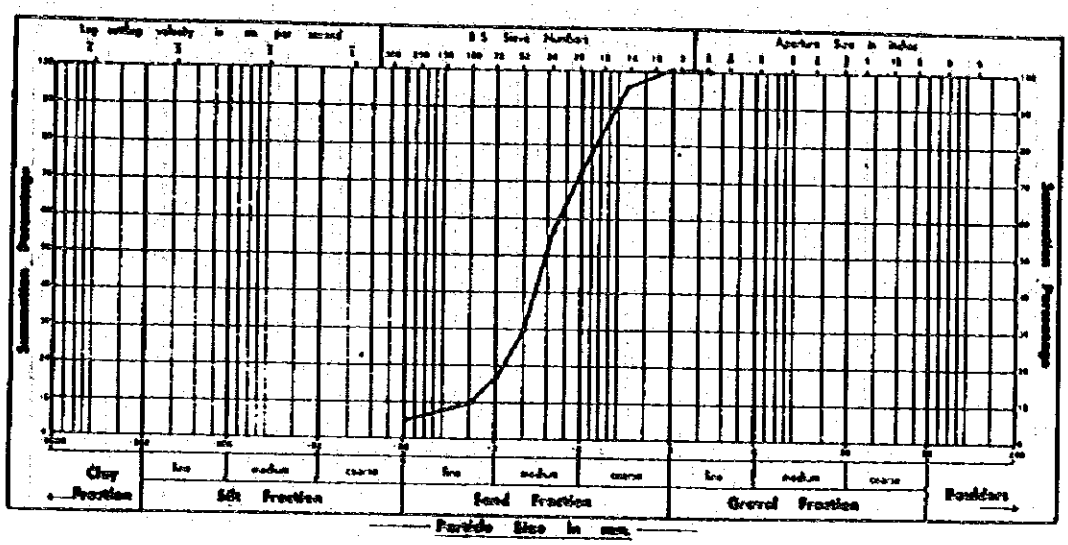


FIG....A4.....

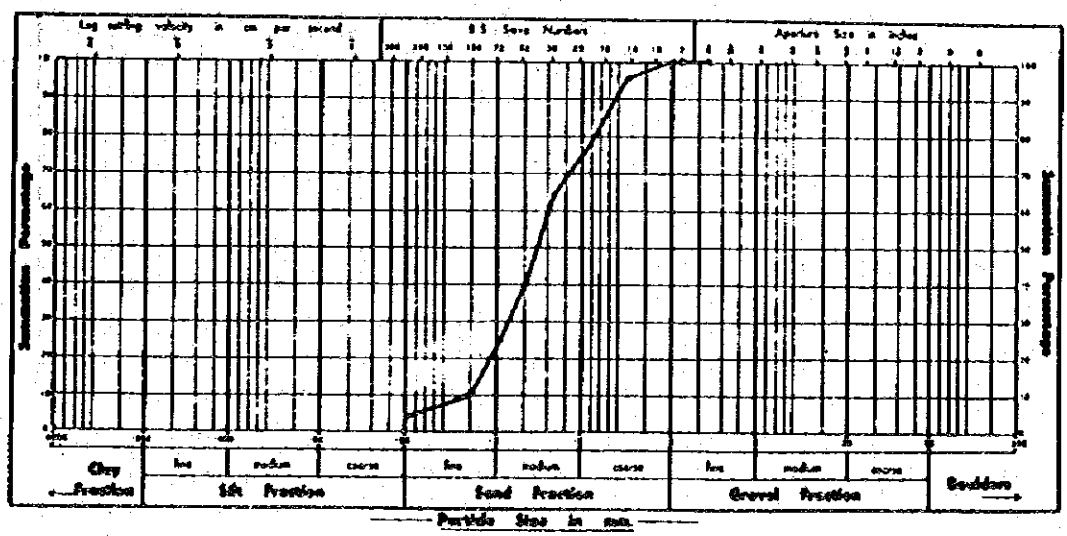
PARTICLE SIZE DISTRIBUTION

LOCATION. PROPOSED NEW OCEAN TERMINAL LAGOS. **DATE OF TEST.** DECEMBER 1978

SAMPLE No. 2 / 5 **DEPTH.** 6 .00m



SAMPLE No. 2 / 12 **DEPTH.** 16 . 50m



SAMPLE No. 2 / 18 **DEPTH.** 25 . 50m

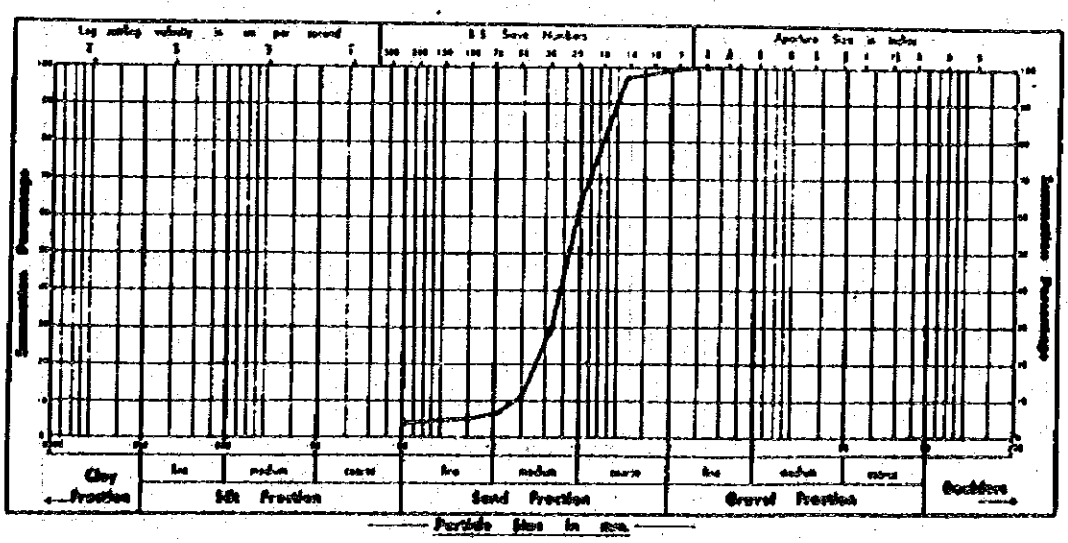
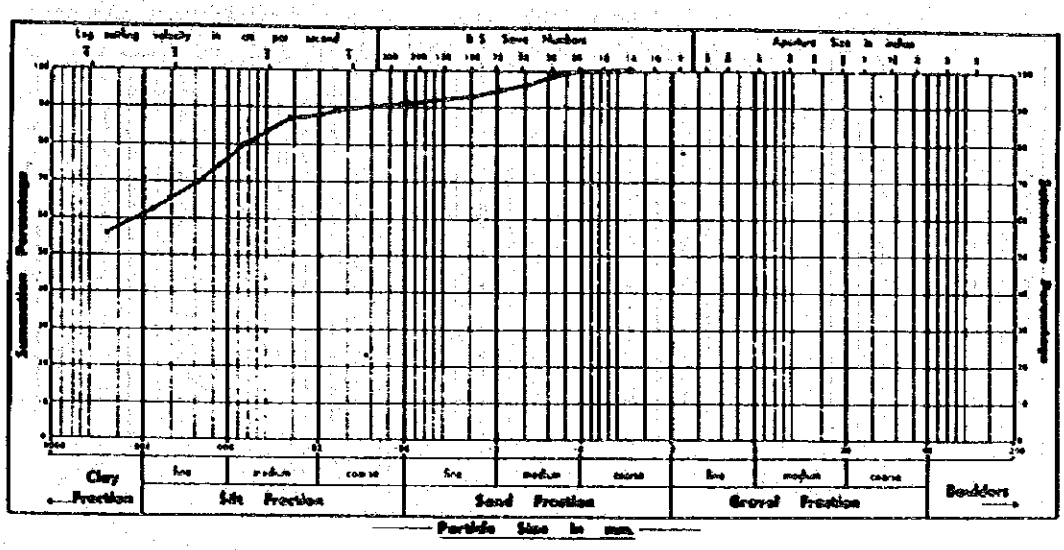


FIG.....A5.....

