No. 7

INTERIM REPORT OF THE JICA

FEASIBILITY STUDY ON PRELIMINARY DESIGN FOR CONSTRUCTION

PART II

FEASIBILITY STUDY ON REVOLVING FUND SYSTEM IN NATIONAL CAPITAL REGION

(SUMMARY REPORT)

JANUARY 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO, JAPAN

FEDERATIVE REPUBLIC OF BRAZIL

FINAL REPORT
ON
THE ITAJAI RIVER BASIN
FLOOD CONTROL PROJECT

PART II

FEASIBILITY STUDY ON RIVER IMPROVEMENT PROJECT IN BLUMENAU-GASPAR STRETCH

SUPPORTING REPORT

JANUARY 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO, JAPAN

ABBREVIATION

JICA	:	Japan International Cooperation Agency
ACARESC	:	Associacao de Credito e Assistencia Rural de Santa Catarina
CASAN	:	Companhia Catarinense de Aguas e Saneamento
CEDEC	:	Coordenacao Estadual de Defesa Civil
CELESC	:	Centrais Eletricas de Santa Catarina
CEPA	:	Instituto de Planejamento e Economia Agricola de Santa Catarina
CIDASC	:	Companhia Integrada de Desenvolvimento Agricola de Santa Catarina
DNAEE	:	Departamento Nacional de Agua e Energia Eletrica
DNER	:	Departamento Nacional de Estradas de Rodagem
DER	:	Departamento de Estradas de Rodagem
DNOS	:	Departamento Nacional de Obras de Saneamento
EMATER	:	Empresa de Assistencia Tecnica e Extencao Rural
EMBRAPA	:	Empresa Brasileira de Pesquisa Agropecuaria
EMATER	:	Empresa de Assistencia Tecnica
EMPASC	:	Empresa de Pesquisa Agropecuaria ria de Santa Catarina
FATMA	:	Fundacao de Amparo a Tecnologia e Meio Ambiente
FGV	:	Fundacao Getulio Vargas
GAPLAN	:	Gabinete de Planejamento e Coordenacao Geral
IBDF	:	Instituto Brasileiro de Desenvolvimento Florestal
IBGE	:	Instituto Brasileiro de Geografia e Estatistica
IBRD	:	Internatinal Bank for Reconstruction and Development
ITAG	:	Instituto Tecnico de Administracao e Gerencia
MA	:	Ministerio da Agricultura
MDUMA	:	Ministerio do Desenvolvimento Urbano e Meio Ambiente
PORTOBRAS	:	Empresa Brasileira de Portos
SAMAE	:	Servico Autonomo Municipal de Agua e Esgoto
SUDEPE	:	Superintendencia do Desenvolvimento da Pesca

ABBREVIATION OF MEASUREMENT

Length

mm	:	millimeter
cm	:	centimeter
m	:	meter
km	:	kilometer

Area

cm^2	:	square centimeter
m^2	:	square meter
ha	:	hectare
km^2	:	square kilometer

Volume

cm^3	:	cubic centimeter
l	:	liter
m^3	:	cubic meter

Weight

g	:	gram
kg	:	kilogram
ton	:	metric ton

Time

s or sec	:	second
min	:	minute
h or hr	:	hour
d	:	day
y or yr	:	year

Others

%	:	percent
°C	:	degree centigrade
10^3	:	thousand
10^6	:	million
10^9	:	billion

Derived Measure

m^3/s	:	cubic meter per second
kwh	:	kilowatt hour

Money

Cz$	:	Cruzado
Cr$	:	Cruzeiro
US$	:	US dollar

ABBREVIATION OF ECONOMIC TECHNICAL TERMS

GDP	:	Gross Domestic Product
GRDP	:	Gross Regional Domestic Product
GVA	:	Gross Value Added
VA	:	Value Added
PV	:	Production Value

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ANNEX I. TOPOGRAPHIC SURVEY

I. TOPORAPHIC SURVEY

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1. INTRODUCTION

The topographic survey for the feasibility study on Blumenau-Gaspar river stretch includes;

(1) Topographic mapping on a scale of 1:10,000 and contour interval of 1 m in Blumenau-Gaspar stretch.

(2) River cross sectional survey on Blumenau-Gaspar stretch in the Itajai river and tributaries flowing into Blumenau city, and

(3) Topographic survey for major structure sites in Blumenau on a scale of 1:1,000 and contour interval of 1 m.

Above topographic surveys were executed from the end of February to the end of May 1987 by TERRA FOTO S/A, Brazilian contractor, which was selected by JICA, under supervision of Study Team. The survey results were carried back to Japan and inspected.

Survey area is illustrated in Fig.I.1.1.

2. SUPERVISION OF TOPOGRAPHIC SURVEY

2.1.1 Ground control survey

The ground control surveys were executed for;

(1) Control points of aerial triangulation for topographic mapping on a scale of 1:10,000,

(2) Basic points of river cross sectional survey, and

(3) Control points of topographic survey for major structure sites on a scale of 1:1,000.

The datum of ground control surveys are;

(1) Vertical : Imbituba, Santa Catarina,

(2) Horizontal : SAD-69 (South American data in 1969) , and

(3) Projection : Universal Transverse Mercator (UTM).

Ground control points surveyed for the feasibility study are listed in Table I.2.1.

The horizontal control survey was carried out by traverse survey method and twenty-nine control points were surveyed. Fourteen points among these control points were set by concrete peg for continuous field works.

The vertical control survey was executed by direct leveling from national bench marks and all results were shown on aerial photographs.

The accuracy of ground control surveys have satisfied our technical specification, especially high accuracy for closure rate of coordinate of traverse was obtained.

The following equipments were used for ground control survey;

(1) Distance measure : Geodimeter (Swedish)
Tellurometer (South African),

(2) Angle measure : Theodolite T-2 (Swiss), and

(3) Leveling : Auto-Level NA-2 (West German).

2.1.2 River cross sectional survey

The river cross sectional surveys were carried out on the Itajai main stream, the Garcia river, the Velha river and the Itoupava river. The interval of cross sections were about 300 m. The datum pegs were drived on the left bank and obtained the coordinates by traverse survey. The land part was surveyed to the extend of 100 m by leveling. The river part was carried out by bathymetric survey. The accuracy of river cross sectional surveys have also satisfied our technical specification.

The following equipments were used for river cross sectional survey;

(1) Distance measure : Geodimeter (Swedish),

(2)	Angle measure	:	Transit T-1A (Swiss),
(3)	Leveling	:	Auto-Level NA-2 (West German), and
(4)	Bathymetic	:	Echo sounder RAYTHEON (American).

2.1.3 Topographic survey for major structure sites

In order to prepare the maps with a scale of 1:1,000 on the river mouth of the Garcia, Velha and Itoupava rivers, the topographic surveys were carried out for acreage of 270,000 m^2 based on ground control points.

2.1.4 Aerial photography

The available aerial photographs for the project area were shot in 1978 by whole Santa Catarina aerial photography program. But, after nine years, many construction works such as building of houses, establishing of national road (BR-470), widening of the river were accomplished. To obtain updated topographic information, it was planned to take new aerial photographs and to revise the topographic appearances.

The application of new aerial photography was submitted to Federal Government of Brazil on March 1987, and permitted on the beginning of May 1987. New aerial photographs on a scale of 1:25,000 were shot under licence (No. 083/87) in the middle of May 1987.

2.2 Indoor Works

2.2.1 Aerial triangulation

The aerial triangulation which was based on ground control survey was executed for topographic mapping on a scale of 1:10,000. As the method of aerial triangulation, the independent analytical method, PAT-M-43, which was developed by Prof. Ackerman of Stuttgart University, West Germany, was applied. The accuracy of aerial triangulation has satisfied our technical specification. The maximum residual error at ground control point was less than one meter.

The following equipments were used for aerial triangulation;

(1)	Point transfer device	:	PUG -4 (Swiss)
(2)	Observation	:	Autograph A-10 (Swiss)
(3)	Recorder	:	EK-22 (Swiss)
(4)	Computer	:	VAX 11/730 (American)

2.2.2 Mapping

The mapping was carried out based on the aerial triangulation. The topographic features were plotted on the polyester bases and edited using Autograph A-10 (Swiss) and Stereo plotter A-8 (Swiss).

2.2.3 Correction of topographic appearance

The change of topographic appearance after the lapse of nine years of old aerial photograph was corrected by means of photogammetric method using new aerial photographs. Autograph A-10 (Swiss) was used to correction.

2.2.4 Drawing

The topographic map on a scale of 1:10,000, river cross sections and topographic map for major structure sites on a scale of 1:1,000 were drawn on polyester bases by black ink.

2.3 Derivered Material

2.3.1 Topographic mapping

(1)	Original map	(polyester base)	1 set
(2)	Copy	(polyester base)	1 set

2.3.2 River cross sectional survey

(1)	Cross section	(polyester base)	1 set

2.3.3 Topographic survey for major structures sites

(1)	Original map	(polyester base)	1 set
(2)	Copy	(polyester base)	1 set

Tables

Table I.2.1 COORDINATES OF GROUND CONTROL POINTS (1/2)

Code No.	Vertex	Coordinates East	Coordinates North	Elevation (m)
0001	VRT-RIB.DO SOUTO	680,304.182	7,035,196.754	536.160
0002	VRT-INDAIAL	676,948.405	7,023,786.060	276.380
0003	VRT-RIB.BRANCO	681,479.614	7,020,886.346	497.660
2000	VRT-PTA.AGUDA	692,609.353	7,022,489.124	167.466
2001	VRT-TORRE	694,455.510	7,019,174.700	243.003
2002	VRT-POCO GRANDE	709,325.838	7,019,950.476	25.714
2003	VRT-CACHORRO	695,858.214	7,036,630.945	827.841
3000	VRT-AUX. IGREJA	702,789.389	7,019,764.606	30.476
3001	VRT-AUX. PLACAS	699,574.879	7,022,817.551	21.781
3002	VRT-AUX.BR-470	699,737.110	7,024,099.942	15.298
3003	VRT-AUX.LOTEAMENTO	693,190.680	7,022,739.166	57.852
3004	VRT-AUX.CEMITERIO	691,311.882	7,016,099.848	59.384
3005	VRT-AUX.PONTE	689,260.747	7,021,191.238	15.670
3006	VRT-AUX. BANESPA	692,675.587	7,020,776.360	12.492
3007	VRT-AUX. PREFEITURA	691,750.417	7,021,733.278	15.050
3008	VRT-AUX. MAFISA	689,690.676	7,026,134.039	19.901
3009	VRT-AUX. AEROPORTO	689,914.897	7,031,616.184	18.000
8000	VG-1400B	0.000	0.000	10.463
8001	VG-001	0.000	0.000	8.746
8002	VG-002	0.000	0.000	8.263
8003	VG-003	0.000	0.000	8.570
8004	VG-004	0.000	0.000	7.033
8005	VG-005	0.000	0.000	61.555
8006	VG-006	0.000	0.000	12.493
8007	VG-007	0.000	0.000	10.604
8008	VG-008	0.000	0.000	11.704
8009	VG-009	0.000	0.000	6.859
8010	VG-010	0.000	0.000	8.799
8011	VG-011	0.000	0.000	7.005
8012	VG-012	0.000	0.000	9.554
8013	VG-013	0.000	0.000	9.654
8014	VG-014	0.000	0.000	16.147
8015	VG-2009A	0.000	0.000	7.634
8016	VG-2009B	0.000	0.000	7.246
8017	VG-2009C	0.000	0.000	10.009
8018	VG-2009E	0.000	0.000	12.257
8019	VG-2009F	0.000	0.000	7.260
8020	VG-2009G	0.000	0.000	16.163
8021	VG-2009H	0.000	0.000	13.618
8022	VG-2009V	0.000	0.000	12.283

Table I.2.1 COORDINATES OF GROUND CONTROL POINTS (2/2)

Code No.	Vertex	Coordinates East	Coordinates North	Elevation (m)
9000	HV-01	688,023.937	7,032,749.218	40.000
9001	HV-02	692,652.855	7,031,300.994	42.560
9002	HV-03	686,393.813	7,026,673.463	94.000
9003	HV-04	693,197.733	7,028,451.208	24.640
9004	HV-05	696,682.644	7,028,844.837	79.216
9005	HV-06	702,693.241	7,028,608.853	286.060
9006	HV-07	686,456.783	7,020,993.424	58.690
9007	HV-08	702,349.071	7,025,294.475	117.390
9010	HV-11	689,527.546	7,016,901.266	171.010
9011	HV-12	693,384.435	7,015,808.415	40.360
9012	HV-13	698,705.447	7,016,224.053	18.266
9013	HV-14	703,217.778	7,015,854.329	19.300
9014	HV-15	709,261.055	7,019,879.571	10.740
9015	HV-16	709,821.464	7,015,713.537	26.398
9016	HV-17	692,682.259	7,020,724.988	12.400
9017	HV-18	691,268.228	7,016,091.307	59.970
9018	HV-19	689,146.991	7,021,210.142	15.220
9019	HV-20	689,674.485	7,026,141.580	24.410
9020	HV-21	702,809.318	7,019,766.312	80.680

Figures

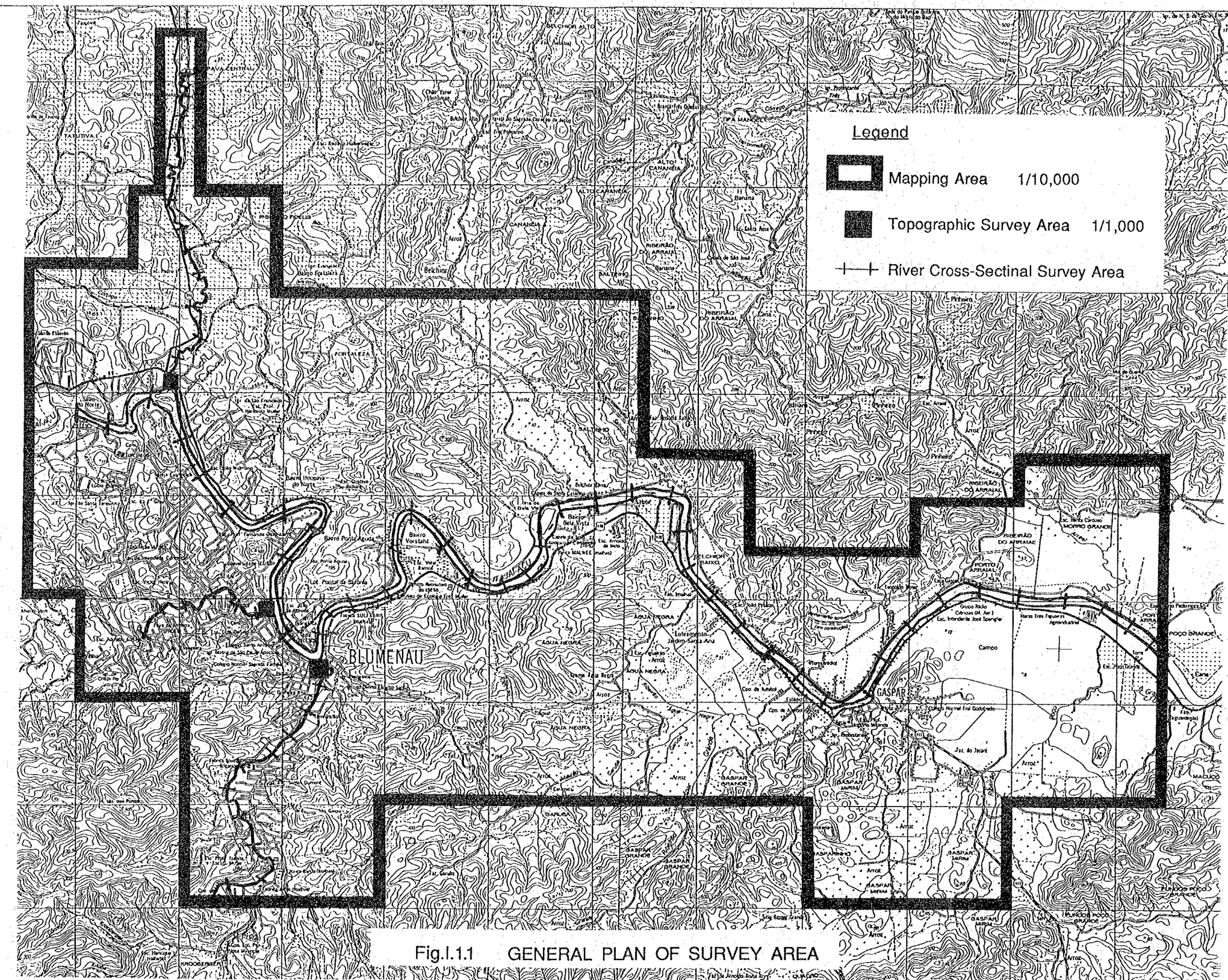

Fig.I.1.1 GENERAL PLAN OF SURVEY AREA

ANNEX II. GEOTECHNICAL SURVEY

II. GEOTECHNICAL SURVEY

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1. INTRODUCTION

Geotechnical investigation was carried out, prior to the commencement of the feasibility Study, to obtain geotechnical features in the project area needed for the same study, in the period from March 1987 to July 1987.

Major objectives of the investigation were to grasp general geologic conditions along the Itajai main river and its tributaries, foundation conditions of proposed structure sites and engineering properties of levee materials.

The investigation work was executed by a local contractor, Tecnosolo S.A., selected on a basis of selective competitive tender, under supervision by an expert of JICA STUDY TEAM.

2. GEOLOGY

2.1 Regional Geology

The regional geology of Santa Catarina state consists of the four major groups of the Precambrian, the Palaeozoic, the Mesozoic and the Cenozoic rocks as shown in Fig.II.2.1.

The Precambrian rocks are distributed along the coast of the Atlantic with about 60 km width. These rocks are divided as follows:

- Archaeozoic complexes of the gneisses and the migmatites consisting of polyphase-banded rocks and blastoporphyritic rocks,
- superior/Archean to inferior/Proterozoic complexes of the Brusque metamorphic complex of mica-schists, metamorphic calcareous rocks, marbles, metamorphic sandstones and metamorphic volcanic rocks, the suite of gneissic granites and the valsungana intrusive suite of granites, and
- media/superior Proterozoic complexes of the Itajai group of ortho-conglomerates, litho-feldspathic sandstone, basic volcanic rocks, siltstones, rhyolites and silt-sandstones, and the Subida intrusive suite of granites.

The Palaeozoic rocks are distributed widely among the Geral mountains and the Mar mountains and sporadically in the other areas. These rocks are sediment accumulated in the Parana tectonic basin. These rocks are sedimentary rocks of glacial, fluvial, coastal or marine deposit origins. The constitutent grain sizes vary from clay to sand and some conglomerate is intercalated locally.

The Mesozoic rocks consist of the aeolian sandstones, the basaltic lava flow or dikes and the alcali rocks. The basaltic lava flows and dikes are distributed widely in the most area westside of the Geral mountains. The aeolian sandstones are distributed along the eastern periphery of the basaltic rocks. The alkali rocks are sporadically distributed concentrically in the area situated between about 28° to 28°30' of the south latitude and 50°10' to 50°20' of the west longitude.

The Cenozoic sediment consists of the semiconsolidated Tertiary/diluvial conglomerate including coarse detritus, the Tertiary/diluvial sediments of terrace deposit and marine deposits, and the alluvial deposits.

The large scale of conglomerate is found only in the limited are of the upstream reach of the Tres Barras river situated at the north-east edge of the State.

The Tertiary/diluvial deposits are developed widely in the coastal area northern from 27° of the south latitude and stretched along the coast with about 2 to 5 km width towards the south from 28° of the south latitude. This sediment is distributed sporadically in the area along the coast between 27° and 28° of the south latitude.

The alluvial deposits are developed widely in the plain area southern from 28°40' of the south latitude and with various scales in the other areas along the rivers.

2.2 Geology in Project Area

2.2.1 General

The Itajai river basin is divided by the Moema mountains (Serra do Moema), the Jaraqua mountains and their feeders at the northern watershed, by the Geral mountains (Sera Geral) and its feeders at the western watershed, and the Tijucas mountains (Serra do Tijucas) and its feeders at the south-eastern watershed as shown in Fig.II.2.2. The main stream crosses the Mar mountains (Serra do Mar) between Lontras and Apiuna, the Pomerode mountains (Serra Pomerode) around Indaial city and the Selke mountains (Serra das Selke) around Blumenau city.

The Itajai river has many tributaries. The main tributaries are, in the order from downstreams, the Itajai Mirim river, the Luis Alves river, the Benedito river, the Itajai do Norte river, the Itajai do Sul and the Itajai do Oeste river.

The geology of Itajai river basin which is illustrated in Fig.II.2.2 consists mainly of the following three groups:

- alluvial deposits of the Cenozoic age distributed widely in the downstream reach of the main stream, the Itajai Mirim river and the Luis Alves river with a maximum depth more than 30 m and narrowly along the upper main stream and the other tributaries with a maximum depth of about 10 m,
- the granulites, migmatites, metamorphic volcanic and sedimentary rock and the intrusive or plutonic rocks of the Precambrian age distributed in the easternside of the Mar mountains, and
- the sedimentary rocks of the Palaeozoic age distributed between the Mar and Geral mountains.

