APPENDIX - C : TOPOGRAPHY

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1. GENERAL

The aerial and ground surveying were planned to supplement the existing survey results as 1:1,000 scale topographical map of main damsite, levelling network, triangulation network, etc., for the feasibility study on Tenom Pangi Hydropower Project Phase III (Sook Reservoir). The surveying works were conducted by the Contractor, JURUKUR PERUNDING SERVICES SDN. BHD. who was directly appointed by the Federal Treasury. They carried out the works about 4.5 months starting from 22nd July to the end of November 1985. The survey results are wholly kept in Hydro/Civil division of SEB.

The conducted surveying items and quantities are as below:

1) Aerial Surveying

(1)	Selection and installation of ground control points	: 9 points
(2)	Control traversing	: 95.4 km
(3)	Minor order levelling	: 93 km
(4)	Aerial triangulation	: 26 models
(5)	Mapping and drafting (1:10,000)	: 5,070 ha
(6)	Mapping and drafting (1:5,000)	: 480 ha

2) Ground Surveying

(1)	Selection and installation of bench marks	: 9 nos
(2)	Third order levelling	: 55.5 km
(3)	Topographical surveying with closed traversing for main damsite (1:500), 1 m contour	: 98.82 ha
(4)	Topographical surveying for saddle damsite (1:500), 1 m contour	: 186.9 ha
(5)	Profile and cross-sectional surveying for main damsite including alternative Sook upstream damsite, 20 m long section	: 7.9 km
(6)	Profile and cross-sectional surveying for saddle damsite, 100 m long section	: 24.8 km

2. AERIAL SURVEYING

Aerial photography was excluded from the aerial surveying since the existing aerial photographs for the topographical maps of 1:50,000 scale are available for the aerial triangulation and photomapping. The required aerial photographs and diapositive films were obtained from the Land and Survey Department in Sabah. Using these diapositive films, the aerial photomapping was conducted for the areas covering the proposed main damsite, saddle damsites, power station site, reservoir area, access and relocation roads, etc. The photomapping scale is 1:10,000.

The aerial photographs used for mapping are as belows;

1)	Date of photography	: June 13th, 1981
2)	Number of index map	: A8126
3)	Aerial camera used	: WILD RC 10
4)	Lens used	: UAg II 3032
5)	Focal length	: 153.15 mm
6)	Photo scale	: 1:30,000
7)	Flight altitude	: 15,000 ft

The aerial triangulation was made in accordance with the analytical block adjustment method. The pass-points and tie-points were pricked and observed on the diapossitive films. The following equipment were used for the aerial triangulation:

1)	Point transfer device	: WILD PUG 4 No. 5992
2)	Stereo comparator	: Zeiss Jena Stecometer No. C-247389
3)	Computer	: DEC VAX 11-750
4)	Software	: PAT M-43, PAT M-PRO

The accuracy of aerial triangulation is expressed by residual at control points. It was satisfactory as shown below:

Item	Maximum Residual	Allowable One
Planimetry	0.97 m	7.2 m
Height	2.37 m	7.2 m

The required maximum residual is specified to be 1.6 o/oo of flight altitude.The stereo plotting was carried out using the following instruments:

1) Making base sheets : WILD TA2 No. FNR 6387
2) Stereo plotting : WILD Aviograph B8S No. 5916 and No. 5920

Relative orientation was carried out to satisfy the requirement of accuracy that the residual parallax of relative orientation should be less than 0.02 mm.

Accuracy of aosotute orientation is quite enough as shown below:

Item	Maximum	Allowable
Scaling Error	0.2 mm	0.5 mm
Height Error	0.69 m	1.5 m

After completion of stereo plotting, the field identification and completion works were carried out using the copies of restitution manuscript. The geographic names such as villages, roads, schools and other topographic features were investigated in the field. The fair drawing was made by inking on the polyester sheets after field completion.

The mapped area is as shown in Figure C1.

3. RECONNAISSANCE SURVEYING

To select the location of control points and bench marks to be newly installed in the project area, reconnaissance surveying was carried out prior to the other surveying works.

The following points were taken into consideration to select the location of control points and nodal points:

(1) Good inter-visibility between the existin trig-stations and control points or nodal points to be newly established.
(2) To be close to the selected pricking points or the post-targeting signals.
(3) To provide a triangulation network with good geometrical shape.
(4) Stability of the ground.
(5) Accessibility.

On the other hand, the location of bench mark was selected so as to form the baseline for the topographical and profile surveyings at main and saddle damsites.

The dimensions of control points and bench marks are as shown in Figure C2.

The control surveying networks and the levelling route are depicted in Figures C3. and C4.

4. CONTROL POINT SURVEYING

Considering the accuracy required, triangulation was carried out to determine the coordinates of control points and pricking points. To minimize errors which may occur in measurement of angles and distance for triangulation, the following criteria were adopted:

(1) To measure two sets of direction angle from 0 degree and 90 degrees
(2) To adopt the closed horizon method for open traverse by measuring an extra half set of angles
(3) To measure the distances of fore and back sight for every setup
(4) To set up the surveying instruments and targets at equal height above the markers as far as possible
(5) To record temperature and air pressure for atmospheric adjustment

It was confirmed during the control point surveying that Suan and Mambulu trig-stations were still sound and stable. On the other hand Lalang trig-stations were selected as the fixed stations for adjustment of surveying results.

The map projection adoption in the State of Sabah is called the Rectified Skew Orthomorphic (RSO). It is summarized as below:

(1) Projection	:	RSO
(2) Origin	:	4°00'N and 115°00'E of Greenwich
(3) Scale factor at origin	:	0.99984
(4) Coordinates of origin	:	E29,352.4763 chains N22,014.3572 chains or E590,477.876 m N442,858.407 m

(5) Initial line of projection : Passes through the origin at an

azimuth of 53°18'56"9537 (E. of true north)

(6) Limits of projection table : North : Parallel of 8°N

: East : Meridian of 109°30'E

: South : Parallel of 0°50'N

: West : Meridian of 119°30'E

The final adjusted observation and coordinates were reduced to the RSO system using the following mathematical models:

S (Spherical) = D x Cos (V) x (1-H/R)

S (Horizontal or RSO) = S x K

where,

D = reduced observed distance, corrected for atmospheric variation

R = main earth radius = 6,370.0 km

H = mean height above mean sea level

V = observed vertical angle

K = mean scale factor = 0.9998534

S = reduced distance after the altitude and earth's curvature corrections

and,

X = Sx sin az

Y = Sx cos az

The results of control points surveying are as shown below:

Station No.	Coordinates of Station		Elevation (m)
	N (m)	E (m)	
MAMBULU	578,633.077	716,079.863	318.597
LALANG	586,480.588	712,297.519	442.691
SUAN	581,492.004	712,171.865	455.077

Station No.	Coordinates of Station N (m)	E (m)	Elevation (m)
C.P.1	587,596.328	722,603.947	341.655
C.P.2	587,280.748	718,599.006	316.196
C.P.3	585,392.811	716,405.023	321.730
C.P.4	583,586.431	718,276.540	303.059
C.P.5	583,730.761	715,776.189	356.654
C.P.6	581,532.308	715,371.934	356.572
C.P.7	576,725.404	721,896.483	459.409
C.P.8	572,871.240	715,153.340	455.728
C.P.9	571,058.129	721,749.243	408.320

The accuracy of control point surveying is sufficiently satisfactory as shown below:

Loop	Accuracy	Mean Accuracy	Required Accuracy
Mambulu to Suan via C.P.7 and C.P.8	1:130,000		
Mambulu to Suan via C.P.4 C.P.5 and C.P.6	1:145,000	1:80,000	1:60,000
C.P.4 to C.P.5 via Lalang	1:70,000		
Lalang to C.P.1 open traverse			
Lalang to C.P.3 via BM5	open traverse		

5. VERTICAL CONTROL SURVEYING

Prior to commencement of vertical control surveyings, accuracy of the existing national bench marks of #213014 and #213015 was checked by the differential levelling method. As the result of check surveying, it was confirmed that the above national bench marks were both sound and stable. Then the bench mark of #213015 was selected as the datum for vertical control surveying in the project area. The bench mark of #213015 is in front of Land and Survey Department Office in Keningau.

The third order levelling was carried out to connect the bench marks newly established with the national bench mark of #213015 using the differential levelling method with two levelling rods. The allowable misclosure for this levelling was 10mm per one way distance in km. To satisfy this requirement, the following countermeasures were taken:

(1) To check the reliability of the levelling instrument by two pegs test once every other day.
(2) To take almost equal distance for backsight and foresifht.
(3) Backsight and foresight distance should be less than 70 m.
(4) To measure the distance between the levelling instrument and rods when adjustment is needed.
(5) To set up levelling rods so that reading rod become greater than 0.3 m.

The results of third order levelling are summarized as shown below:

Station No.	Elevation (m)	Coordinates of Station	
		N(m)	E(m)
B.M.1	280.115	583,600.334	715,506.826
B.M.2	293.337	583,703.961	715,665.128
B.M.3	294.723	583,754.759	715,263.057
B.M.4	306.029	583,899.061	715,485.384
B.M.5	352.168	585,961.012	716,739.295

Station No.	Elevation (m)	Coordinates of Station	
		N (m)	E (m)
B.M.6	354.662	585,716.077	716,871.179
B.M.7	316.937	586,233.081	718,233.792
B.M.8	317.919	587,021.662	718,852.532
B.M.9	310.656	587,431.531	720,302.292

The minor order levelling was conducted to connect the control points newly established with the national bench mark of #213015. The allowable misclosure was 60 mm per one way distance in km. Taking into account the allowable misclosure and the field conditions, the double scale rod method was adopted for the minor order levelling to shorten the time period required for the field works. Comparing with the conventional differential and double setting method, it can shorten the time required for the field surveying works by a half or one third. It is possible to avoid blunders in levelling by checking the reading of scale 1 (S1) and scale 2 (S2) with the rejection criterion of S1-S2 > 5 mm.

The results of minor order levelling are shown in Section 4 together with the results of control point surveying.

The minor order pricking survey was conducted concurrently with the minor order levelling to provide a chain of auxiliary control or check points for the aerial triangulation. The location of pricking points was pricked using a pocket stereoscope and pricking pin.
The accuracy of vertical control surveying is summarized as below:

Loop	Observed Misclosure (m)	Allowable Misclosure (m)
BM1	0.005	0.031
BM2	0.009	0.031

Loop	Observed Misclosure (m)	Allowable Misclosure (m)
BM3	0.005	0.031
BM4	0.006	0.031
BM5	0.006	0.022
BM6	0.006	0.022
BM7	0.003	0.020
BM8	0.003	0.020
BM9	0.003	0.020
Minor Order Levelling:		
Main loop	0.217	0.445
Others	0.050	0.150

6. TOPOGRAPHICAL SURVEYING

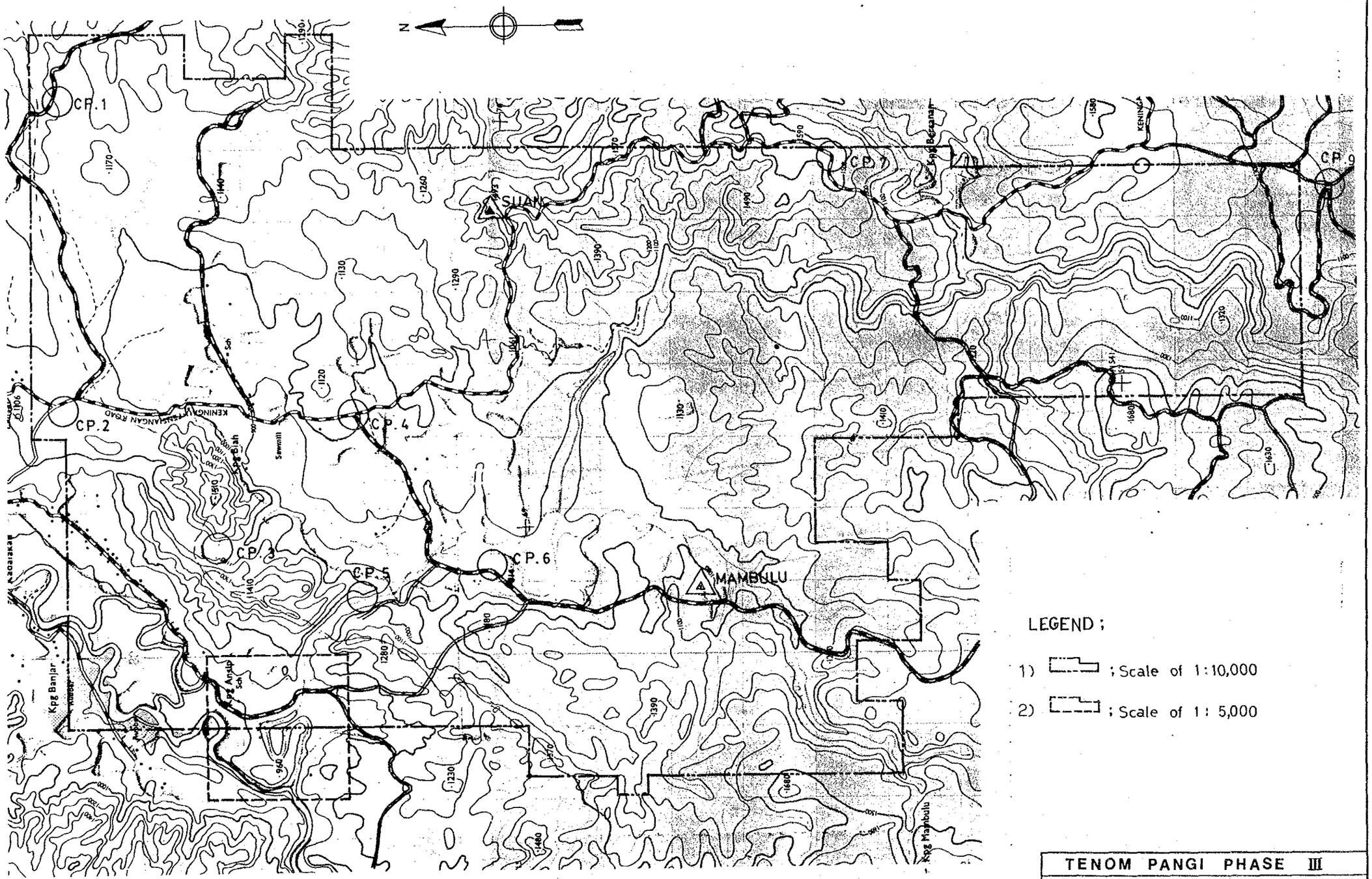
Topographical surveying was carried out for the area covering the proposed main damsite and saddle damsites. It consists of profile and cross-sectional surveyings, closed control traversing and 1 m contour topographical survey based on the surveying for 10 m by 10 m grid lines covering the survey area. Elevation of control points was surveyed by the trig-heighting method. But whenever misclosure was bigger than the allowable limit, the conventional levelling was carried out to satisfy the required accuracy. The tachymetry method was adopted to produce the topographical maps of 1:500 scale for the main and saddle damsites.

The accuracy of the control traversing for damsites are as shown below:

Loop	Observed Accuracy
Main damsites:	
Loop A	1:5,380
Loop B	1:5,380
Loop C	1:6,300
Loop D	1:4,610
Loop M1	1:9,206
Loop MDS	1:4,885
No. 1 Saddle damsite	Open travers
No. 2 Saddle damsite	1:13,000

The average accuracy of the control traversing for main and saddle damsites was 1:6,833 against 1:5,000 of the specified accuracy.

FIGURE NO. C 1



LEGEND ;

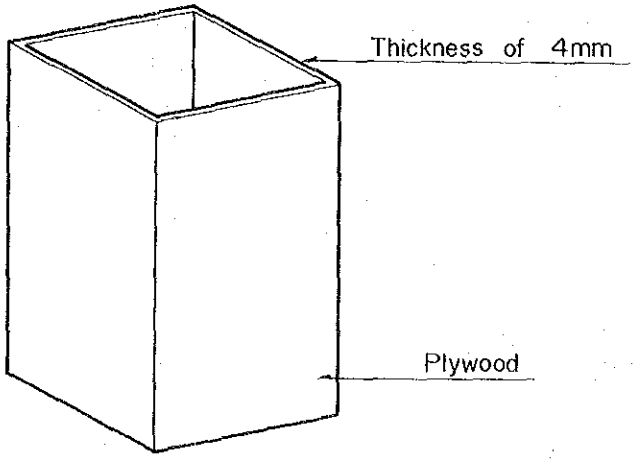
1) ; Scale of 1:10,000

2) ; Scale of 1: 5,000

SCALE 0 2.5 Km
(1 : 50,000)