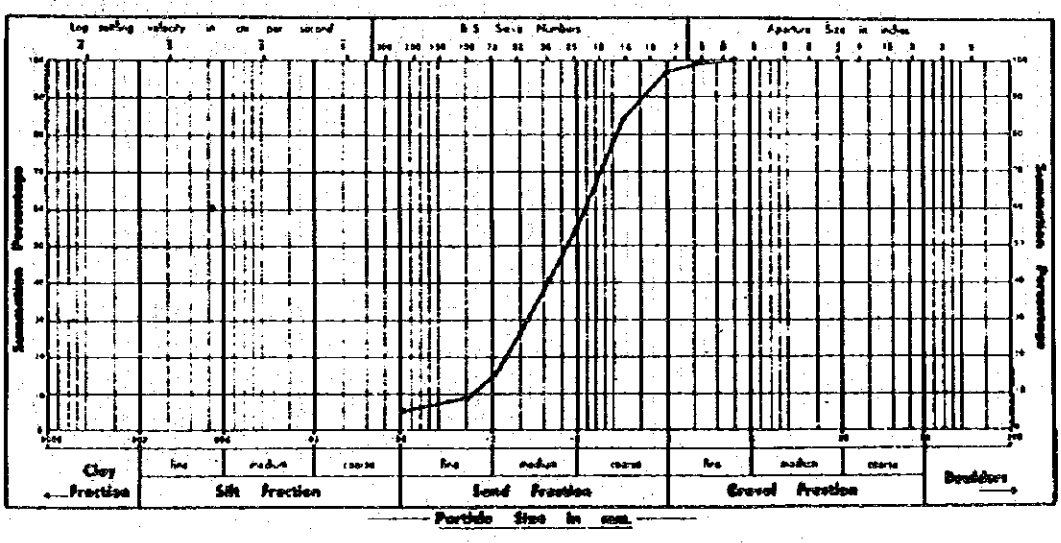
PARTICLE SIZE DISTRIBUTION

LOCATION. NEW OCEAN TERMINAL LAGOS. **DATE OF TEST.** DECEMBER 1978

SAMPLE No. 2 / 20 **DEPTH.** 20.50m



SAMPLE No. 2 / 23 **DEPTH.** 33.00m



SAMPLE No. **DEPTH.**

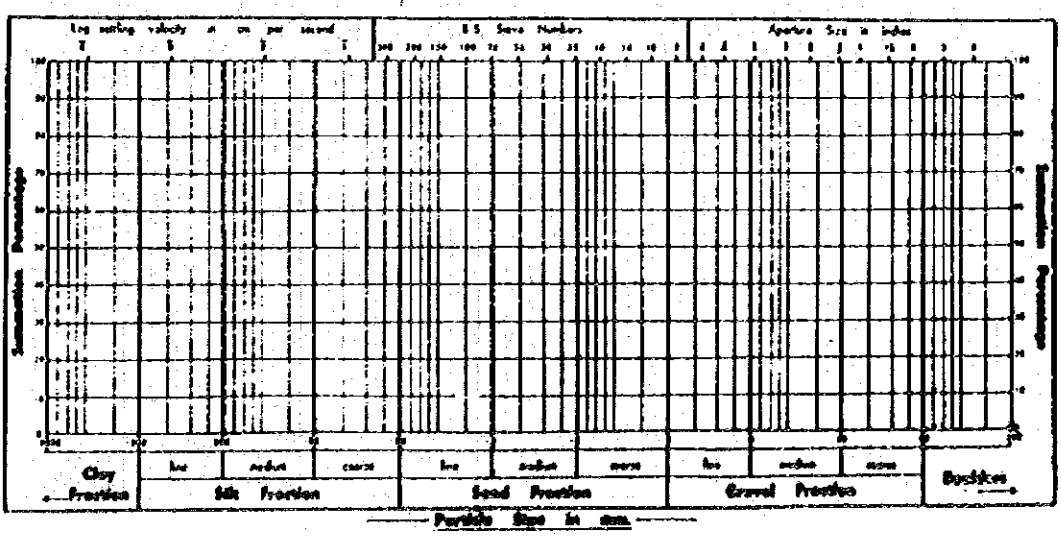
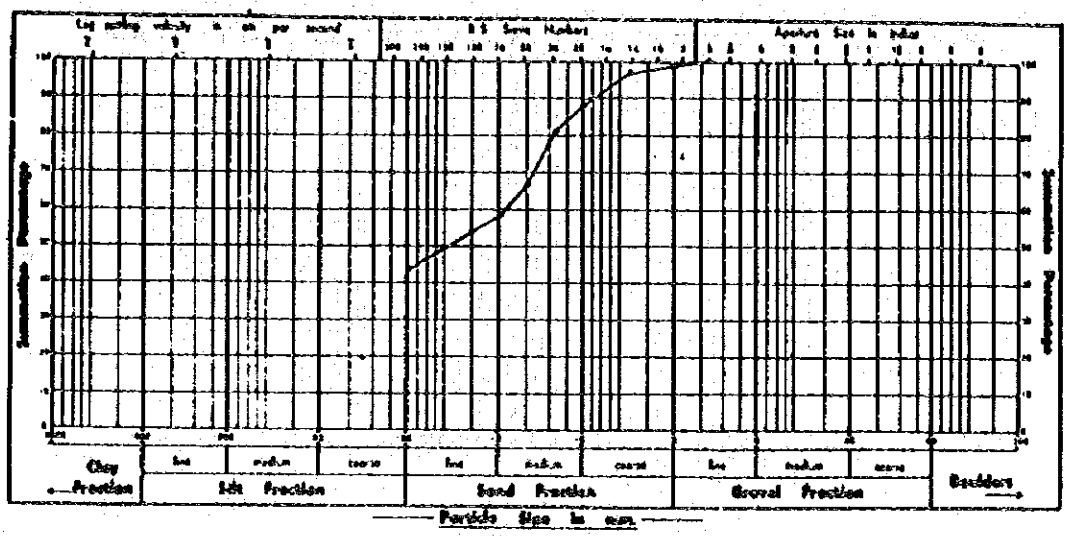


FIG.....A.6.....

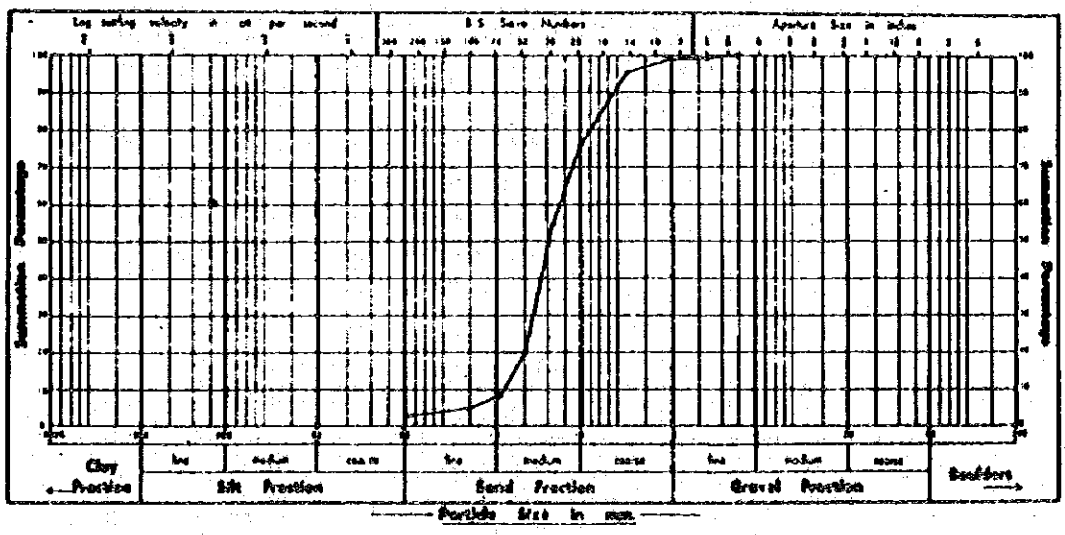
PARTICLE SIZE DISTRIBUTION

LOCATION. NEW OCEAN TERIBNAL LAGOS. **DATE OF TEST.** DECEMBER 1978.

SAMPLE No. 3/4 **DEPTH.** 4·50m



SAMPLE No. 3/10 **DEPTH.** 13·50m



SAMPLE No. 3/17 **DEPTH.** 24·00m

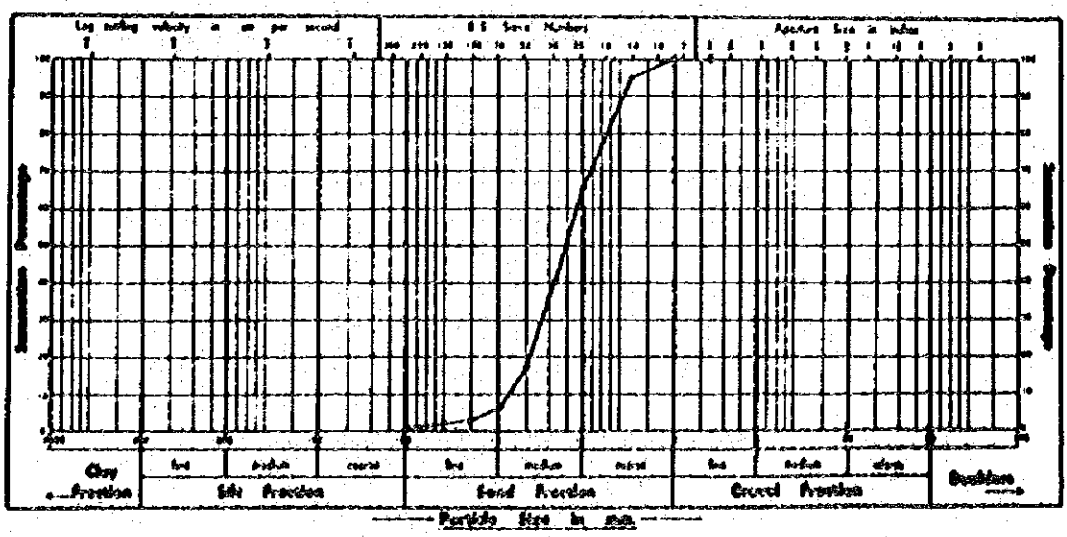
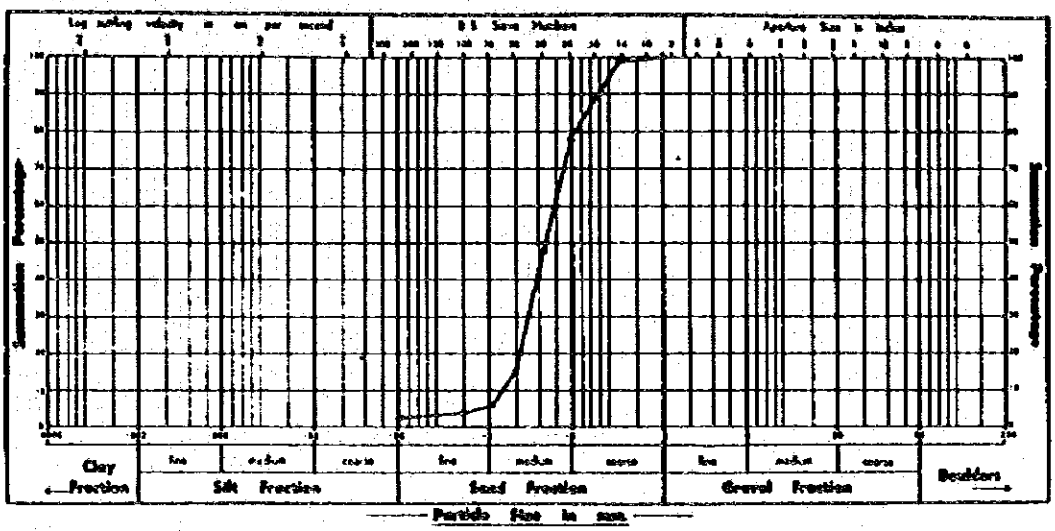


FIG.....A7.....