2.2.2 In and around project area

In the right-side area downstream from the easternside of the Mar mountains including the Benedito river and the Luis Alves river basins, the gneisses of Archaeozoic granulite is widely distributed. These rocks are also distributed locally in the right bank around Indaial city.

The anky-metamorphic sandstones of the medium and superior Proterozoic age accompanied with the conglomerate of the same age are distributed in the limited portions of this area along the main stream downstream from Blumenau and around the downstream reach of the Luis Alves river. In this limited area, the anky-metamorphic phyllite and shale from the superior Proterozoic to the Cambrian is distributed locally. The many faults are found in this limited area. Each rock in the gently sloped portion of this area is generally covered with weathered zone of more than 10 m.

In the left side area of the main stream downstream from the eastern of the Mar mountains including the Itajai Mirim river basin, the various Precambrian rocks are distributed complicately.

The micaschist aged from the superior Archaeozoic to the inferior Proterozoic is distributed locally in the Tijucas mountains near the river and in the Itajai mountains near Ilhota and Gaspar, and distributed widely in the same mountains at both sides of the middle-

upper reaches of the Itajai Mirim river. this rock layer is occasionally intercalated with meta-calcareous rocks, dolomite and marbles.

The Archaeozoic gneisses are stretched narrowly south-westward from Gaspar to near the Mar mountains and distributed locally around the midpoint between Gaspar and Ilhota and around the midpoint between Ilhota and Itajai.

The anky-metamorphic sandstone is also stretched narrowly along the northern of the gneisses accompanied with the metamorphic conglomerates.

The anky-metamorphic shale and phyllite from the superior Proterozoic to the Cambrian age is distributed widely south-westward from Blumenau to the eastside of the Mar mountains crossing the main stream between the northern Apiuna and Subida.

The anky-metamorphic sandstone of the medium-superior Proterozoic age is distributed locally along the northwestside of the above mentioned shale crossing the main stream between Ascurra and the northern Apiuna.

The granites from the Archaeozoic to the Proterozoic age are distributed widely in the Itajai mountains and the Tijucas mountains around Brusque. The granites of the superior Proterozoic are distributed locally in the Itajai and Tijucas mountains near the above mentioned granite masses and around Subida at the right bank of the main stream.

The metavolcanic-sedimentary sequence is distributed sporadically in the Itajai and Tijucas mountains with a shape of narrow strip from north-east to south-west. In the area along the Itajai Mirim river near to the Mar mountains, however, this sequence is distributed with a width of about 5 km and a length of about 20 km from the same direction as mentioned above. In the other areas than the ones mentioned above, this sequence is distributed with a shape of narrow strip along the southern of the anky-metamorphic sandstone from Gaspar afore-mentioned. Each rock in the gently sloped portion of this area is generally covered with a thick weathered rock layer of more than 10 m depth.

In the area downstream from the eastside of the Mar mountains, the alluvial deposits are developed along the mainstream and the tributaries. The distribution area of these deposits is widened along the main stream downstream from the vicinity of Gaspar and around the confluences with the Luis Alves river and the Itajai Mirim river. According to the current geotechnical investigation result, the depth of the alluvial deposits that mainly consist of clayey soil and fine sand, are estimated to be approximately 30 m at maximum in the project area and this clayey deposit has been found to contain thick layer of organic matter locally, particularly downstream the middle point between Blumenau and Gaspar, though the riverbed deposit consists mainly of fine to medium sand containing a little coarser particles.

In the areas other than this, the alluvial deposits consist mainly of sandy silt or silty sand intercalated with gravels. The depth of those layers is estimated generally at about 10 m in view that base rocks are occasionally found to crop out in the riverbed in the other areas.

The diluvial deposits are distributed in the right bank of the Itajai river along the coast of the Atlantic.

The Palaeozoic sedimentary rocks from the Carboniferous period to the inferior Permian period is distributed in the waterhead areas of the Benedito river and its tributary at the eastern slope of the Mar mountains.

3. FIELD WORKS AND LABORATORY TESTS

3.1 General

(1) Work items and quantities

Items and quantities of the field works and laboratory tests are shown in Table II.3.1 as a comparison between contract and execution. Since the subsurface geologic conditions encountered in the course of the investigation were appreciably different from those expected, that is, wider distribution of sandy deposits and shallower existence of stiff layer than expected, the executed quantities of the field works and the laboratory tests were much reduced.

(2) Locations

Locations of the field works consisting of core drillings, Dutch cone soundings, auger borings and test pittings are shown on Fig.II.3.2, while the laboratory tests were executed mainly in the laboratories in Rio de Janeiro, which are owned by the contractor and universities in Rio de Janeiro, and in a laboratory of the university of Blumenau.

(3) Testing Standards

Testing standards principally utilized for both the field works and the laboratory tests are listed in Table II.3.2. Although some tests such as permeability test in-situ and undisturbed sampling were executed based on common practices in Brazil, which differ slightly from the standards listed, they were within permissible limits.

(4) Equipment Utilized

Equipments utilized for this investigation are listed in Table II.3.3. Some of the rotary drilling equipments had been broken down often during the investigation work due to improper maintenance of the equipments, which caused some delay of completion of the field work. The other equipments were generally in acceptable conditions.

3.2 Field Works

The field works mainly aim at obtaining in-situ geotechnical conditions of the project area as well as collecting soil samples of both disturbed and undisturbed for the laboratory tests.

(1) Core drilling

Core drilling with in-situ tests that is one of the most useful means to survey subsurface geologic condition, was carried out at fifteen locations along the Itajai river in the project area. Results of core drilling inclusive of permeability tests in-situ, standard penetration tests (SPT), ground water level measurement and locations of undisturbed sampling are compiled in a form of geologic log as shown on Fig.II.3.2. Total drilling length was 341.05 m.

(2) Dutch cone sounding

Results of Dutch cone sounding are illustrated on Fig.II.3.3, which present cone penetration resistance of subsurface soils up to approximately 15 m in maximum depth. Total sounding length was 797.93 m.

(3) Auger boring

Auger boring was carried out as a supplemental mean to the Dutch cone sounding, to enable to classify subsurface soils up to 5 m deep at the same locations as the sounding. Total boring length was 270.87 m.

(4) Test pit

Test pitting was carried out aiming at collecting disturbed soil samples for laboratory tests to examine suitability of materials obtainable and enabling close observation of subsurface conditions for levee materials. Total pitting length was 57.95 m.

3.3 Laboratory Tests

The laboratory soil tests aim at classifying soils for identification of soil characteristics and at obtaining such engineering properties of soils as shear strength, compressibility, permeability and compaction. Results of laboratory tests are summarily shown in Table II.3.4.

4. GEOTECHNICAL EVALUATION OF THE PROJECT AREA

4.1 General Geologic Situations

(1) Depth of base rock along main stream

The core drilling results suggest that depth of base rock along the main river becomes deeper toward the downstream in the project area as shown below.

Location/Section	Depth of rock to be referred	Drill hole
1. confluence with Itoupava and its immediate downstream	12m - 24m	SM-12,13,14 & 15
2. Section between confluences with Velha and Garcia	17m - 23m	SM-8,9,10 & 11
3. Sta. 64km - 59km	23m - 24m	SM-6 & 7
4. Sta. 56km - 46km	27m - 31m (or>31m)	SM-1,2,3,4 & 5

(2) Alluvial deposits along main stream

Over the base rock, alluvial deposits consisting mainly of clayey soils and fine sand are distributed widely up to the ground surface. The alluvial deposits are normally soft in case of clayey soils and loose in case of sand, which suggest that they are not suitable as supporting layer for proposed structure foundations.

It is noted that ultra-soft deposits, which consist mainly of organic clayey soils and have penetration resistance of less than 2 kg/cm2 in Dutch cone sounding, have been confirmed to exist. Those deposits are found in vicinities of the confluence with the Itoupava river (refer to Fig.II.3.3(1)), the right bank low land area around Sta.73.5 km (refer to Figs.II.3.3(2) & (3)), the confluence with the Garcia river (refer to Fig.II.3.3(4)) and sporadic spots in a section between Sta.60 km and 45 km on both banks (refer to Figs.II.3.3(5)-(8)).

(3) Subsurface situations along tributaries

Results of the sounding along three tributaries indicate that firm layers which can support the structure foundations are distributed at 10 m depth or less from the ground surface, and rather soft alluvium is deposited over the firm layers along the existing river channel floor.

4.2 Structure Foundation

4.2.1 Introduction

The field investigation indicates that reliable supporting layers do not exist or are very thin even if they exist, between the ground surface and the base rock at the proposed structure sites such as pump stations and bridges, as seen on Fig.II.3.2 and Fig.II.3.3. Accordingly, it is recommended that those structures are founded on the base rocks in principle.

4.2.2 Shear strength characteristics

Since the soft alluvium inclusive of ultra-soft alluvium are deposited thickly in the project area, stability of levee foundations and of cut slopes formed with construction of the flood diversion channel in Gaspar and with the widening of the main river, is to be examined thoroughly, if the heightening of levee is more than 5 meters and the cut slopes to be formed is steeper than the existing slopes.

(1) Since laboratory shear test for undisturbed sandy soil was not done due to difficulty in its sampling, evaluation of shear strength is to be made by using the results of SPT and Dutch cone sounding.

Fig.II.4.1 shows relationship between N-value in SPT and cone penetration resistance in Dutch cone sounding for sandy soils. The relationship has broad distribution that may be resulted from some difference of subsurface conditions due to separated locations between the core drilling and the Dutch cone sounding, though those two locations are generally close with distance of some meters or less than 10 meters. However it is judged that the formula proposed by Meyerhof, $q_c = 4N$, is applicable for this project area taking into account the above and the results of laboratory tests.

And shear strength of sandy soils is proposed to evaluate by using the commonly applied following formula proposed by Dunham,

$$\phi = 12N^{0.5} + 15$$

(2) For clayey soils, shear strength can be evaluated by results of unconfined compression tests and consolidated undrained triaxial compression tests that are obtained as follows:

	Unconfined compression	CU - Test	
	q_u (kg/cm)	C_{cu}(kg/cm2)	ø(degree)
Max.	1.75	0.4	26
Min.	0.18	0.1	12
Mean	0.69	0.26	20

However it is noted that the above results were obtained mainly from soft to medium clayey soils. Therefore, evaluation of shear strength

of clayey soils inclusive of very soft and ultra-soft clay is to be made by using the results of Dutch cone sounding. In this case, the following formula proposed by Begeman is applicable.

$$q_c = 14\ C_u \quad (kg/cm^2)$$

(3) Taking into consideration the above discussion, and all the results of field works and laboratory tests, it is proposed to apply following shear strength for stability analyses required.

Clayey soil	q_c (kg/cm2)	C_u (kg/cm2)
ultra-soft	0 - 2	0 - 0.1
soft	2 - 4	0.1 - 0.3
medium	4 - 20	0.3 - 0.8

Sandy soil	N-Value	q_c (kg/cm2)	ø (degree)
very loose	0 - 4	0 - 16	25
loose	4 - 10	16 - 40	30
medium	10 - 30	40 - 120	35

4.2.3 Settlement characteristics

Results of laboratory consolidation test are useful to evaluate settlement characteristics of clayey soil foundation in case the soft ground is loaded with levee embankment. The results of consolidation tests are summarised as below.

	Compression index C_c
Max.	0.98
Min.	0.12
Mean	0.27

The above result indicates that compression index for medium to soft clay is about 0.2 and that for very soft clay is about 1.0. Although no consolidation test result was obtained for ultra-soft clay, it is expected that its compression index is obviously more than 1.0 and might be about 2.0 or more.

4.3 Levee Materials

4.3.1 General

(1) The levee material investigation was carried out aiming to examine suitability of materials obtainable near the embankment sites by means of sixteen numbers of test pittings in the field and the laboratory tests as mentioned in the preceding sections.

(2) The investigation was focussed on two potential material sources; one is residual soils that are distributed superficially on most of hill slopes in the project area, and the other is alluvial deposits that form the Itajai river banks.

4.3.2 Soil classification

As seen on Fig.II.4.2, a large part of residual soils are classified into clayey soil, i.e. CL, CH or C'H, that has relatively higher plasticity.

On the other hand, the river bank materials (TP-9 & 16) are classified into silty soil, i.e. CL-ML that has relatively low plasticity.

4.3.3 Engineering properties

Engineering properties of those materials were examined through respective laboratory tests, of which results are presented hereunder.

(1) Permeability

Coefficient of permeability of the residual soils and the river bank materials under the maximum dry density and optimum moisture content were obtained as below.

	Residual soil	River bank material
Max (cm/s)	2×10^{-5}	2×10^{-6}
Min (cm/s)	1×10^{-7}	1×10^{-7}
Mean(cm/s)	9×10^{-7}	6×10^{-6}

These results show that both materials have low enough permeability as the levee materials.

(2) Shearing strength

Shearing strength of those materials was examined by triaxial compression test under consolidated undrained condition with pore-pressure measurement, and their results are as follows.

	Residual soil	River bank material
Cohesion (Kg/cm2)		
Max	1.0	-
Min	0.25	-
Mean	0.71	0.1
Internal friction (degree)		
Max	29.0	-
Min	18.2	-
Mean	23.9	33

The above results show that those materials have relatively high shear strength so that slope stability problem in relation with levee embankment is to be focussed chiefly on the levee foundations.

(3) Compressibility

Compressibility of those materials was examined by one dimensional consolidation meter, of which results are as follows.

	Residual soils	River bank soil
Max.	0.37	-
Min.	0.12	-
Mean	0.23	0.16

The above results indicate that compressibility of those materials are relatively small so that potential compressive settlement of levee will not be large after construction.

(4) Resistibility of piping and erosion

Resistibility against piping phenomenon or erosion is preliminarily evaluated by using plasticity index in case of cohesive soil. In Fig.II.4.2, residual soils having plasticity index of more than 20 can be classified as high resistible soil against piping or erosion.

The river bank materials (TP-9 & 16) that have very low plasticity index of about 7 or less and consist of silty soils, are susceptible to piping or erosion.

The remainder residual soils that have plasticity index of 9 to 18, consist of highly weathered rocks of which textures are still observed. Those soils should be regarded as low to medium resistibility against piping and erosion.

(5) Workability in embankment work

Fig.II.4.3 shows relations between natural moisture content (NMC) and optimum moisture content(OMC) that is derived from laboratory compaction test. It is seen that most of soils have higher NMC than OMC by four(4) to nineteen(19) percent. However it is noted that unexpectedly continuous rainfall occurred during this investigation work, which might have resulted in extraordinarily higher NMC of the soils. Taking into consideration such seasonal variation of moisture content, it is expected that annual average NMC will be much closer to OMC. However some measure to adjust the NMC might be required so as to assure good workability of embankment work for such type of soils as CH and MH that are commonly regarded as relatively poor materials for workability in case their NMC is higher than OMC by several percents.

4.3.4 Available quantity of residual soils

As discussed in the preceding clause, the residual soils which are deemed to be suitable for the levee embankment are distributed on most of hill slopes in the project area so that its available quantity is expected to be much greater than required for the proposed embankment work for levee heightening.

5. SUMMARY OF GEOTECHNICAL INVESTIGATION

Main points of the result of the geotechnical investigation are summarized as follows:

(1) The major structures proposed are to be founded on the base rock, depth of which ranges from 12 m to 31 m or more and which has a trend to become deeper toward the downstream along the Itajai river.

(2) The proposed structures in the vicinities of three tributaries could be founded on firm layers or base rock that are distributed at around 10 m depth or less under the ground surface.

(3) The stability of cut slopes, which will be steeper than existing, and of foundations of levee having more than 5 m, is to be examined thoroughly in case the ultra-soft deposits are distributed appreciably thick thereunder.

The engineering properties of foundation soils are given in the preceding chapter.

(4) The earth materials for levee is obtainable from residual soils that are suitable for levee embankment and are distributed on hill slopes with available quantity far more than required.

Tables

Table II.3.1 COMPARISON OF WORK QUANTITIES BETWEEN CONTRACT AND EXECUTION

Items	Quantity (1) Contract	Quantity (2) Executed	(3)=(2)/(1) Ratio (%)	Amount Executed (US$)
Field Works				
1. Transportation	L.S.	L.S.	100	9,068.89
2. Assembling/ Dismantling	14	15	107	687.90
3. Drilling	350 m	341.05	97	12,124.32
4. Permeability test in-situ	45	34	76	2,189.94
5. SPT	175	136	78	3,153.84
6. Undisturbed sampling	70	22	31	1,598.30
7. Sounding	900	797.93	89	49,471.66
8. Auger boring	350	270.87	77	4,466.64
9. Test pit	70	57.95	83	2,896.50
Sub-total				85,657.99
Laboratory Tests				
1. Moisture content	140	104	74	1,500.72
2. Specific gravity	105	69	66	995.67
3. Particle size	105	69	66	2,133.48
4. L.L.	105	69	66	995.67
5. P.L.	105	69	66	995.67
6. Compaction	21	18	86	547.20
7. Permeability	21	18	86	1,706.58
8. Unconfined compression	70	21	30	714.21
9. Triaxial (cu)	12	8	67	1,525.20
10. Triaxial (cu)	12	11	92	2,970.11
11. Consolidation	21	21	100	3,150.00
Sub-total				17,234.51
Grand total				102,892.50

Table II.3.2 TESTING STANDARDS

Items	Standards
Field Works	
1 Core drilling	Earth manual
2 Permeability test in-situ	Earth manual E-18
3 Standard penetration test	ASTM D1586-74
4 Undisturbed sampling	ASTM D1587-74
5 Deep sounding (Dutch-cone)	ASTM D3441-79
6 Anger Boring	ASTM D1452-72
- Visual manual procedure for "Description of soil"	ASTM D2488-69 (1975)
7 Test pit	- ditto -
Laboratory Tests	
8 Moisture content test	ASTM D 2216
9 Specific gravity	ASTM D 854
10 Particle size	ASTM D 422
11 Liquid limit	ASTM D 423
12 Plastic limit	ASTM D 424
13 Compaction	ASTM D 698
14 Permeability (Variable Lend)	ASTM D 2435
15 Unconfined compression	ASTM D 2166
16 CU-Test with undisturbed	Earth manual E-17
17 CU-Test with remoulded	- ditto -
18 Consolidation (Undisturbed)	ASTM D 2435
19 Remoulded	

Table II.3.3 EQUIPMENT UTILIZED

Items	Quantity	Model No.	Manufactured
Field Equipment			
Rotary drilling equipment	2	MAQUESONDA, MACH-850	Brasil
Rotary drilling equipment	2	SONDEQ, SS-21	Brasil
Water pump	2	MAQUESONDA MT-100	Brasil
Water pump	5	SOCAR BS-101	Brasil
Dutch-cone sounding	2	MAQUESONDA Cap. 2t	Brasil
Laboratory Equipment			
Triaxial compression test apparatus	2	Ronald Top LTD.	Brasil
Consolidation test apparatus	10	Soil Test Inc.	USA
Other test apparatus		Solo Test LTD.	Brasil

Table II.3.4 SUMMARY OF LABORATORY TEST (1/10)

SAMPLE NO				SM-1(1)	(2)	(3)	(4)	SM-2(1)	(2)	SM-3(1)	(2)	(3)
SAMPLE DEPTH			(m)	13-13.5	16-16.6	20-20.6	20.6-21.1	7.5-8.0	18.5-19	9-9.5	9.5-10	15.0-15.5
GRADATION	GRAVEL		(%)	0	0	0	0	0	0	0	0	0
	SAND		(%)	38	27	20	26	56.9	31.9	51.7	23	20
	SILT		(%)	39	37	40	32	32.5	46.6	35.3	46	38
	CLAY		(%)	23	36	40	42	10.6	21.5	13	31	42
	MAX DIAMETER		(mm)	2	2	2	2	2	0.84	2	2	2
	COEFFICIENT OF UNIFORMITY		Uc	-	-	-	-	-	-	-	-	-
	COEFFICIENT OF CURVATURE		Uc	-	-	-	-	-	-	-	-	-
CON-SISTENCY	LIQUID LIMIT		wL(%)	63	63	59	33	NP	33.9	29.99	35.2	48.3
	PLASTIC LIMIT		wP(%)	34	25	27	15	-	19.1	18.19	20.1	24.7
	PLASTICITY INDEX		IP	29	38	32	18	-	14.8	11.8	15.1	23.6
PERMEABILITY			K(cm/s)	-	-	-	-	-	-	-	-	-
COM-PACTION	MAX DRY DENSITY		γm(kg/cm3)	-	-	-	-	-	-	-	-	-
	OPTIMUM MOISTURE CONTENT		w0(%)	-	-	-	-	-	-	-	-	-
SPECIFIC GRAVITY OF SOIL			Gs	2.28	2.56	2.43	2.69	2.69	2.58	2.73	2.71	2.74
NATURAL STATE	WATER CONTENT		w (%)	110	59	59	26	25.2	31.18	33.95	38.68	42
	WET DENSITY		γt(g/m3)	1.386	1.624	1.602	1.957	1.967	1.829	1.753	1.71	-
	VOID RATIO		e	2.45	1.51	1.42	0.73	-	-	-	-	-
	DEGREE OF SATUPATION		Sr(%)	100	100	100	96	-	-	-	-	-
MECHANICAL PROPERTIES	UNCONFINED COM-PRESSION	COMPRESSIVE STRENGTH	qu(kg/cm2)	0.65	0.36	0.7	0.4	0.4	0.75	0.28	0.4	-
		MODULUS OF ELASTICITY	E50(kg/cm2)	-	-	-	-	-	-	-	-	-
		SENSITIVITY RATIO	St	-	-	-	-	-	-	-	-	-
	**	TYPE OF TEST	***	-	-	-	-	-	-	-	-	CU
		COHESION	C(kg/cm2)	-	-	-	-	-	-	-	-	0.25
	(2)	ANGLE OF INTERNAL FRICTION	ø (o)	-	-	-	-	-	-	-	-	16
	CONSOLI-DATION	YIELD STRESS OF CONSOLIDATION	Py(kg/cm2)	-	-	-	-	1.2	-	2.2	-	1.7
		COMPRESSION INDEX	Cc	-	-	-	-	0.22	-	0.12	-	0.51
CLASSIFICATION				C'H	CH	CH	CL	-	CL	CL	CL	CL