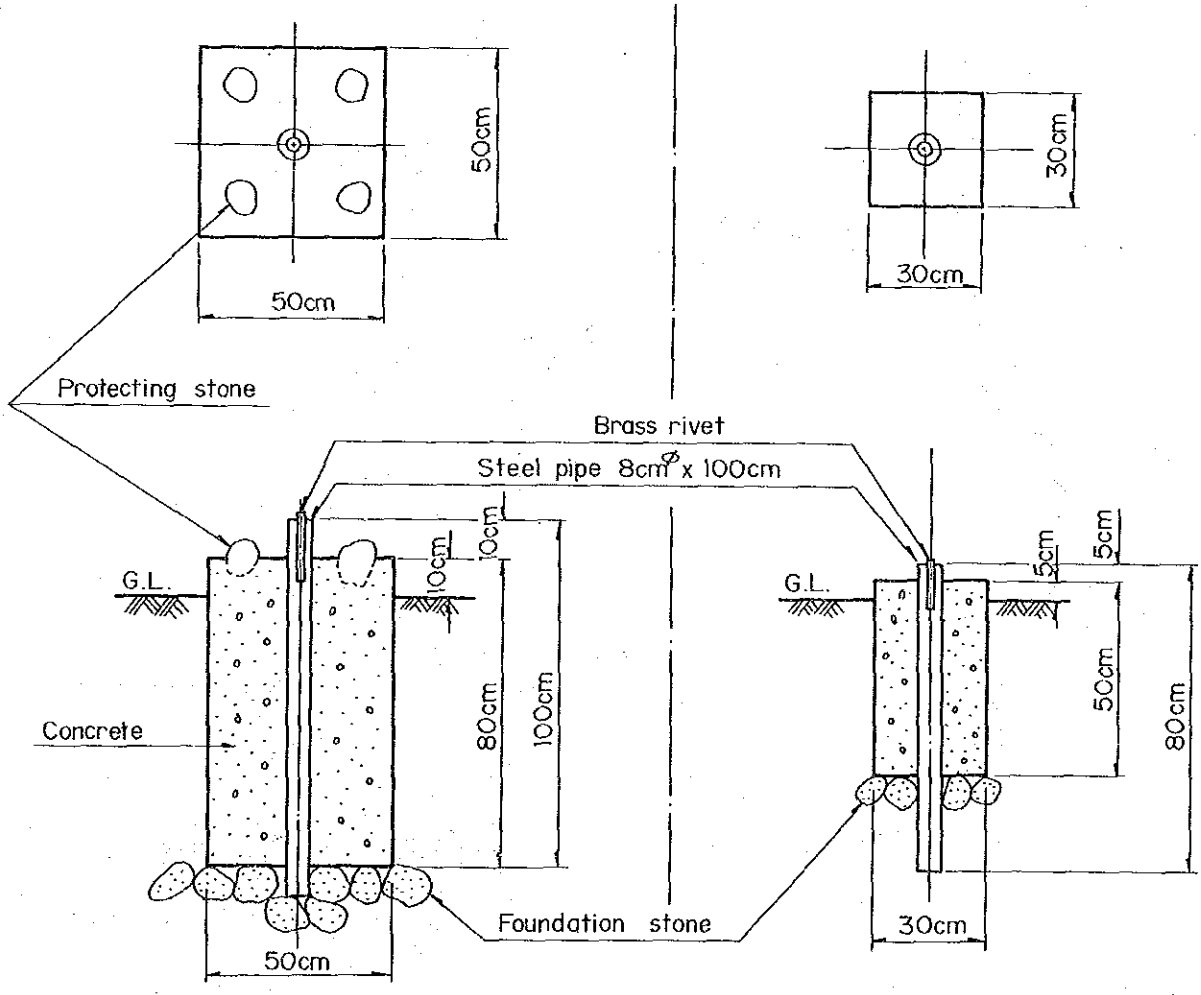
TENOM PANGI PHASE III
SOOK RESERVOIR
AEROPHOTO MAPPING AREA
SEB / JICA

FIGURE NO. : C 2



Bench Mark

Control Point

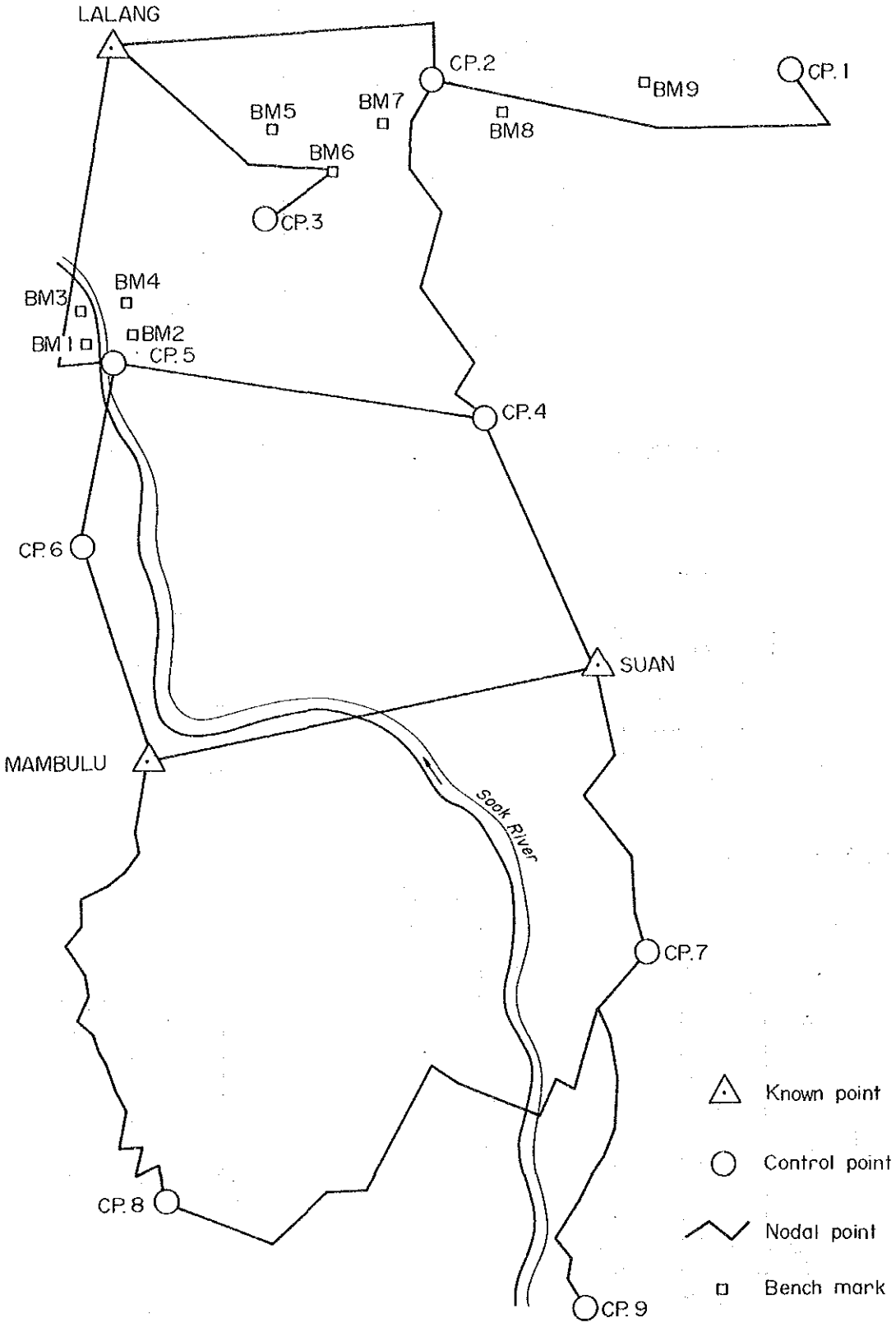


(Installation of control point & B.M.)

TENOM PANGI PHASE III
MONUMENTATION
SEB / JICA

CP Survey Networks

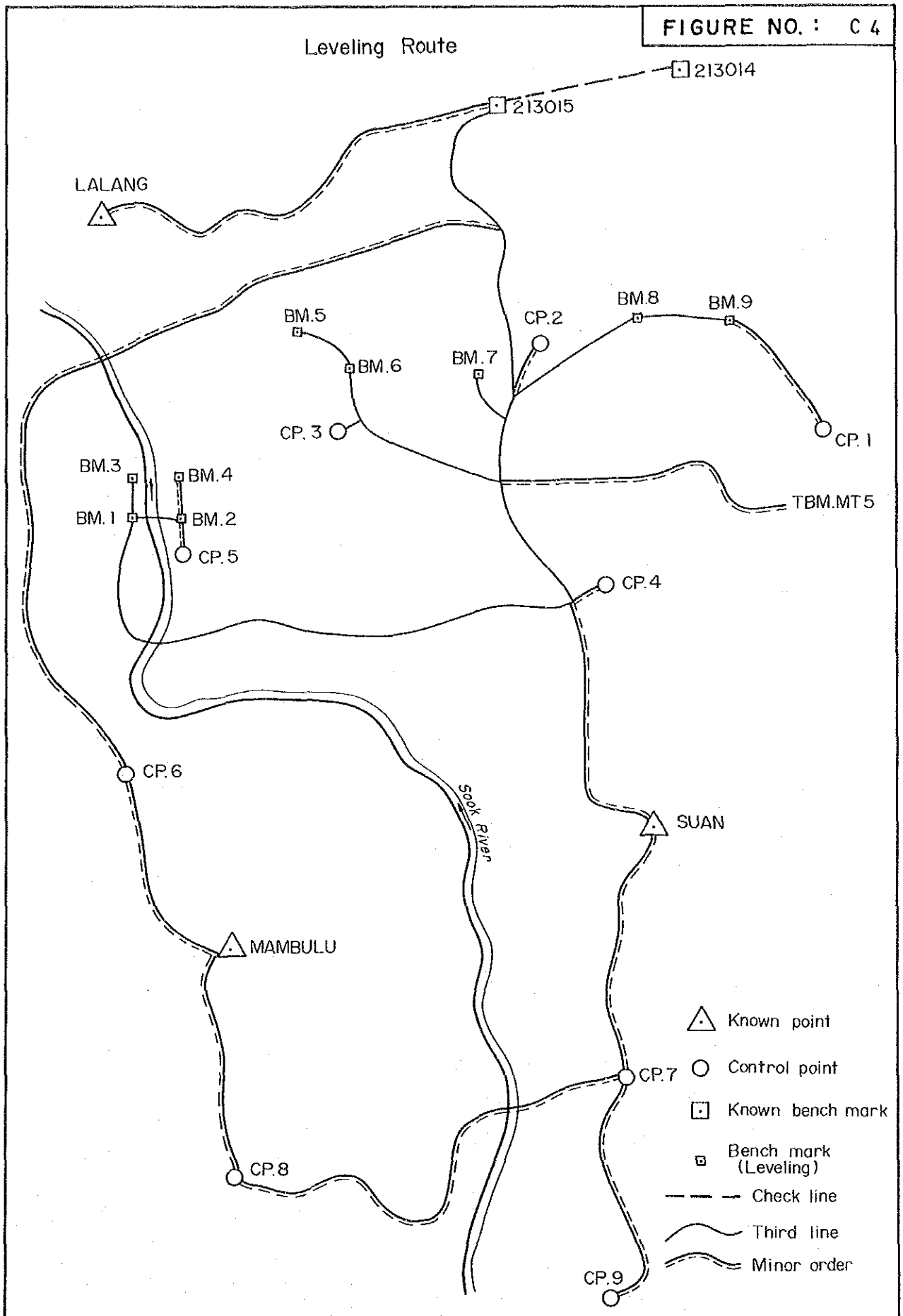
FIGURE NO. : C 3



TENOM PANGI PHASE III

HORIZONTAL NETWORK CONFIGURATION AND CONNECTION LINE

SEB / JICA



VERTICAL NETWORK CONFIGURATION AND LEVELING ROUTE

APPENDIX - D : CONSTRUCTION MATERIALS

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1. INTRODUCTION

The proposed Tenom Pangi Hydroelectric Power Development Project, Phase III (Sook Reservoir) comprises the construction of a-70-m-high main dam, a-12-m-high saddle dam, power station, spillway and other appurtenant structures. Construction materials such as impervious soil, sand gravel and rock are required for forming the dam embankments while sand and gravel are also required for concrete works.

On the site reconnaissance and geological investigation the rockfill type with center core for main dam and the homogeneous earthfill type for saddle dam were selected taking stability and economy into account.

Based on these view-points, ground reconnaissances at and around the project area were conducted to locate potential borrow areas and quarry sites. subsequently, materials survey and laboratory tests were conducted on these areas in order to clarify properties and obtainable quantities of the materials, and to determine the design value.

As for the materials survey, excavation of 15 testpits, drilling of 3 boreholes and 3 sampling from outcrops were carried out to obtain samples for laboratory tests.

The laboratory tests such as concrete aggregate tests, soil material tests including triaxial compression and permeability tests, and rock tests were excuted for obtained samples.

Field sampling and laboratory tests were conducted by the contractor, Ground Engineering (Sabah) Sdn. Bhd. and their analysis and evaluation were excuted for all materials prepared from data submitted by the contractor.

2. REQUIRED MATERIALS AND THEIR QUANTITIES

Required quantities of embankment materials for main dam and saddle dam, and concrete aggregates, which are estimated from the preliminary designs, are shown in Table D 1.

3. MATERIALS SURVEY AND SAMPLING

Construction materials such as embankment materials and concrete aggregates are widely distributed in the project area close to the principal structures.

Based on the field reconnissance, borrow areas and quarry sites were selected taking into account topographical and geological conditions as well as hauling distance to the main dam and the saddle dam. Locations of the proposed borrow areas and the quarry site are shown in Fig. D 1.

For the borrow areas and quarry site excavation of 15 test pitting, drilling of 3 boreholes and sampling of 3 outcrops were made and samples were collected for the laboratory tests. Quantities of collected samples are shown in Table D 2.

The test-pits for impervious materials, measuring 1.5m by 1.5m, were excavated by a backhoe or a hand shovel to depth of about 5m if unobstructed by hard, fresh rock layers while the pits for filter materials and aggregates are excavated to depth of 2m. Two types of representative samples, namely, sealed disturbed soil samples for natural moisture content tests and bulk samples for physical and mechanical property tests were obtained from evey 1m depth.

Diameter of core drilling at the quarry site was 66mm and drilling depth was 40m.

The samples for rock materials were taken from outcrops along the gorge in the quarry site while samples for impervious materials were

taken from outcrops along the temporary road for investigation of main damsite.

Field reconnissance and materials survey were executed from July 26, 1985 to August 20, 1985.

3.1 Impervious Core Materials for Proposed Main Dam

Survey area for impervious core materials covers Borrow Area A near the confluence of the Sook and Biah rivers in the Sook reservoir and quarry sites scattered in the range approximately 1 to 2 km upstream of the right bank of the proposed damsite. On the other hand, usable materials are existing along the temporary road which was constructed for the survey on main dam foundation. Therefore, sampling from outcrop along this road was executed for laboratory tests. The locations of testpits, boreholes and outcrop are shown in Fig. D 2.

3.1.1 Borrow Area A

Borrow Area A is in the extensive terrace zone which is located at left bank of the Biah river, and large quantity of terrace deposits are existing in the zone.

5 testpits were made in this area and samples were collected. The results of testpitting are shown in Fig. D 3. According to the results of excavation of testpits, terrace deposits are divided into two layers.

The upper layer of terrace deposits except top soil, consists of impervious fine-grained soil such as silty clay or clay which is generally yellowish-brown and reddish-brown in colour while lower layer of terrace deposits is silty sand-gravel layer.

These materials can be easily excavated by ordinary excavators or bulldozers equipped with rippers, and are suitable for forming the impervious core.

3.1.2 Quarry Site

The survey area for impervious materials in the quarry site is existing in a gentle slope portion of the mountain along the Biah river. Two testpits were excavated for this area. These materials consist of terrace deposits with fine clay and clayey gravel layer, and highly weathered sandstone including thin layer of strongly weathered shale seems to be sandy clay or clay as indicated in the Fig. D 3. The colour of these materials is generally yellowish-brown or reddish-brown, and contents of gravel in gradation are somewhat higher than the materials of Borrow Area A. These materials are also suitable for the impervious core and, with regard to hauling distance to the main dam, the quarry site is superior to Borrow Area A.

3.1.3 Temporary Road Area

A temporary road has been constructed from the village of Kuala Biah to the damsite along the Sook river as shown in Fig. D 2. In spite of the area around the temporary road being outside of the materials survey in this time, the sampling was executed from this area on account of the suitability of materials.

The material is residual soil with impervious clay, to be originated from sandstone, and this material seems to be suitable for impervious core and economical because of its short hauling distance.

3.2 Embankment Materials for Saddle Dam

Borrow Area B for the embankment materials of the saddle dam is in the Sook reservoir and approximately 300 to 500m upstream of the saddle dam site which is located at the northern part of the reservoir about 6 km from the proposed main damsite as indicated in Fig. D 1. This area consists of high terrace and some stok-farm exists in the proposed area. For materials survey, three testpits were made in the area as shown in Fig. D 4.

The materials in this area are widely distributed along the saddle dam axis and consist of terrace deposits with impervious silty clay or clay which is generally yellowish-brown or reddish-brown in colour while the moisture contents of the materials are somewhat high. The results of testpits are shown in Fig. D 3.

Therefore, the materials in this area will be available sufficiently for embankment though some adjustment of moisture content will be necessary.

3.3 Filter Materials and Concrete Aggregates

The proposed Borrow Area C for the filter material and concrete aggregates is in the Pegalan river about 1.5 to 5 km upstream from its confluence with the Sook river as shown in Figure 1. This area mainly consists of fluvial deposits. 5 testpits were excavated in this area as shown in Fig. D 5 and D 6. The materials in the downstream area of Borrow Area C are sand-gravel layer for all stratum while the materials in the upstream area are composed of fine sand and sand-gravel layer as shown in Fig. D 3.

Sand-gravel layers except fine sand layer in an upper portion can be used for filter materials and concrete aggregatres in sufficient quantities though the materials are somewhat coarse in gradation.

3.4 Rock Materials

The quarry site is located approximately 1 to 2 km north of the proposed damsite as discribed before. The topography, geology and results of core drilling for this site are discribed in Appendix of Geology.

The materials in this site consist of shale and sandstone except terrace deposits of a thin layer in upper portion, and the main rock is sandstone. The locations of outcrops and drilling are shown in Fig. D 2.

According to the results of core drilling as described in Appendix of Geology, a highly weathered layer is found in the bedrock at the quarry site. Nevertheless, as a result of site the investigation it is considered that the material around the borehole No.Q85-3 in the most upstream portion will be most suitable.

Obtainable quantities of rock materials are uncertain due to highly weathered rock existing in the site.

4. LABORATORY TEST

4.1 General

Laboratory tests were carried out to examine characteristics and properties of the sampled construction materials so as to ascertain their suitability of utilization in the proposed works and to determine design values. These tests were executed from August 5 to November 6, 1985.

Various tests were carried out in accordance with ASTM Standards and JSF* Standards.

Table D 3 summarizes the quantities and specification of the tests on the construction materials.

* The Japanese Society of Soil Mechanics and Foundation Engineering

4.2 Tests on Soil Materials

Samples obtained from test-pits and outcrops are tested in the laboratories to determine the following values :

- natural moisture contents
- specific gravity
- grain size distribution
- Atterberg limits
- behaviours when compacted
- strength, and

- permeabilities when compacted

The natural moisture content is determined by the standard over-dry method.

Compaction tests are carried out on samples with partciles larger than 12.5 mm sieved off and by compacting in 3 layers by dropping a 2.5 kg rammer from a height of 30 cm for 25 times on each of the 3 layers in a 1,000 cm^3 mould.

ASTM Standard is adopted for the unconsolidated undrained triaxial tests while JAF Standard is adopted for the consolidated undrained triaxial test with pore pressure measured to determine cohesion and friction parameters of samples. The sizes of compacted test specimens are 3.8 cm in diameter and 8 cm in height. Constant optimum water content and optimum water content plus 2% are adopted for the both triaxial tests. Lateral confining pressure of 1, 2, 4 and 8 kgf/cm^2 and an axial loading rate of 1%/min are used.

The variable head method is used for the determination of the permeability coefficient of samples compacted according to the results of compaction tests.

4.3 Tests on Sand-Gravel

Samples obtained from testpits are tested in the laboratories to determine the following :

- specific gravity and absorption
- soundness of gravel
- abrasion of gravel
- grain size distribution and finess modulus
- organic impurity of sand

- scratch hardness of gravel
- unit weight of gravel

Organic impurities tests of sand samples are carried out in accordance with ASTM C 40-79 using the tonnic acid method.