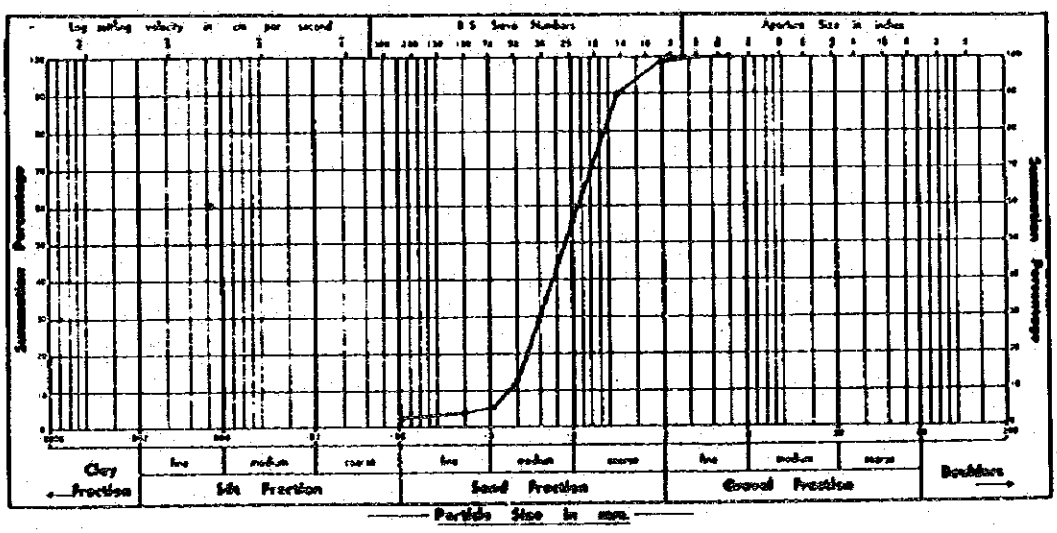
PARTICLE SIZE DISTRIBUTION

LOCATION. NEW OCEAN TERMINAL LAGOS **DATE OF TEST.** DECEMBER 1978

SAMPLE No. 3 / 25 **DEPTH.** 38.00m



SAMPLE No. 3 / 30 **DEPTH.** 43.50m



SAMPLE No. **DEPTH.**

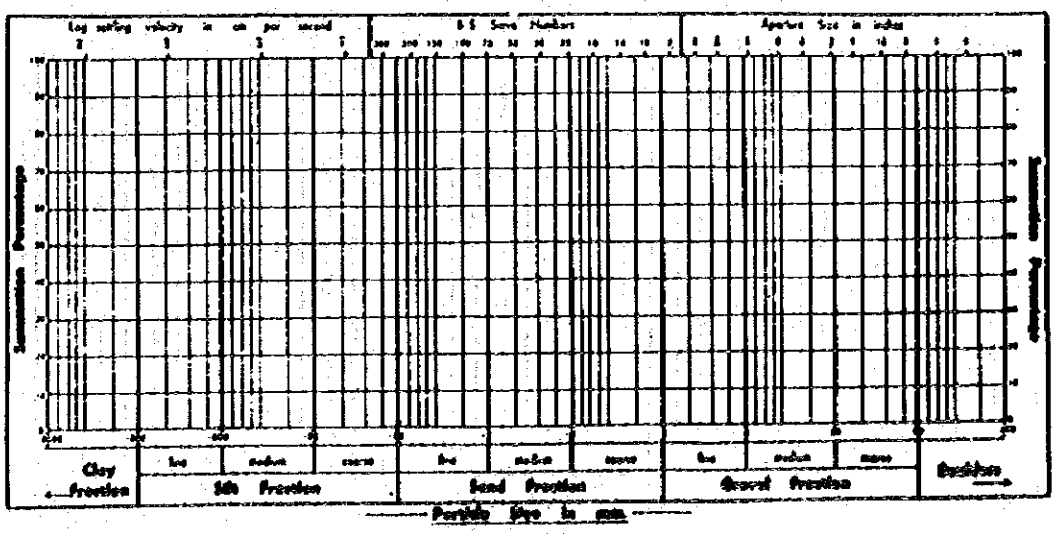
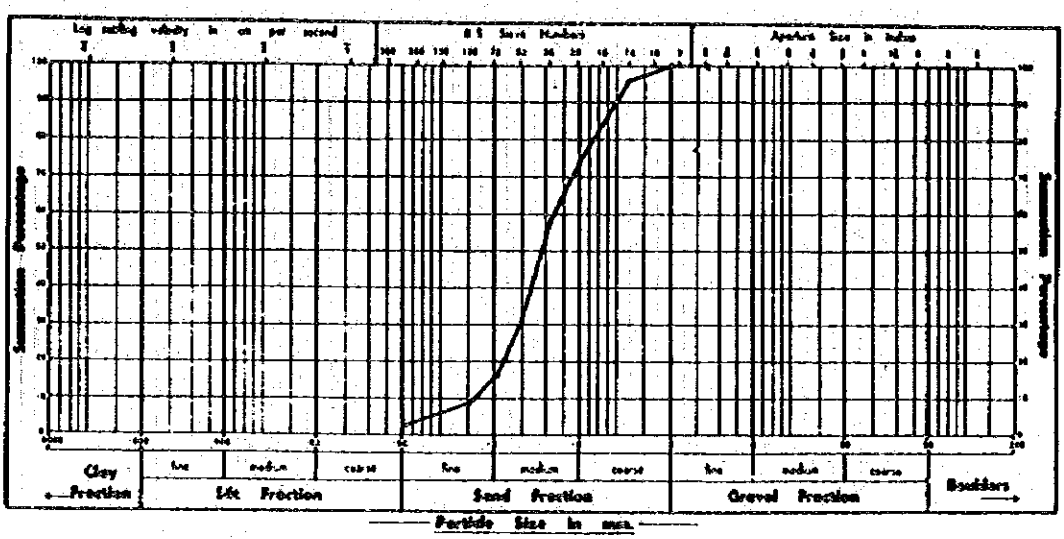


FIG.....A8.....

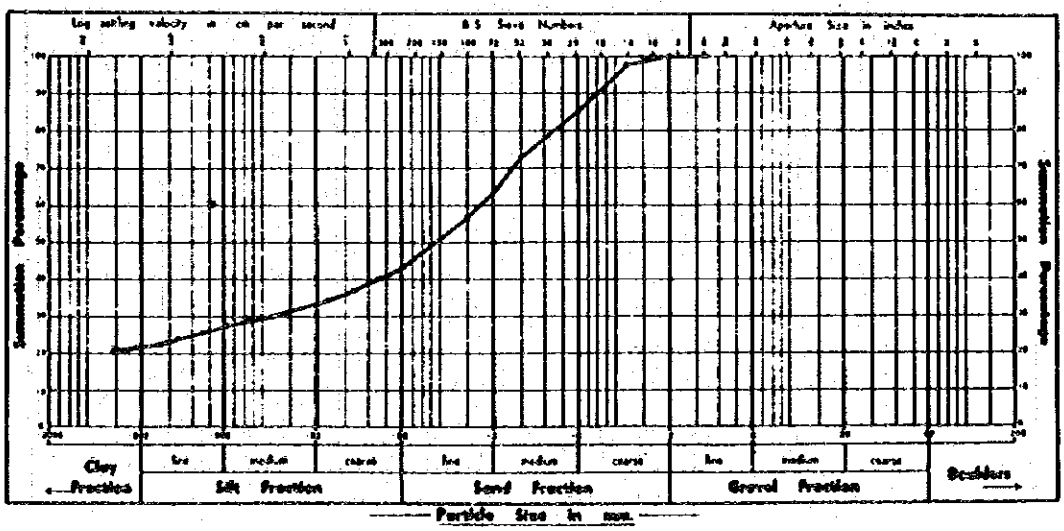
PARTICLE SIZE DISTRIBUTION

LOCATION. NEW OCEAN TERMINAL LAGOS **DATE OF TEST.** DECEMBER 1978

SAMPLE No. 4 / 5 **DEPTH.** 6 . 00m



SAMPLE No. 4 / 11 **DEPTH.** 13 . 50m



SAMPLE No. 4 / 18 **DEPTH.** 24 . 00

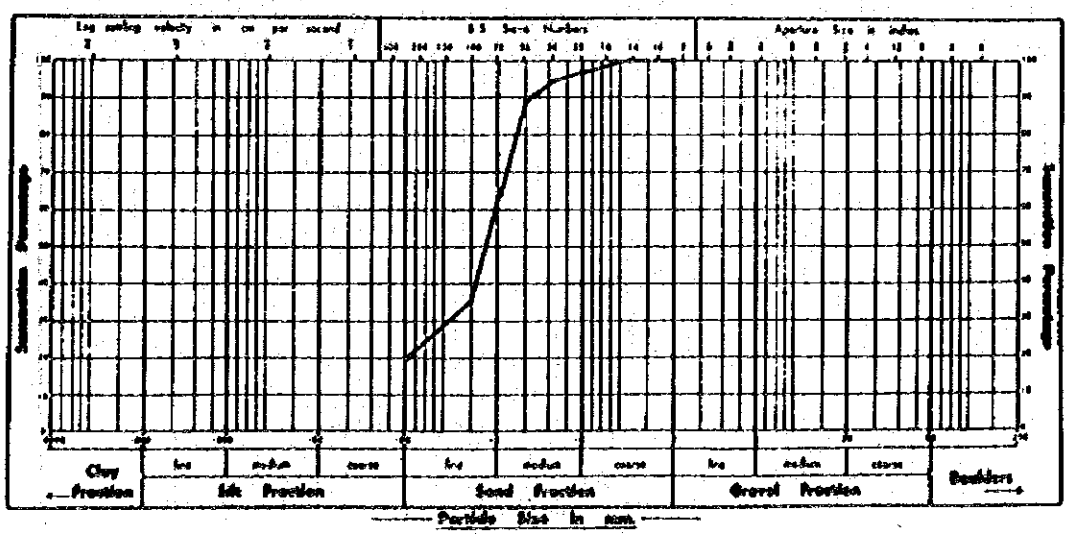
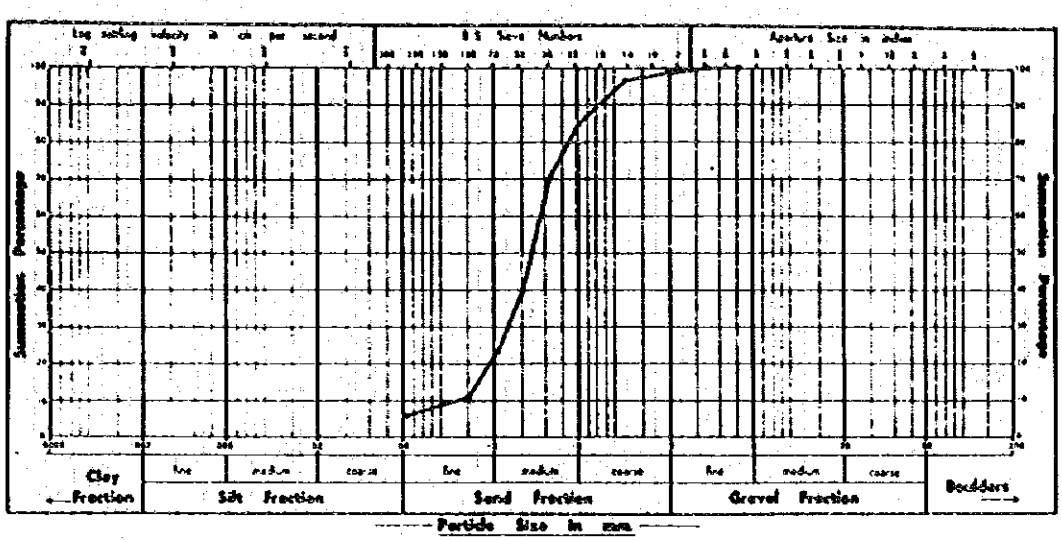


FIG.....A9.....