** (1): DIRECT SHEAR (2): TRIAXIAL COMPRESSION
*** UNCONSOLIDATED UNDRAINED: UU CONSOLIDATED UNDRAINED: CU CONSOLIDATED DRAINED: CD

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Table II.3.4 SUMMARY OF LABORATORY TEST (2/10)

SAMPLE NO				SM-3(5)	(6)	(7)	(8)	SM-4(1)	SM-5(1)	(2)	SM-8(1)	(3)
SAMPLE DEPTH			(m)	19-19.5	19.5-20.0	25-25.5	25.5-26	20-20.5	5-5.5	5.5-6	5-5.5	10.5-11
GRADATION	GRAVEL		(%)	0	0	0	0	0	0	0	1.1	0
	SAND		(%)	9.2	3.8	4.3	15.4	0.3	2.2	3.4	18.9	25
	SILT		(%)	53.2	56.2	41.8	46.4	64.1	70.3	58.1	60	55
	CLAY		(%)	44	40	37.5	31	35.6	27.5	38.5	20	20
	MAX DIAMETER		(mm)	0.84	0.42	0.42	2	0.42	0.42	0.42	10	0.84
	COEFFICIENT OF UNIFORMITY		Uc	-	-	-	-	-	-	-	-	-
	COEFFICIENT OF CURVATURE		Uc	-	-	-	-	-	-	-	-	-
CON-SISTENCY	LIQUID LIMIT		wL(%)	45	49	48	38	63	38	41	33.9	28.2
	PLASTIC LIMIT		wP(%)	25	22	21	25	38	20	28	21.3	18.9
	PLASTICITY INDEX		IP	20	24	27	13	25	18	13	12.6	9.3
PERMEABILITY			K(cm/s)	-	-	-	-	-	-	-	-	-
COM-PACTION	MAX DRY DENSITY		γm(kg/cm3)	-	-	-	-	-	-	-	-	-
	OPTIMUM MOISTURE CONTENT		w0(%)	-	-	-	-	-	-	-	-	-
SPECIFIC GRAVITY OF SOIL			Gs	2.66	2.69	2.62	2.52	2.35	2.67	2.7	2.64	2.68
NATURAL STATE	WATER CONTENT		w(%)	28.85	31.23	48.23	29.69	63.67	37.95	36.5	28.9	31.02
	WET DENSITY		γt(g/m3)	2.048	-	1.984	2.015	1.611	1.896	-	-	1.869
	VOID RATIO		e	-	-	-	-	-	-	-	-	-
	DEGREE OF SATUPATION		Sr(%)	-	-	-	-	-	-	-	-	-
MECHANICAL PROPERTIES	UNCONFINED COM-PRESSION	COMPRESSIVE STRENGTH	qu(kg/cm2)	1.75	-	1.5	1.7	0.75	0.95	-	-	0.18
		MODULUS OF ELASTICITY	E50(kg/cm2)	-	-	-	-	-	-	-	-	-
		SENSITIVITY RATIO	St	-	-	-	-	-	-	-	-	-
	**	TYPE OF TEST	***	CU	-	-	-	CU	CU	-	CU	CU
		COHESION	C(kg/cm2)	0.1	-	-	-	0.25	0.3	-	0.2	0.25
	(2)	ANGLE OF INTERNAL FRICTION	ø (o)	20	-	-	-	12	19.5	-	26	26
	CONSOLI-DATION	YIELD STRESS OF CONSOLIDATION	Py(kg/cm2)	3.7	3.3	1.5	0.7	1.9	0.65	0.7	1.3	1.6
		COMPRESSION INDEX	Cc	0.23	0.22	0.19	0.13	0.98	0.2	0.17	0.23	0.21
CLASSIFICATION				ML	CL	CL	ML	C'H	CL	ML	CL	CL

** (1): DIRECT SHEAR (2): TRIAXIAL COMPRESSION
*** UNCONSOLIDATED UNDRAINED: UU CONSOLIDATED UNDRAINED: CU CONSOLIDATED DRAINED: CD

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Table II.3.4 SUMMARY OF LABORATORY TEST (3/10)

SAMPLE NO				SM-9(1)	SM-11(1)	(2)	(3)	SM-12(1)	SM-13(1)	(3)	SM-14(1)
SAMPLE DEPTH			(m)	5-5.5	5-5.5	7.5-8	9-9.5	5-5.5	5-5.5	10.5-11	5-5.5
GRADATION	GRAVEL		(%)	0	0	0	0	0	0	0	0
	SAND		(%)	44.7	11	6	20.5	49.6	13.3	15	18.2
	SILT		(%)	41.1	63	42	53	35.4	39.7	46.6	62.9
	CLAY		(%)	14.2	26	52	26.5	15	26.4	38.4	18.9
	MAX DIAMETER		(mm)	0.84	0.42	0.42	2	0.84	0.42	2	0.84
	COEFFICIENT OF UNIFORMITY		Uc	-	-	-	-	-	-	-	-
	COEFFICIENT OF CURVATURE		Uc	-	-	-	-	-	-	-	-
CON-SISTENCY	LIQUID LIMIT		wL(%)	28.8	33	49	26	NP	31	50	27
	PLASTIC LIMIT		wP(%)	17	20	23	10	-	19	21	20
	PLASTICITY INDEX		IP	11.8	13	26	16	-	12	29	7
PERMEABILITY			K(cm/s)	-	-	-	-	-	-	-	-
COM-PACTION	MAX DRY DENSITY		γm(kg/cm3)	-	-	-	-	-	-	-	-
	OPTIMUM MOISTURE CONTENT		wo (%)	-	-	-	-	-	-	-	-
SPECIFIC GRAVITY OF SOIL			Gs	2.71	2.83	2.72	2.78	2.52	2.55	2.63	2.6
NATURAL STATE	WATER CONTENT		w (%)	47.9	29.1	30.51	23.99	22.59	28.89	27.57	35.95
	WET DENSITY		γt(g/m3)	1.719	-	1.943	2.078	1.998	2.012	2.001	1.725
	VOID RATIO		e	-	-	-	-	-	-	-	-
	DEGREE OF SATUPATION		Sr(%)	-	-	-	-	-	-	-	-
MECHANICAL PROPERTIES	UNCONFINED COM-PRESSION	COMPRESSIVE STRENGTH	qu(kg/cm2)	0.48	-	0.74	0.28	0.3	0.6	1	0.38
		MODULUS OF ELASTICITY	E50(kg/cm2)	-	-	-	-	-	-	-	-
		SENSITIVITY RATIO	St	-	-	-	-	-	-	-	-
	** (2)	TYPE OF TEST	***	-	-	-	-	-	CU	-	CU
		COHESION	C(kg/cm2)	-	-	-	-	-	0.4	-	0.3
		ANGLE OF INTERNAL FRICTION	ø (o)	-	-	-	-	-	18.5	-	24
	CONSOLI-DATION	YIELD STRESS OF CONSOLIDATION	Py(kg/cm2)	-	1.2	-	-	1.2	1.2	-	1.4
		COMPRESSION INDEX	Cc	-	0.19	-	-	0.24	0.19	-	0.28
CLASSIFICATION				CL	CL	CL	CL	-	CL	CH	CL-ML

** (1): DIRECT SHEAR (2): TRIAXIAL COMPRESSION
*** UNCONSOLIDATED UNDRAINED: UU CONSOLIDATED UNDRAINED: CU CONSOLIDATED DRAINED: CD

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TABLE II.3.4 SUMMARY OF LABORATORY TEST (4/10)

SAMPLE NO				TP-1	TP-2		TP-3		TP-4		
SAMPLE DEPTH			(m)	1	1	1.5	1	2	1	1.5	1.0-1.5
GRADATION	GRAVEL		(%)	0.1	0.1	0	0	0	0	0	0
	SAND		(%)	4.5	3.7	3.4	3	11.4	1.4	1.2	1.1
	SILT		(%)	37.4	70.8	37.6	34	44.6	46.8	47.2	55.9
	CLAY		(%)	58	25.4	59	63	44	51.8	51.6	43
	MAX DIAMETER		(mm)	10	4.76	2	2	2	1.2	1.2	2
	COEFFICIENT OF UNIFORMITY		Uc	-	-	-	-	-	-	-	-
	COEFFICIENT OF CURVATURE		Uc	-	-	-	-	-	-	-	-
CON-SISTENCY	LIQUID LIMIT		wL(%)	59	35	58	59	5	46.9	49.6	64
	PLASTIC LIMIT		wP(%)	31	21	26	28	27	31.7	31.4	29
	PLASTICITY INDEX		IP	28	14	32	31	23	15.2	18.2	35
PERMEABILITY			K(cm/s)	1X10-6	2X10-6	-	3X10-7	-	-	-	8X10-7
COM-PACTION	MAX DRY DENSITY		γm(kg/cm3)	1.461	1.7	-	1.485	-	-	-	1.557
	OPTIMUM MOISTURE CONTENT		wo (%)	28.6	19	-	28.8	-	-	-	24.2
SPECIFIC GRAVITY OF SOIL			Gs	2.61	2.67	2.62	2.63	2.7	2.702	2.744	2.64
NATURAL STATE	WATER CONTENT		w (%)	32.5	24	29.3	31.4	29.3	35.6	31.8	30.13
	WET DENSITY		γt(g/m3)	-	-	-	-	-	-	-	-
	VOID RATIO		e	-	-	-	-	-	-	-	-
	DEGREE OF SATUPATION		Sr(%)	-	-	-	-	-	-	-	-
MECHANICAL PROPERTIES	UNCONFINED COM-PRESSION	COMPRESSIVE STRENGTH	qu(kg/cm2)	-	-	-	-	-	-	-	-
		MODULUS OF ELASTICITY	E50(kg/cm2)	-	-	-	-	-	-	-	-
		SENSITIVITY RATIO	St	-	-	-	-	-	-	-	-
	**	TYPE OF TEST	***	$\overline{CU}$	$\overline{CU}$	-	-	-	-	-	$\overline{CU}$
		COHESION	C(kg/cm2)	0.92	0.44	-	-	-	-	-	0.25
	(2)	ANGLE OF INTERNAL FRICTION	ø (o)	18.2	24.1	-	-	-	-	-	29
	CONSOLI-DATION	YIELD STRESS OF CONSOLIDATION	Py(kg/cm2)	0.72	1.1	-	-	-	-	-	0.78
		COMPRESSION INDEX	Cc	0.25	0.16	-	-	-	-	-	0.37
CLASSIFICATION				C'H	CL	CH	CH	C'H	ML	ML	CH

** (1): DIRECT SHEAR (2): TRIAXIAL COMPRESSION
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Table II.3.4 SUMMARY OF LABORATORY TEST (5/10)

SAMPLE NO				TP-5			TP-6			
SAMPLE DEPTH			(m)	1.5	2	4	1.5	2	3-3.5	4.5-5
GRADATION	GRAVEL		(%)	0.3	0.1	0.3	1.4	1.3	0	0.4
	SAND		(%)	14.9	2.6	17.8	21.9	23.2	30.9	29
	SILT		(%)	18.2	48.4	15.9	24	26.6	45.6	24.1
	CLAY		(%)	66.6	49	66	52.7	48.9	23.5	46.5
	MAX DIAMETER		(mm)	4.8	2	4.8	9.5	9.5	2	4.67
	COEFFICIENT OF UNIFORMITY		Uc	-	-	-	-	-	-	-
	COEFFICIENT OF CURVATURE		Uc	-	-	-	-	-	-	-
CON-SISTENCY	LIQUID LIMIT		wL(%)	86.3	49	80.8	74.3	71.3	45	77
	PLASTIC LIMIT		wP(%)	59.6	28	52.9	50.3	40.3	29	36
	PLASTICITY INDEX		IP	26.7	21	27.9	24	31	16	41
PERMEABILITY			K(cm/s)	-	3X10-6	-	-	-	8X10-6	6X10-6
COM-PACTION	MAX DRY DENSITY		γm(kg/cm3)	-	1.527	-	-	-	1.554	1.467
	OPTIMUM MOISTURE CONTENT		wo (%)	-	25.5	-	-	-	23.8	27.8
SPECIFIC GRAVITY OF SOIL			Gs	2.736	2.67	2.631	2.636	2.643	2.67	2.66
NATURAL STATE	WATER CONTENT		w (%)	44.56	43.78	41.45	33.38	33	27.16	24.73
	WET DENSITY		γt(g/m3)	-	-	-	-	-	-	-
	VOID RATIO		e	-	-	-	-	-	-	-
	DEGREE OF SATUPATION		Sr(%)	-	-	-	-	-	-	-
MECHANICAL PROPERTIES	UNCONFINED COM-PRESSION	COMPRESSIVE STRENGTH	qu(kg/cm2)	-	-	-	-	-	-	-
		MODULUS OF ELASTICITY	E50(kg/cm2)	-	-	-	-	-	-	-
		SENSITIVITY RATIO	St	-	-	-	-	-	-	-
	**	TYPE OF TEST	***	-	$\overline{CU}$	-	-	-	$\overline{CU}$	-
		COHESION	C(kg/cm2)	-	0.52	-	-	-	0.8	-
	(2)	ANGLE OF INTERNAL FRICTION	ø (o)	-	25	-	-	-	20	-
	CONSOLI-DATION	YIELD STRESS OF CONSOLIDATION	Py(kg/cm2)	-	0.45	-	-	-	0.6	-
		COMPRESSION INDEX	Cc	-	0.24	-	-	-	0.12	-
CLASSIFICATION				MH	ML	MH	C'H	C'H	ML	C'H

** (1): DIRECT SHEAR (2): TRIAXIAL COMPRESSION
*** UNCONSOLIDATED UNDRAINED: UU CONSOLIDATED UNDRAINED: CU CONSOLIDATED DRAINED: CD

(BAR OVER THE SYMBOL SHOWS THE MEASUREMENT OF PORE WATER PRESSURE)

Table II.3.4 SUMMARY OF LABORATORY TEST (6/10)

SAMPLE NO				TP-7		TP-8		TP-9		TP-10	
SAMPLE DEPTH			(m)	1	1.5	1.5	2	1.5	2	1	2
GRADATION	GRAVEL		(%)	0	0	0.2	0.1	0	0	0.3	0
	SAND		(%)	0.1	1.2	4	5.7	41.5	46.2	17.9	31.9
	SILT		(%)	39.9	32.8	37.8	49.2	39.3	37.1	25.9	36.6
	CLAY		(%)	60	66	58	45	19.2	16.7	55.9	31.5
	MAX DIAMETER		(mm)	0.84	2	10	4.76	0.6	0.84	4.8	0.84
	COEFFICIENT OF UNIFORMITY		Uc	-	-	-	-	-	-	-	-
	COEFFICIENT OF CURVATURE		Uc	-	-	-	-	-	-	-	-
CON-SISTENCY	LIQUID LIMIT		wL(%)	62	55.8	80	50	25.5	24	59.2	36
	PLASTIC LIMIT		wP(%)	32	36.6	36	24	18.6	17	30.7	18
	PLASTICITY INDEX		IP	30	19.2	44	26	6.9	7	28.5	18
PERMEABILITY			K(cm/s)	7X10-7	-	2X10-5	-	-	2X10-6	-	2X10-7
COM-PACTION	MAX DRY DENSITY		γm(kg/cm3)	1.471	-	1.47	-	-	1.84	-	1.742
	OPTIMUM MOISTURE CONTENT		wo (%)	27.5	-	26.7	-	-	14	-	17.3
SPECIFIC GRAVITY OF SOIL			Gs	2.71	2.732	2.64	2.66	2.629	2.64	2.694	2.6
NATURAL STATE	WATER CONTENT		w (%)	39.62	34.5	38.4	26.8	26.13	27.55	32.47	31.64
	WET DENSITY		γ t(g/m3)	-	-	-	-	-	-	-	-
	VOID RATIO		e	-	-	-	-	-	-	-	-
	DEGREE OF SATUPATION		Sr(%)	-	-	-	-	-	-	-	-
MECHANICAL PROPERTIES	UNCONFINED COM-PRESSION	COMPRESSIVE STRENGTH	qu(kg/cm2)	-	-	-	-	-	-	-	-
		MODULUS OF ELASTICITY	E50(kg/cm2)	-	-	-	-	-	-	-	-
		SENSITIVITY RATIO	St	-	-	-	-	-	-	-	-
	** (2)	TYPE OF TEST	***	$\overline{CU}$	-	$\overline{CU}$	-	-	$\overline{CU}$	-	$\overline{CU}$
		COHESION	C(kg/cm2)	1	-	1	-	-	0.1	-	0.7
		ANGLE OF INTERNAL FRICTION	ø (o)	20	-	23.5	-	-	33	-	21
	CONSOLI-DATION	YIELD STRESS OF CONSOLIDATION	Py(kg/cm2)	0.4	-	0.75	-	-	-	-	0.75
		COMPRESSION INDEX	Cc	0.26	-	0.2	-	-	-	-	0.19
CLASSIFICATION				C'H	MH	C'H	CH	CL-ML	CL-ML	C'H	CL

** (1): DIRECT SHEAR (2): TRIAXIAL COMPRESSION
*** UNCONSOLIDATED UNDRAINED: UU CONSOLIDATED UNDRAINED: CU CONSOLIDATED DRAINED: CD

(BAR OVER THE SYMBOL SHOWS THE MEASUREMENT OF PORE WATER PRESSURE)

Table II.3.4 SUMMARY OF LABORATORY TEST (7/10)

SAMPLE NO				TP-10	TP-11			TP-12		
SAMPLE DEPTH			(m)	3	1	1.5-2.0	2	1	2	3
GRADATION	GRAVEL		(%)	0	0	0	0	3.1	3.5	3.3
	SAND		(%)	20.6	3.5	20	5	15.3	22	18.5
	SILT		(%)	32.9	49.6	54	69.6	59.8	55.3	64.6
	CLAY		(%)	46.5	46.9	26	25.4	21.8	19.2	13.6
	MAX DIAMETER		(mm)	0.6	2	0.42	1.2	4.8	4.8	4.8
	COEFFICIENT OF UNIFORMITY		Uc		-	-	-	-	-	-
	COEFFICIENT OF CURVATURE		Uc		-	-	-	-	-	-
CON-SISTENCY	LIQUID LIMIT		wL(%)	42.1	41	38	35.5	48.7	51	50
	PLASTIC LIMIT		wP(%)	24.1	26.5	18	23.9	34.6	26	35.7
	PLASTICITY INDEX		IP	18	14.5	20	11.6	14.1	25	14.3
PERMEABILITY			K(cm/s)	-	-	1x10-6	-	-	7x10-6	-
COM-PACTION	MAX DRY DENSITY		$\bar{\gamma}$m(kg/cm3)	-	-	1.61	-	-	1.435	-
	OPTIMUM MOISTURE CONTENT		wo (%)	-	-	22.8	-	-	26.5	-
SPECIFIC GRAVITY OF SOIL			Gs	2.63	2.704	2.76	2.617	2.561	2.72	2.625
NATURAL STATE	WATER CONTENT		w (%)	31.52	33.96	27.7	24.04	35.34	34.86	33.97
	WET DENSITY		$\bar{\gamma}$ t(g/m3)	-	-	-	-	-	-	-
	VOID RATIO		e	-	-	-	-	-	-	-
	DEGREE OF SATUPATION		Sr(%)	-	-	-	-	-	-	-
MECHANICAL PROPERTIES	UNCONFINED COM-PRESSION	COMPRESSIVE STRENGTH	qu(kg/cm2)	-	-	-	-	-	-	-
		MODULUS OF ELASTICITY	E50(kg/cm2)	-	-	-	-	-	-	-
		SENSITIVITY RATIO	St	-	-	-	-	-	-	-
	** (2)	TYPE OF TEST	***	-	-	-	-	-	-	-
		COHESION	C(kg/cm2)	-	-	-	-	-	-	-
		ANGLE OF INTERNAL FRICTION	ø (o)	-	-	-	-	-	-	-
	CONSOLI-DATION	YIELD STRESS OF CONSOLIDATION	Py(kg/cm2)		-	-	-	-	-	-
		COMPRESSION INDEX	Cc		-	-	-	-	-	-
CLASSIFICATION				CL	ML	CL	ML	ML	CH	ML-MH