The suitability of gravels as concrete aggregates is tested by the sodium sulphate soundness test, the scratch hardness test using a brass rod, and the Los Angeles Abrasion test.

4.4 Tests on Rocks

Rock materials obtained from the outcrops and coredrilling in the quarry site are tested for their specific gravity, absorption, abrasion and scratch hardness. In addition to the above tests, uniaxial compressive strength tests are carried out for drilling core to determine their strength.

5. LABORATORY TESTS RESULTS AND EVALUATION

A summary of test results and evaluation on the construction materials are as follows, and detailed data of laboratory tests submitted by the contractor are also attached in this volume.

5.1 Impervious Core Materials for Proposed Main Dam

Laboratory tests on impervious core materials for the proposed main dam were carried out for the samples taken from Borrow Area A, the quarry site and outcrops of the temporary road area.

5.1.1 Test Results

The test results on impervious core materials are shown in Table D 4. A summary of tests conducted is as follows :

1) Borrow Area A

This area is terrace deposits consisting of silty clay, fine clay, clayey sand-gravel, sand and sand-gravel layer as shown in Fig. D 3.

The results of the survey and various tests on these materials are as follows :

(1) Specific gravity is between 2.72 and 2.87, while natural water contents are from 10.4 to 31.1%.

(2) In grain-size distribution, the maximum particle size is 100 mm. The contents of under-19.1-mm size are 61.1 to 100%, under-4.75-mm size 47.0 to 100% and under-0.075-mm size 1.9 to 86.9% indicating a fairly broad distribution range.

(3) However, the materials except sand-gravel layer existing in the pits SP-3, 4 and 5 indicates distribution of silty clay or clay of fine. grain size.

(4) According to the Unified Soil Classification System (ASTM D 2487) and based on gradation and the Atterberg limits tests, the materials are classified as clayey gravel (GC), silty gravel (GM), gravely sand (SP), silty sand (SM), clayey sand (SC), sandy or silty clay (CL) and fat clay (CH).

(5) The optimum water contents obtained in compaction tests are from 21.0 to 25.3%, and maximum dry density is 1.57 to 1.66 t/m^3. The coefficients of permeability at the optimum water content are 2.7×10^{-8} to 2.9×10^{-7} cm/sec. The difference between the natural water content and the optimum water content is 0.9 to 2.7% (average 1.7%) and the natural water content is higher.

(6) The strength parameters of cohesion (c) is 0.57 and internal friction (ø) is 17.69^{o} for a sample from SP-7 in terms of effective stress. They are obtained from the consolidated undrained triaxial compression (CU) tests with constant optimum water content. While at constant optimum water content + 2%, cohesion (c) of 0.58 and internal friction (ø) of 14.84^{o} are obtained.

In terms of total stress at constant optimum water content obtained from the unconsolidated undrained triaxial compression (UU) tests, cohesion (C) is 0.95 kg f/cm^2 and internal friction (ø) is 25.40^{o} with normal stress ranging between 2 to 4 kg f/cm^2. While at

constant optimum water content + 2%, cohesion (C) of 0.70 kg f/cm^2 and internal friction (ø) of 19.29^o are obtained.

2) Quarry Site

This area consists of terrace deposits with layers of fine clay and clayey gravel, and highly weathered sand stone including thin layers of strongly weathered shell seems to be sandy clay or clay as indicated in Fig. D 3.

The summary of test results is as follows:

(1) Specific gravity is between 2.77 and 2.87, and natural water contents are comparatively low in the range of 12.8 to 21.2% (average 17.6%).

(2) In grain size distribution, the maximum particle size is 25 mm. Content of under-19.1-mm is 89 to 100%, under-4.75-mm is 74.1% to 100%, and under-0.075-mm is 45.6 to 83%.

(3) According to the Unified Soil Classification System, the material belongs to clayey sand (SC), silty clay (CL) and fat clay (CH).

(4) As a result of compaction-permeability tests, the optimum water contents are 17.0 and 19.0%, the maximum dry densities are 1.67 and 1.74 t/m^3, and the coefficients of permeability at optimum water content are 4.0 x 10^{-7} and 4.2 x 10^{-8} cm/sec. The natural water contents are 0.4 and 1.4% higher than the optimum water contents.

3) Temporary Road Area

This area is residual soil consisting of clay. The sample was taken from outcrop of the temporary road which was constructed for the

survey of the main dam site as shown in Fig. D 2. The summary of tests results is as given below :

(1) Specific gravity is 2.83, and natural water content is 17.0%.

(2) In grain size distribution, the maximum size is 1.2 mm, contents of under 19.1, 4.75, 0.075 mm are 100, 100, 63.5% respectively.

(3) The material is classified as sandy clay (CH).

(4) As a result of compaction-permeability tests, optimum water content and maximum dry density are 18.5% and 1.737 t/m^3 respectively, and the coefficients of permeability at optimum water content were 2.6 x 10^{-7} cm/sec. The natural water contents are 1.5% lower than the optimum water contents.

5.1.2 Evaluation

An overall observation of test results on impervious core materials obtained from various invertigation areas is described as follows:

(1) The materials of Borrow Area A and the temporary road are a fine-grained soil except materials of pit No. SP-3 and 5 in Borrow Area A which are sand-gravel, and according to the Unified Soil Classification System, most of them are clay (ch, CH). However, sand-gravel layer mentioned above are almost coarse grained, classified as silty gravel (GM) to sand (SP, SM). The materials distributed at the upper parts of the quarry site are fine-grained, classified as clayey sand (SC) and clay (ch, CH). But these materials are somewhat coarser than those of Borrow Area A and the temporary road. The grain-size distribution curves of these materials are shown in Fig. D 7 to D 10.

(2) According to the Atterberg limits tests results, the materials of all areas except pit No. SP-3 and 5 in Borrow Area A indicate that the plasticity index is over 25, and the liquid limits are relative to natural water content as shown in Fig. D 11 and Fig. D 12.

(3) The coefficients of permeability at optimum water contents are under 4.0×10^{-7} cm/sec for materials of all areas, and it is judged that the materials except sand-gravel layer in Borrow Area A are suitable as impervious core materials.

(4) The maximum dry density obtained from compaction tests is 1.737 t/m^3 for the material obtained from the temporary road. The remainder are in the order of 1.706 t/m^3 for the quarry site, 1.610 t/m^3 for Borrow Area A in average.

(5) The natural water contents are somewhat higher than the optimum water contents except the temporary road. By area, the natural water contents are higher by 0.9 and 2.7% for Borrow Area A, 0.4 and 1.4% for the quarry site. Correlation between natural water contents and optimum water contents is shown in Fig. D 13.

(6) Strength parameters are obtained by the triaxial compression test. The strength parameters of representative samples in Borrow Area A indicate typical clayey material.

(7) Based on the above results, it is considered that Borrow Area A is suitable for impervious core material of the main dam in view of quantity and properties. According to the test results, materials of the quarry site and area of the temporary road are also suitable for impervious core materials considering the hauling distance and the properties of materials.

5.2 Embankment Materials for Saddle Dam

Laboratory tests on embankment materials for the saddle dam were performed on samples collected from 3 test pits in Borrow Area B.

5.2.1 Test Results

The test results on embankment materials are shown in Table D 5. A summary of tests conducted is as follows :

(1) This area is fine-grained terrace deposits consisting of silty clay, clay with sand and clay as shown in the Fig. D 3.

(2) Specific gravity is between 2.76 and 2.86 and natural water contents are from 19.2 to 27.8%.

(3) In grain size distribution, the maximum particle size is 2.0 mm, the contents of under-0.075-mm size is 59.3 to 85.4% indicating a fairly narrow distribution range.

(4) According to the Unified Soil Classification System (ASTM D 2487) based on gradation and the Atterberg limits test, the materials belong to sandy or silty clay (CL) and fat clay (CH).

(5) As a result of compaction-permeability test, optimum water contents are 18.6 to 19.5%, maximum dry densities are 1.707 to 1.744 t/m^3, and the coefficents of permeability at optimum water contents are 4.0×10^{-7} to 4.8×10^{-8} cm/sec. The natural water contents are 1.6 to 5.5% higher than the optimum water contents.

(6) The strength parameters in terms of effective stress from sample SP-8 obtained from the consolidated-undrained triaxial compression (CU) test with constant optimum water contents are cohesion (c) of 0.4 kg f/cm^2 and internal friction (ø) of 26.01^{o}. While at

constant optimum water content + 2%, cohesion (c) of 0.62 kg f/cm^2 and internal friction (ø) of 21.75° obtained.

On the other hand, the strength parameters in terms of total stress at constant optimum water contents obtained from the unconsolidated-undrained triaxial compression (UU) test are cohesion (c) of 1.05 kg f/cm^2 and internal friction (ø) of 25.40° with normal stress ranging from 2 to 4 kg f/cm^2. While the strength parameters at constant optimum water content + 2% are cohesion (c) of 1.55 kg f/cm^2 and internal friction (ø) of 26.57.°

5.2.2 Evaluation

The following evaluation is made on the materials from Borrow Area B based on the above test results.

(1) The materials in Borrow Area B are widely distributed along the saddle dam axis, and indicate fine-grained soil as silty clay or clays (CL, CH). The grain-size distribution curves of these materials prepared from data submited by the contractor are shown in Fig. D 14.

(2) According to the Atterberg limits tests results, the materials indicate high plasticity index (PI: over 24) as shown in Fig. D 12.

(3) The coefficients of permeability at optimum water contents are under 1.5 x 10^{-7} cm/sec. Thus, it is considered that the materials in this area are usable as embankment materials for the saddle dam.

(4) The maximum dry density obtained from compaction tests is 1.744 t/m^3 , and average dry density is 1.724 t/m^3. The maximum natural water content is 5.5% point higher than the optimum water content. Therefore, adjustment of water content will be required.

Correlation between natural water content and optimum water content is indicated in Fig. D 13.

(5) From the triaxial compression test results, the unconfined undrained compressive strength parameters at constant optimum water content are cohesion (c) of 1.05 kg f/cm^2 and internal friction (ø) of 25.40^o. While the consolidated undrained compressive strength parameters (effective stress) are cohesion (c) of 0.41 kg f/cm^2 and internal friction (ø) of 26.01^o. These results indicate general strength of clayey material.

(6) Based on the above results and taking into account quantities, properties and hauling distance, it is considered that Borrow Area B is available for the saddle dam. However, in actual use, it will be necessary to make adjustments in water content.

5.3 Filter Materials and Concrete Aggregates from Fluvial Deposits

Laboratory tests on filter materials for dams and concrete aggregates for principal structures were executed for the samples taken from 5 test-pits in Borrow Area C.

5.3.1 Test Results

The tests results on concrete aggregates and filter materials are shown in Table D5. A summary of tests conducted is as follows :

(1) The specific gravities of fine aggregates are 2.56 to 2.63, and absorption rates are 0.9 to 1.2% while the specific gravities of coarse aggregates are 2.60 to 2.66, and absorption rates are 0.5 to 1.1%.

(2) The gradation of river-bed deposits reveals that maximum particle size is 275 mm, and contents of 37.5 mm and over are 9.5 to 41.5% (average 31%), 37.5 to 4.75 mm 40.1 to 50.8% (average 46%), 4.75 to 0.15 mm 10.2 to 29.3% (average 23%), under-0.15-mm 1.4 to 5.5% (average 3.3%), and under-0.075-mm 0.3 to 2.4 % (average 1.4%).

(3) The gradation of fine aggregates shows contents of under-0.15-mm size are 4.7 to 25.8% (average 15.7%). The fineness modulus of fine aggregatres are between 1.97 to 2.71 (average 2.35).

(4) The results of soundness tests of coarse aggregares using sodium sulfate solution are 0.4 to 1.2% (average 0.6%). The abrasion losses of coarse aggregares are 29.0 to 31% (average 29.8%) for size 9.5 to 37.5 mm, and all satisfied the requirments of ASTM C33 (soundness by use of sodium sulfate solution not more than 12% for coarse aggregate, abrasion loss not more than 50%).

(5) The results of scratch hardness of coarse aggregatres are 1.96 to 7.08% (average 4.55%). The unit weight of coarse aggregartes are 1.717 to 1.754 t/m^3 (average 1.738 t/m^3).

(6) As a result of organic impurity tests of fine aggregates using sodium hydroxide solution, out of four samples, one (GP-3) is unsatisfactory.

5.3.2 Evaluation

An overall observation of test results on filter materials and concrete aggregates obtained from Borrow Area C is discribed as follows :

1) Concrete Aggregates

(1) Both fine and coarse aggregates show favourable values regarding specific gravity and absorption.

(2) In gradations, as shown in Fig. D 15 in case of maximum size 37.5 mm to be made, the ratios of particle sizes over and under-4.75-mm are 45.9% and 23.1% and close to the sand-aggregare ratio (S/A = 40%) of concrete.

(3) However, the contents of under-0.15-mm size in fine aggregates are high, averaging 15.7% as shown in Fig. D 16. Also, there is distribution of fine materials not passing organic impurity tests. Therefore, in order to use these materials, it will be necessary to wash them and to adjust the gradation.

(4) Both fine and coarse aggregate from this area meet the quality requirments of soundness, abrasion loss.

(5) Based on the above results, it is considered that the materials in Borrow Area C is available for concrete aggregates in view of quantity and quality. However, for the fine aggregares common washing and adjustment of gradation will be necessary.

2) Filter Materials

(1) The quality of material in Borrow Area C for filter material are all satisfied as indicated above 1).

(2) In gradation as shown in Fig. D 17, the materials in Borrow Area C bring about somewhat a coarse gradation curve compared with the proposed one. Therefore in actual use, it will be necessary to process coarse materials to get a suitable gradation curve. For upstream portion (SP-3, 4 and 5) of Borrow Area C, the top soil consisting of fine sand should be removed before taking the materials.

5.4 Rock Materials for Rockfill and Concrete Aggregates

Laboratory tests were preformed on samples taken from outcrops and drilling cores in the quarry site.

5.4.1 Test Results

The results of tests on rock materials are shown in Table D 5 and D6. The results of the various tests are summarized below :

(1) The specific gravities of the materials from outcrops are 2.53 and 2.60, absorption rates 0.6 and 2.0%, while the specific gravities of boring cores are 2.67 to 2.73, and absorption rates 0.6 to 1.65%.

(2) The soundness of the materials from outcrops are 1.9 to 3.0%.

(3) The abrasion losses of the materials from outcrops are 47 and 60% (average 53.5%) for size 9.5 to 37.5 mm, while the abrasion losses of boring cores are 30 and 36% (average 33%).

(4) The results of scratch hardness tests of the materials from outcrops are 2.81 and 5.56% (average 4.19%) while the scratch hardness of boring cores are 9.17 and 17.44% (average 13.31%).

(5) Unconfined compressive strengths with boring cores are in the range of 267 to 1,824 kg f/cm^2 with the majority over 450 kg f/cm^2, and strengths of dry condition (average 862 kg f/cm^2) are higher than strengths of SSD condition (average 538 kg f/cm^2) as shown in Fig. D 18.

5.4.2 Evaluation

The following evaluation may be made on the materials from the quarry site based on the above results.

(1) In the boring cores of Q 85-2, there was no suitable sample for the rock materials test. Therefore, cores of Q 85-2 were exempted from the rock materials test.

(2) According to the results of the abrasion losses and scratch hardness tests, the materials from outcrops indicate unfavorable value for the abrasion losses, and the boring cores of Q 85-1 (5-10 m depth, classified D) show high value (17.44%) of scratch hardness compared with other rock materials.

(3) According to the results of the unconfined compressive strength tests, the average strengths of the drilling cores classified as C and D are 600 to 1,148 kg f/cm^2.

(4) Based on the above results, it is considered that rockfill materials from the quarry site are available except highly weathered sandstone and shell, and that the fresh materials in this site can be used for concrete aggregares. Therefore, the fresh materials will be adopted as concrete aggregates.

6. CONCLUSION AND RECOMMENDATION

Based on the results of field reconnaissance, materials survey and laboratory tests, the following conclusions and recommendations are made on the construction materials.

6.1 Impervious Core Materials for Proposed Main Dam

1) Area of materials survey for impervious core materials covers Borrow Area A near the confluence of the Sook and Biah rivers in the Sook reservoir and the quarry site scattered in the range approximately 1 to 2 km upstream of the right bank of the proposed damsite. On the other hand, usable materials are existing along the temporary road which was constructed for the survey of main dam foundation. Therefore, sampling from outcrops along this road was executed for laboratory tests.

2) These materials consist of terrace deposits at Borrow Area A, highly weathered sandstone and shale including terrace deposits existing on the bed rock at the quarry site, and residual soil to be originated from sandstone along the temporary road area.

   The materials in these areas were impervious fine-grained soil which maximum size are 2 to 20 mm, content of under 0.075 mm were more than 60% in grain size distribution, and those are silty clay (CL) or clay (CH) according to the Unified Soil Classification System.

3) Materials of Borrow Area A, which consist of terrace deposits, will be suitable for impervious core materials of the main dam in view of their properties and sufficient quantity.

On the other hand, materials surrounding the quarry site and those obtained along the temporary road are also suitable for impervious core materials, and those areas are more profitable compared with Borrow Area A for their short hauling distance. However, with regard to those areas, sufficient survey of materials to grasp obtainable quantities were not excuted this time. Therefore it will be necessary for further investigations to be made to confirm the depth in which the material is available and range of distribution and to select the most suitable borrow area.

6.2 Embankment Materials of Saddle Dam

1) Proposed Borrow Area B for the embankment materials of the saddle dam is in the Sook reservoir and at about 300 to 500m upstream of the saddle dam which is located at the most northern part of the reservoir approximately 6 km from the proposed main damsite.

   The materials of this area are terrace deposits and are widely distributed along the saddle dam axis in the area. The materials are impervious fine-grained soils which maximum size is 2 mm, content of under-0.075-mm averages about 70% and which belong to silty clay or clay (CL, CH) according to the Unified Soil Classification System.

2) As a result of the materials survey and laboratory tests, the materials of Borrow Area B will be available for the proposed dam in sufficient quantity.

3) However, according to the geological survey of the saddle dam foundation, a thick sand-gravel layer exists beneath the proposed impervious layer in this area including Borrow Area B. Therefore, it is considered that the excavation of the impervious layer has a

possibility to exert a bad influence on seepage flows of the saddle dam foundation.