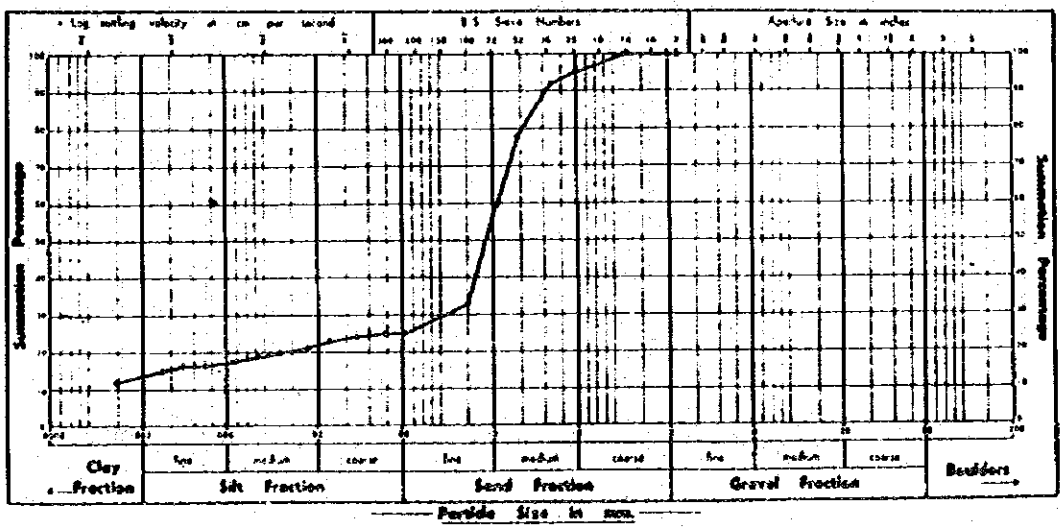
PARTICLE SIZE DISTRIBUTION

LOCATION. NEW OCEAN TERMINAL LAGOS **DATE OF TEST.** DECEMBER 1978

SAMPLE No. 4 / 25 **DEPTH.** 3.50m



SAMPLE No. 4 / 28 **DEPTH.** 39.00m



SAMPLE No. 4 / 33 **DEPTH.** 46.50m

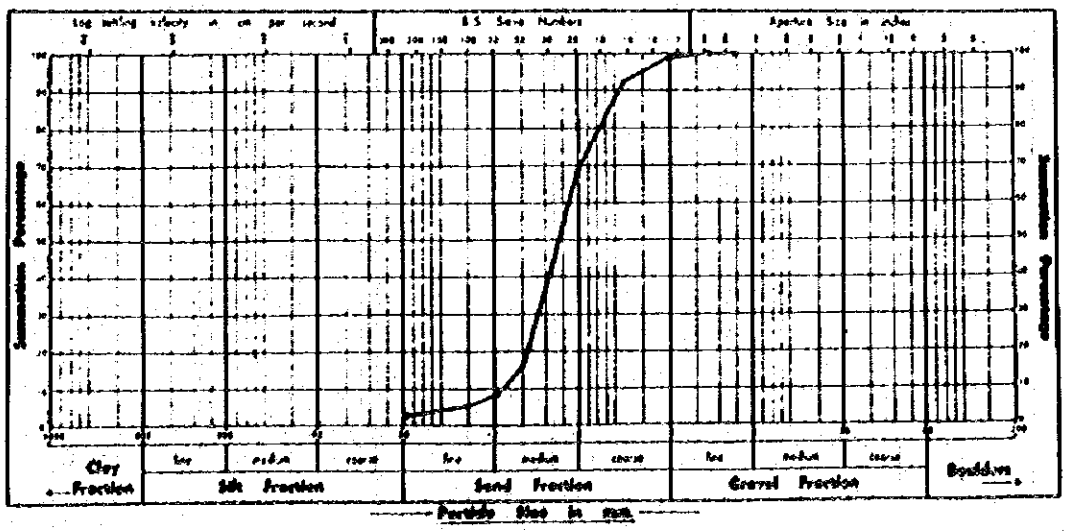
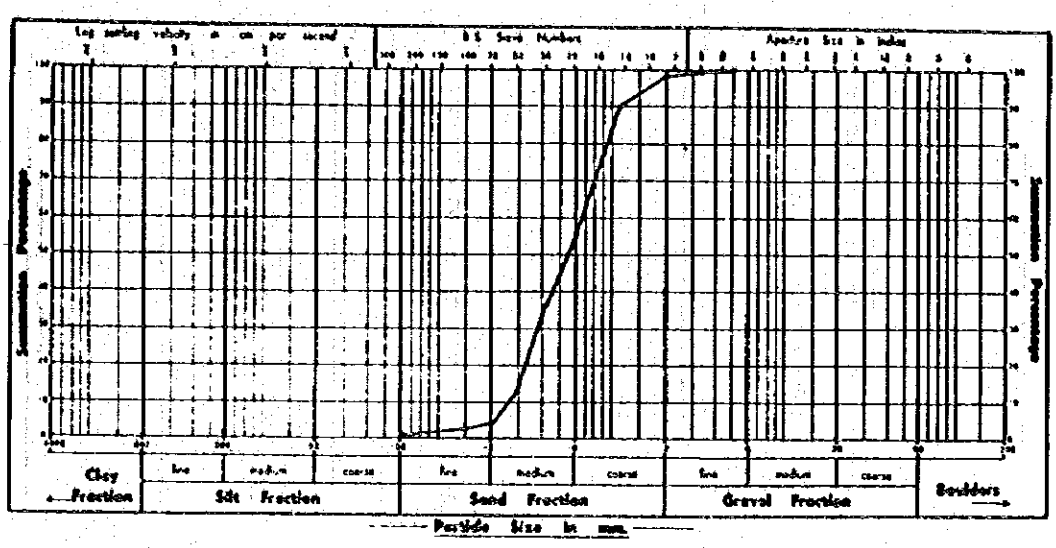


FIG.....A.10.....