** (1): DIRECT SHEAR (2): TRIAXIAL COMPRESSION
*** UNCONSOLIDATED UNDRAINED: UU CONSOLIDATED UNDRAINED: CU CONSOLIDATED DRAINED: CD

(BAR OVER THE SYMBOL SHOWS THE MEASUREMENT OF PORE WATER PRESSURE)

Table II.3.4 SUMMARY OF LABORATORY TEST (8/10)

SAMPLE NO				TP-13				TP-14			
SAMPLE DEPTH			(m)	1	1.5	3	3	1	2	3	4
GRADATION	GRAVEL		(%)	0.2	0.4	0.1	0.2	0	0	0	-
	SAND		(%)	22.4	21.8	22.7	21.9	8.5	11.1	7.4	-
	SILT		(%)	31.7	36.3	31.7	35.9	59.9	45.3	66.9	-
	CLAY		(%)	45.7	41.5	45.5	42	31.6	34.2	25.6	-
	MAX DIAMETER		(mm)	4.8	4.8	4.8	4.8	1.2	0.42	2	-
	COEFFICIENT OF UNIFORMITY		Uc	-	-	-	-	-	-	-	-
	COEFFICIENT OF CURVATURE		Uc	-	-	-	-	-	-	-	-
CON-SISTENCY	LIQUID LIMIT		wL(%)	57.6	69.8	55	67	64.5	66	64.8	-
	PLASTIC LIMIT		wP(%)	36.9	33.1	33.7	36	41.4	41	41	-
	PLASTICITY INDEX		IP	20.7	36.7	21.3	31	23.1	25	23.8	-
PERMEABILITY			K(cm/s)	-	2x10-7	-	1x10-7	-	8x10-7	-	-
COM-PACTION	MAX DRY DENSITY		γm(kg/cm3)	-	1.528	-	1.488	-	1.343	-	-
	OPTIMUM MOISTURE CONTENT		wo (%)	-	24.6	-	29.2	-	33	-	-
SPECIFIC GRAVITY OF SOIL			Gs	2.69	2.67	2.657	2.7	2.695	2.94	2.662	-
NATURAL STATE	WATER CONTENT		w (%)	29.2	30.66	30.87	30.93	45.94	43.82	45.86	45.97
	WET DENSITY		γ t(g/m3)	-	-	-	-	-	-	-	-
	VOID RATIO		e	-	-	-	-	-	-	-	-
	DEGREE OF SATUPATION		Sr(%)	-	-	-	-	-	-	-	-
MECHANICAL PROPERTIES	UNCONFINED COM-PRESSION	COMPRESSIVE STRENGTH	σu(kg/cm2)	-	-	-	-	-	-	-	-
		MODULUS OF ELASTICITY	E50(kg/cm2)	-	-	-	-	-	-	-	-
		SENSITIVITY RATIO	St	-	-	-	-	-	-	-	-
	**	TYPE OF TEST	***	-	$\overline{CU}$	-	-	-	$\overline{CU}$	-	-
		COHESION	C(kg/cm2)	-	0.5	-	-	-	1	-	-
	(2)	ANGLE OF INTERNAL FRICTION	ø (o)	-	33	-	-	-	25	-	-
	CONSOLI-DATION	YIELD STRESS OF CONSOLIDATION	Py(kg/cm2)	-	-	-	-	-	0.75	-	-
		COMPRESSION INDEX	Cc	-	-	-	-	-	0.32	-	-
CLASSIFICATION				C'H	C'H	C'H	CH	C'H	C'H	C'H	-

** (1): DIRECT SHEAR (2): TRIAXIAL COMPRESSION
*** UNCONSOLIDATED UNDRAINED: UU CONSOLIDATED UNDRAINED: CU CONSOLIDATED DRAINED: CD

(BAR OVER THE SYMBOL SHOWS THE MEASUREMENT OF PORE WATER PRESSURE)

Table II.3.4 SUMMARY OF LABORATORY TEST (9/10)

SAMPLE NO				TP-15			TP-16		
SAMPLE DEPTH			(m)	1.5	2	3	1	1.5	2.5
GRADATION	GRAVEL		(%)	0.1	0.6	0	0	0	0.1
	SAND		(%)	27	23.7	22.7	32.5	39	45.6
	SILT		(%)	42.9	46.1	44.9	46.7	41.8	62.5
	CLAY		(%)	30	29.6	32.4	20.8	19.2	16.8
	MAX DIAMETER		(mm)	4.8	10	2	1.2	0.6	4.8
	COEFFICIENT OF UNIFORMITY		Uc	-	-	-	-	-	-
	COEFFICIENT OF CURVATURE		Uc	-	-	-	-	-	-
CON-SISTENCY	LIQUID LIMIT		wL(%)	31.5	36	33	27.5	26.8	25.2
	PLASTIC LIMIT		wP(%)	22.4	22	22.4	20.4	19.7	19.7
	PLASTICITY INDEX		IP	9.1	14	10.6	7.1	7.1	5.5
PERMEABILITY			K(cm/s)	-	3x10-7	-	-	-	1x10-7
COM-PACTION	MAX DRY DENSITY		γm(kg/cm3)	-	1.732	-	-	-	1.746
	OPTIMUM MOISTURE CONTENT		wo (%)	-	19.6	-	-	-	17.2
SPECIFIC GRAVITY OF SOIL			Gs	2.558	2.67	2.691	2.415	2.604	2.54
NATURAL STATE	WATER CONTENT		w (%)	24.84	25.52	25.03	26.77	26.94	27.51
	WET DENSITY		γt(g/m3)	-	-	-	-	-	-
	VOID RATIO		e	-	-	-	-	-	-
	DEGREE OF SATUPATION		Sr(%)	-	-	-	-	-	-
MECHANICAL PROPERTIES	UNCONFINED COM-PRESSION	COMPRESSIVE STRENGTH	qu(kg/cm2)	-	-	-	-	-	-
		MODULUS OF ELASTICITY	E50(kg/cm2)	-	-	-	-	-	-
		SENSITIVITY RATIO	St	-	-	-	-	-	-
	**	TYPE OF TEST	***	-	-	-	-	-	-
		COHESION	C(kg/cm2)	-	-	-	-	-	-
	(2)	ANGLE OF INTERNAL FRICTION	ø (o)	-	-	-	-	-	-
	CONSOLI-DATION	YIELD STRESS OF CONSOLIDATION	Py(kg/cm2)	-	-	-	-	-	0.75
		COMPRESSION INDEX	Cc	-	-	-	-	-	0.16
CLASSIFICATION				ML	CL	CL	CL-ML	CL-ML	CL-ML

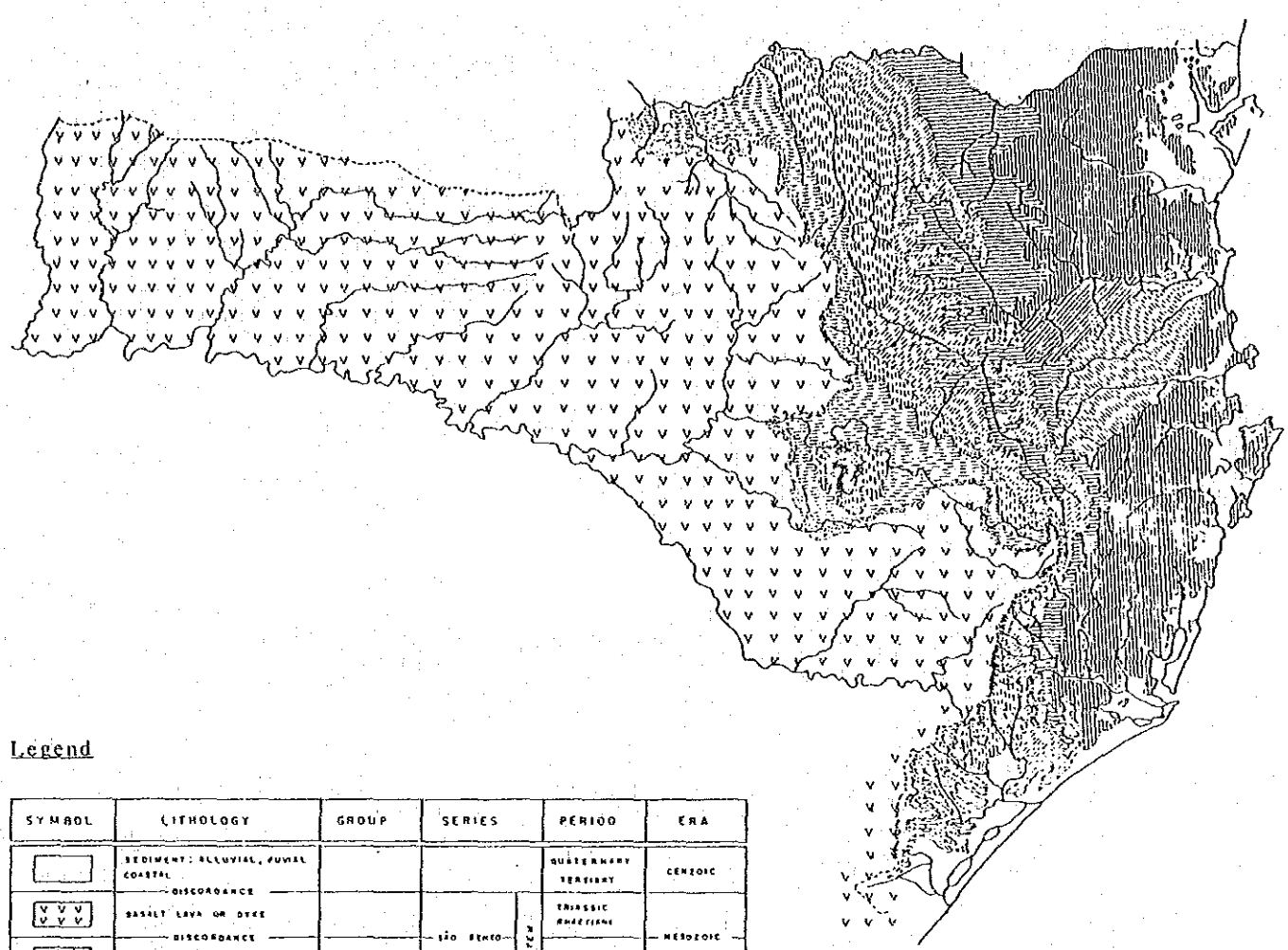
** (1): DIRECT SHEAR (2): TRIAXIAL COMPRESSION
*** UNCONSOLIDATED UNDRAINED: UU CONSOLIDATED UNDRAINED: CU CONSOLIDATED DRAINED: CD

(BAR OVER THE SYMBOL SHOWS THE MEASUREMENT OF PORE WATER PRESSURE)

Table II.3.4 SUMMARY OF LABORATORY TEST (10/10)

Sample NO.		Depth (m)	Natural Moisture Content (%)
SM-2	(3)	19-19.5	28.0
	(4)	25-25.5	33.2
	(5)	25.5-26	31.8
SM-3	(4)	15.5-16	39.5
	(6)	19.5-20	32.7
SM-4	(2)	20.5-21	52.8
SM-5	(2)	5.5-6	35.4
SM-6	(1)	5-5.5	18.3
	(2)	5.5-6	20.2
SM-8	(2)	5.5-6	29.6
	(4)	11-11.5	26.7
SM-9	(2)	5.5-6	32.3
SM-12	(2)	5.5-6	19.8
SM-13	(2)	5.5-6	27.3
SM-14	(2)	5.5-6	30.8
TP-5		1.0	41.66
		3.0	43.93
TP-6		1.0	36.85
		4.0	23.93
TP-7		2.0	29.47
TP-9		1.0	26.65
		3.0	20.80
TP-10		1.5	30.39
		4.0	30.05
		5.0	32.25
TP-11		0.5	32.25
		3.0	22.65
TP-12		1.5	34.09
		3.5	33.90
TP-13		5.0	31.24
TP-14		1.5	44.66
TP-15		1.0	24.33
		4.0	24.77

Figures



Legend

SYMBOL	LITHOLOGY	GROUP	SERIES		PERIOD	ERA
	SEDIMENT: ALLUVIAL, FLUVIAL COASTAL				QUATERNARY TERTIARY	CENZOIC
	DISCORDANCE					
	BASALT LAVA OR DYKE		SÃO BENTO	SYSTEM	TRIASSIC RHAETIAN	MESOZOIC
	DISCORDANCE					
	AEOLIC SANDSTONE				TRIASSIC	
	DISCORDANCE					
	COASTAL SEDIMENTARY ROCKS: SILTSTONE, SHALE, SANDSTONE	RIO DO RASTO	PASSA DOIS	CATARINA	PERMIAN	PALAEOZOIC
	MARINE SEDIMENTARY ROCKS: SHALE, SILTSTONE, SANDSTONE, PHYLLITE	ESTRADA NOVA				
	MARINE SEDIMENTARY ROCKS OF SANAT SILTSTONE	GUATÁ	TUBARÃO	SANTA	CARBONIFEROUS	
	FLUVIAL SEDIMENTARY ROCKS OF FINE SANDSTONE	ITARARÉ				
	DISCORDANCE					
	ANAMETAMORPHIC SANDSTONE, SHALE SILTSTONE; PHYLLITE; VOLCANICS PHYLLITE		ITAJAÍ		CAMBRIAN	
	DISCORDANCE					
	SCHISTS, METAVOLCANIC-SEDIMENT		BRUSQUE		ALGONKIAN	PROTEROZOIC
	DISCORDANCE					
	GNEISSES, MIGMATITES				ARCHAEN	ARCHAEOZOIC
	GRANITE + INTRUSIVE ACID				POST ALGONKIAN	
	RHYOLITE + INTRUSIVE BASIC				POST CAMBRIAN (?) PRE RHAETIC (?)	
	DIABASE + INTRUSIVE BASIC				RHAETICA (?)	

Fig. II.2.1 REGIONAL GEOLOGICAL MAP OF SANTA CATARINA STATE

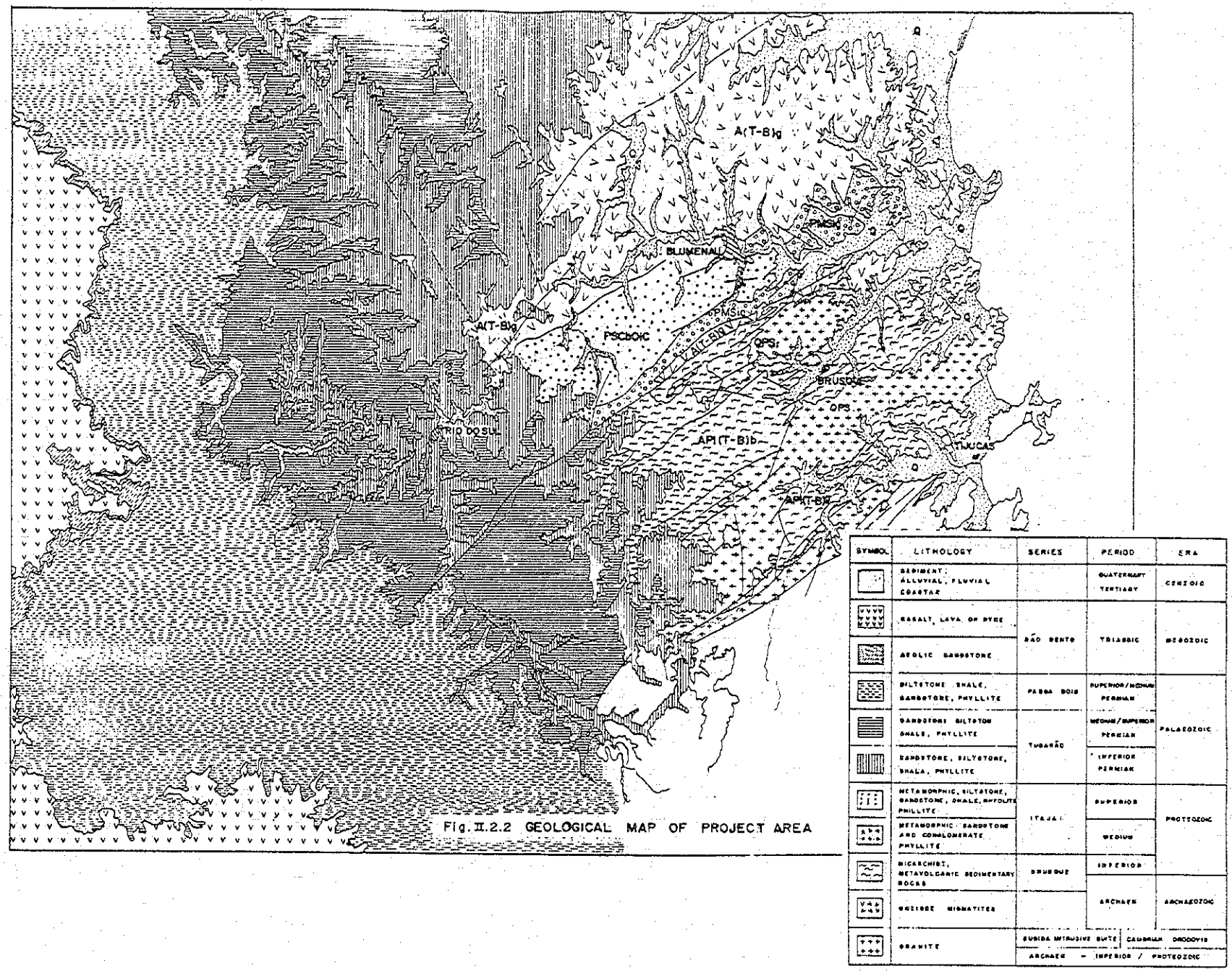


Fig. II.2.2 GEOLOGICAL MAP OF PROJECT AREA

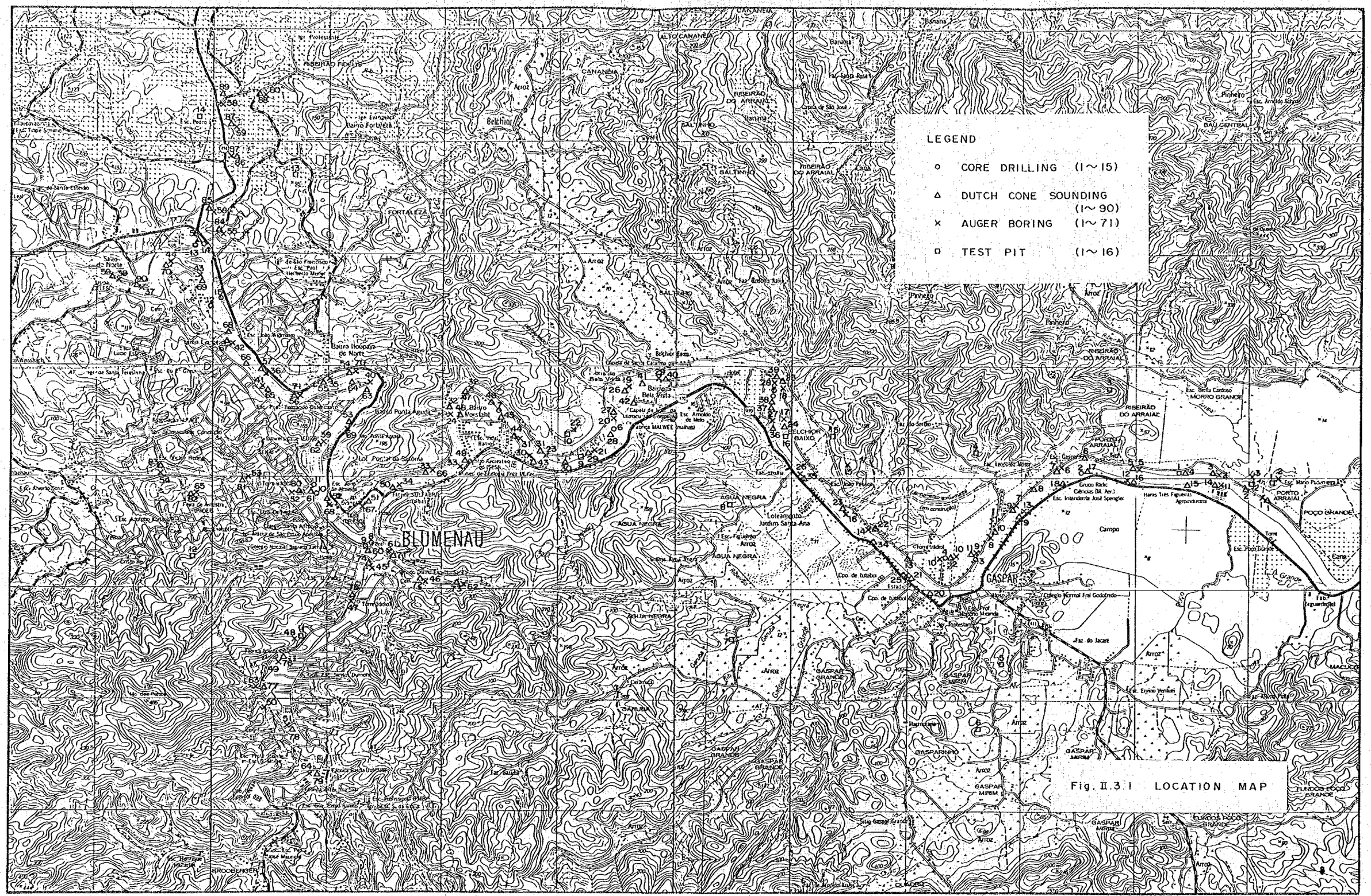


Fig. II.3.1 LOCATION MAP

Fig.II.3.2 GEOLOGIC LOG OF DRILL HOLE (1/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