4) Consequently, it is desirable to select another borrow area instead of Borrow Area B for embankment materials. As for new proposed area, the south side of Borrow Area B and left bank of the Biah river seem to be available for material sources of the saddle dam according to the result of field investigation as shown in Fig. D 1. Therefore with regard to this area, further survey and labortory test will be necessary to confirm properties and quantity.

to be available for material sources of the saddle dam according to the result of field investigation as shown in Fig. D 1. Therefore with regard to this area, further survey and laboratory test will be necessary to confirm properties and quantity.

6.3 Filter Materials

1) Proposed Borrow Area C for the filter materials is in the Pegalan river about 1.5 to 5 km upstream from its confluence with the Sook river.

2) This area mainly consists of fluvial deposits. The downstream area of Borrow Area C are sand-gravel layer for all stratum while the upstream area are composed of fine sand and sand-gravel layer.

   The sand-gravel except fine sand indicates relatively coarse gradation. The maximum size is about 100 mm and sand content (5 mm under) is approximately 23% while the coarser parts of the materials are stable. Therefore, sufficient amount of materials in this area will be suitable for filter materials though some gradation adjustment will be necessary.

6.4 Rock Materials

1) The proposed quarry site for the rock materials is located approximately 1 to 2 km north of the proposed damsite. The materials in this site consist of shale and sandstone except terrace deposits of thin layer in upper portion. Main rock is sandstone.

2) According to the results of core drilling as discribed in geological survey and laboratory tests, highly weathered layer is existing in the bedrock at the quarry site.

Nevertheless, it is considered that the materials around the borehole No. Q 85-3 will be most suitable as a result of site investigation. Thus, it will be necessary to confirm the properties and quantity of materials in this area.

6.5 Concrete Aggregates

As for the concrete aggregates, materials of Borrow Area C which consist of fluvial deposits will be suitable for the proposed structures though they contain silt particles and fine aggregates are somewhat little in quantity. also, fresh materials of the quarry site for rockfill materials can be used for concrete aggregatres.

Table D1 REQUIRED MATERIALS

(Unit: m^3)

Materials	Volume			
	main dam	saddle dam	aggregates	Total
Core	242,000	-	-	242,000
Filter	194,000	38,000	-	232,000
Rock	1,290,000	113,000	-	1,403,000
Impervious soil	-	250,000	-	250,000
Sand-gravel	-	-	30,000	30,000
Total	1,726,000	401,000	30,000	2,157,000

Table D2 QUANTITIES OF COLLECTED SAMPLES

Item	Quantity (Place)
Impervious core materials	34 (50 kg/place)
Impervious materials	15 (50 kg/place)
Filter materials and aggregates	15 (50 kg/place)
Rock materials	2(200 kg/place)

Table D3 ITEMS AND QUANTITIES OF LABORATORY TESTS

	Item	Quantities	Remarks
(1)	Rockfill Materials & Aggregates		
	a) Specific Gravity &		ASTMC 127-84
	Water Absorption	19 Samples	ASTMC 128-84
	b) Soundness	7 "	ASTMC 88-83
	c) Abrasion	9 "	ASTMC 131-81
	d) Grain Size Analysis	5 "	ASTMC 136-84
	e) Organic Impurities	5 "	ASTMC 40-79
	f) Scratch Hardness	9 "	ASTMC 851-76
	g) Unit Weight	5 "	ASTMC 29-78
	h) Compression Strength	20 "	ASTMD2938-79
(2)	Soil Materials		ASTMC 127-84
	a) Specific Gravity	36 "	ASTMC 127-84
	b) Moisture Content	57 "	ASTMD2216-80
	c) Grain Size Analysis	38 "	ASTMD 422-63
	d) Atterberg Limit	32 "	ASTMD4318
	e) Compaction	45 Specimen	ASTMD 698-78
	f) Permeability	36 "	Falling-head
	g) UU Triaxial Compression	16 "	ASTMD2850-82
	h) CU Triaxial Compression	16 "	JSF Standard

Table D4 TEST RESULTS OF SOIL MATERIALS (1/3)

Place and Name	Sample No.	Depth of Sampling (m)	Soil Classification	Specific Gravity +12.5mm	Specific Gravity -12.5mm	Water Content (%)	Atterberg Limits LL. (%)	Atterberg Limits PL. (%)	Atterberg Limits PI.	Grain Size Analysis Max. Grain Size (mm)	Grain Size Analysis mm -38.1 (%)	Grain Size Analysis mm -19.1 (%)	Grain Size Analysis mm -4.75 (%)	Grain Size Analysis mm -0.075 (%)	Grain Size Analysis mm -0.005 (%)	Remarks
Borrow Area A	SP-3	1.0	CL		2.84	25.0	35.0	15.6	19.4	1.2	100	100	100	75.8	30.0	
"		2.0					-	-	-							
"		3.0	SP		2.85	14.8	-	-	-	100	69.5	68.2	61.0	3.8	-	
"		4.0	SP	2.42		19.5	-	-	-	50	92.0	86.2	76.6	1.9	-	
"		5.0	SM			20.6	-	-	-	50	94.4	89.9	81.1	17.9	-	
"	SP-4	1.0	GC	2.49	2.84	10.4(13.3)	76.0	29.5	46.5	80	84.0	68.9	47.0	22.0	18.0	
"		2.0				30.0	70.2	28.8	41.4	-	-	-	-	-	-	
"		3.0	CH		2.86	27.5	-	-	-	0.85	100	100	100	72.6	62.0	
"		4.0				29.2	-	-	-	-	-	-	-	-	-	
"		5.0			2.76	23.4	53.4	22.6	30.8	-	-	-	-	-	-	
"		Mixed	CH		2.83	19.3	65.3	23.4	41.9	1.0	100	100	100	86.5	58.0	2 m - 5 m Depth
"	SP-5	1.0	SM		2.87	11.6	-	-	-	4.75	100	100	100	39.8	-	
"		2.0	SC	1.84	2.74	24.3(30.0)	28.3	16.6	11.7	20	100	100	96.3	40.0	29.5	
"		3.0	SM			15.2	-	-	-	37.5	100	97.6	94.2	31.1	-	
"		4.0	SM	2.49	2.86	10.1	-	-	-	50	92.4	76.7	60.3	11.2	-	
"		5.0	GM			12.9	-	-	-	80	70.5	61.6	49.5	15.8	-	
"	SP-6	1.0	CL		2.72	21.1	49.4	22.4	27.0	1.2	100	100	100	70.6	42.5	
"		2.0				22.6	-	-	-	-	-	-	-	-	-	
"		3.0	CH		2.86	26.1	63.0	24.8	38.2	2.0	100	100	100	72.2	54.5	
"		4.0				29.3	-	-	-	-	-	-	-	-	-	
"		5.0	SC	2.50	2.84	16.5(20.2)	62.2	23.4	38.8	37.5	100	90.0	68.9	39.7	20.0	
"		Mixed	CL		2.86	15.2	45.3	17.2	28.1	1.0	100	100	100	65.0	40.0	1 m - 2 m Depth
"	SP-7	1.0	CL		2.86	18.5	46.3	18.1	28.2	0.85	100	100	100	80.3	49.0	
"		2.0				30.5	74.3	30.8	43.5	-	-	-	-	-	-	
"		3.0	CH		2.81	28.9	69.3	26.1	43.2	1.2	100	100	100	86.9	59.0	
"		4.0			2.87	24.0	-	-	-	-	-	-	-	-	-	
"		5.0				24.4	-	-	-	-	-	-	-	-	-	
"		Mixed	CL		2.85	20.1	48.9	21.8	27.1	1.2	100	100	100	72.0	45.0	2 m - 5 m Depth

Table D4 TEST RESULTS OF SOIL MATERIALS (2/3)

Place and Name	Sample No.	Depth of Sampling (m)	Soil Classification	Specific Gravity +12.5mm	Specific Gravity -12.5mm	Water Content (%)	Atterberg Limits LL. (%)	Atterberg Limits PL. (%)	Atterberg Limits PI.	Grain Size Analysis Max. Grain Size (mm)	Grain Size Analysis mm -38.1 (%)	Grain Size Analysis mm -19.1 (%)	Grain Size Analysis mm -4.75 (%)	Grain Size Analysis mm -0.075 (%)	Grain Size Analysis mm -0.005 (%)	Remarks
Quarry Area	SP-1	1.0	CH		2.77	18.2	57.4	26.3	31.1	2.0	100	100	100	76.4	49.0	
"		2.0	SC	2.52	2.85	19.2(13.5)	58.4	26.7	31.7	25	100	98.5	74.1	45.6	27.8	
"		3.0	CH		2.86	20.2(21.7)	61.7	25.6	35.9	25	100	99.2	95.0	74.8	32.5	
"		4.0	CH		2.83	16.7(18.6)	55.9	26.9	29.0	19	100	100	89.2	66.0	32.5	
"		5.0	CH		2.87	21.2(20.8)	55.3	23.5	31.8	25	100	89.0	85.7	76.2	34.0	
"		Mixed	CH		2.85	13.6	57.5	27.6	29.9	25	100	99.3	91.7	77.0	37.0	3 m - 5 m Depth
"	SP-2	1.0	CH		2.85	18.8(18.4)	56.0	28.3	26.7	12.5	100	100	99.1	83.0	42.5	
"		2.0	CL		2.84	12.8(15.3)	48.2	20.8	27.4	19.0	100	100	97.8	79.0	55.5	
"		3.0	CL	2.23	2.84	13.5(18.4)	42.9	16.9	26.0	19.0	100	100	90.4	67.7	41.0	
"		Mixed	CL'		2.83	12.5	45.4	14.5	30.9	25	100	99.2	92.6	62.0	30.5	1 m - 3 m Depth
Temporary Road			ML		2.87	12.9	45.7	28.1	17.6	1.2	100	100	100	63.5	30.5	
Borrow Area B	SP-8	1.0	CL		2.76	21.0	40.0	15.9	24.1	0.85	100	100	100	85.4	61.0	
"		2.0			2.80	23.4	-	-	-	-	-	-	-	-	-	
"		3.0	CH			21.9	56.2	20.9	35.3	0.85	100	100	100	82.9	44.5	
"		4.0			2.80	19.2	-	-	-	-	-	-	-	-	-	
"		5.0				19.7	-	-	-	-	-	-	-	-	-	
"		Mixed			2.84	12.4	56.4	22.0	34.4	1.2	100	100	100	80.8	44.0	2 m - 5 m Depth
"	SP-9	1.0	CH		2.85	18.2	55.2	25.6	29.6	2.0	100	100	100	59.3	41.0	
"		2.0				22.3	-	-	-	-	-	-	-	-	-	
"		3.0			2.86	22.5	-	-	-	-	-	-	-	-	-	
"		4.0	CH		2.85	27.8	-	-	-	1.0	100	100	100	71.7	55.0	
"		5.0				27.1	55.0	24.8	30.2	-	-	-	-	-	-	
"	SP-10	1.0				24.7	-	-	-							
"		2.0	CL		2.83	20.0	38.2	13.6	24.6	2.0	100	100	100	72.2	42.0	
"		3.0				21.6	-	-	-							
"		4.0	CH		2.85	22.9	50.7	22.4	28.3	1.0	100	100	100	92.8	75.5	
"		5.0			2.85	25.1	-	-	-							
"		Mixed-1	CL		2.86	10.2	47.4	17.8	29.6	1.2	100	100	100	70.9	38.0	1 m - 2 m Depth
"		Mixed-2	CH		2.87	12.4	70.0	28.7	41.3	1.2	100	100	100	84.4	48.0	3 m - 5 m Depth

Table D4 TEST RESULTS OF SOIL MATERIALS (3/3)

Place and Name	Sample No.	Compaction & Permeability			Triaxial Compression Test															
					UU Test								$\overline{CU}$ Test							
					Aimed Water Content = Wopt.				Aimed Water Content = Wopt.+2%				Aimed Water Content = Wopt.				Aimed Water Content = Wopt.+2%			
		Opt. Water Content (%)	Max. Dry Density (t/m^3)	Coef. of Permea-belity (cm/sec)	Water Content (%)	Dry Density (t/m^3)	C (σ=2-4kgf/cm^2) (kgf/cm^2)	ϕ (deg.)	Water Content (%)	Dry Density (t/m^3)	C (σ=2-4kgf/cm^2) (kgf/cm^2)	ϕ (deg.)	Water Content (%)	Dry Density (t/m^3)	$\overline{C}$ (kgf/cm^2)	$\overline{\phi}$ (deg.)	Water Content (%)	Dry Density (t/m^3)	$\overline{C}$ (kgf/cm^2)	$\overline{\phi}$ (dge.)
Borrow Area A	SP-4 Mixed	24.8	1.600	2.9×10^{-7}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
"	SP-6 Mixed	21.0	1.660	7.0×10^{-8}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
"	SP-7 Mixed	25.3	1.570	2.7×10^{-8}	25.4	1.582	0.95	25.40	27.3	1.572	0.70	19.29	27.6	1.550	0.57	17.69	27.9	1.598	0.58	14.84
Quarry Site	SP-1 Mixed	19.0	1.740	4.2×10^{-8}																
"	SP-2 Mixed	17.0	1.671	4.0×10^{-7}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Temporary Road	-	18.5	1.737	2.6×10^{-7}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Borrow Area B	SP-8 Mixed	19.5	1.722	1.5×10^{-7}	20.1	1.708	1.05	25.40	22.3	1.657	1.55	26.57	21.1	1.771	0.41	26.01	22.9	1.646	0.62	21.75
"	SP-10 Mixed	18.6	1.744	4.8×10^{-8}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
"	SP-10 Mixed	19.4	1.707	4.0×10^{-7}																

Table D5 TEST RESULTS OF CONCRETE AGGREGATES, FILTER MATERIALS AND ROCKFILL MATERIALS

Place, Name and Sample No.		Specific Gravity	Absorption (%)	Grain Size Analysis -80 mm (%)	-63.5 mm (%)	-50 mm (%)	-37.5 mm (%)	-25 mm (%)	-19.1 mm (%)	-12.5 mm (%)	-9.5 mm (%)	-4.75 mm (%)	-2.36 mm (%)	-1.18 mm (%)	-0.6 mm (%)	-0.3 mm (%)	-0.15 mm (%)	-0.075 mm (%)	Soundness	Abrassion 9.5-37.5 mm (%)	Organic Impurities	Scratch Hardness (%)	Unite Weight (t/m³)	Fineness Modulus (FM)
Borrow Area C																								
GP-1	Fine Agg.	2.61	1.0									100	87.3	78.3	51.3	28.2	4.7	1.1			passed			2.55
	Coars Agg.	2.62	0.5	100	98.9	94.5	74.9	58.6	46.3	24.0	16.0	0.3							0.6	30		7.08	1.721	
	Original			98.6	97.8	94.9	81.5	70.5	62.1	46.8	41.4	30.7	26.7	24.0	15.7	8.6	1.4	0.3						
GP-2	Fine Agg.	2.62	0.9									99.7	80.3	64.4	49.7	25.1	9.2	5.0			passed			2.71
	Coars Agg.	2.60	0.5	100	89.2	79.5	66.6	49.2	35.8	21.0	13.4	1.7							0.5	31		5.16	1.717	
	Original			88.0	81.1	74.9	66.6	55.5	46.9	37.0	32.6	25.1	20.2	16.2	12.5	6.3	2.3	1.3						
GP-3	Fine Agg.	2.63	1.2									95.8	80.5	70.1	62.7	48.3	19.1	8.2						
	Coars Agg.	2.65	1.1	100	95.9	83.5	69.8	47.5	28.8	20.0	12.9	2.2							1.2	30	unpassed	4.95	1.754	
	Original			97.6	94.7	85.9	76.3	60.6	47.4	40.0	36.2	28.7	23.1	20.1	18.0	13.9	5.5	2.4						
GP-4	Fine Agg.	2.56	1.9									99.8	87.1	76.9	69.3	50.0	19.8	8.4			passed			1.97
	Coars Agg.	2.60	0.6	93.3	86.7	76.4	68.4	48.9	36.0	21.0	14.6	1.2							0.4	29		3.59	1.752	
	Original			85.1	75.4	67.9	61.9	47.7	38.2	28.0	22.6	12.6	10.4	9.1	8.2	6.0	2.4	1.0						
GP-5	Fine Agg.	2.62	1.1									99.9	83.9	66.1	53.8	41.5	25.8	10.7			passed			2.28
	Coars Agg.	2.66	0.5	96.0	78.5	71.3	59.3	47.2	36.7	23.0	15.5	1.3							0.5	29		1.96	1.745	
	Original			86.6	71.8	66.8	58.5	50.1	42.8	33.0	28.1	18.4	15.4	12.2	9.9	7.6	4.7	2.0						
Quarry Site																								
Quarry No.1		2.53	2.0																3.0	60	-	5.56	-	-
" No.2		2.60	0.6																1.9	47	-	2.81	-	-
Q85-1 (5 - 10 m)		2.67	1.42																-	36	-	17.44	-	-
Q85-3 (15 - 20 m)		2.67	1.39																-	30	-	9.17	-	-