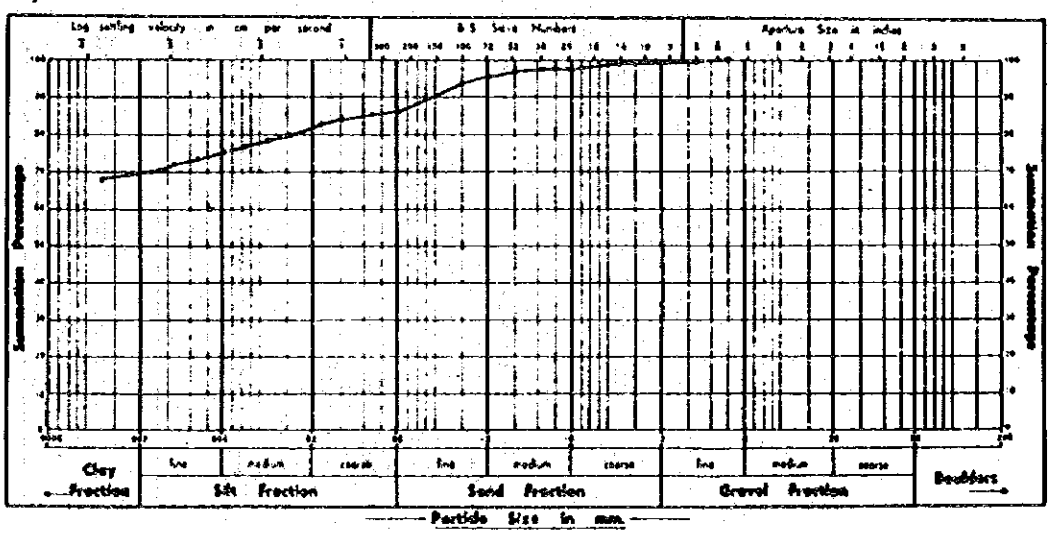
PARTICLE SIZE DISTRIBUTION

LOCATION. PROPOSED NEW OCEAN TERMINAL, LAGOS. **DATE OF TEST.** DECEMBER 1978

SAMPLE No. S/4 **DEPTH.** 4.50m



SAMPLE No. S/12 **DEPTH.** 16.50m



SAMPLE No. **DEPTH.**

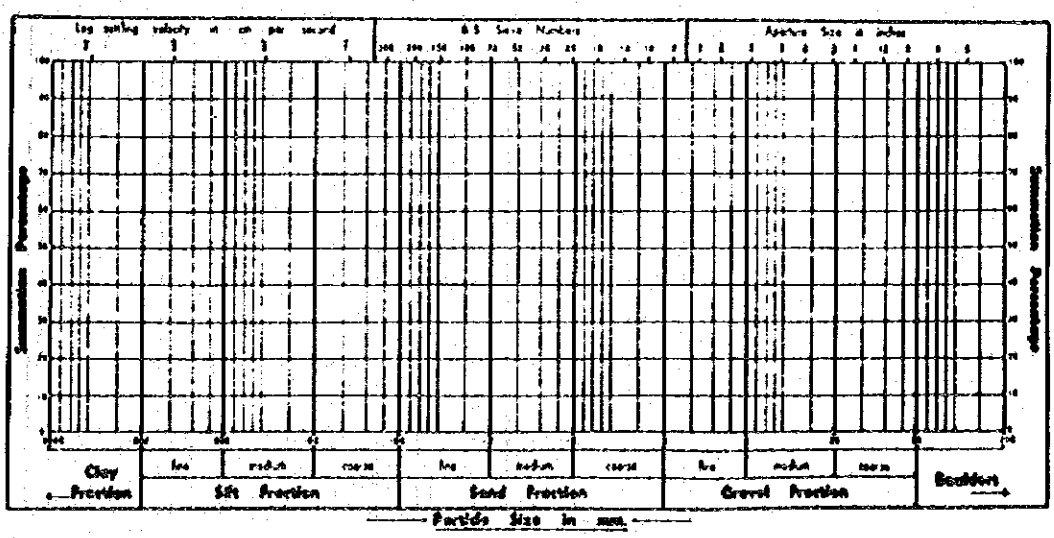
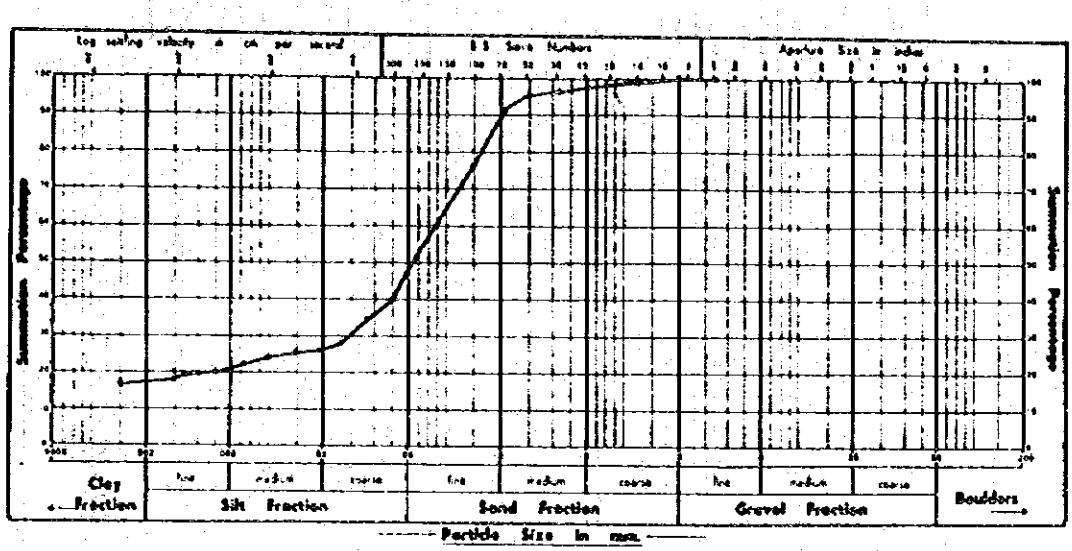


FIG.....A11.....

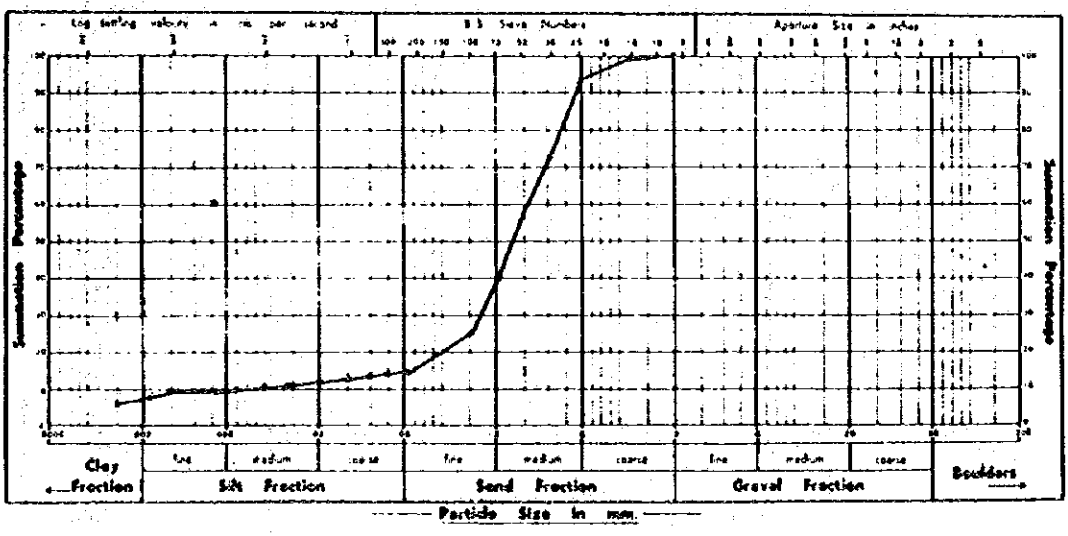
PARTICLE SIZE DISTRIBUTION

LOCATION. PROPOSED NEW OCEAN TERMINAL, LAGOS. **DATE OF TEST.** DECEMBER 1978

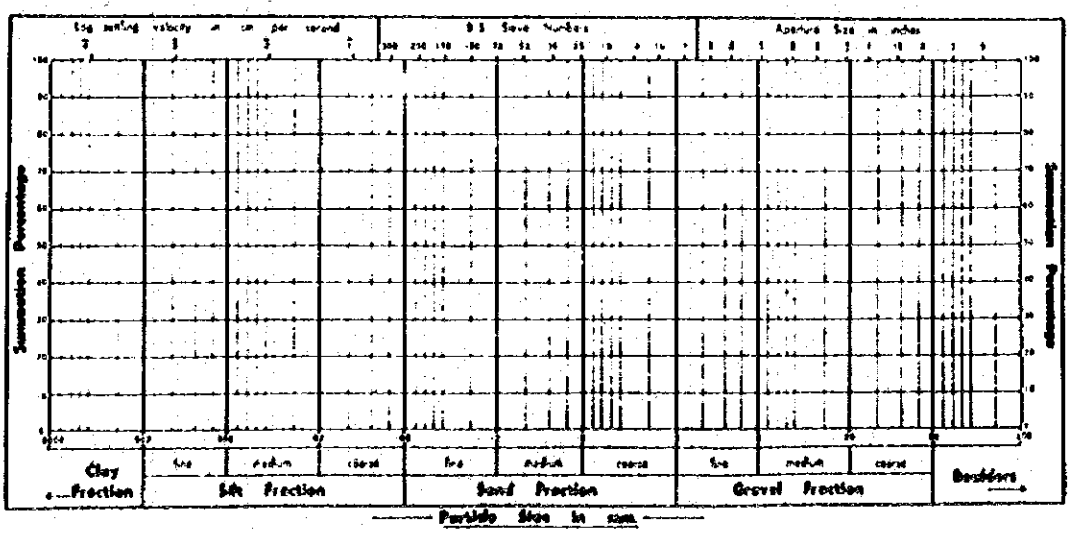
SAMPLE No. S/20 **DEPTH.** 28.50m



SAMPLE No. S/26 **DEPTH.** 36.00m



SAMPLE No. **DEPTH.**



JOB PROPOSED NEW OCEAN TERMINAL LAGOS.