HOLE NO: SM-1 GROUND EL.: 10,317 ANGLE FROM VERTICAL: VERTICAL

DEPTH OF GROUND WATER TABLE: 4,12 m DATE: 23~29 APRIL 1987 SURVEYED BY:

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	OBSERVATION RECORD: LOG	CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY
	0,3	0,3			ORGANIC CLAY	LIGHT BROWN	· Soft	90%
	1,4	1,1			SILT	BROWN	· Soft	50 %
	4,0	2,6			SANDY. SILT	LIGHT BROWN	· Very soft	15 %
	11,8	7,8			SAND	LIGHT BROWN	· Fine sand · Very loose	5 %
	20,6	8,8			ORGANIC CLAY	BLACK	· Very soft general	4 %
	24,0	3,4			CLAY	GREY	· Medium soft · Higl plastic	50 %
	24,45	0,45			CLAY	LIGHT GREY	· Medium	100 %
	25,00	0,55			SAND	YELLOWISH GREY	· Fine	0%

STANDARD PENETRATION TEST

DEPTH	BLOW / PENE cm	BLOWS PER 15cm: 15cm	BLOWS PER 15cm: 30cm
2,15	1	1	
2,45	30	30	
4,15	3	1	2
4,45	30	15	15
6,15	2	1	1
6,45	30	15	15
8,15	3	1	2
8,45	30	15	15
10,15	4	2	2
10,45	30	15	15
12,15	1	1	
12,45	30	30	
14,15	5	2	3
14,45	30	15	15
16,75	1	1	
17,05	30	30	
18,15	1	1	
18,45	30	30	
21,10	5	2	3
21,40	30	15	15
22,00	4	2	2
22,30	30	15	15
24,00	5	2	3
24,30	30	15	15

N-VALUE: 10 20 30 40

SAMPLING	PERMEABILITY IN SITU (cm/sec)
13,0	
1	
13,5	
16,0	$4,94 \times 10^{-6}$
2	
16,6	
20,0	
3	
4	
21,1	
	$1,12 \times 10^{-5}$

Fig. II.3.2 GEOLOGIC LOG OF DRILL HOLE (2/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

HOLE NO: SM-2 GROUND EL: 7,621 ANGLE FROM VERTICAL: VERTICAL

DEPTH OF GROUND WATER TABLE: 9,08 DATE: 12~31 MAY, 1987 SURVEYED BY:

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	OBSERVATION RECORD: CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY	STANDARD PENETRATION TEST: DEPTH	BLOW / PENE cm	BLOWS PER 15cm: 15cm	30cm	SAMPLING	PERMEABILITY IN SITU (cm/sec)
	2,0	2,0		SILTY CLAY	BROWN	· MEDIUM	100 %						
	2,45	0,45		CLAY	LIGHT BROWN	· SOFT	100 %	2,15	3	1	2		
								2,45	30	15	15		
	4,0	1,55		SILTY SAND	BROWN ~LIGHT BROWN	· FINE SAND · LOOSE	90%						
	4,45	0,45		SILT	LIGHT BROWN		50 %	4,15	4	2	2		
								4,45	30	15	15		
	6,0	1,55		SAND	BROWN	· FINE SAND · LOOSE	25%						
	6,45	0,45		SILT	GREY	· SOFT	100 %	6,15	3	1	2		
								6,45	30	15	15		
	7,0	0,55		SAND	GREY	· FINE SAND	35%						
	7,5	0,5		CLAY	BLAC	· SOFT	100%					7,5	
												1	1,36x10⁻⁵
				SILTY SAND	BROWN	· FINE SAND · VERY LOOSE	50%					8,0	
	8,95	1,45						8,65	3	1	2		
								8,95	30	15	15		
								10,15	9	4	5		
								10,45	30	15	15		
								12,15	18	8	10		
								12,45	30	15	15		
				SAND	LIGHT BROWN	· FINE~MEDIUM · LOOSE~MEDIUM	20%						
								14,45	15	7	8		
								14,45	30	15	15		
													1,75x10⁻⁶
								16,15	12	3	9		
								16,45	30	15	15		
								18,15	8	3	5		
	18,5							18,45	30	15	15	18,5	
												2	
				SILTY SAND	GREY		90%					3	
												19,5	
	20,45							20,15	6	3	3		
				CLAY	BLACK	· ORGANIC · MEDIUM	90%						
	21,8	1,35											
								22,15	4	2	2		
								22,45	30	15	15		
				SILTY CLAY	GREY	· MEDIUM	100%						
								24,15	7	3	4		1,18x10⁻⁵
								24,45	30	15	15		
												25,0	
												4	
	26,0	4,2										5	
												26,0	

N-VALUE: 10 20 30 40

Fig.II.3.2 GEOLOGIC LOG OF DRILL HOLE (3/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

HOLE NO: SM-3 GROUND EL: 9,689 ANGLE FROM VERTICAL: VERTICAL

DEPTH OF GROUND WATER TABLE: 8,20 DATE: 1~21 MAY, 1987 SURVEYED BY:

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	LOG	CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY
	1,0	1,0		W	SAND	LIGHT BROWN	· ROAD SUBGRADE	40%
	2,5	1,5			SAND	BROWN	· FINE SAND · VERY LOOSE	30%
	3,7	1,2			SILTY CLAY	BROWN	· MEDIUM	65%
	6,0	2,3			CLAY	GREY & BROWN	· MEDIUM	60%
	7,0	1,0			SILTY SAND	BROW	· FINE · LOOSE	80%
	8,0	1,0			SAND	BROW	· FINE SAND	50%
	10,0	2,0			SILT	GREY	· VERY LOOSE	30%
	11,0	1,0			SILTY SAND	GREY	· FINE · LOOSE	60%
	12,0	1,0			SILT	GREY		80%
	13,0	1,0			SAND	GREY	· FINE · LOOSE	20%
	15,0	2,0			CLAYEY SILT	DARK GREY	· SOFT	10%
	19,0	4,0			CLAY	DARK GREY	· MEDIUM~SOFT	40%
	22,0	3,0			CLAY	BROWN	· MEDIUM	
	25,0	3,0			CLAY	BROWN & GREY	· STIFF ~ MEDIUM	75%
	27,5	2,5			CLAY	BROWNISH GREY	· MEDIUM	50%
	28,5	1,0			SAND & GRAVEL		MAX SIZ 30mm	10%
	30,4	1,9			GRAVEL		10 ~ 20mm	5%
	32,5	2,1			ROCK	DARK GREEN	ALTERNATION OF SILT STONE & SAND STONE	50%

STANDARD PENETRATION TEST

DEPTH	BLOW / PENE cm	BLOWS PER 15cm 15cm	30cm
2,15	3	1	2
2,45	30	15	15
4,15	4	2	2
4,45	30	15	15
6,15	6	3	3
6,45	30	15	15
8,15	1	1	
8,45	30	30	
10,15	4	2	2
10,45	30	15	15
12,15	6	2	2
12,45	30	15	15
14,15	3	1	2
14,45	30	15	15
16,15	5	2	3
16,45	30	15	15
18,15	1	1	
18,45	30	30	
20,15	7	3	4
20,45	30	15	15
22,15	12	5	7
22,45	30	15	15
24,15	5	2	3
24,45	30	15	15
26,15	8	3	5
26,45	30	15	15
28,15	38	14	24
28,45	30	15	15

N-VALUE: 10 20 30 40

SAMPLING	PERMEABILITY IN SITU (cm/sec)
9,0	
1	
2	
10,0	
15,0	
3	
4	3.08×10^{-6}
16,0	
19,0	
5	
6	
20,0	
25,0	1.78×10^{-6}
7	
8	
26,0	

2.15×10^{-6}

Fig.II.3.2 GEOLOGIC LOG OF DRILL HOLE (4/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

HOLE NO: SM-4 GROUND EL: 7,256 ANGLE FROM VERTICAL: VERTICAL

DEPTH OF GROUND WATER TABLE: 7,20 DATE: 10~14 JUNE, 1987 SURVEYED BY:

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	OBSERVATION RECORD: LOG	CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY
	1,60	1,6		W		GREY~REDDIS BROWN	SUBGRADE OF ROOD	45%
	2,45	0,85			SAND	LIGHT BROWN	·MEDIUM SIZE ·LOOSE	20%
	3,00	0,55			SANDY SILT	BROWN	·FINE SOND	30%
	4,45	1,45			SAND	BROWN	·MEDIUM~COARSE ·LOOSE	35%
	6,00	1,55			SAND	LIGHT BROWN	·FINE ·LOOSE	30%
	8,45	2,45	▽		ORGANIC CLAY	BLACK	·THIN SILT LAYER & PEAT INTERCALATED ·SOFT	95%
	16,45	8,00			SILTY SAND	GREY	·FINE SAND ·MEDIUM	35%
	21,60	5,15			ORGANIC CLAY	BLACK~DARK GREY	·16,45~18,0m ALTERNATION OF ORGANIC CLAY & FINE SAND (OR SILT) ·18,0~21,6m MOSTLY ORGANIC CLAY ·SOFT	60%
	26,50	4,90			SILTY SAND	GREY	·FINE SAND ·LOOSE	40%
	29,50	3,00			ROCK		GNEISS	50%

STANDARD PENETRATION TEST

DEPTH	BLOW / PENE cm	BLOWS PER 15cm 15cm	30cm	N~VALUE
2,15	6	3	3	
2,45	30	15	15	
4,15	5	2	3	
4,45	30	15	15	
6,15	4	2	2	
6,45	30	15	15	
8,15	3	1	2	
8,45	30	15	15	
10,15	17	8	9	
10,45	30	15	15	
12,15	14	7	7	
12,45	30	15	15	
14,15	22	11	11	
14,45	30	15	15	
16,15	6	1	5	
16,45	30	15	15	
18,15	4	2	2	
18,45	30	15	15	
19,15	3	2	1	
19,45	30	15	15	
22,15	2	1	1	
22,45	30	15	15	
24,15	7	3	4	
24,45	30	15	15	
26,15	9	2	7	
26,45	30	15	15	

N~VALUE scale: 10 20 30 40

SAMPLING: 20,0 / 1 / 2 / 21,0

PERMEABILITY IN SITU (cm/sec): $1,69 \times 10^{-6}$; $8,00 \times 10^{-6}$

Fig. II.3.2 GEOLOGIC LOG OF DRILL HOLE (5/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

HOLE NO.: SM-5 GROUND EL.: 9,904 ANGLE FROM VERTICAL: VERTICAL

DEPTH OF GROUND WATER TABLE: 4,07 DATE: 26~31 MAY, 1987 SURVEYED BY:

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	OBSERVATION RECORD: CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY	STANDARD PENETRATION TEST: DEPTH	BLOW / PENE cm	BLOWS PER 15cm: 15cm	30cm	SAMPLING	PERMEABILITY IN SITU (cm/sec)
	0,5	0,5		SILTY SAND	BROWN	· FILL MATERIAL	95%						
	1,0	0,5		SILTY SAND	GREY	· FINE SAND	60%						
	1,5	0,5		CLAYEY SILT	DARK BROWN	· MEDIUN	50%						
	2,45	0,95		SANDY SILT	BROWN	· FINE SAND · MEDIUM	85%	2,15 2,45	7 30	3 15	4 15		
	4,45	2,0	▽	SILTY CLAY	LIGHT BROWN	· MEDIUM	70%	4,15 4,45	5 30	2 15	3 15		
	6,2	1,75		SILTY CLAY	BROWN	· MEDIUM ~ SOFT	90%	6,15 6,45	3 30	1 15	2 15	5,0 2 6,0	
	8,8	2,6		ORGANIC CLAY	BLACK	· MEDIUM	80%	8,15 8,45	5 30	2 15	3 15		$1,27 \times 10^{-4}$
	10,0	1,2		SANDY CLAY	BLACK	ORGANIC MATERIAL	40%	10,15 10,45	3 30	1 15	2 15		
	12,0	2,0		SAND		· FINE · VERY LOOSE	0%						
	12,6	0,6		CLAY	BLACK	· STIFF	100%	12,15 12,45	15 30	6 15	9 15		
	14,5	1,9		SAND	GREY	· FINE ~ MEDIUM · VERY LOOSE	10%	14,15 14,45	8 30	4 15	4 15		
	15,0	0,5		CLAY	DARK GREY	· ORGANIC	80%						
	25,0	10,0		SAND	GRAY	· MEDIUM · CONTAINING SMALL AMOUNT OF FINE SAND · LOOSE ~ MEDIUM	15%	16,15 16,45 18,15 18,45 20,15 20,45 22,15 22,45 24,15 24,45	5 30 23 30 15 30 14 30 11 30	2 15 11 15 7 15 6 15 5 15	3 15 12 15 8 15 8 15 6 15		$4,84 \times 10^{-6}$ $2,02 \times 10^{-6}$

N-VALUE: 10 20 30 40

Fig.II.3.2 GEOLOGIC LOG OF DRILL HOLE (6/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

HOLE NO: SM-6 GROUND EL: 7,272 ANGLE FROM VERTICAL: VERTICAL

DEPTH OF GROUND WATER TABLE: 10,40 DATE: 11~15 JUNE, 1987 SURVEYED BY:

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY
	1,5	1,5		CLAY	BROWN	·Soft	80%
	2,0	0,5		SANDY SILT	BROWN	·Fine sand	80%
	6,0	4,0		SILTY SAND	BROWN	·Fine sand ·Loose	50%
	9,0	3,0		SAND	BROWN ~ GREYISL BROWN	·Fine sand ·Loose	40%
	10,0	1,0		SAND	BROWN	·Fine sand	40%
	14,0	4,0		SAND	GREY	·Medium sand ·Small amount of Fine sand ·Medium	35%
	16,2	2,2		SANDY SILT	BROWN	·Fine sand ·Medium	50%
	17,0	0,8		SAND	GREY	·Fine~medium	50%
	18,0	1,0		SAND	REDDISH BROWN	·Fine medium ·Containing a few gravel (2cm)	20%
	20,0	2,0		GAVELLY SAND	REDDISH BROWN	·Well graded	10%
	22,6	2,6		SANDY GRAVEL	GREYISL	·Gravel size 1cm~5cm	20%
	24,6	2,0		ROCK	VIOLET	·Metamorphosed Sand stone	90%

STANDARD PENETRATION TEST

DEPTH	BLOW / PENE cm	BLOWS PER 15cm 15cm	30cm
2,15	3	1	2
2,45	30	15	15
4,15	4	2	2
4,45	30	15	15
6,15	4	2	2
6,45	30	15	15
8,15	8	3	5
8,45	30	15	15
10,15	9	4	5
10,45	30	15	15
12,15	10	4	6
12,45	30	15	15
14,15	6	2	4
	30	15	15
16,15	10	4	6
16,45	30	15	15
18,15	17	7	10
18,45	30	15	15
20,15	23	13	10
20,45	30	15	15
22,15	40	16	24
22,45	30	15	15

N-VALUE: 10 20 30 40

SAMPLING: 5,0 / 1 / 2 / 6,0

PERMEABILITY IN SITU (m/sec): $8,33 \times 10^{-6}$; $5,28 \times 10^{-6}$; $2,74 \times 10^{-6}$

Fig.II.3.2 GEOLOGIC LOG OF DRILL HOLE (7/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

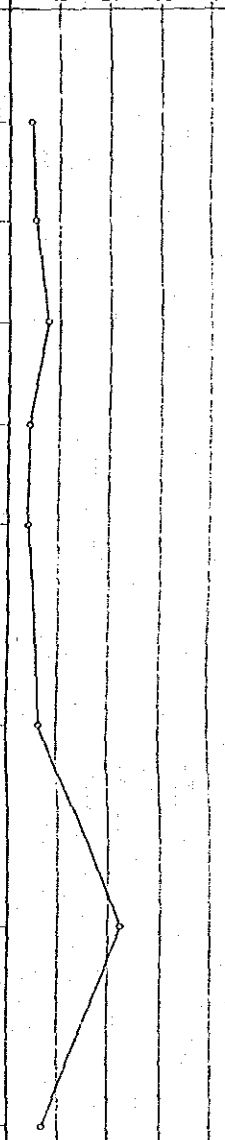
HOLE NO: SM-7 GROUND EL.: 12,179 ANGLE FROM VERTICAL: VERTICAL

DEPTH OF GROUND WATER TABLE: 13,80 DATE: 24 MAY ~ 3 JUNE, 1987 SURVEYED BY:

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	OBSERVATION RECORD: LOG	CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY
					SILTY SAND	BROWN	· FINE SAND · LOOSE	40%
	4,5	4,5						
	5,0	0,5			SAND	GREY	· FINE~MEDIUM	50%
					SILTY SAND	BROWN	· FINE SAND · COMPACT	60%
	7,0	2,0						
					SAND	GREY	· FINE · LOOSE	20%
	10,45	3,45						
	11,0	0,55			SILT	BROWN		90%
	12,0	1,0			SAND	GREY	· FINE ~ MED	20%
	13,0	1,0			SILTY CLAY	DARK GREY	· MEDIUM	60%
	14,0	1,0			SAND	GREY	· MEDIUM SAND	20%
	15,0	1,0			SILTY SAND	DARK GREY	· FINE · COMPACT	90%
	15,5	0,5			SAND	GREY	· FINE	20%
	16,0	0,5			SILTY SAND	DARK GREY	· FINE / COMPACT	80%
	17,0	1,0			SILTY CLAY	DARK GREY	· SOFT	50%
	17,5	0,5			SAND	GREY	· FINE	10%
	18,0	0,5			CLAY	DARK GREY	· SOFT	100%
	18,45	0,45			SAND	DARK GREY	· MED.~COARSE, MEDIUM	20%
					SAND	GREY	· FINE · LOOSE	20%
	23,5	5,05						
	25,6	2,1			ROCK	VIOLET	· METAMORPHOSED SAND STONE	75%

STANDARD PENETRATION TEST

DEPTH	BLOW / PENE cm	BLOWS PER 15cm: 15cm	30cm
2,15	4	2	2
2,45	30	15	15
4,15	5	2	3
4,45	30	15	15
6,15	8	3	5
6,45	30	15	15
8,15	4	2	2
8,45	30	15	15
10,15	4	2	2
10,45	30	15	15
14,15	6	2	4
14,45	30	15	15
18,15	22	11	11
18,45	30	15	15
22,15	7	3	4
22,45	30	15	15



SAMPLING

PERMEABILITY IN SITU (cm/sec)

$3,54 \times 10^{-6}$

$1,95 \times 10^{-5}$

Fig.II.3.2 GEOLOGIC LOG OF DRILL HOLE (8/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

HOLE NO: SM-8 GROUND EL: 10,290 ANGLE FROM VERTICAL: VERTICAL

DEPTH OF GROUND WATER TABLE: 2,86 DATE: 2~4 JUNE, 1987 SURVEYED BY:

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	LOG	CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY
	0,8	0,8		W	SILTY CLAY	BROWN	· FILL MATERIAL	80%
	3,4	2,6			CLAYEY SILT	GREYISH BROWN	· CONTAINING SMALL AMOUNT OF SAND SPORADICALLY · SOFT	80%
	4,6	1,2			CLAY	GREY	· FAT · SOFT	100%
	7,0	2,4			SILT CLAY	GREY	· SOFT	50%
	8,0	1,0			CLAY	GREY	· SOFT	100%
	9,0	1,0			SILTY SAND	GREY	· FINE · LOOSE	70%
	10,0	1,0			CLAY	DARK GRAY	· ORGANIC · SOFT	100%
	12,8	2,8			CLAYEY SILT	GREY	· MEDIUM	60%
	13,5	0,7			SILTY SAND	BROWN GREY	· MEDIUM	60%
	14,3	0,8			GRAVEL		SIZE: 20mm~50mm	30%
	19,0	4,7			ROCK/ GNEISS	GREY	14,3 ~ 14,6: HIGHLY FRACTURED CALCITE VEIN CRACK: 30mm~300mm	90%