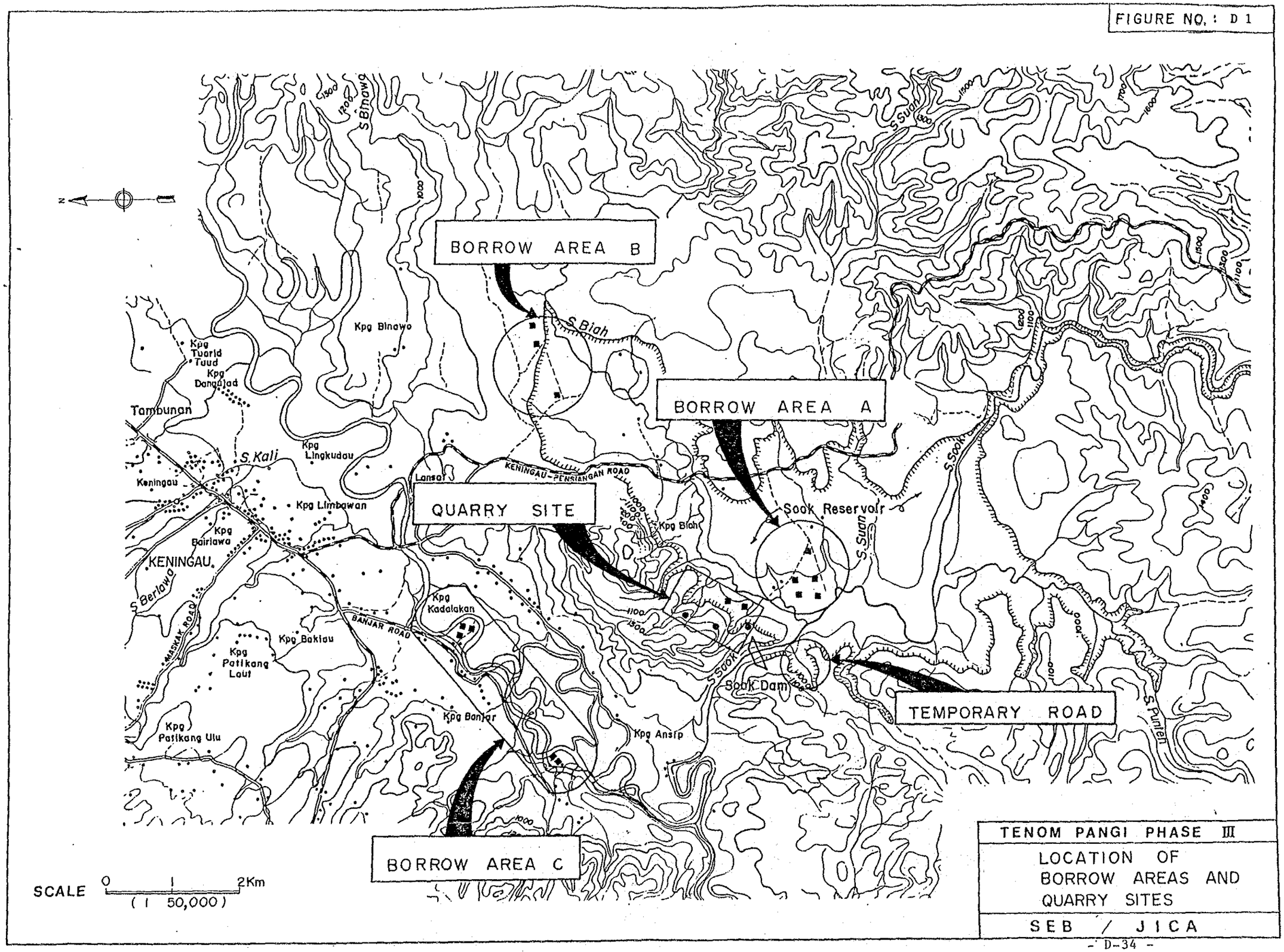
)

Table D6 RESULT OF TESTS (BORING CORE)

Name	Sample No.	Depth (m)	Classification	Specific Gravity	Absorption (%)	Dry or SSD Density (t/m^3)	Compre. Strength (kg/cm^2)
Q85-1	1	5.43 - 5.75	CM	2.725	1.18	2.580	D 710.1
	2	5.43 - 5.75	"			2.614	S 465.6
	3	6.49 - 6.60	"	2.683	1.65	2.580	S 292.0
	4	6.49 - 6.60	"			2.498	D 291.7
	5	7.09 - 7.19	CL-CM	2.692	1.65	2.536	D 903.9
	6	7.35 - 7.45	CL-CM			2.560	S 536.4
	7	30.27 - 30.91	CH			2.592	D1,088.8
	8	30.27 - 30.91	"			2.578	D1,824.4
	9	30.27 - 30.91	"	2.699	0.97	2.590	D1,113.0
	10	30.27 - 30.91	"			2.621	S 764.5
	11	30.27 - 30.91	"			2.624	S 667.8
	12	30.27 - 30.91	"			2.616	S 812.9
Q85-3	13	7.32 - 7.53	CL			2.555	D 557.3
	14	7.32 - 7.53	"	2.688	1.33	2.592	S 580.4
	15	10.19 - 10.33	"			2.557	D 692.0
	16	10.19 - 10.33	"			2.598	S 459.7
	17	14.53 - 14.73	"	2.673	1.16	2.556	D 643.6
	18	14.53 - 14.73	"			2.597	S 580.7
	19	15.17 - 15.37	CM			2.638	S 900.8
	20	15.17 - 15.37	"	2.690	1.24	2.613	D 508.1
	21	15.64 - 15.74	"			2.570	D1,113.6
	22	16.43 - 16.53	"			2.595	S 266.9
	23	18.38 - 18.69	"	2.680	0.77	2.620	S 429.8
	24	18.38 - 18.69	"			2.585	D 629.1
	25	35.50 - 35.70	CH	2.689	0.73	2.605	D 758.0
	26	35.50 - 35.70	"			2.620	S1,193.1
	27	37.04 - 37.14	"	2.706	0.62	2.613	D 958.2
	28	38.49 - 38.59	"			2.620	S 459.2

Note: D and S denote Dry and SSD condition respectively.