QUICK UNDRAINED TRIAXIAL COMPRESSION TEST

Sample No. 2/20
Specimen Type UNDISTURBED

MOHR CIRCLES DIAGRAM

Undrained Cohesion (C_u) = 10 t/m²
Undrained Angle of Friction (ϕ_u) = 2 Degrees

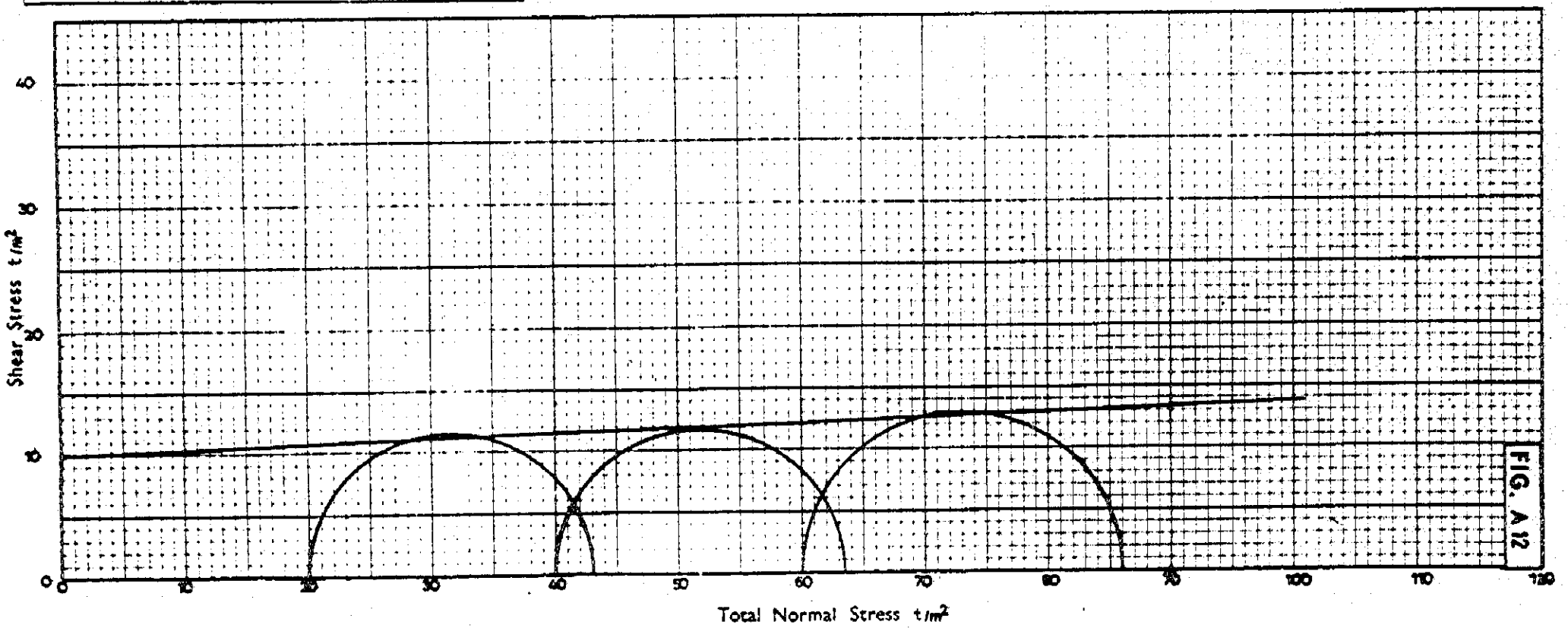


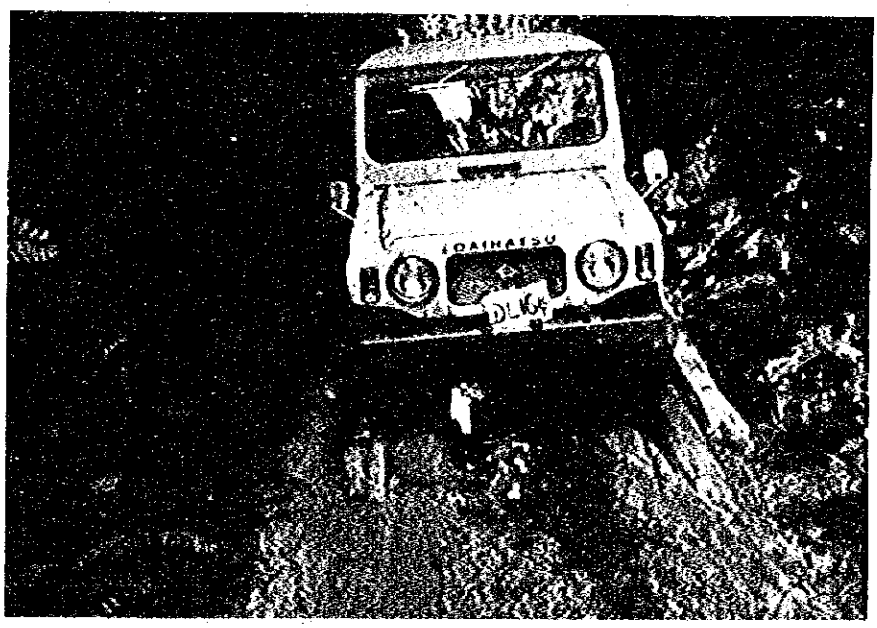
FIG. A12

2. Photos of Site Works

" Maroko" equipment base

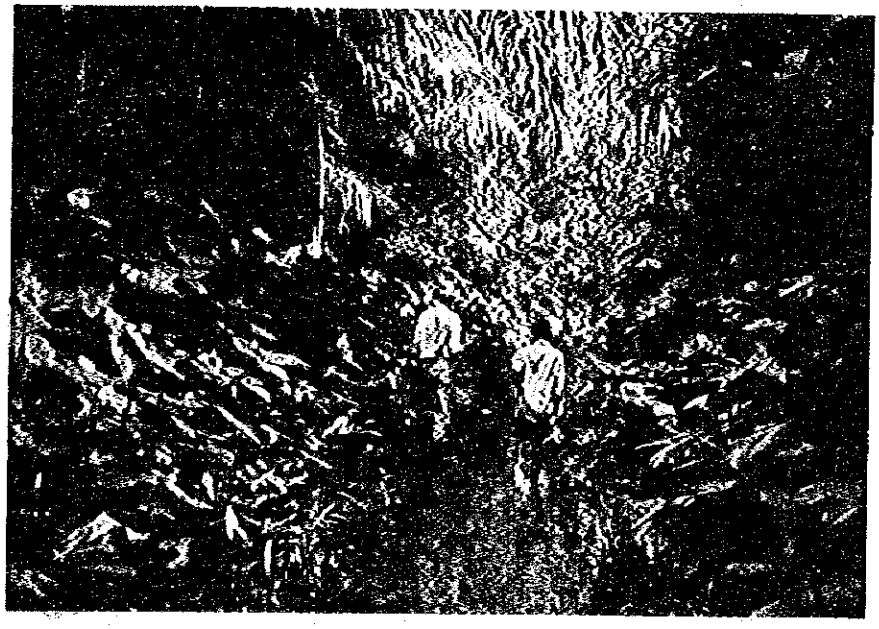
Mobilization of machines to the site

Access to the site (1/2)



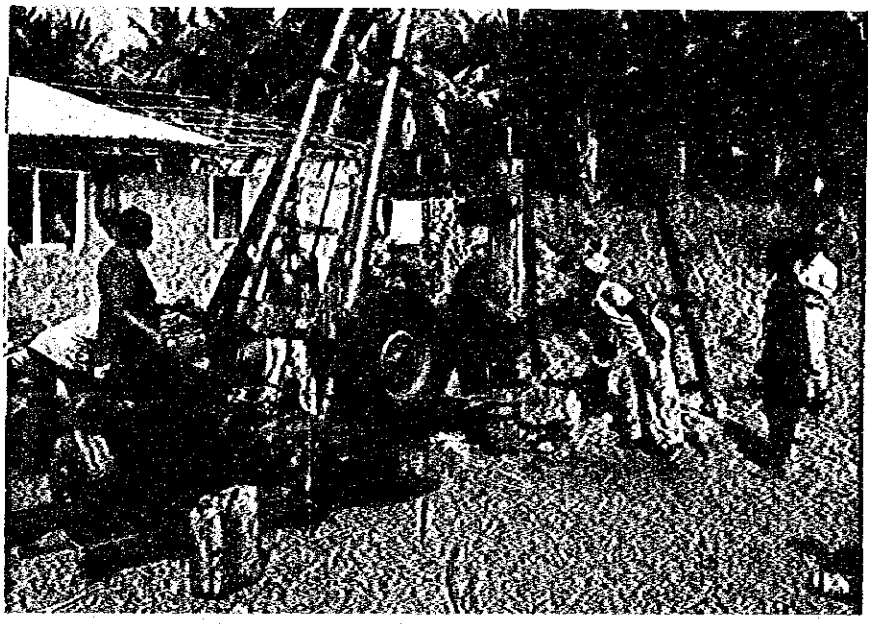
Access to the site (2/2)

Connection between boreholes No. 1 and No. 4 (1/2)

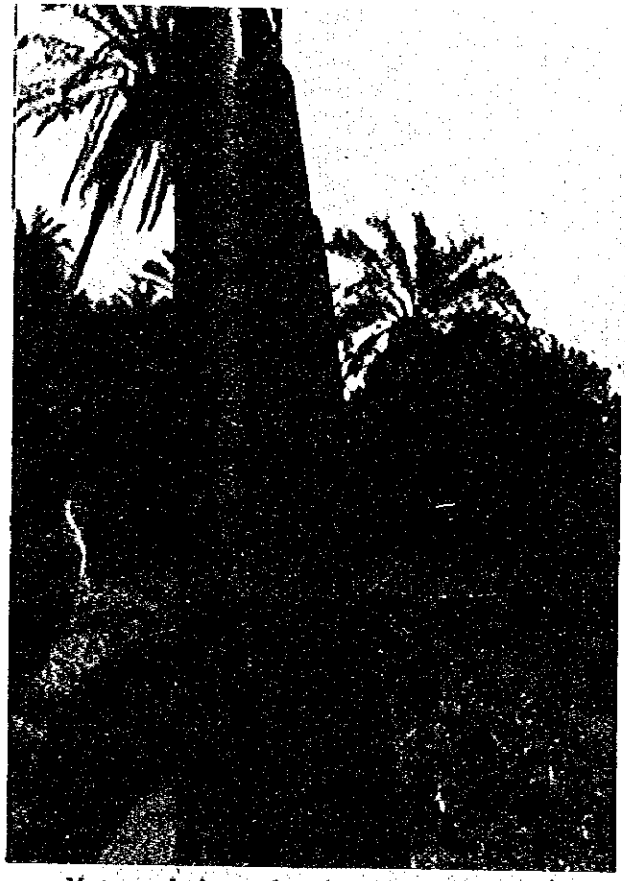


Connection between boreholes No. 1 and No. 4 (2/2)

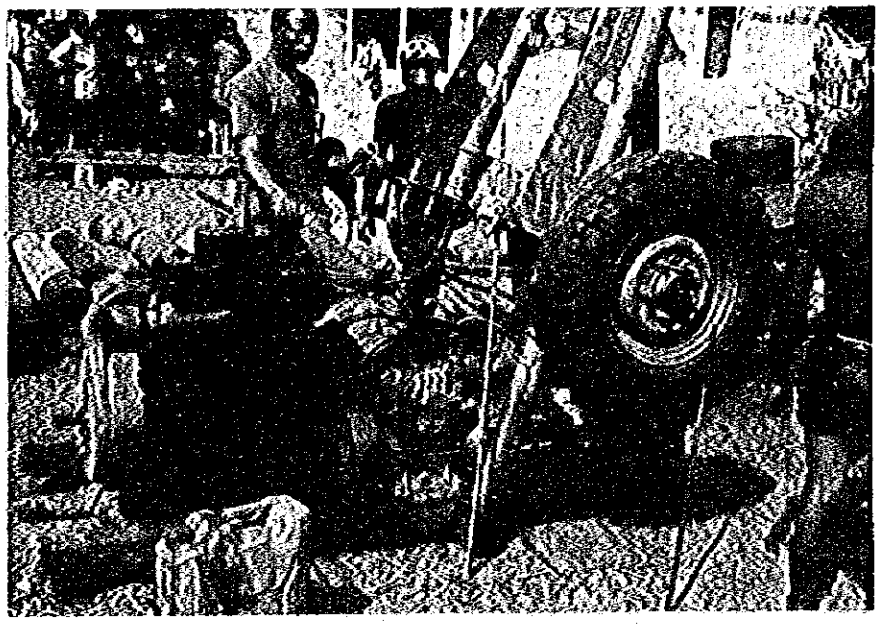
Motor-driven boring machine (1/4)