STANDARD PENETRATION TEST

DEPTH	BLOW / PENE cm	BLOWS PER 15cm 15cm	30cm	N-VALUE
2,15	3	1	2	
2,45	30	15		
4,15	2	1	1	
4,45	30	15	15	
6,15	3	1	2	
6,45	30	15	15	
8,15	5	2	3	
8,45	30	15	15	
10,15	7	3	4	
10,45	30	15	15	
12,15	9	3	6	
12,45	30	15	15	

N-VALUE: 10 20 30 40

SAMPLING	PERMEABILITY IN SITU (cm/sec)
5,0	
1	
2	
6,0	
	$1,03 \times 10^{-5}$
10,5	
3	
4	
11,5	

Fig.II.3.2 GEOLOGIC LOG OF DRILL HOLE (9/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

HOLE NO: SM-9 GROUND EL: 7,100 ANGLE FROM VERTICAL: VERTICAL

DEPTH OF GROUND WATER TABLE: 7,20 DATE: 4~8 JUNE, 1987 SURVEYED BY:

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	OBSERVATION RECORD: LOG	CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY	STANDARD PENETRATION TEST: DEPTH	BLOW / PENE cm	BLOWS PER 15cm: 15cm	30cm	N-VALUE	SAMPLING	PERMEABILITY (IN SITU) (cm/sec)
	0,7	0,7			SAND CLAY	LIGHT BROWN	ALTERNATION OF S+C	70%							
	2,8	2,1			SILTY CLAY	GREY	· SOFT	85%	2,15 / 2,45	2 / 30	1 / 15	1 / 15			
	6,0	4,2			SILT SAND	BROWN	· FINE SAND · VERY LOOSE	65%	4,15 / 4,45	2 / 30	1 / 15	1 / 15		5,0 / 1 / 2	
	6,5	0,5			SAND	BROWN	· MEDIUM & DENSE	20%	6,0 / 6,2	10 / 5				6,0	
	8,0	1,5			SILTY SAND	BROWN	· FINE SAND	50%							8,19x10⁻⁶
	9,65	1,85			SAND	GREY	· MED. SAND · MEDIUM	20%	8,15 / 8,45	14 / 30	7 / 15	7 / 15			
	11,3	1,45			GRAVEL OR PEBBLE			50%							
	16,1	4,8			SANDY & SILTY CLAY WITH GRAVEL & PEBBLE			15%							4,39x10⁻⁶
	20,0	3,9			ROCK		GNEISS	80%							1,81x10⁻⁶
															2,73x10⁻⁵

Fig. II.3.2 GEOLOGIC LOG OF DRILL HOLE (10/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

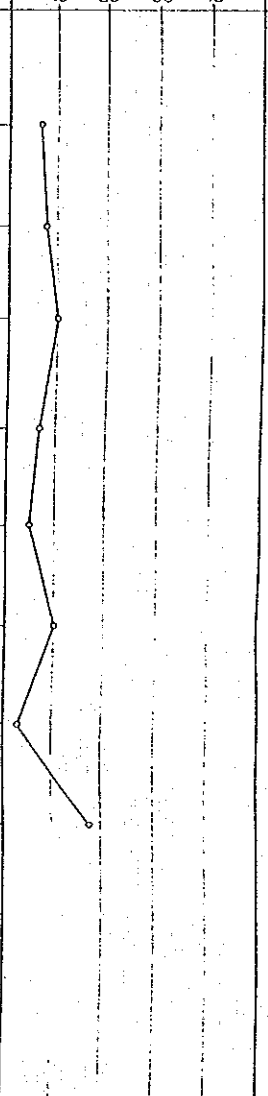
HOLE NO: SM-10 GROUND EL: 10,467 ANGLE FROM VERTICAL: VERTICAL

DEPTH OF GROUND WATER TABLE: 20,00 DATE: 6~12 JUNE, 1987 SURVEYED BY:

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	LOG	CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY
	1,0	1,0			SILTY CLAY	BROWN	· SMALL AMOUNT OF ROOTS	50%
	6,45	5,45			GRAVELLY CLAY	REDDISH	· MEDIUM~STIFF	40%
	7,0	0,55			CLAY	BROWN		55%
	7,5	0,5			CLAYEY SILT	BROWN		100%
	8,2	0,7			CLAY	GREY		100%
	11,5	3,3			SAND	REDDISH BROWN	· MEDIUM · LOOSE	20%
	11,9	0,4			GRAVELLY SAND		GRAVEL 20~50mm	
	12,0	0,1			CLAY	DARK GREY	· FINE ~MEDIUM	10%
	13,0	1,0			SAND	LIGHT GREY	· MEDIUM (Dr)	
	14,0	1,0			SILTY SAND	GREY	· FINE SAND	10%
	17,0	3,0			SAND	LIGHT REDDISH BROWN	· MEDIUM · LOOSE~MEDIUM	20%
	19,8	2,8			GRAVEL		ROUND 20~30mm	20%
	21,6	1,8			ROCK		CONGLOMERATE	20%

STANDARD PENETRATION TEST

DEPTH	BLOW / PENE cm	BLOWS PER 15cm 15cm	30cm	N-VALUE	SAMPLING	PERMEABILITY IN SITU (cm/sec)
2,15	7	3	4			
2,45	30	15	15			
4,15	8	3	5			
4,45	30	15	15			
6,15	10	2	8			
6,45	30	15	15			
8,15	7	2	5			$2,88 \times 10^{-6}$
8,45	30	15	15			
10,15	5	2	3			
10,45	30	15	15			
12,15	10	3	7			
12,45	30	15	15			
14,15	3	1	2			
14,45	30	15	15			
16,15	17	5	12			$1,24 \times 10^{-5}$
6,45	30	15	15			



$1,11 \times 10^{-5}$

Fig.II.3.2 GEOLOGIC LOG OF DRILL HOLE (11/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

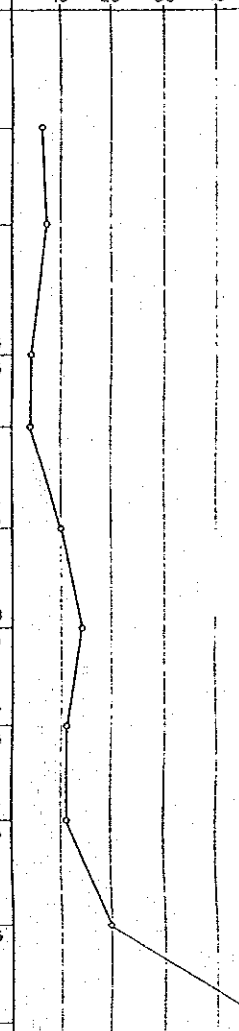
HOLE NO: SM-11 GROUND EL: 14,065 ANGLE FROM VERTICAL: VERTICAL

DEPTH OF GROUND WATER TABLE: 6,80 DATE: 5~9 JUNE, 1987 SURVEYED BY:

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	LOG	CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY
	1,7	1,7		W		REDDISH BROWN	FILL MATERIAL	90%
	2,0	0,3			SILTY CLAY	BROWN	· MEDIUM	100%
	4,45	2,45			CLAY	LIGHT BROWN	· MEDIUM	80%
	9,00	4,55			CLAY	LIGHT BROWN	· SOFT	45%
	10,3	1,3			CLAY	LIGHT BROWN	· MEDIUM	50%
	15,2	4,9			CLAY	REDDISH BROWN	· STIFF	60%
	16,3	1,1			CLAY	GREYISH BROWN	· MEDIUM ~ STIFF	100%
	21,25	4,95			SAND	LIGHT BROWN	· FINE ~ MEDIUM SIZE · MEDIUM ~ DENSE	20%
	23,25	2,0			ROCK	VIOLET	· METAMORPHOSED SAND STONE	50%

STANDARD PENETRATION TEST

DEPTH	BLOW / PENE cm	BLOWS PER 15cm 15cm	30cm
2,15	6	3	3
2,45	30	15	15
4,15	7	3	4
4,45	30	15	15
6,65	4	1	3
6,95	30	15	15
8,15	4	2	2
8,45	30	15	15
10,15	10	4	6
10,45	30	15	15
12,15	14	6	8
12,45	30	15	15
14,15	11	4	7
14,45	30	15	15
16,0	11	4	7
16,3	30	15	15
18,15	20	9	11
18,45	30	15	15
20,0	15		
20,05	5		



SAMPLING	PERMEABILITY IN SITU (cm/sec)
5,0	
1	
5,5	
7,5	
2	$2,78 \times 10^{-6}$
8,0	
9,0	
3	
9,5	
	$5,66 \times 10^{-6}$

Fig.II.3.2 GEOLOGIC LOG OF DRILL HOLE (12/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

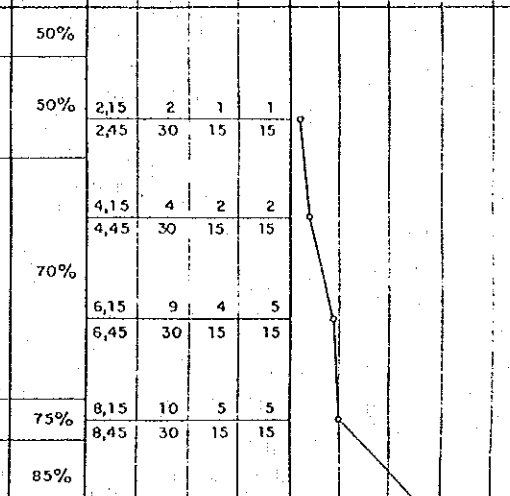
HOLE NO: SM-12 GROUND EL: 12,597 ANGLE FROM VERTICAL: VERTICAL

DEPTH OF GROUND WATER TABLE: 0,50 DATE: 15~16 JUNE, 1987 SURVEYED BY:

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	OBSERVATION RECORD: LOG	CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY
	1,0	1,0			SANDY SILT	BROWN	· FINE SAND · MEDIUM	50%
	3,0	2,0			SILTY CLAY	BROWN	· VERY SOFT	50%
	7,8	4,8			SILTY CLAY	BROWN	· SOFT ~ MEDIUM	70%
	8,6	0,8			SILTY SAND	BROWN	· FINE SAND · MEDIUM	75%
	10,0	1,4			SAND	GREYISH BROWN	· FINE SAND · MEDIUM	85%
	11,6	1,6			SAND	LIGHT BROWN	· MEDIUM SAND · MEDIUM	85%
	13,6	2,6			ROCK	GREY	· GNEISS	100%

STANDARD PENETRATION TEST

DEPTH	BLOW / PENE cm	BLOWS PER 15cm: 15cm	BLOWS PER 15cm: 30cm	N-VALUE
2,15	2	1	1	
2,45	30	15	15	
4,15	4	2	2	
4,45	30	15	15	
6,15	9	4	5	
6,45	30	15	15	
8,15	10	5	5	
8,45	30	15	15	
10,15	29	13	16	
10,45	30	15	15	



SAMPLING: 5,0 / 1 / 2 / 6,0

PERMEABILITY IN SITU (cm/sec): $2{,}01 \times 10^{-4}$

Fig. II.3.2 GEOLOGIC LOG OF DRILL HOLE (13/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

HOLE NO: SM-13 GROUND EL: 14,230 ANGLE FROM VERTICAL: VERTICAL

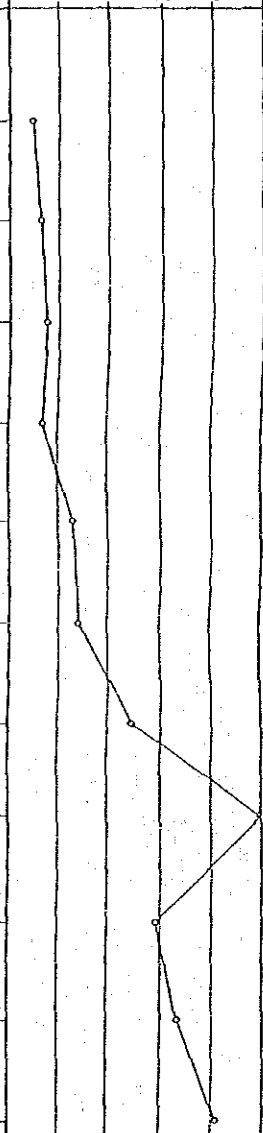
DEPTH OF GROUND WATER TABLE: 7,86 DATE: 10~13 JUNE, 1987 SURVEYED BY:

OBSERVATION RECORD

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	LOG	CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY
	0,5	0,5			ORGANIC CLAY	BLACK		20%
	1,2	0,7			SANDY CLAY	REDDISH BROWN		70%
	8,9	7,7			SILTY CLAY	BROWN	· MEDIUM	50%
	9,6	0,7			SILT	GREY	· STIFF	100%
	10,45	0,85			SILT	BROWN	· STIFF	70%
	13,7	3,25			CLAY	YELLOWISL BROWN	· STIFF	45%
	22,45	8,75			SILTY CLAY	BROWN/YELLOW	· DECOMPOSED GNEISS · GRAVELS OF GNEISS CONTAINED SPORADICALLY	50%
	23,0	0,55			SANDY GRAVEL		QUARTZITE GRAVEL	30%
	24,0	1,0			SAND	GREY	FINE ~ MEDIUM	20%
	28,0	4,0			ROCK	GREY	· GNEISS	25%

STANDARD PENETRATION TEST

DEPTH	BLOW / PENE cm	BLOWS PER 15cm 15cm	30cm
2,15	5	2	3
2,45	30	15	15
4,15	6	2	4
4,45	30	15	15
6,15	7	3	3
6,45	30	15	15
8,15	6	3	3
8,45	30	15	15
10,15	13	5	8
10,45	30	15	14
12,15	14	5	9
12,45	30	15	15
14,15	25	10	15
14,45	30	15	15
16,0	25		
16,06	6		
18,15	29	13	16
18,45	30	15	15
20,15	33	15	18
20,45	30	15	15
22,15	41	18	23
22,45	30	15	15



SAMPLING	PERMEABILITY IN SITU (cm/sec)
5,0	
1	
2	
6,0	
	$1,66 \times 10^{-5}$
10,5	
3	
11,0	
	$9,01 \times 10^{-6}$

Fig.II.3.2 GEOLOGIC LOG OF DRILL HOLE (14/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

HOLE NO: SM-14 GROUND EL: 14,414 ANGLE FROM VERTICAL: VERTICAL

DEPTH OF GROUND WATER TABLE: 11,93 DATE: 7~9 JUNE, 1987 SURVEYED BY:

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	OBSERVATION RECORD: LOG	CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY
	0,4	0,4		W		BLACK,GREY	DECOMPOSED GNEISS	100%
	2,5	2,1			SILTY CLAY	REDDISH BROWN	FILL MATERIAL	50%
	5,0	2,5			SILTY SAND	BROWN	· FINE SAND · MEDIUM DENSITY	80%
	9,6	4,6			SILT	GREY	· STIFF~MEDIUM	65%
	11,3	1,7			CLAY	GREY	· SOFT~MEDIUM	70%
	13,7	2,4	▽		SAND	LIGHT BROWN	· MEDIUM SAND DENSITY	20%
	17,0	3,3			ROCK		GNEISS	100%

STANDARD PENETRATION TEST: DEPTH	BLOW / PENE cm	BLOWS PER 15cm: 15cm	30cm	SAMPLING	PERMEABILITY IN SITU (cm/sec)
2,15	9	4	5		
2,45	30	15	15		
4,15	10	4	6		
4,45	30	15	15	5,0	
				1	
6,15	9	4	5	2	
6,45	30	15	15	6,0	
8,15	9	3	6		5,85x10⁻⁵
8,45	30	15	15		
10,0	4	2	2		
10,3	30	15	15		
12,15	15	6	9		
12,45	30	15	15		

N-VALUE: 10 20 30 40

Fig. II.3.2 GEOLOGIC LOG OF DRILL HOLE (15/15)

PROJECT: GEOTECHNICAL INVESTIGATION FOR ITAJAI RIVER BASIN FLOOD CONTROL PROJECT (JICA)

HOLE NO: SM-15 GROUND EL: 8,364 ANGLE FROM VERTICAL: VERTICAL

DEPTH OF GROUND WATER TABLE: 6,12 DATE: 17~18 JUNE, 1987 SURVEYED BY:

ELEVATION (m)	DEPTH (m)	THICKNESS (m)	G.W.L (m)	OBSERVATION RECORD: LOG	CLASSIFICATION	COLOR	DESCRIPTION	CORE RECOVERY
	1,6	1,6			SANDY SILL	BROWN	· MEDIUM	90%
	2,45	0,85			SAND	BROWN	· FINE SAND · LOOSE	70%
	4,0	1,55			SANDY SILT	BROWN	· FINE SAND · MEDIUM	100%
	6,45	2,45	▽		BOULDERS		· WEATHERED BOULDER	5%
	7,0	0,55			BOULDER		· GNEISS	20%
	8,1	1,1			SAND	GREY	· MEDIUM SAND	20%
	8,3	0.2			GRAVEL		QUARTZITE	50%
	10,8	2,5			ROCK	DARK GREY	GNEISS	80%

STANDARD PENETRATION TEST

DEPTH	BLOW / PENE cm	BLOWS PER 15cm: 15cm	BLOWS PER 15cm: 30cm	N-VALUE	SAMPLING	PERMEABILITY IN SITU (cm/sec)
2,15	4	2	2			
2,45	30	15	15			
4,0	7	3	4			
4,3	30	15	15			
6,15	27	14	13			
6,45	30	15	15			
8,0	25					$2,77 \times 10^{-5}$
8,05	5					