FIGURE NO. : D 1

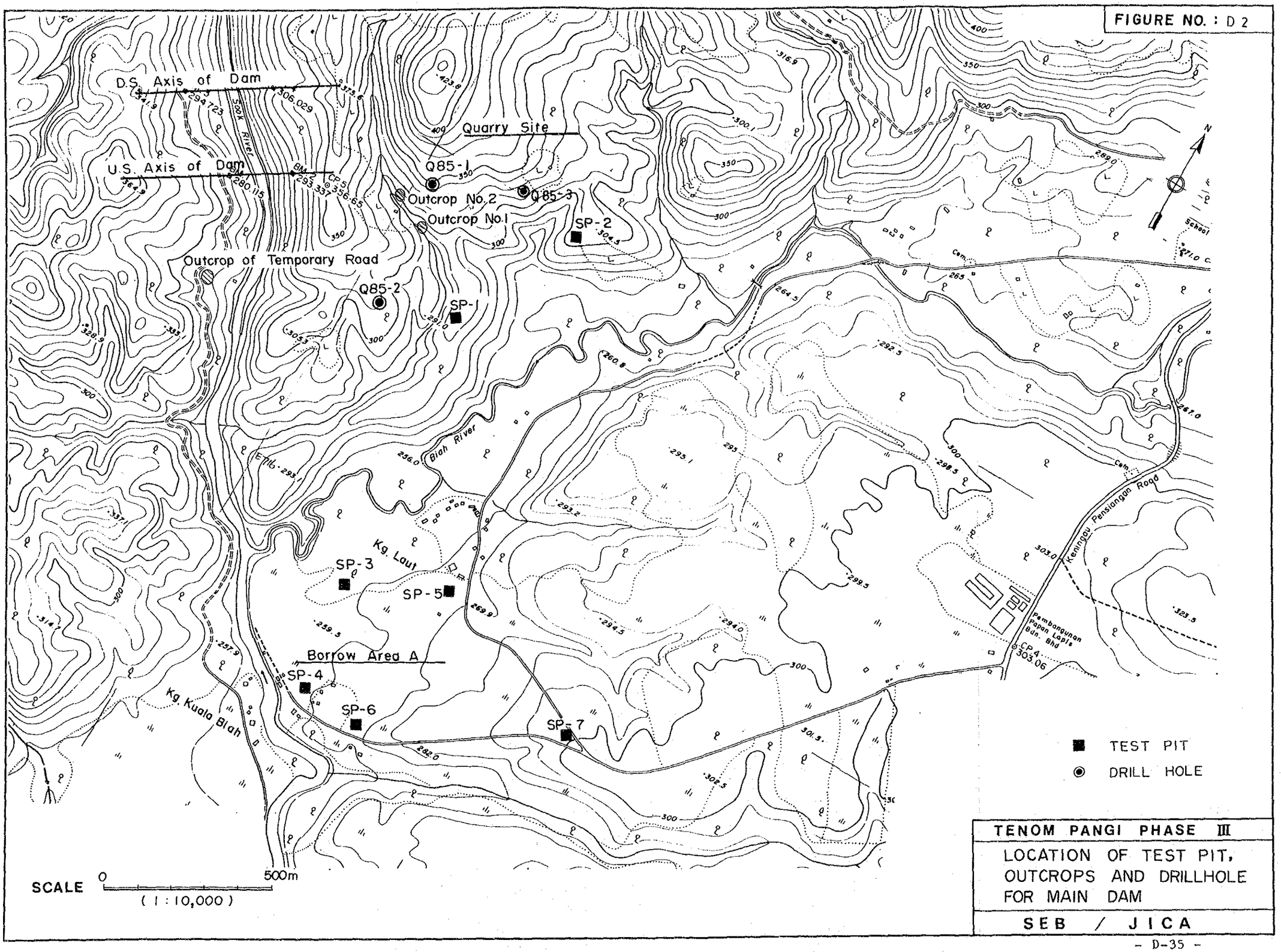


TENOM PANGI PHASE III

LOCATION OF BORROW AREAS AND QUARRY SITES

SEB / JICA

FIGURE NO. : D 2



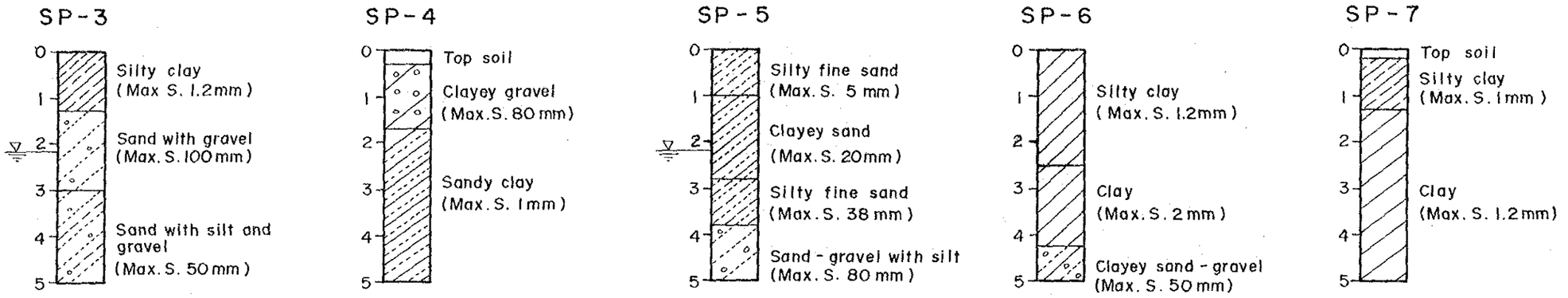
TENOM PANGI PHASE III

LOCATION OF TEST PIT, OUTCROPS AND DRILLHOLE FOR MAIN DAM

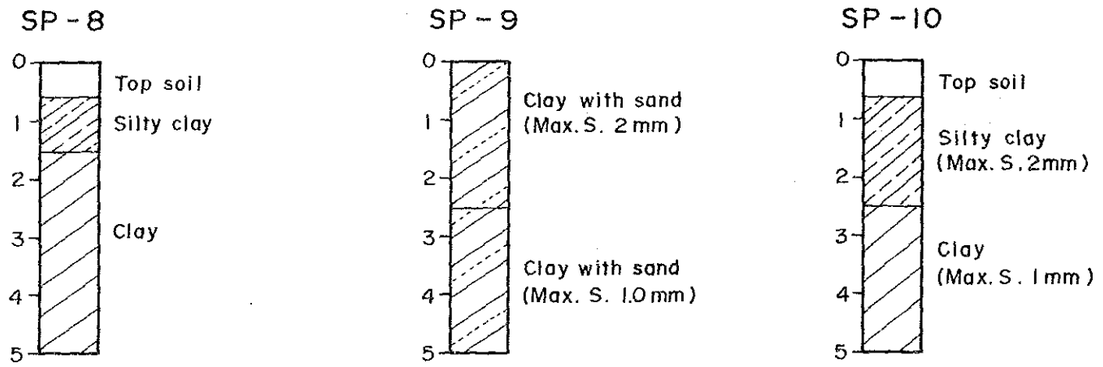
SEB / JICA

FIGURE NO. : D 3

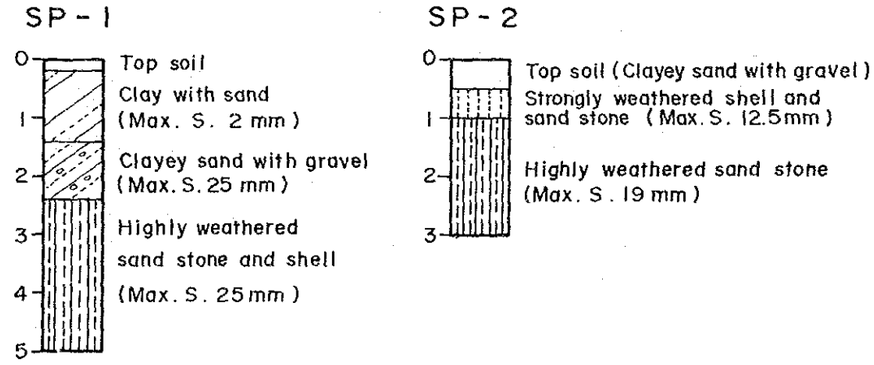
BORROW AREA - A



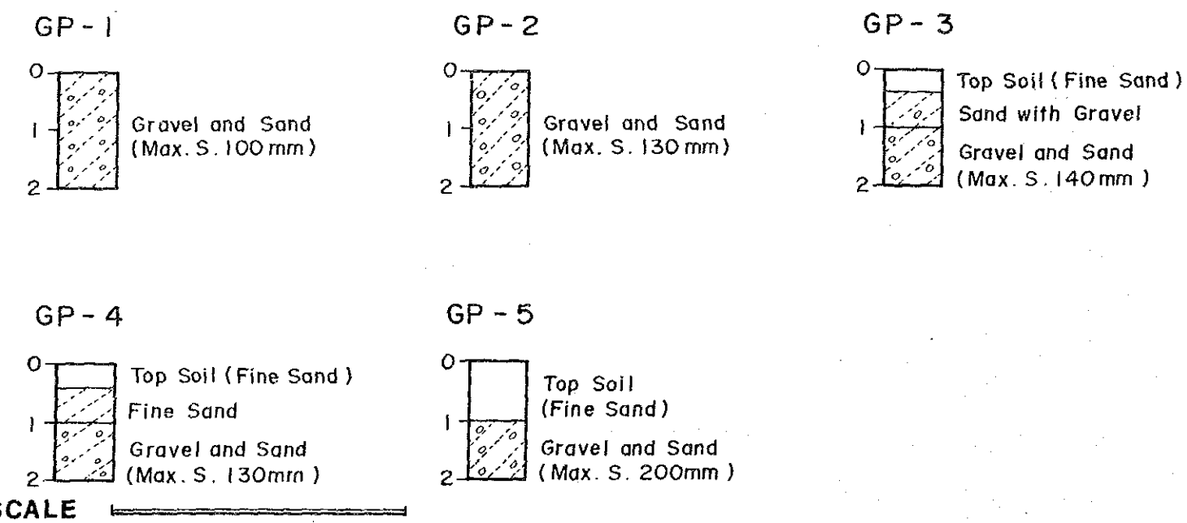
BORROW AREA - B



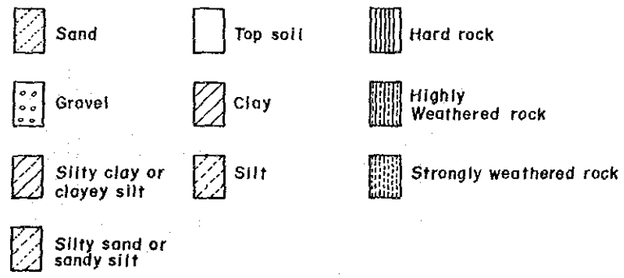
QUARRY SITE



BORROW AREA - C



LEGEND FOR TEST PIT

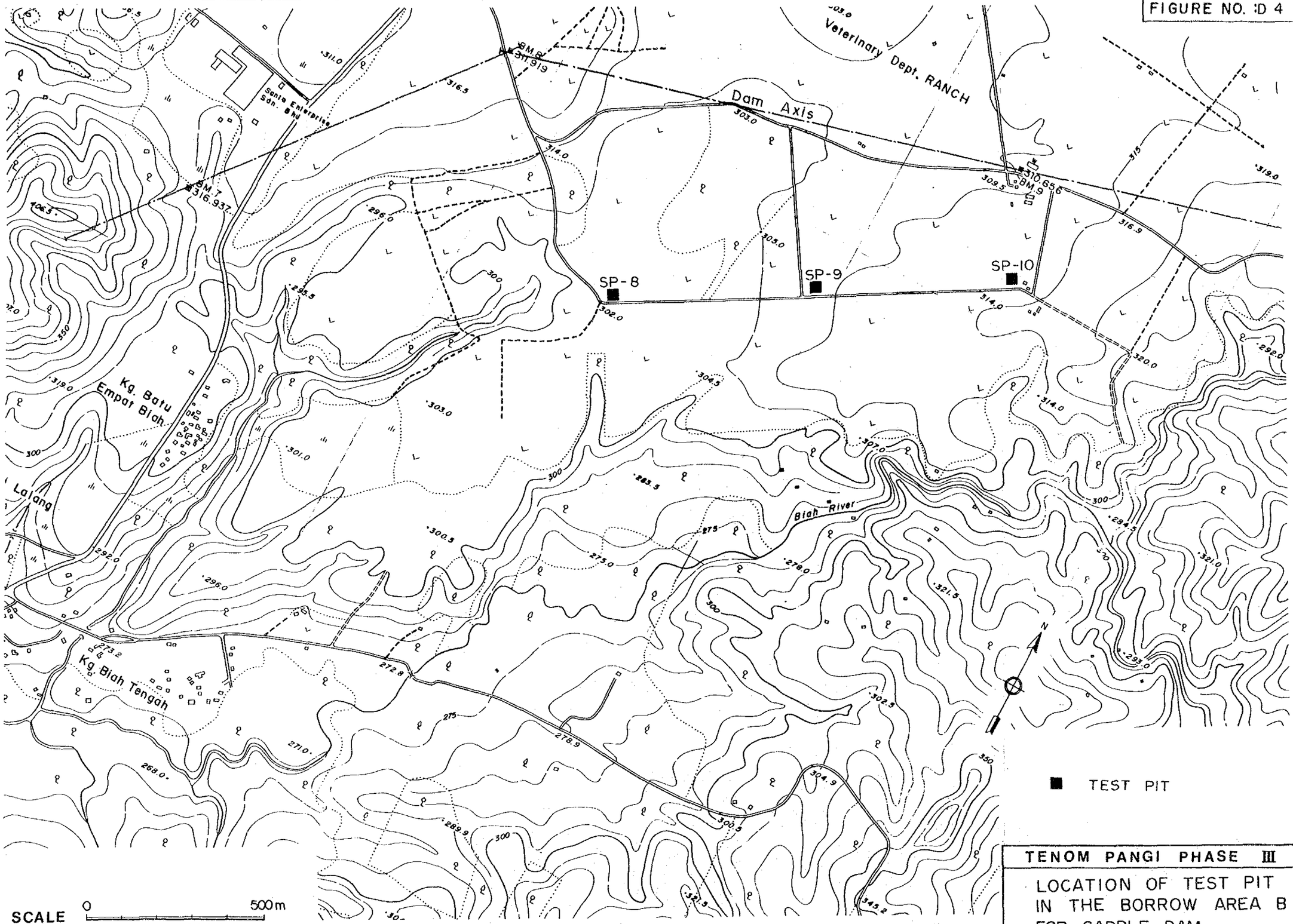


TENOM PANGI PHASE III

SUMMARY OF TEST PIT LOGS

SEB / JICA

FIGURE NO. :D 4



TENOM PANGI PHASE III

LOCATION OF TEST PIT IN THE BORROW AREA B FOR SADDLE DAM

SEB / JICA

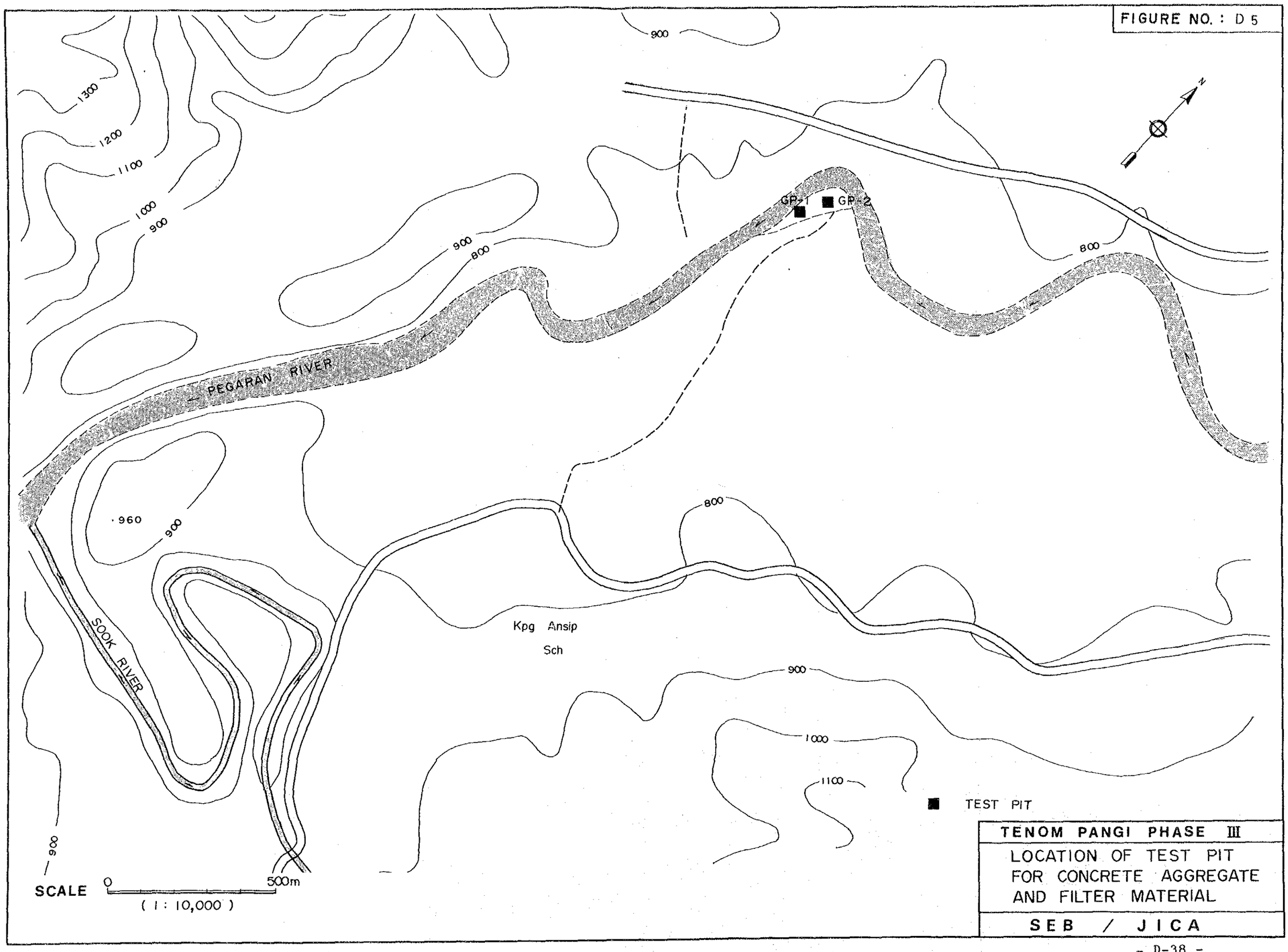
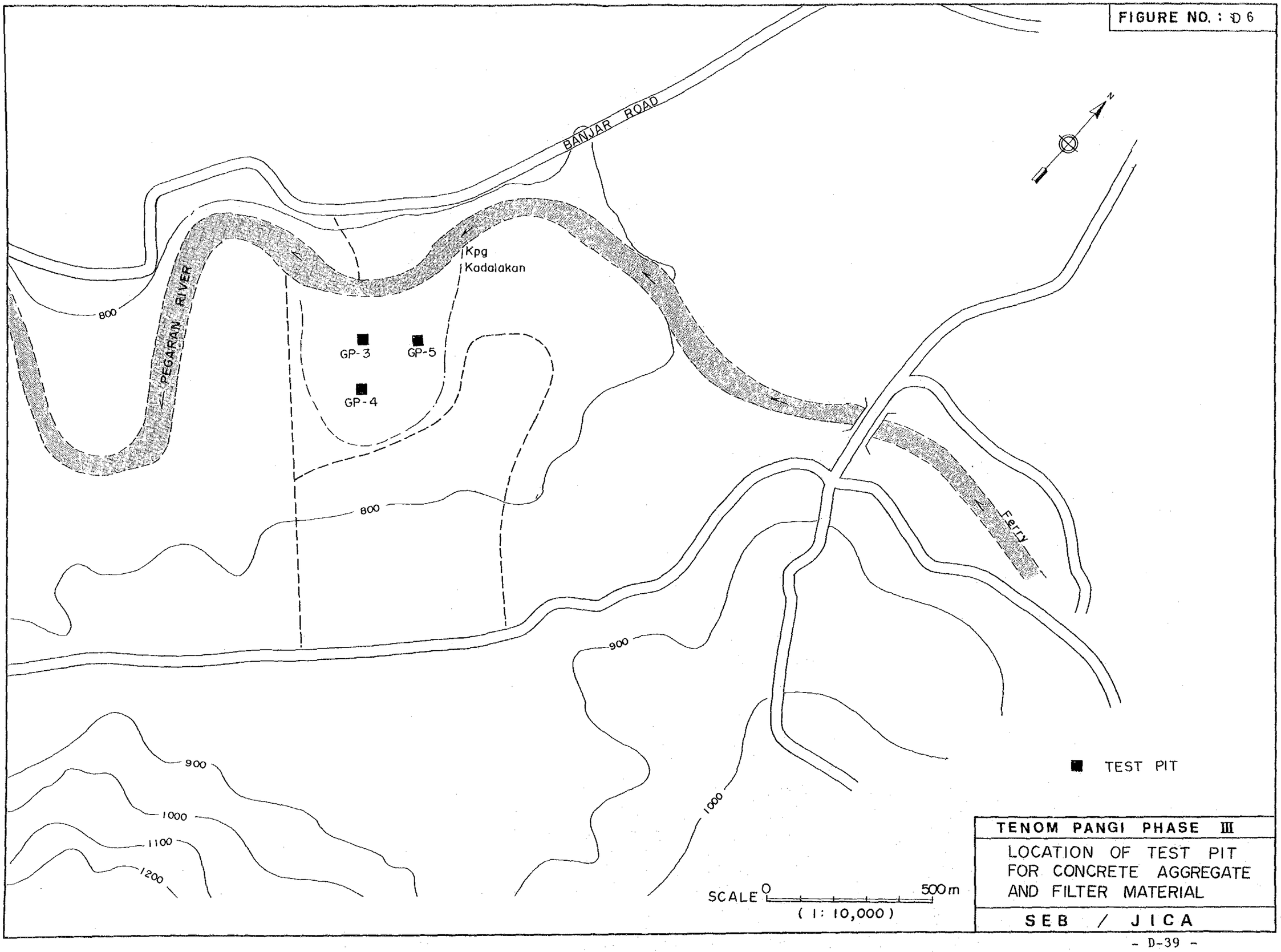


FIGURE NO. : D 5
900
1300
1200
1100
1000
900
900
800
800
GP-1
GP-2
PEGARAN RIVER
960
900
800
SOOK RIVER
Kpg Ansip
Sch
900
1000
1100
TEST PIT
900
SCALE
0
500m
(1 : 10,000)
TENOM PANGI PHASE III
LOCATION OF TEST PIT
FOR CONCRETE AGGREGATE
AND FILTER MATERIAL
SEB / JICA

FIGURE NO. : D 6



TENOM PANGI PHASE III
LOCATION OF TEST PIT FOR CONCRETE AGGREGATE AND FILTER MATERIAL
SEB / JICA

Fig.- D 7 BORROW AREA A - GRADATION CURVE (EXCEPT SAND - GRAVEL LAYER)

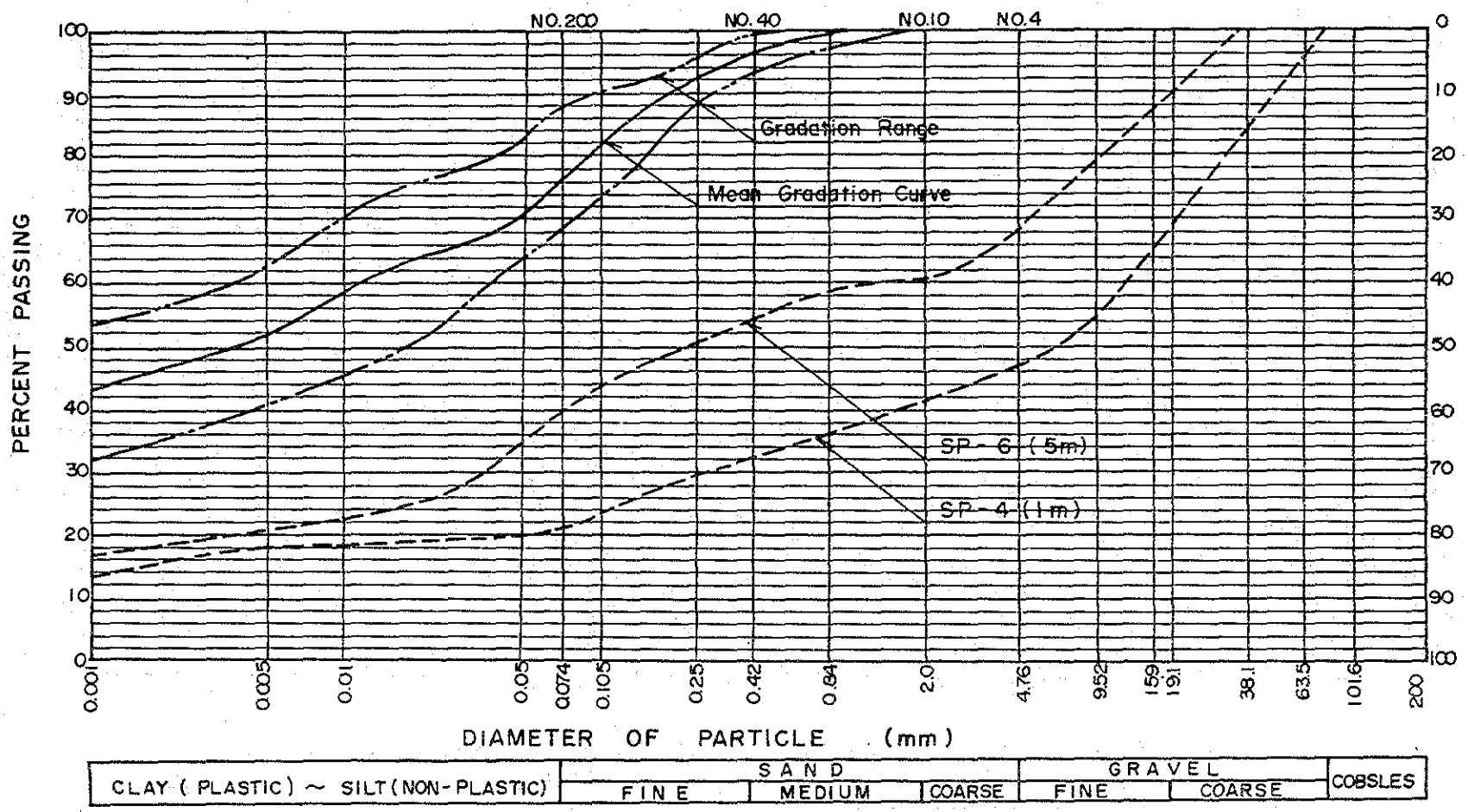


Fig.- D 8 BORROW AREA A - GRADATION CURVE (SAND - GRAVEL LAYER)