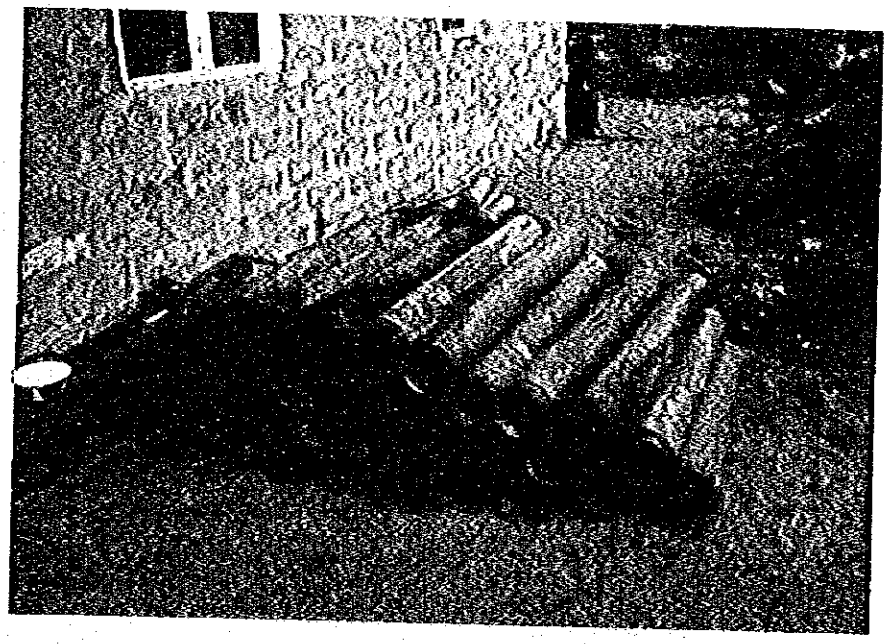
Motor-driven boring machine (2/4)



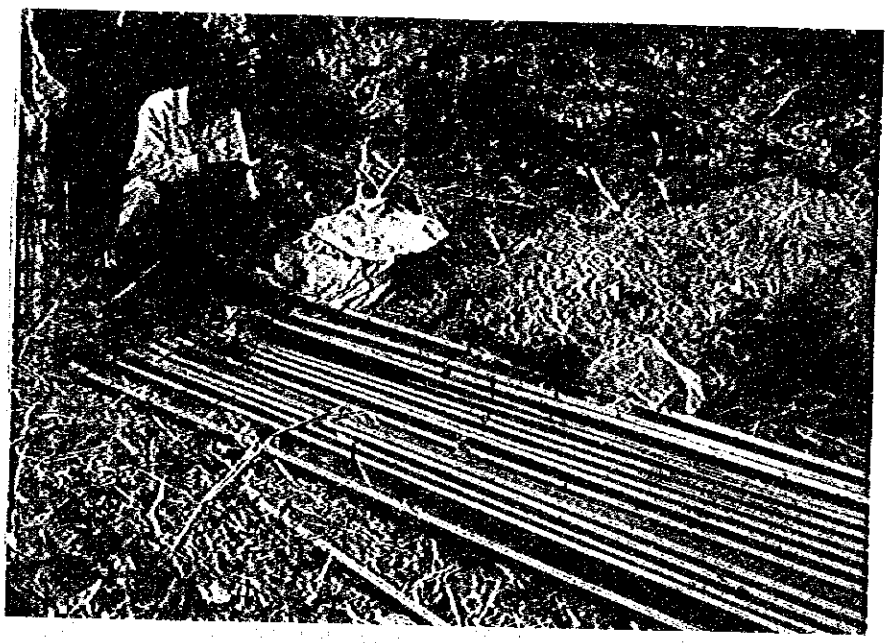
Motor-driven boring machine (3/4)



Motor-driven boring machine (4/4)

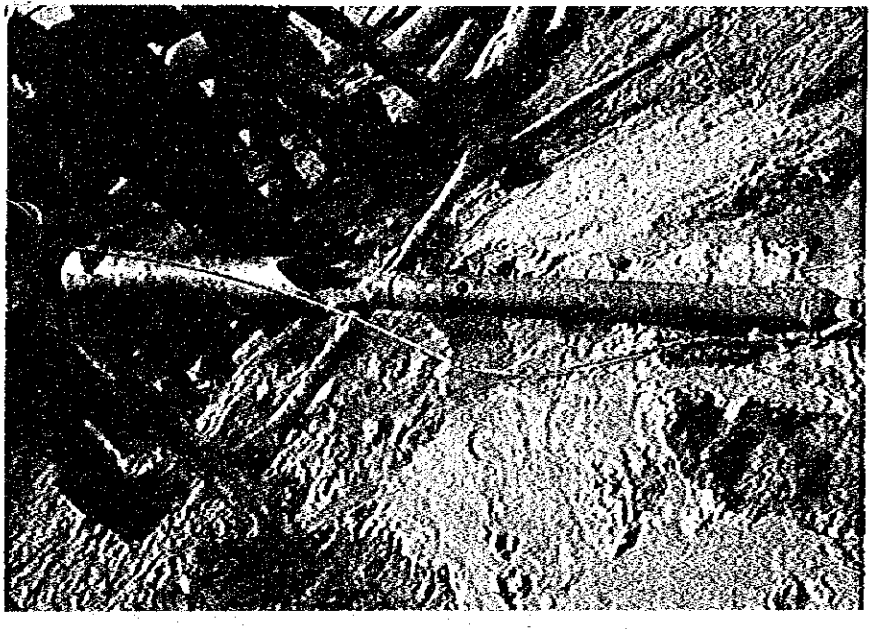


Casing pipes



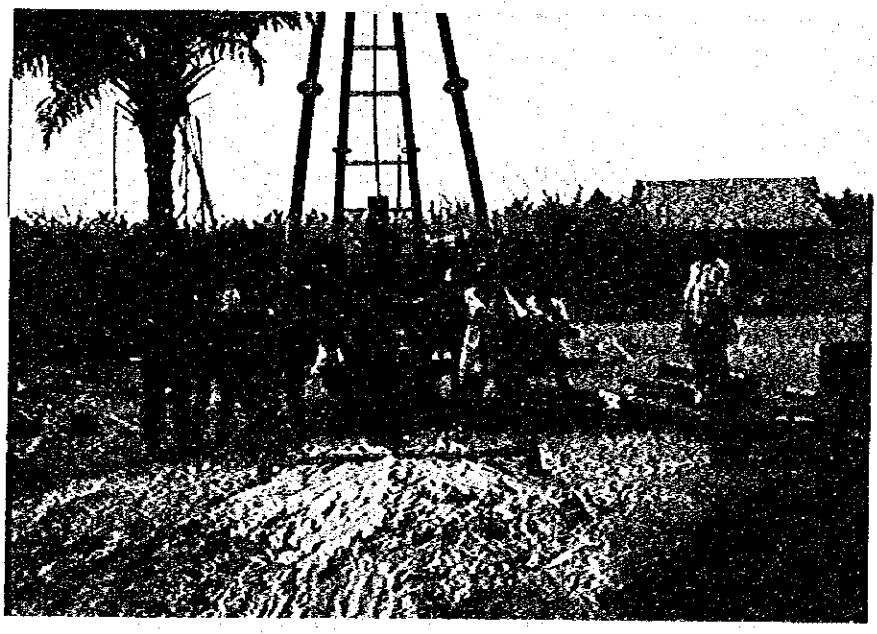
Steel rigs for Standard Penetration Test

Setting of boring head

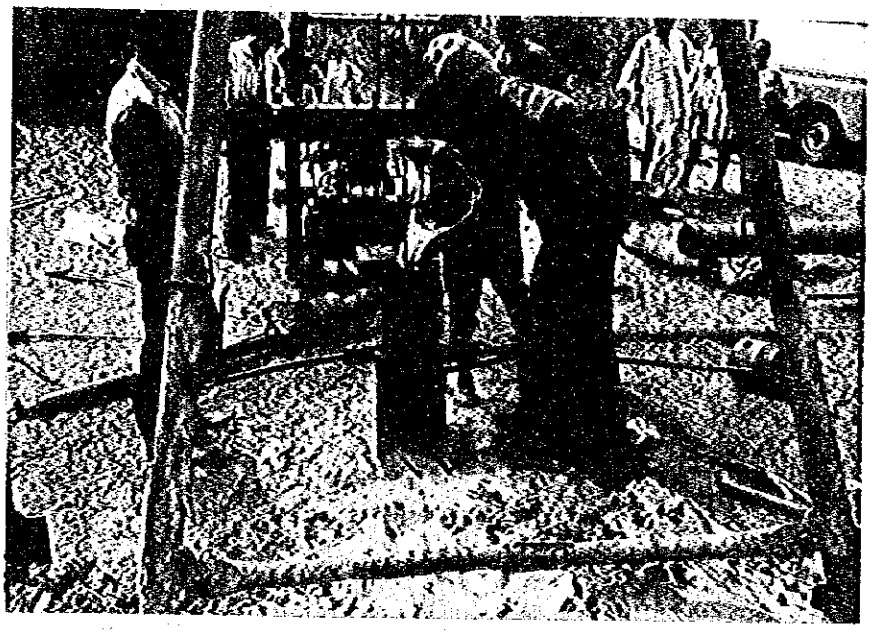


Disporsal of bored materials

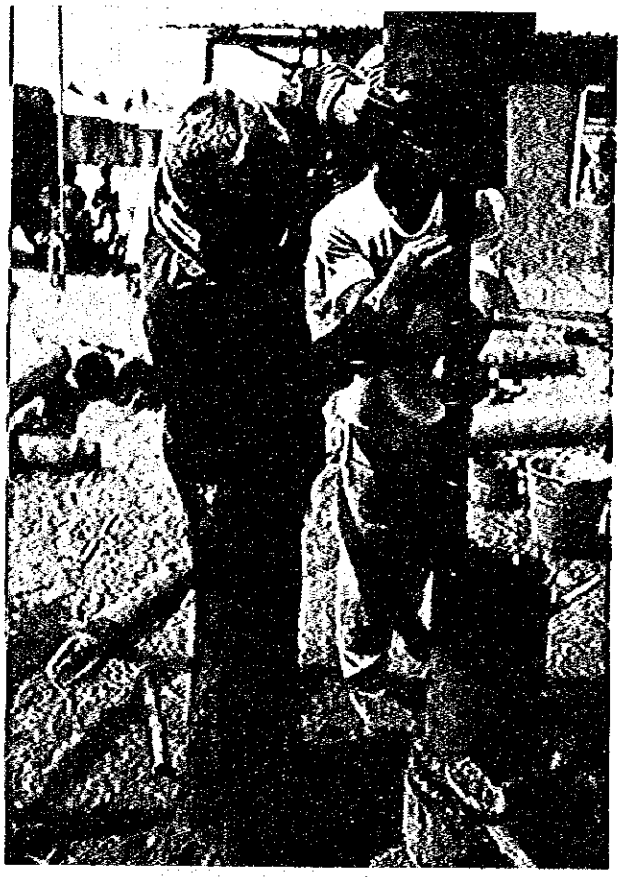
Setting of casing pipe.