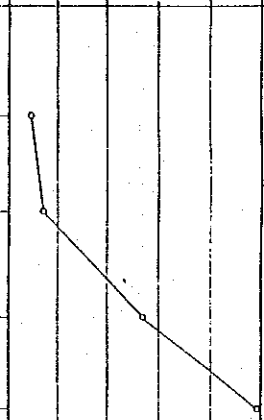
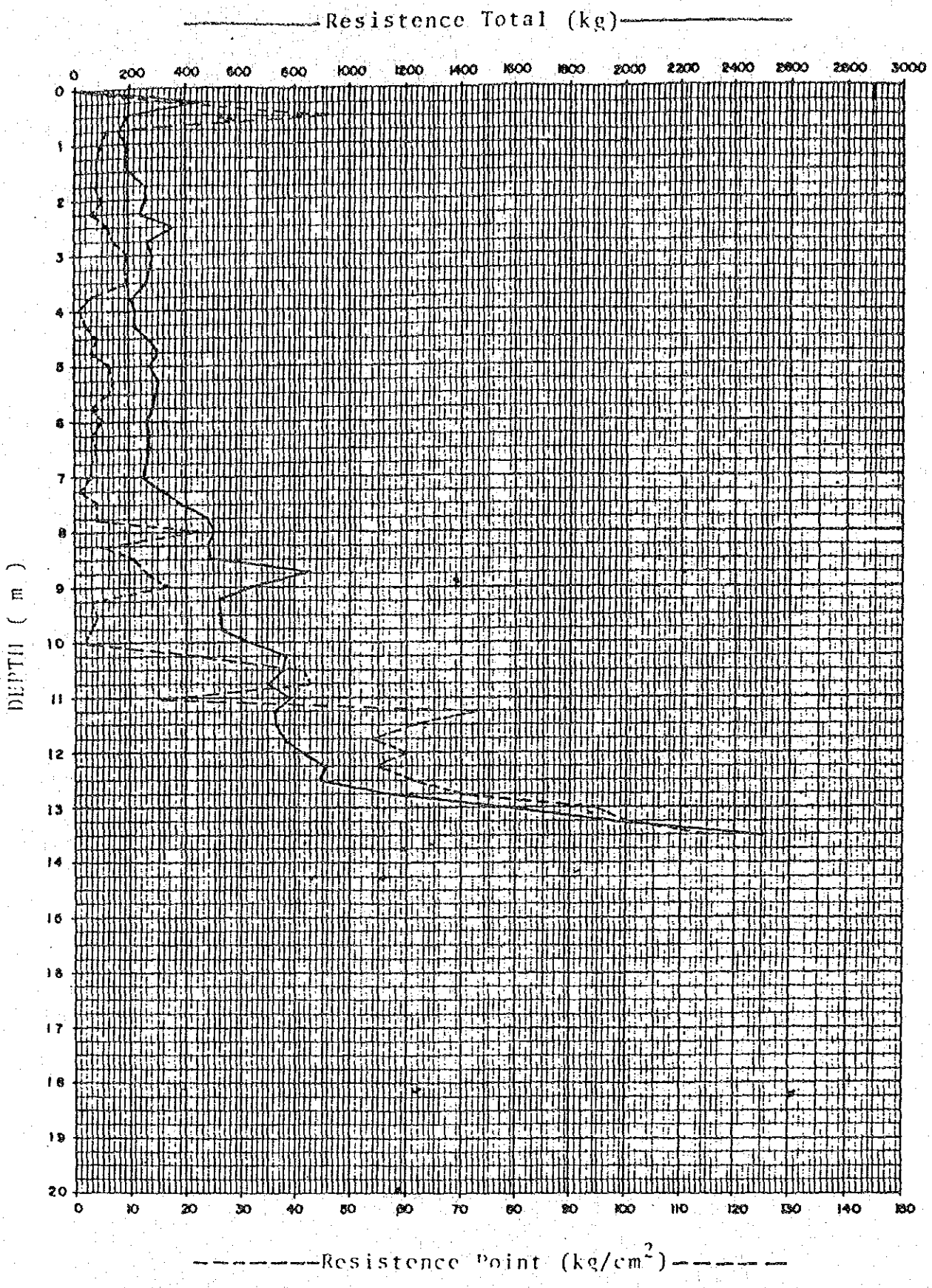
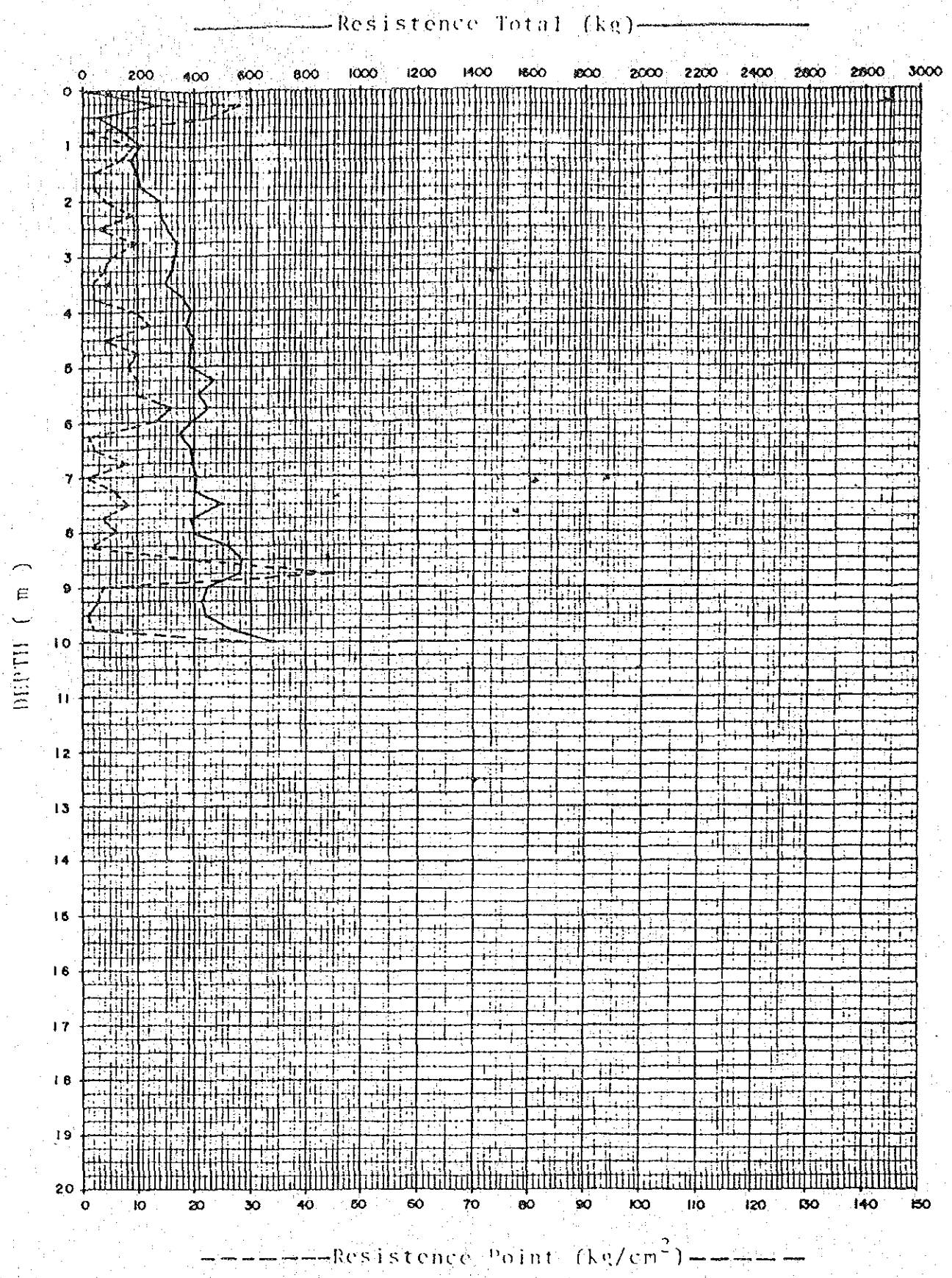


Fig.II33 DUTCH CONE SOUNDING TEST RESULT (1/8)



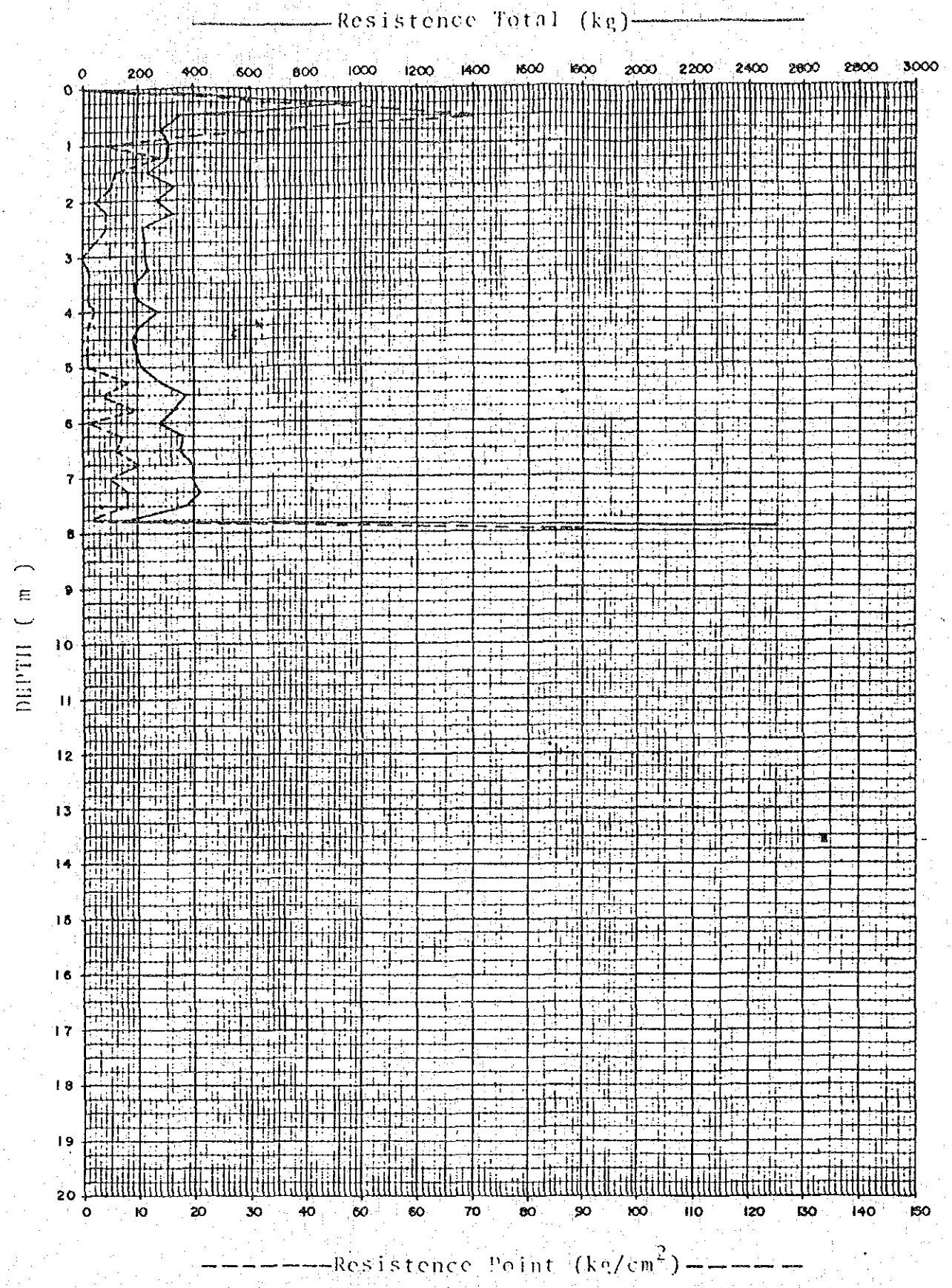
PROJECT NAME: JAPAN INTERNATIONAL COOPERATION AGENCY LOCATION : Itajai River - BLUMENAU - SC - BRAZIL		REF.: RS/SC/5444
Nº 58	DRAWER: Alan	DRAWING Nº:
ELEVATION: 14,230	DATE : June,04/87	ENGINEER:

Fig.II.33 DUTCH CONE SOUNDING TEST RESULT (2/8)



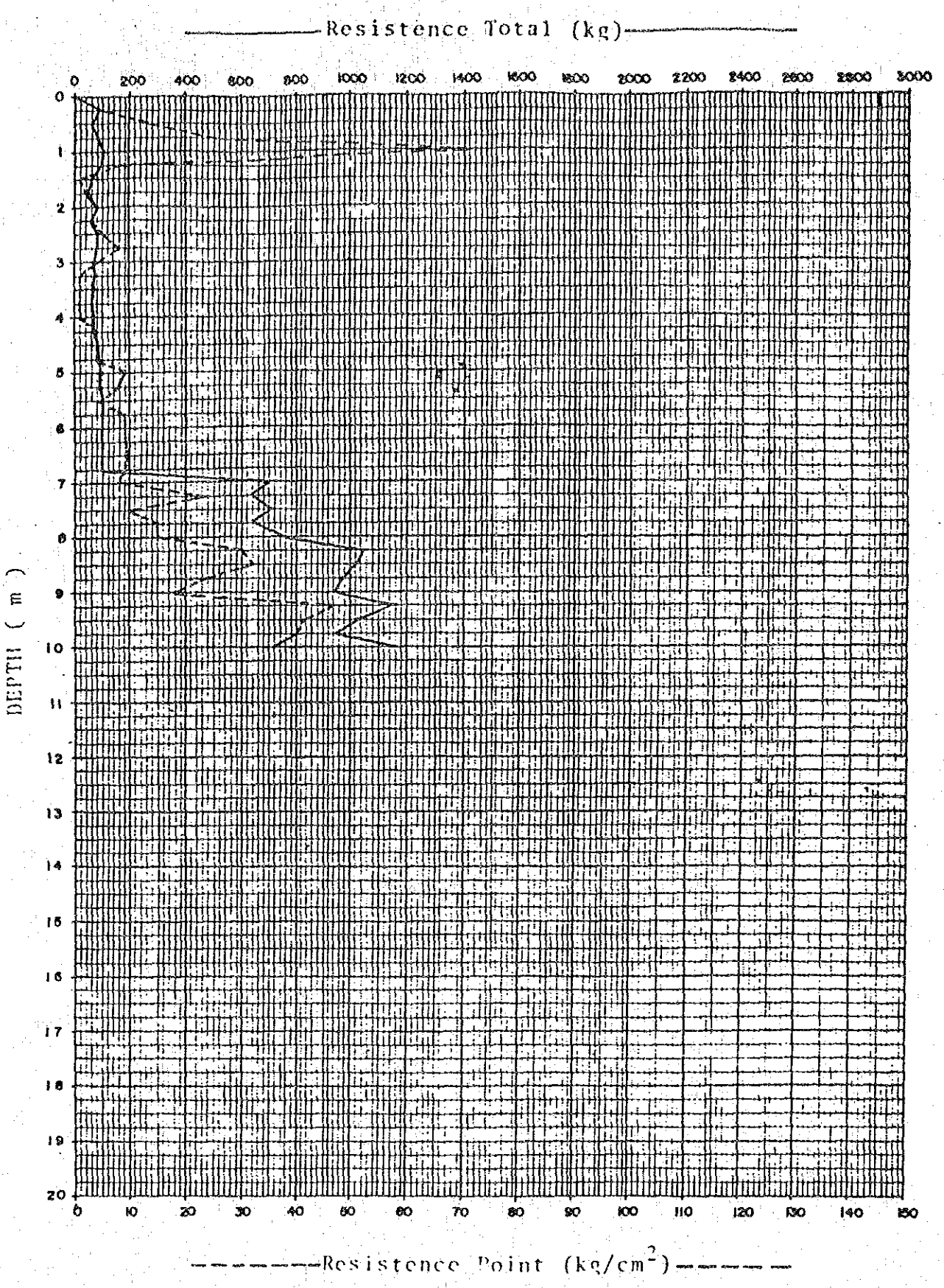
PROJECT NAME: JAPAN INTERNATIONAL COOPERATION AGENCY LOCATION : Itajai River - BLUMENAU - SC - BRAZIL		REF. : RS/SC/5444
Nº 65	DRAWER: Alan	DRAWING Nº:
ELEVATION: 14,488	DATE : June,10/87	ENGINEER:

Fig.II 33 DUTCH CONE SOUNDING TEST RESULT (3/8)



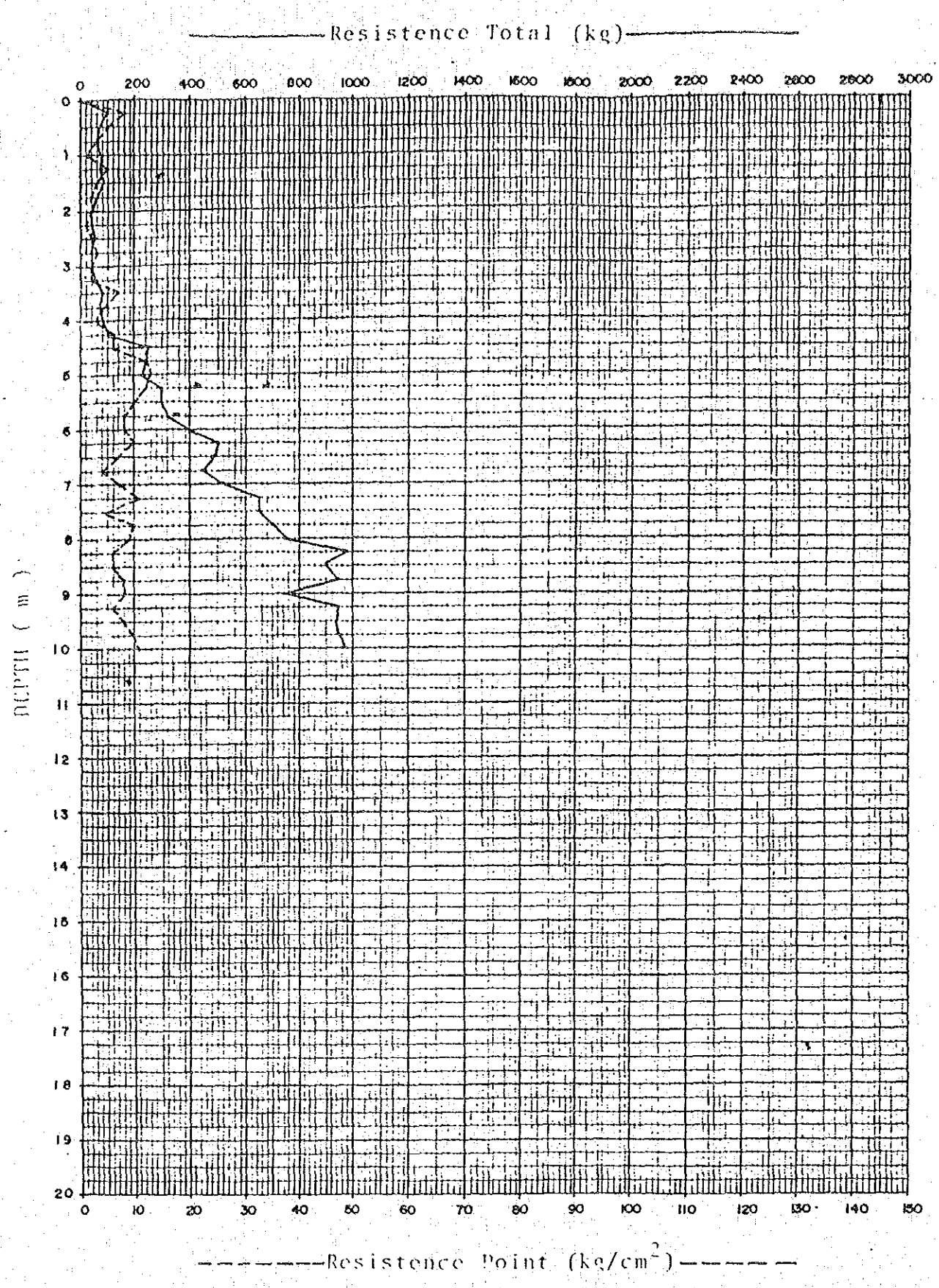
PROJECT NAME: JAPAN INTERNATIONAL COOPERATION AGENCY LOCATION : Itajai River - BLUMENAU - SC - BRAZIL		REF.: RS/SC/5444
Nº 66	DRAWER: Alex	DRAWING Nº:
ELEVATION: 9,950	DATE: June,10/87	ENGINEER:

Fig.II33 DUTCH CONE SOUNDING TEST RESULT (4/8)



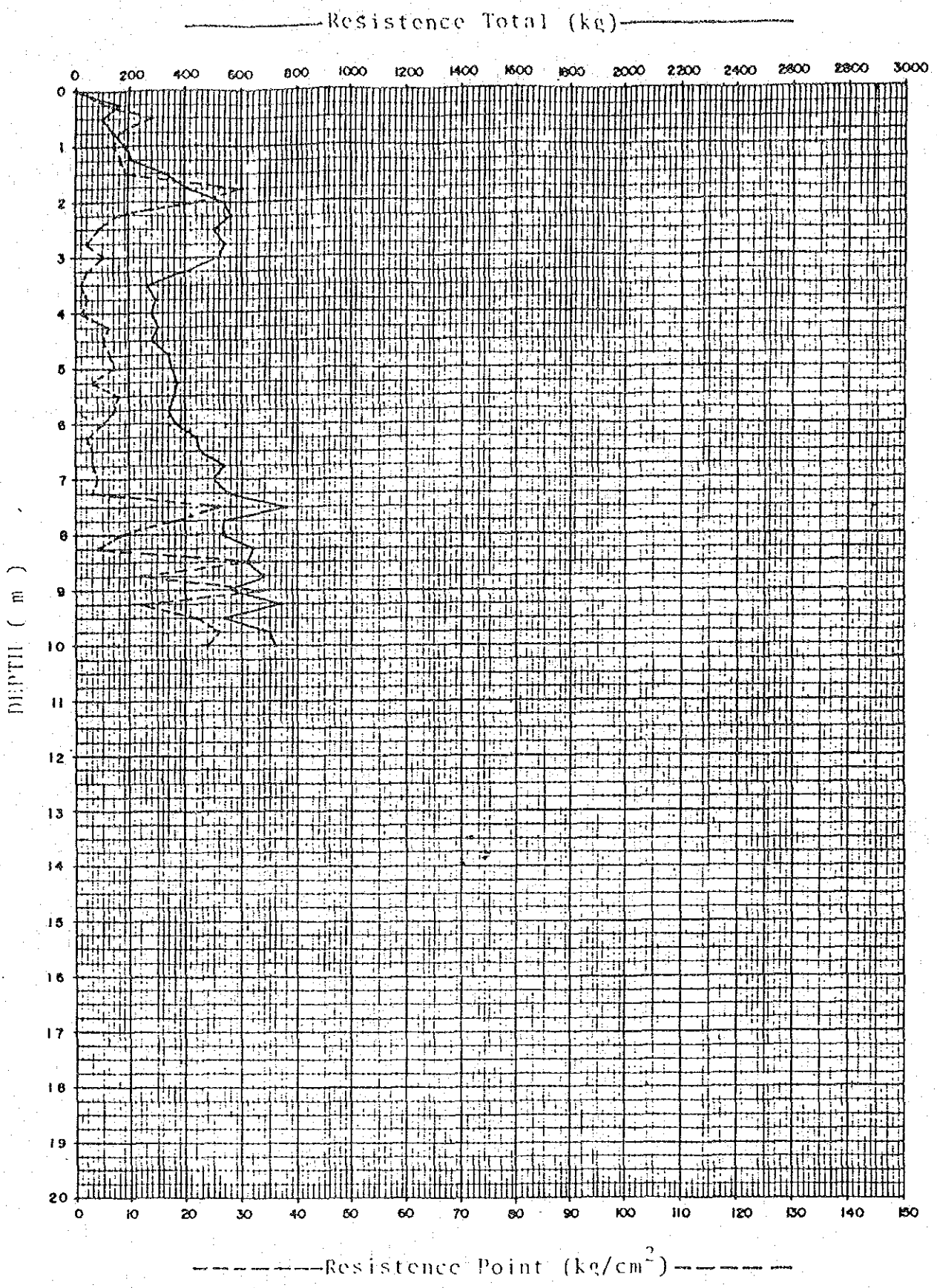
PROJECT NAME: JAPAN INTERNATIONAL COOPERATION AGENCY LOCATION : Itajai River - BLUMENAU - SC - BRAZIL		REF.: RS/SC/5444
Nº 60	DRAWER:	DRAWING Nº:
ELEVATION: 7,522	DATE : June,05/87	ENGINEER:

Fig.II33 DUTCH CONE SOUNDING TEST RESULT (5/8)



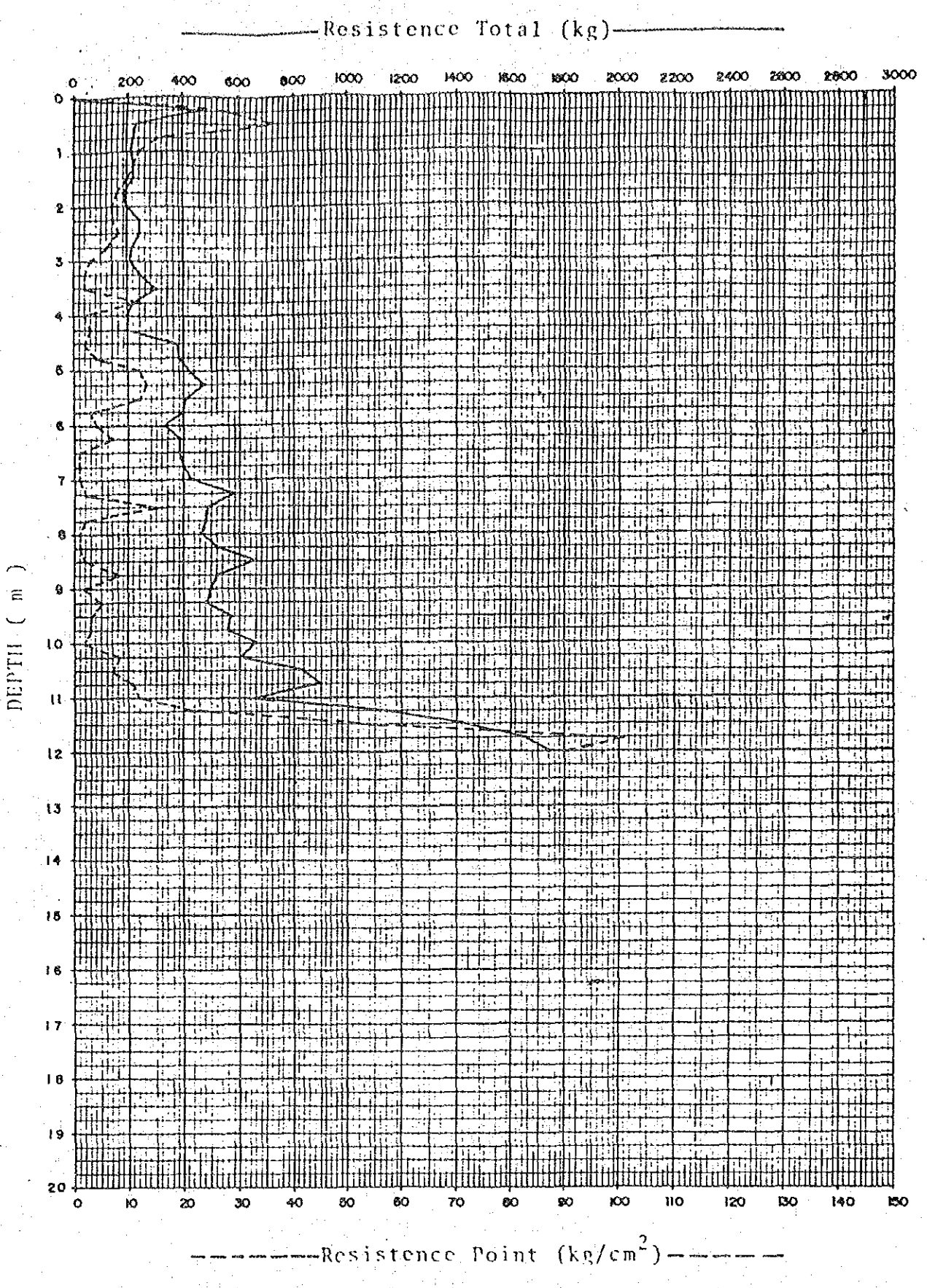
PROJECT NAME: JAPAN INTERNATIONAL COOPERATION AGENCY LOCATION : Itajai River - BLUMENAU - SC - BRAZIL		REF.: RS/SC/5444
Nº 40	DRAWER: Alonso	DRAWING Nº:
ELEVATION: 11,708	DATE : May,27/87	ENGINEER:

Fig.II.33 DUTCH CONE SOUNDING TEST RESULT (6/8)



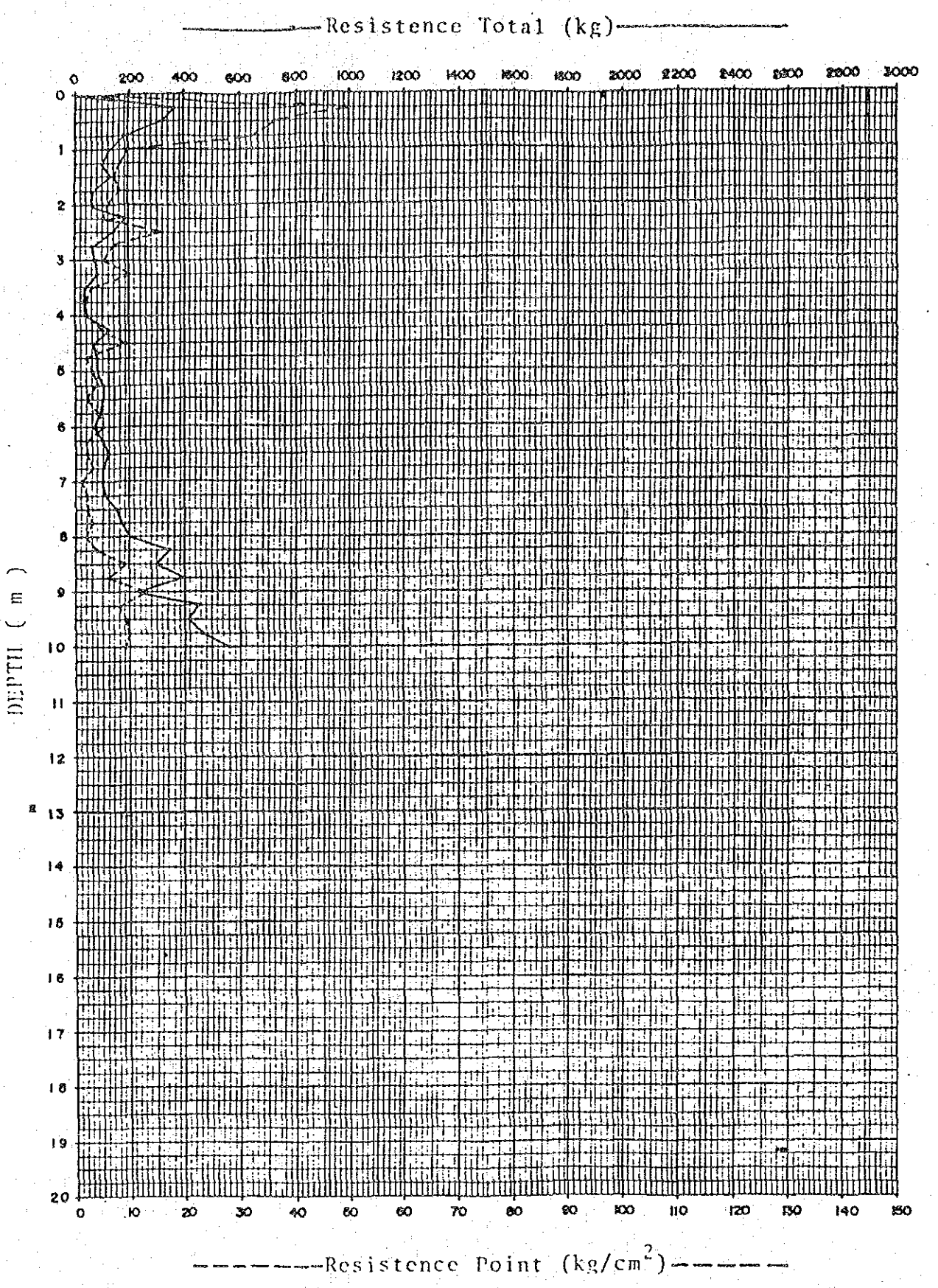
PROJECT NAME: JAPAN INTERNATIONAL COOPERATION AGENCY LOCATION : Itajai River - BLUMENAU - SC - BRAZIL		REF.: RS/SC/5444
Nº 23	DRAWER: Alonso Ico.	DRAWING Nº:
ELEVATION: 8,956	DATE : May,09/87	ENGINEER:

Fig.II.33 DUTCH CONE SOUNDING TEST RESULT (7/8)



PROJECT NAME: JAPAN INTERNATIONAL COOPERATION AGENCY LOCATION : Itajai River - BLUMENAU - SC - BRAZIL		REF.: RS/SC/5444
Nº 21	DRAWER: Alan Kim	DRAWING Nº:
ELEVATION: 8,977	DATE : May,11/87	ENGINEER:

Fig.II.3.3 DUTCH CONE SOUNDING TEST RESULT (8/8)



PROJECT NAME: JAPAN INTERNATIONAL COOPERATION AGENCY LOCATION : Itajai River - BLUMENAU - SC - BRAZIL		REF.: RS/SC/5444
Nº 19	DRAWER:	DRAWING Nº: RS18815
ELEVATION: 8,127	DATE : May/12/87	ENGINEER:

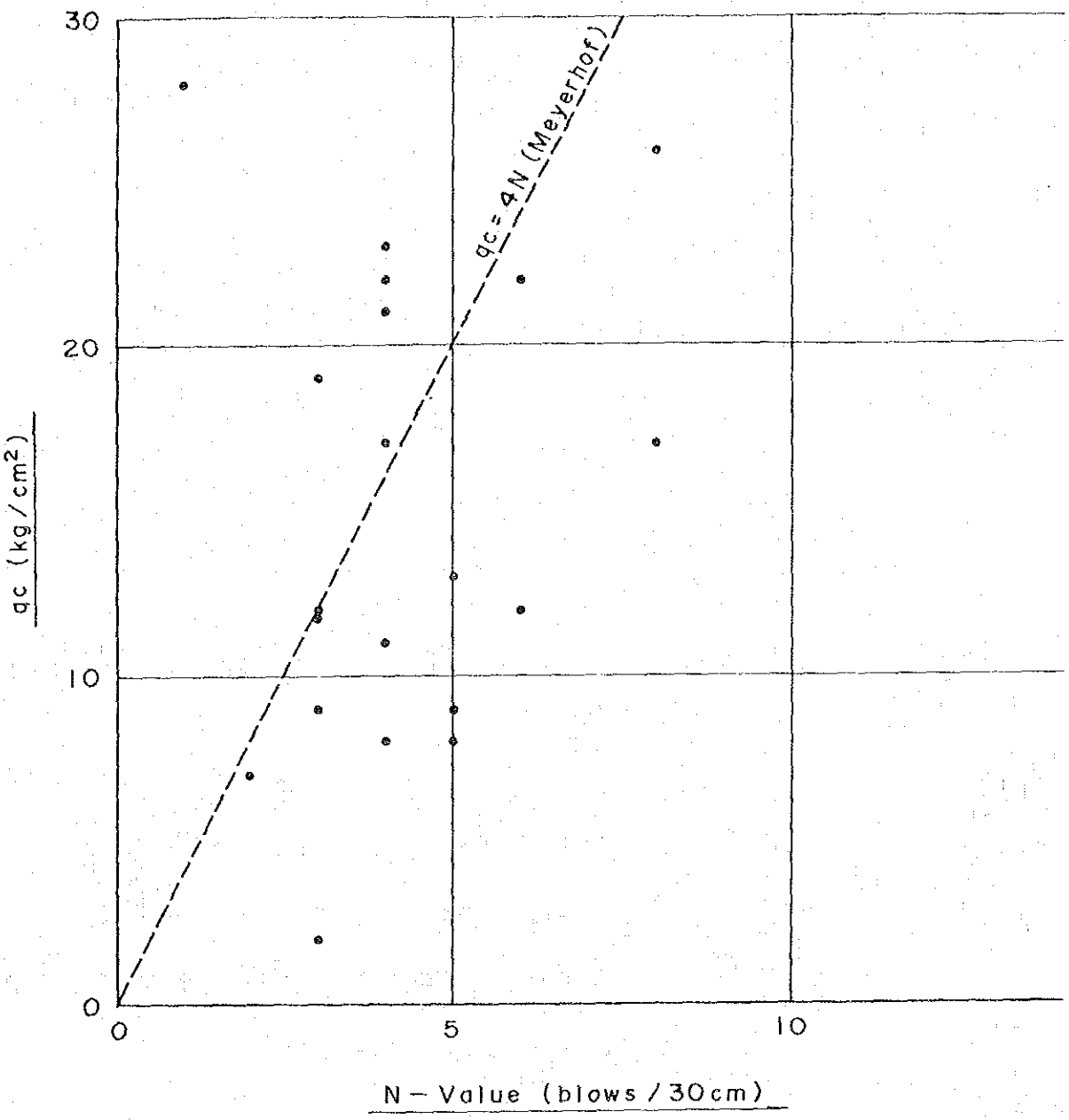


Fig.II.4.1 RELATIONSHIP BETWEEN SPT (N – VALUE) AND CONE RESISTANCE (qc) FOR SANDY SOILS

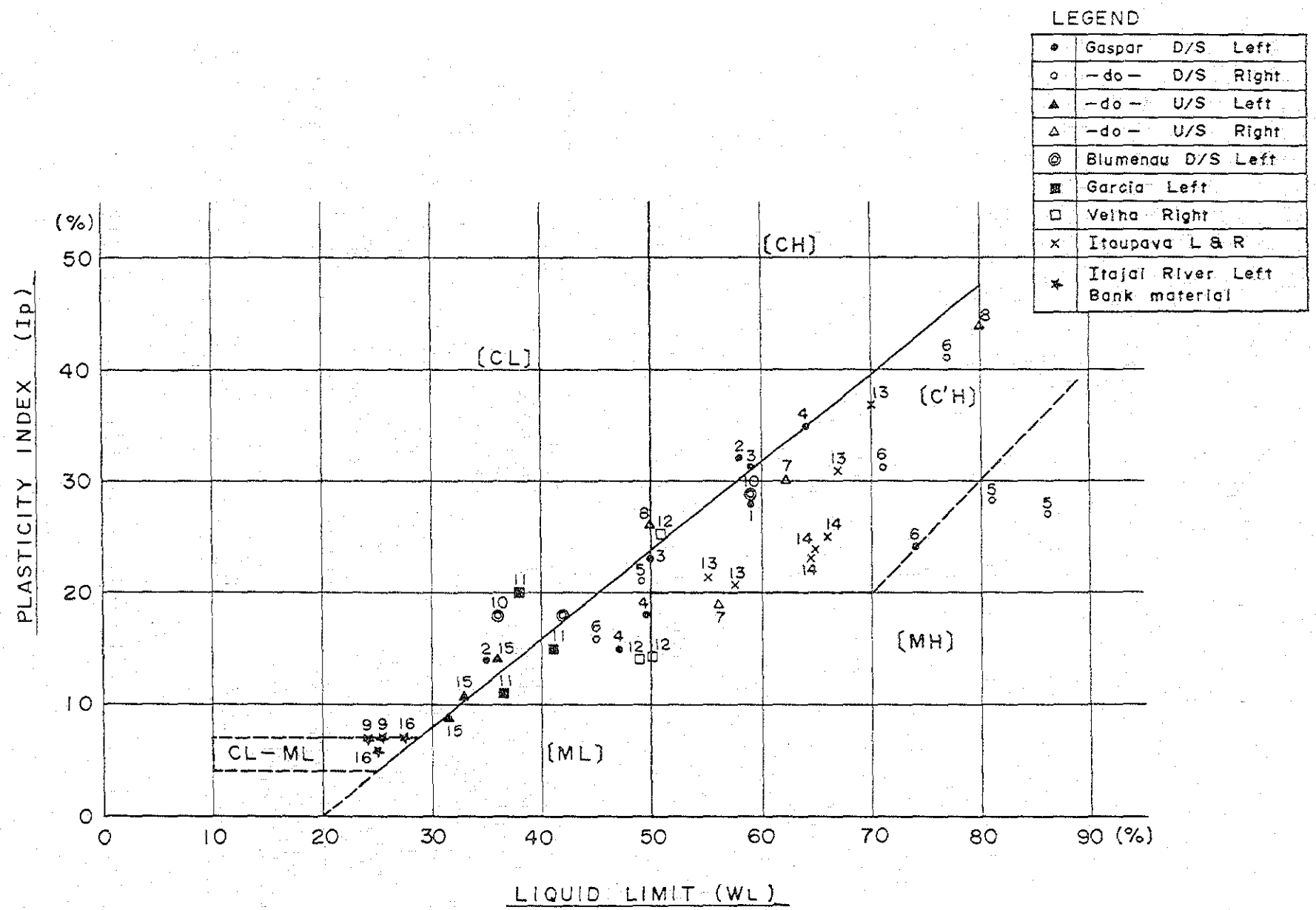


Fig. II.4.2 PLASTICITY CHART OF FILL MATERIAL

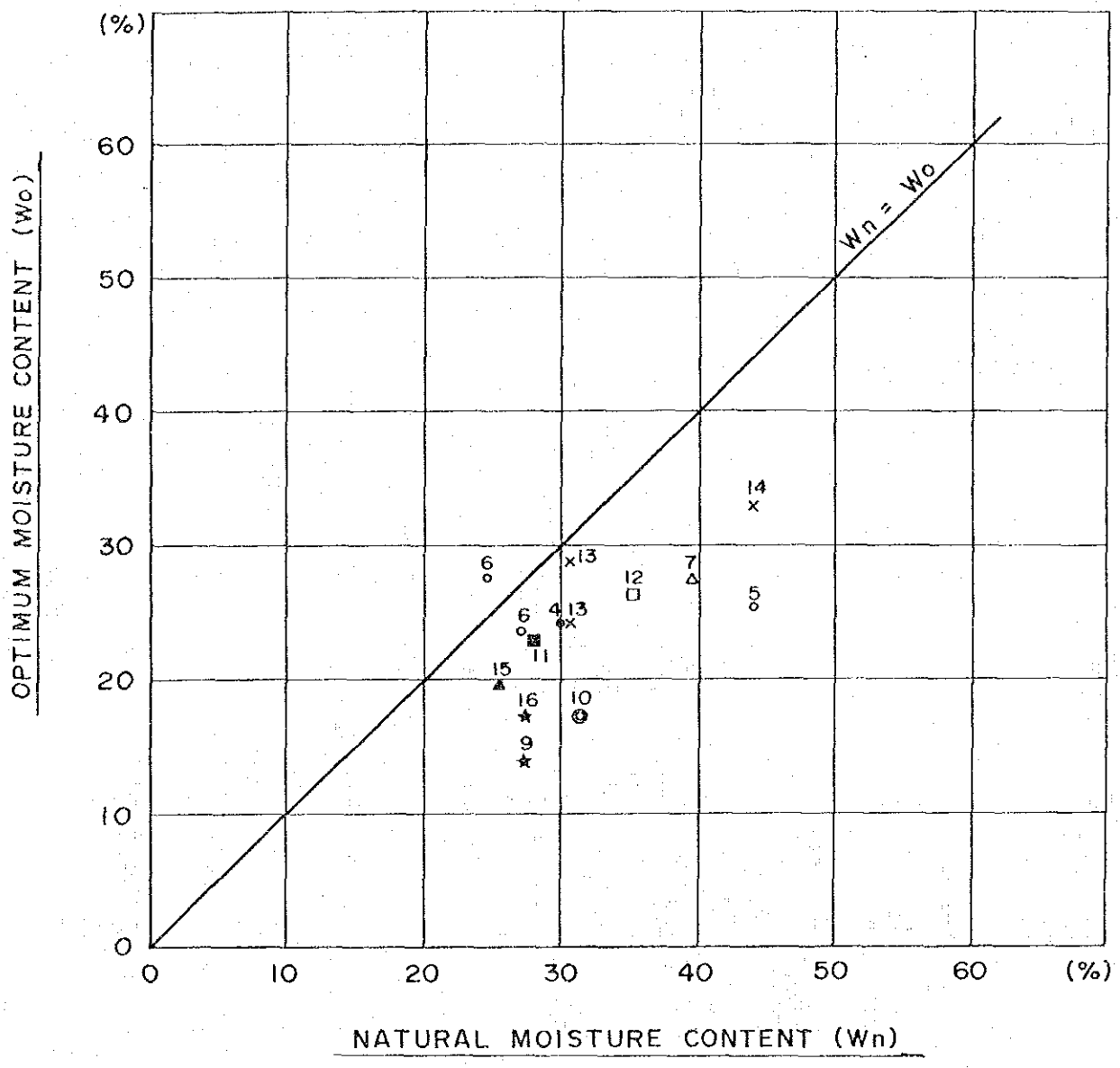


Fig.II.4.3 RELATION BETWEEN NATURAL MOISTURE CONTENT AND OPTIMUM MOISTUR CONTENT