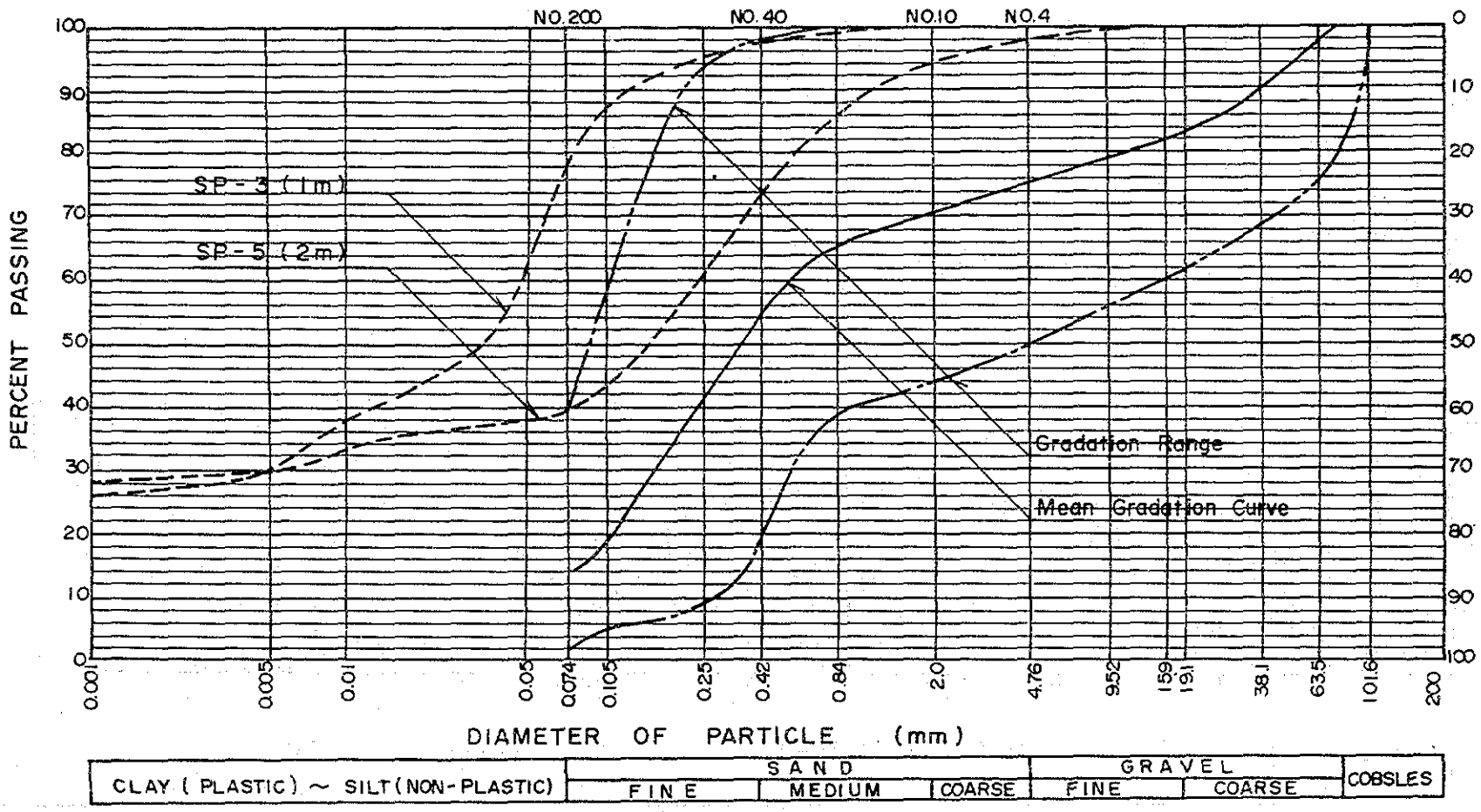


Fig.- D 9 QUARRY SITE - GRADATION CURVE

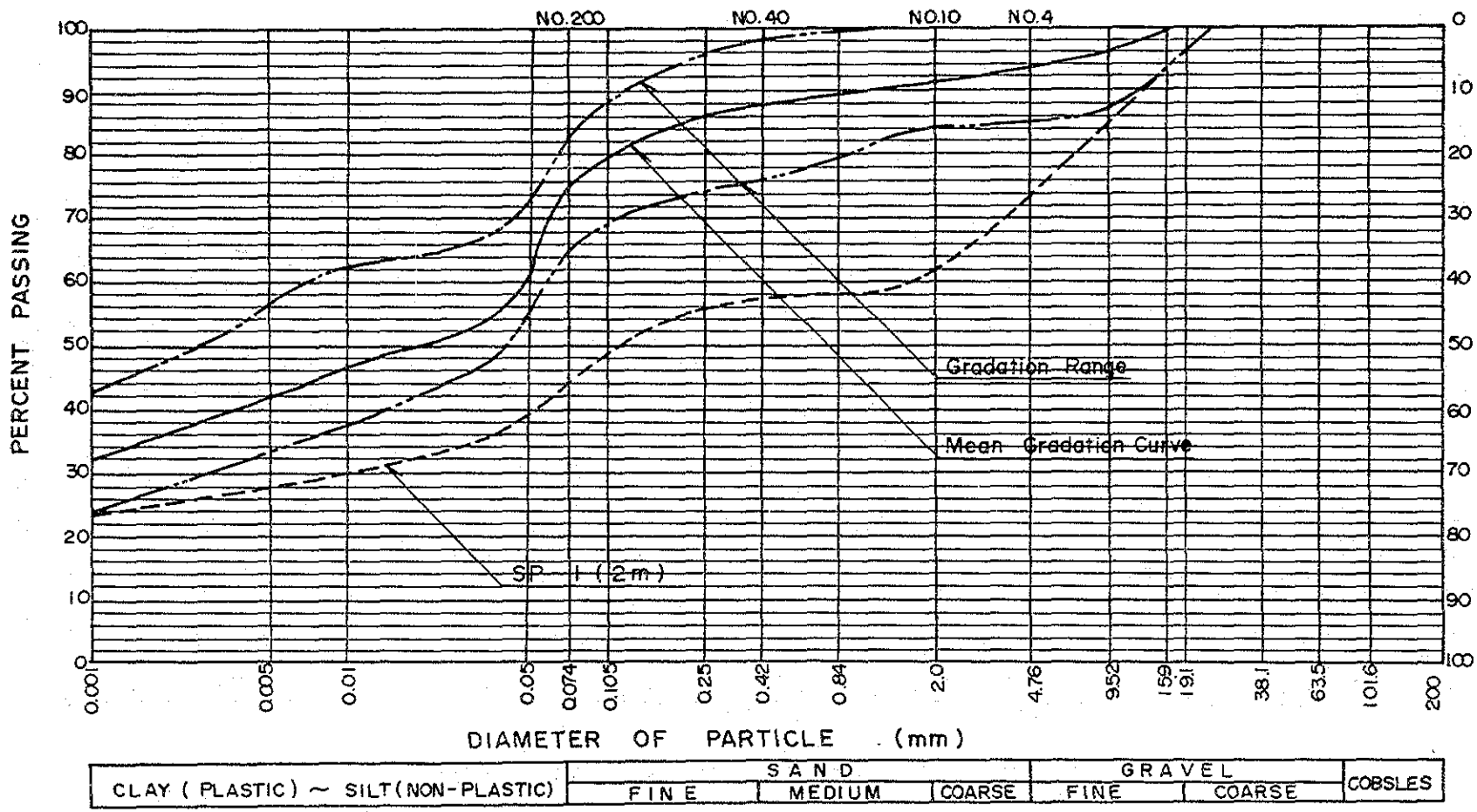


Fig.- D10 TEMPORARY ROAD - GRADATION CURVE

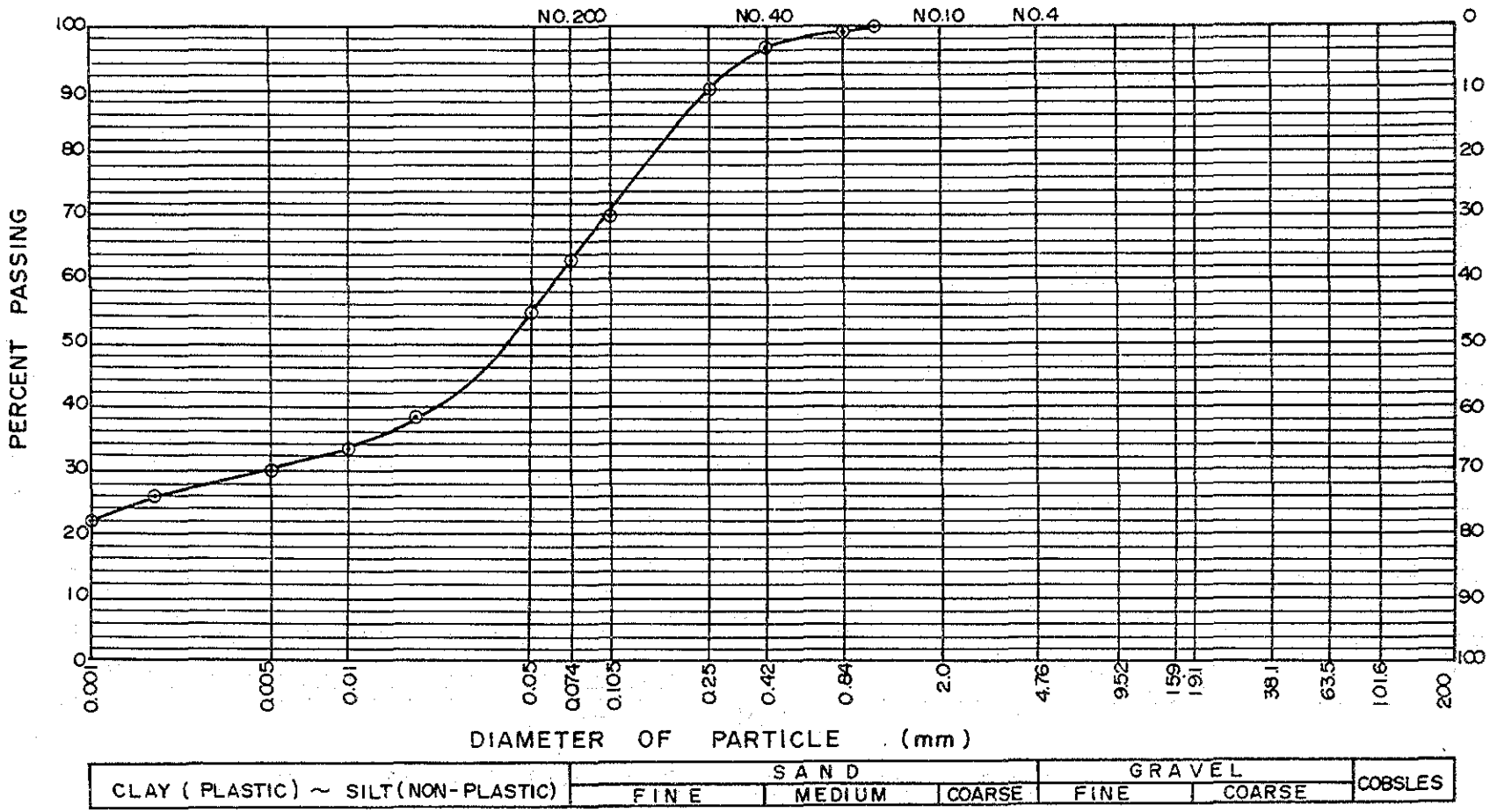
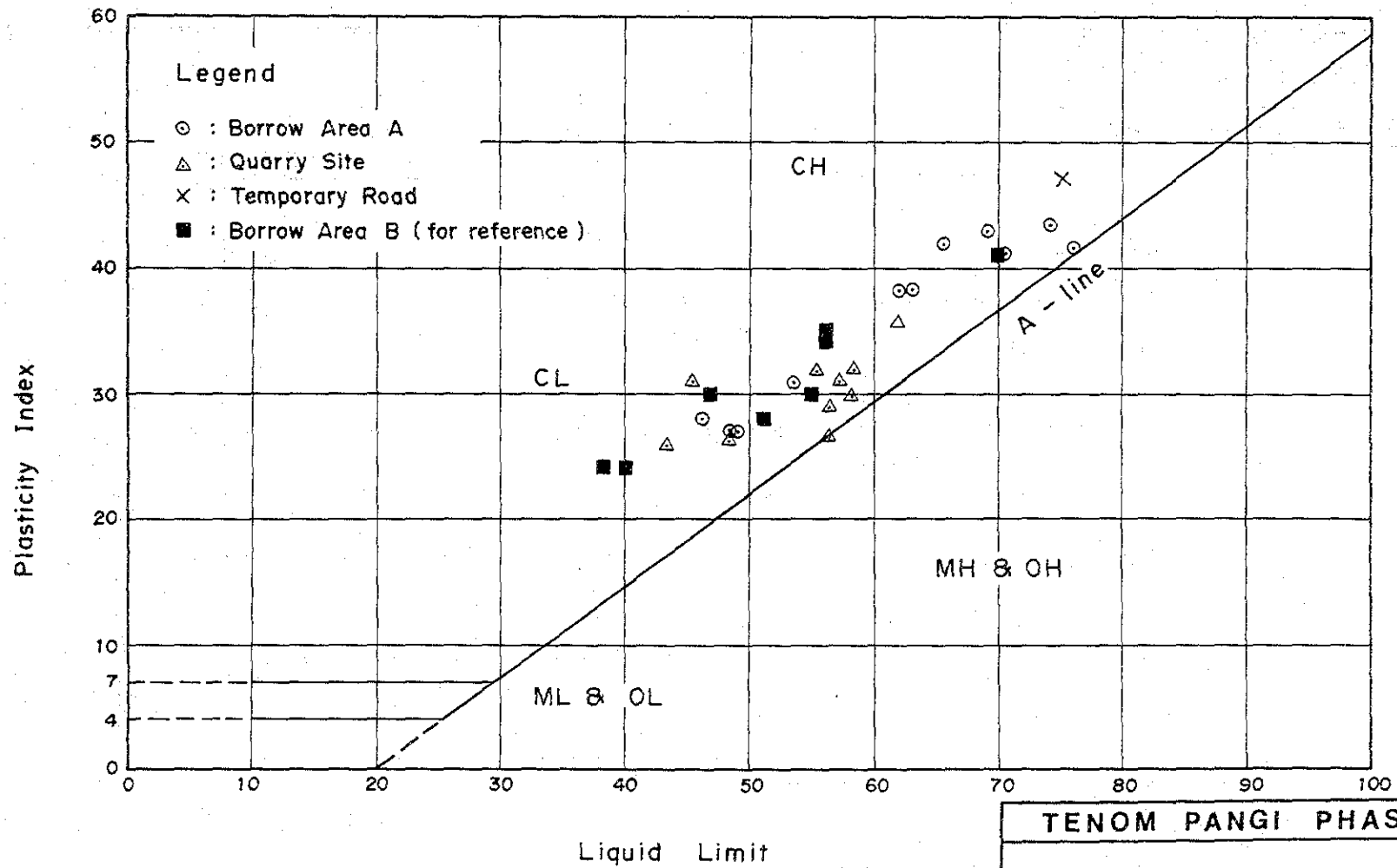