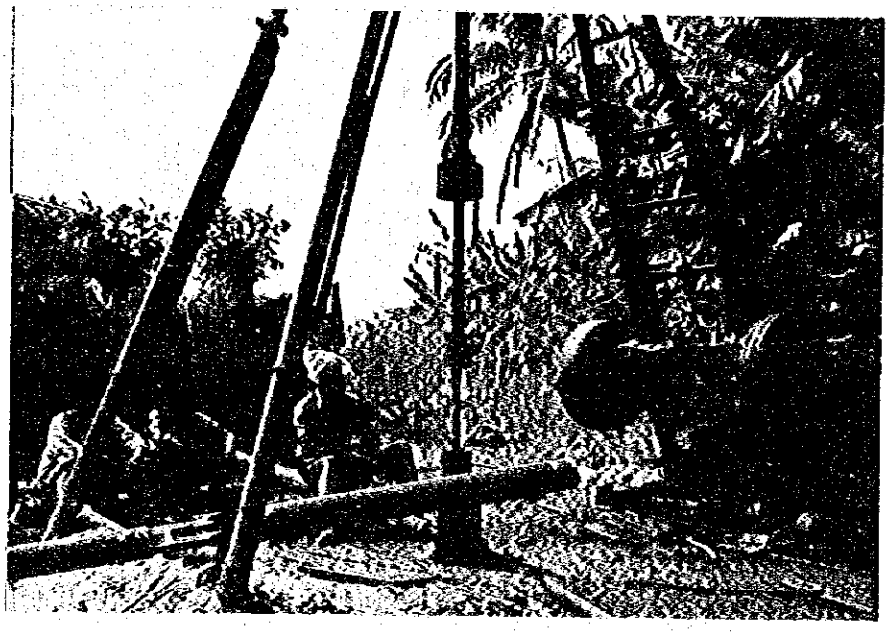
Installation of casing pipe



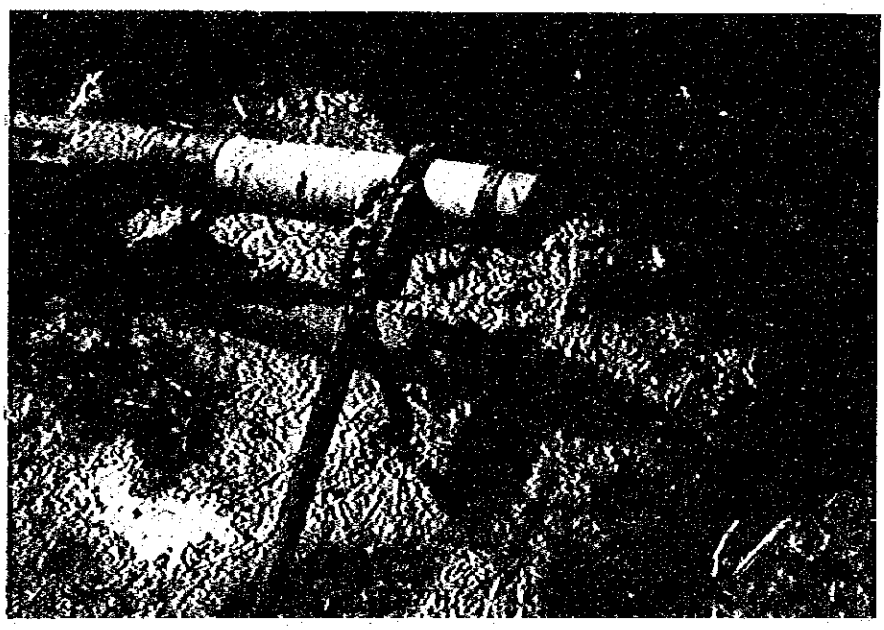
Poring of water into bonehole



Preparation for Standard Penetration Test



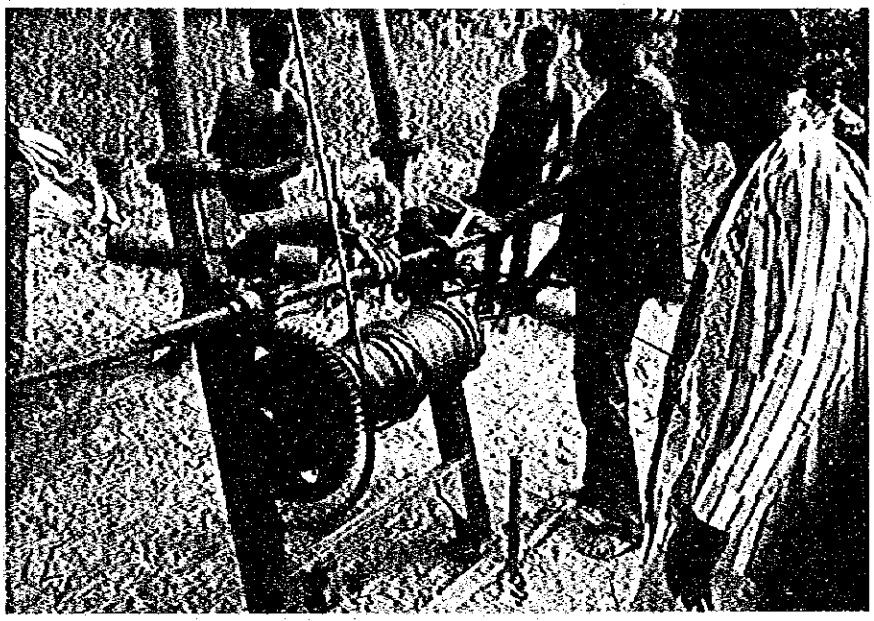
Measuring of Standard Penetration Test value (N value)



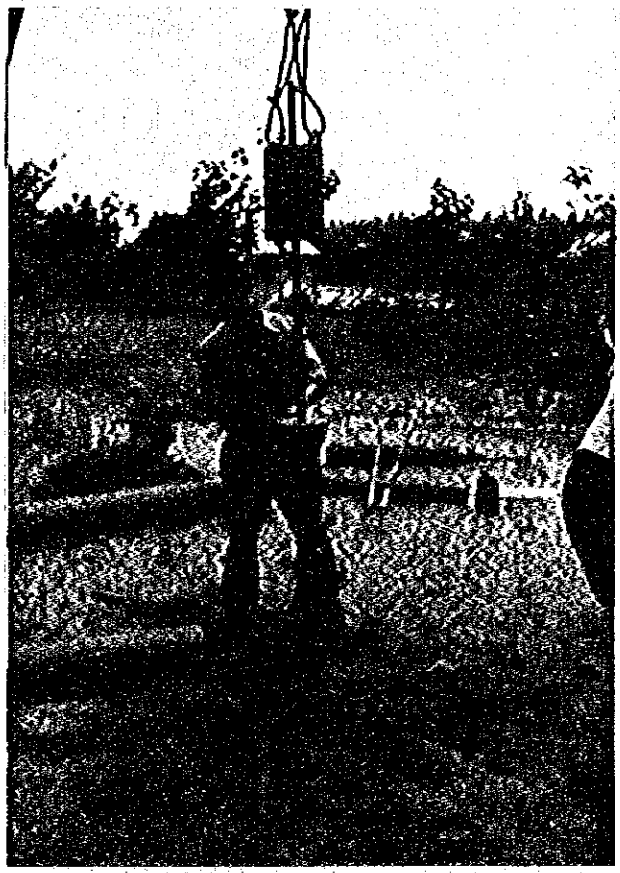
Thin-walled sampling

Collection of samples

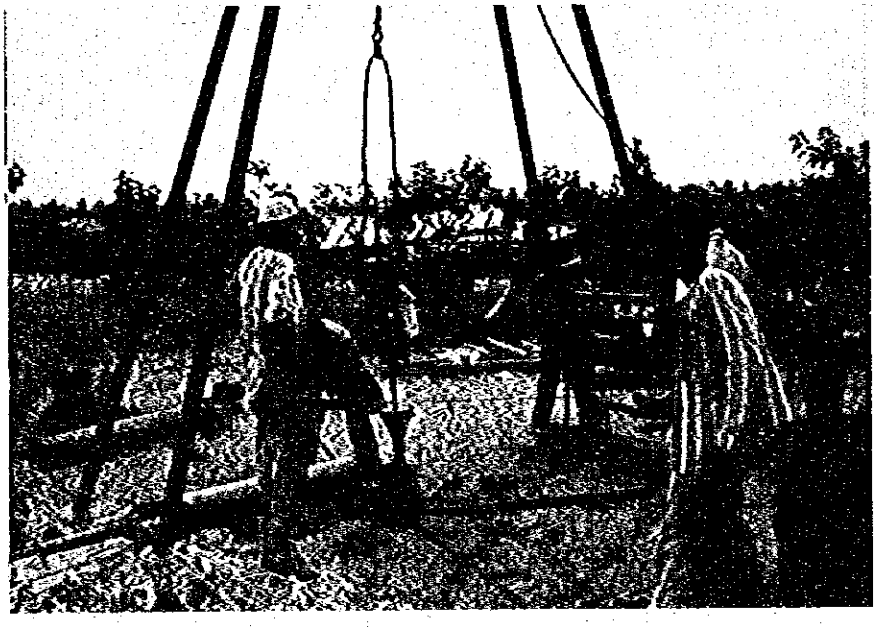
Manual- type boring machine (1/2)



Manual-type boring machine (2/2)



Preparation for Standard Penetration Test
by manual-type machine



Measuring of Standard Penetration Test value
(N value) by manual-type machine

Operation of manual-type boring machine