FIGURE NO. : D 11



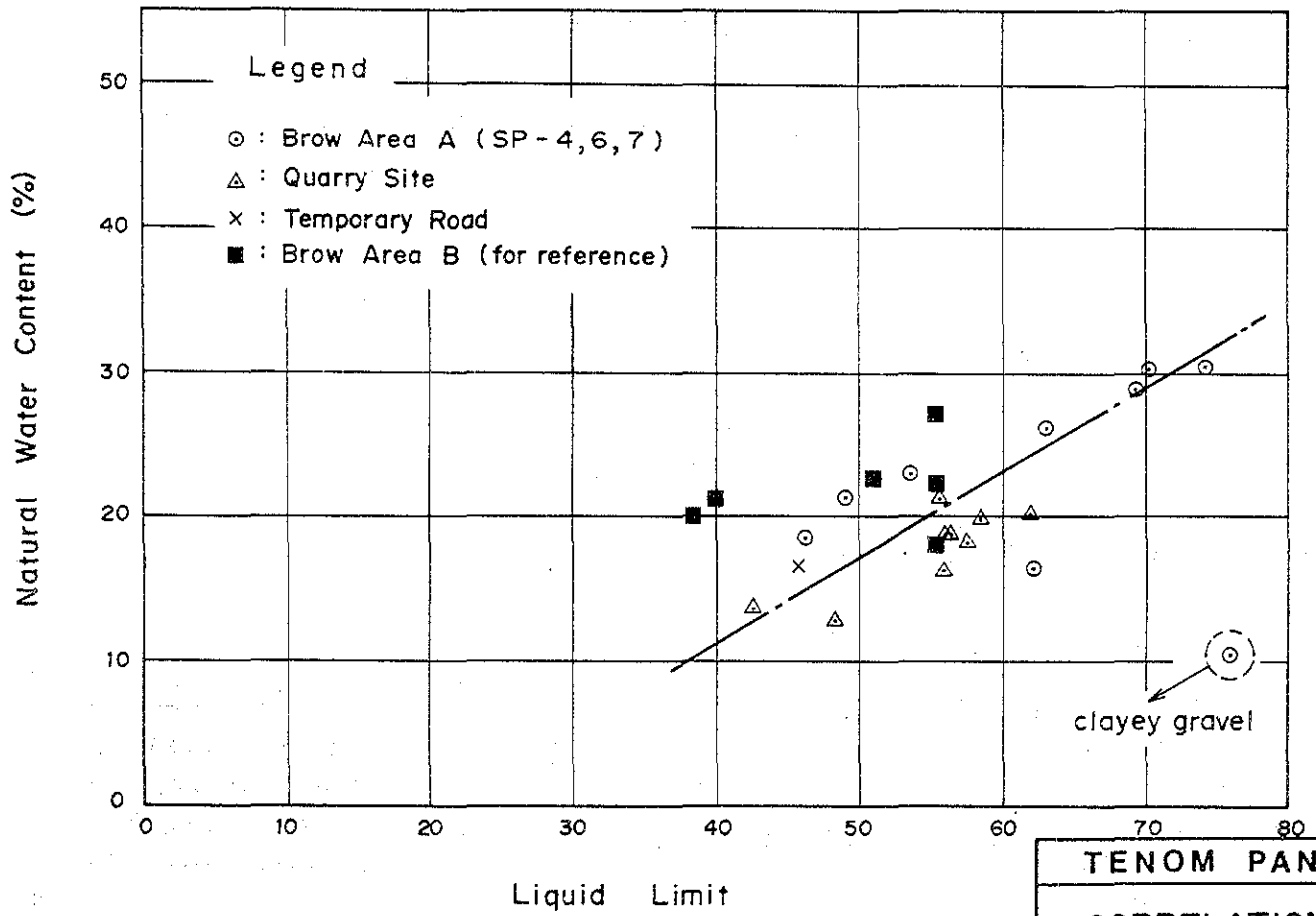
SCALE

TENOM PANGI PHASE III

PLASTICITY CHART

SEB / JICA

FIGURE NO. : D 12



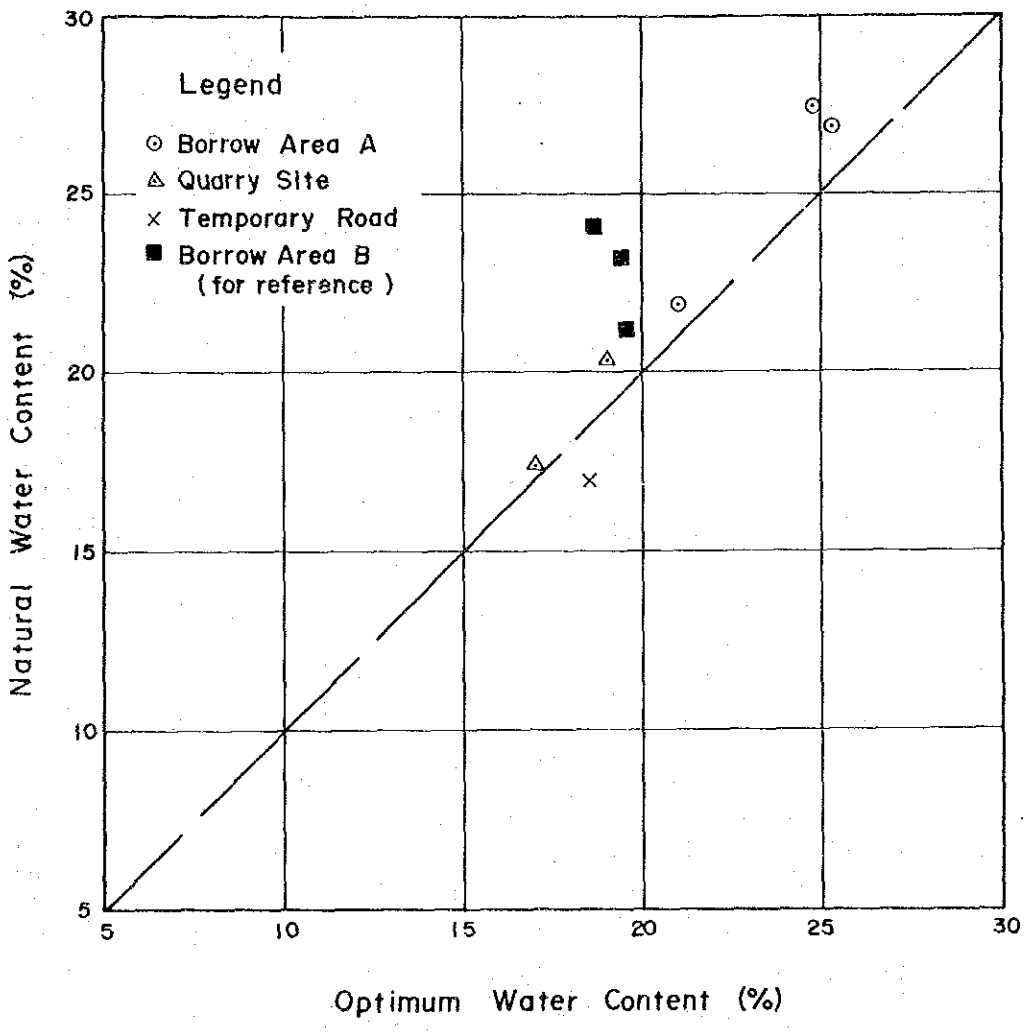
SCALE

TENOM PANGI PHASE III

CORRELATION BETWEEN LIQUID LIMIT AND NATURAL WATER CONTENT

SEB / JICA

FIGURE NO. : D13



TENOM PANGI PHASE III

CORRELATION BETWEEN NATURAL WATER CONTENT AND OPTIMUM WATER CONTENT

SEB / JICA

Fig.-D14 BORROW AREA B - GRADATION CURVE

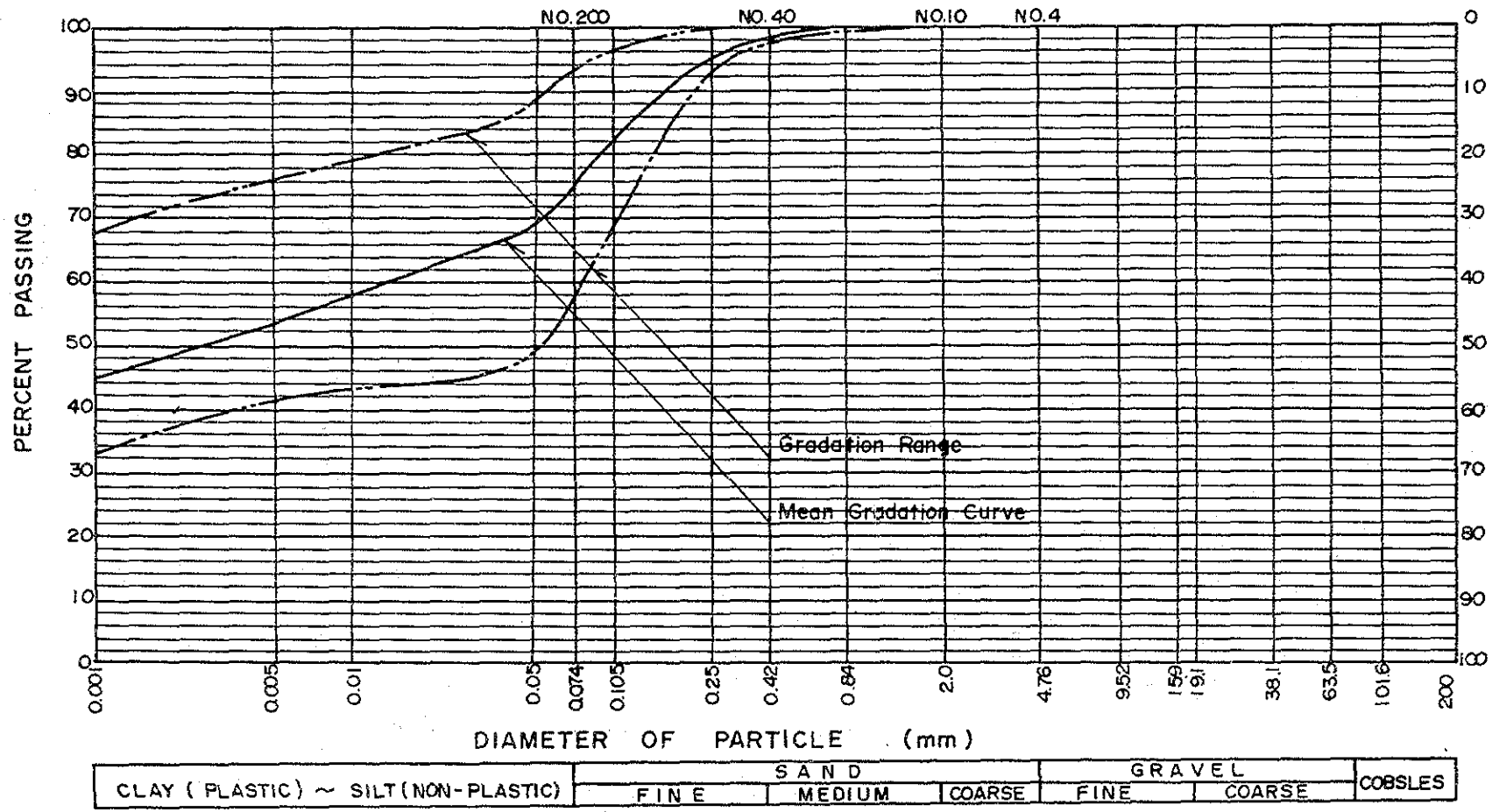


Fig. -D15 BORROW AREA C - GRADATION CURVE

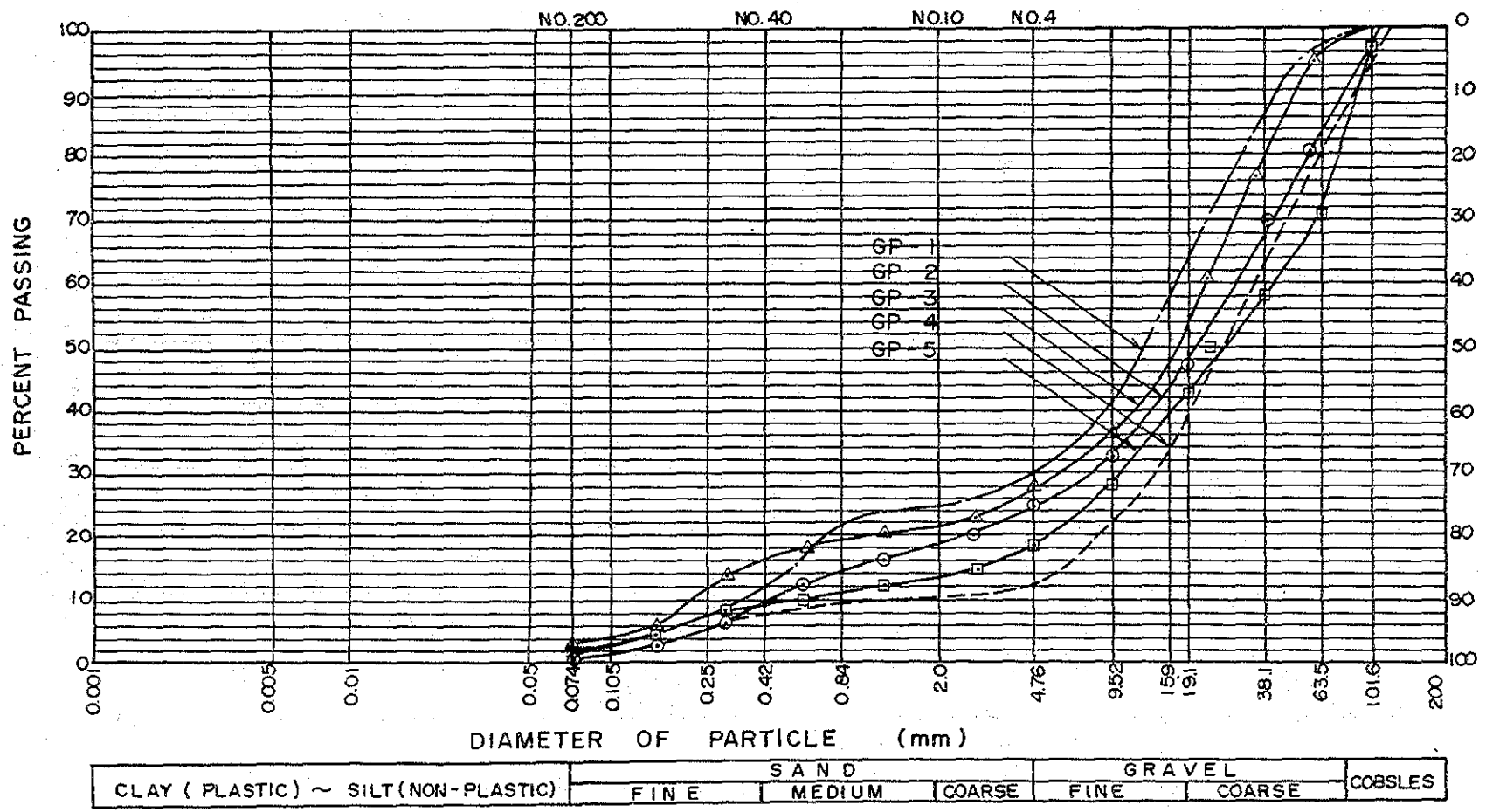
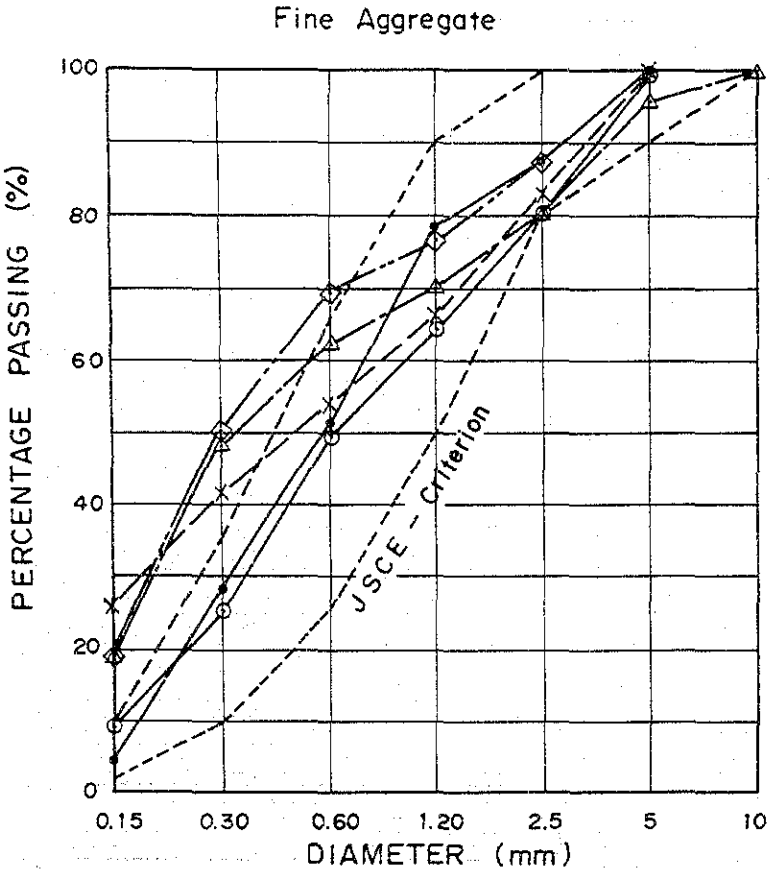
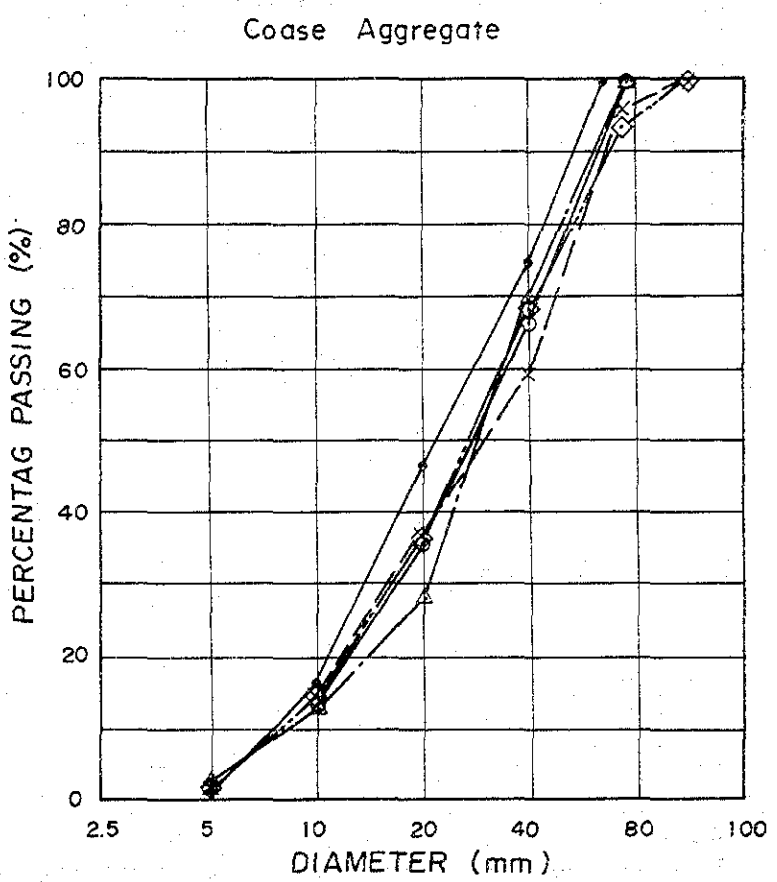


FIGURE NO. : D 16





LEGEND

: GP-1 : GP-3 : GP-5

: GP-2 : GP-4

SCALE

TENOM PANGI PHASE III

GRADATION CURVE OF FINE AND CORASE AGGREGATE

SEB / JICA

Fig. -D17 RELATION BETWEEN SOIL MATERIALS AND FILTER MATERIALS

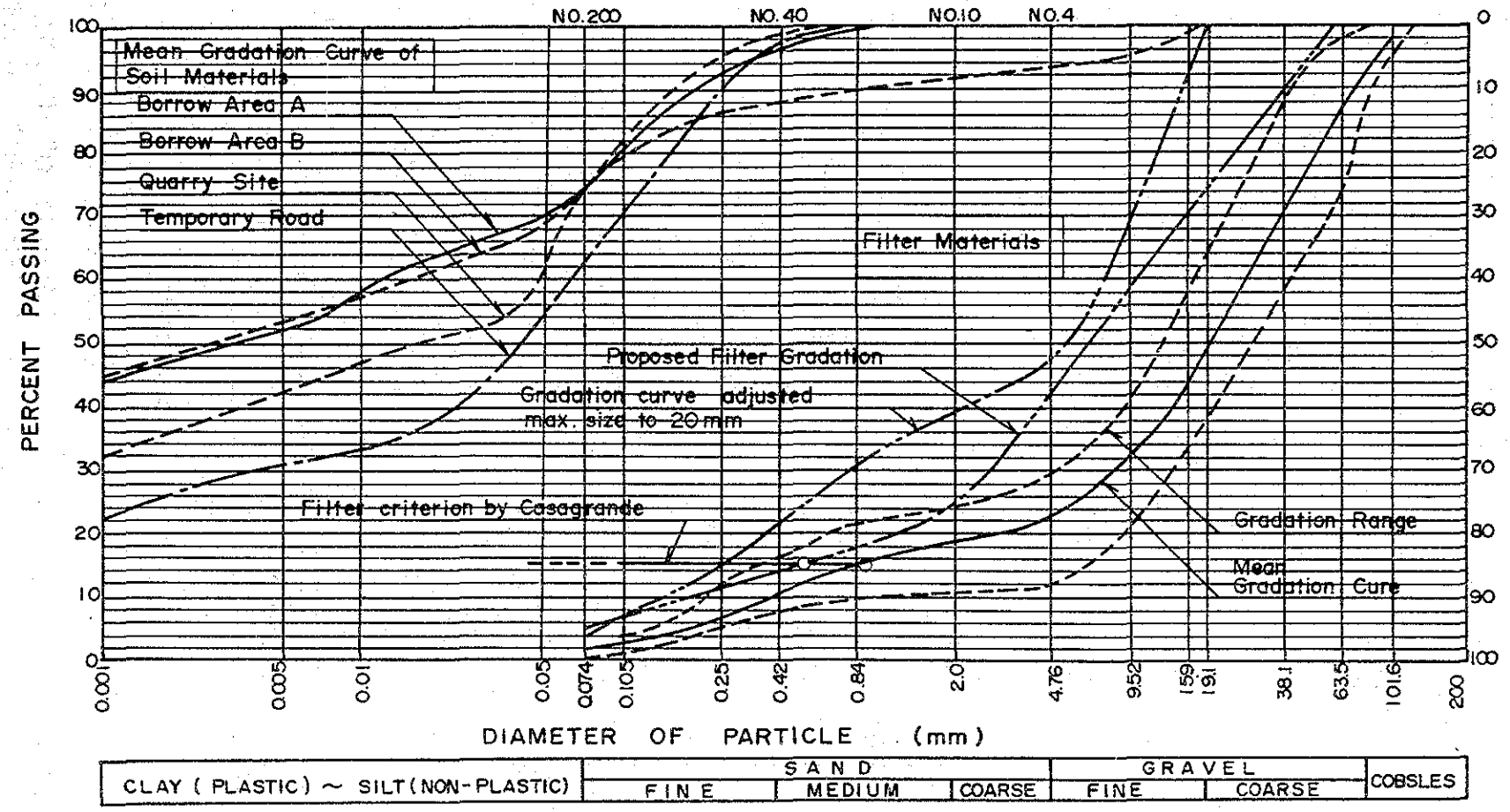
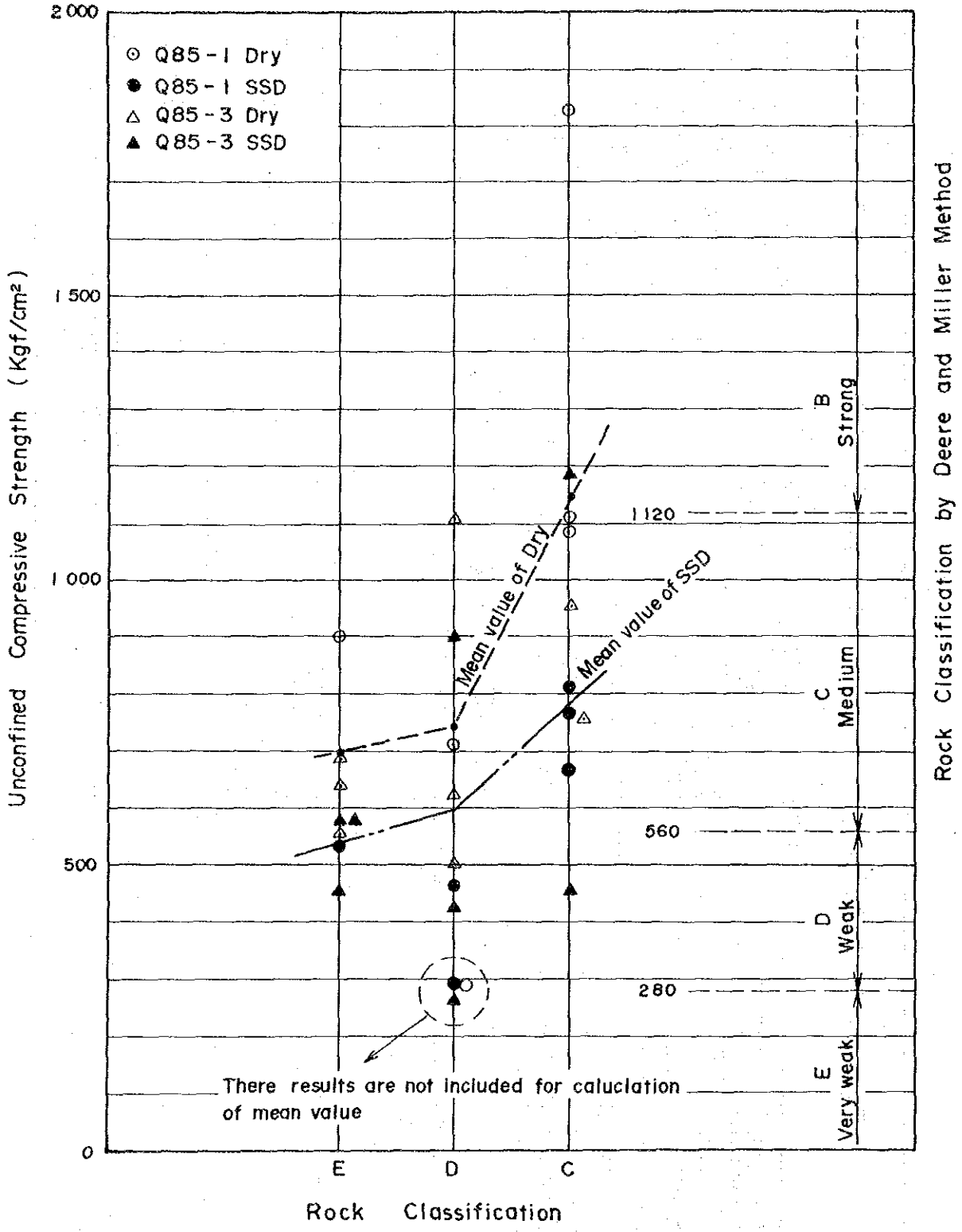


FIGURE NO. : D 18



TENOM PANGI PHASE III

RESULTS OF UNCONFINED COMPRESSIVE STRENGTH TESTS

SEB / JICA