# Appendix 8
# Natural Conditions Survey Results
# - Topographic/Geotechnical

Appendix-8 Natural Conditions Survey Results - Topographic/Geotechnical

# 1. Topographic Survey

## 1-1 Topographic Survey Summary

(1) Scope of Work

Number of bridges: 45 (construction 22, procurement 23)

| Item | Survey Item | Bridge Type | Survey quantities |
|---|---|---|---|
| Plan extent of survey | Direction of road | Procurement | 50m＋ river width ＋50m |
| | | Construction | 150m＋ river width ＋150m |
| | Direction of river | Procurement | Upstream and downstream 25m from road centerline |
| | | Construction | Upstream and downstream 500m from road centerline |
| Survey item and method | Road center line survey | Procurement | Total length＝150m x 23 bridges＝ 3,450m<br>{1 bridge＝50m＋bridge length (50m)＋50m ＝ 150m} |
| | | Construction | Total length＝360m x 22 bridges＝ 7,920m<br>{1 bridge ＝150m＋bridge length (60m)＋150m ＝ 360m} |
| | Road cross section survey | Procurement | Approach roads: each 20m pitch<br>6 sections/site x width 50m (25m from road centerline)<br>Total length＝6 x 50m x 23 sites＝6,900m<br>Total 6 sections/site x23＝138 sections |
| | | Construction | Approach roads each 20m pitch<br>14 sections/site x width 50m (25m from road centerline)<br>Total length＝14 x 50m x 22 sites＝15,400m<br>Total = 14 sections/site x 22 ＝ 208 sections |
| | River longitudinal section | Procurement | 50m (upstream and downstream 25m) x 23 sites ＝ 1,150m |
| | | Construction | 1,000m (upstream and downstream) x 22 sites ＝ 22,000m |
| | River cross-section survey | Procurement | 1 cross-section = 25m+50m+25m =100m<br>3 No. sections/site, total 3 x 23=69 sections<br>Total length = 100m x 3 sections x 23 sites = 6,900m |
| | | Construction | 1 cross-section = 25m+60m+25m =110m<br>5 No.sections/site, total = 5x22=110 sections<br>Total length = 110m x 5 sections x 22 sites =12,100m |
| | Plane table | Range | {(100x23)+(300x22)}x width 50m =44.5ha |
| | Leveling | Installation of Temporary Bench Mark 45 | |

(2) Survey Output

| | | |
|---|---|---|
| Bridge and Road | Plan Map | Scale 1/200 |
| | Longitudinal Profile | Scale V: 1/200 H: 1/200 |
| | Cross Section | Scale V. H: 1/100 |
| River | Longitudinal Profile | Scale V: 1/100 H: 1/500 |
| | Cross section | Scale V: 1/100 H: 1/200 |

## 2. Geotechnical Investigation

### 2-1 General

(1) The Purpose and the Scope of the Investigation

Geotechnical investigation was carried out at a total of 27 bridge sites to obtain data for bridge foundation and soft ground treatment design. Of these, 22 bridges are to be constructed on site and 5 are to be prefabricated structures. In this report these are subsequently termed 'construction' and 'procurement' bridges respectively. Machine boring survey were carried out including standard penetration tests, undisturbed sampling, and laboratory soil testing (physical and mechanical properties).

A summary of the extent of the survey is shown in Table 8-2 and on the location map.

(2) Machine boring survey

In order to determine the geological conditions at the 27 bridges, two boreholes were sunk at each site. The survey was carried out by eight drilling teams using XJ-100 type Chinese-made rigs over a one-month period. Details are shown in Table 8-2 and in the table below.

Table 8-1 Quantities of ASTM Standards In-situ Tests and Laboratory Soil Tests

| Item | ASTM standard | Bridge Foundation | Laboratory Soil Test | Total | Remarks |
|---|---|---|---|---|---|
| Standard Penetration Test | D-1586 | 576 | - | 576 | |
| Undisturbed Sampling | D-1587 | 87 | - | 87 | |
| Specific Gravity | D-854-58 | - | 135 | 135 | |
| Natural Moisture Content | D-2216 | - | 127 | 127 | |
| Grading | D-422 | - | 142 | 142 | |
| Liquid Limit | D-423 | - | 87 | 87 | |
| Plastic Limit | D-424 | - | 87 | 87 | |
| Bulk Density | - | - | 50 | 50 | Caliper method |
| Unconfined Compression | D-2166 | - | 27 | 27 | |
| Consolidation | D-2435 | - | 20 | 20 | |

# Table 8-2 Boring Results

| Province/ City | Br. No. | Br. Name | Len -gth (m) | Const * Procure ** | Position N | Position E | Position Alti (m) | Log. No. | Location Left / Right | Height (m) | Depth (m) | Soft Strata Depth (m) | Medium -Hard Strata Depth (m) | Rock Boulder Strata Depth (m) | Depth to Bearing Strata (m) | Name of Soil | N Value | Water Level (m) | Ground Water Level (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| THANH HOA | (4) | THACH QUANG | 99 | ** | 20° 17'.824 | 105° 32'.534 | 12.4 | BH-1 | L/S | 34.11 | 30.0 | - | 21.4 | 8.6 | 21.4 | Limestone | Rock | 27.50 | -6.60 |
| | (5) | THACH DINH | 93 | * | 20° 09'.894 | 105° 38'.923 | 3.1 | BH-1 | R/S | 29.50 | 30.0 | 16.0 | - | 14.0 | 16.0 | Siltstone | Rock | 20.50 | -8.90 |
| | | | | | | | | BH-2 | L/S | 30.10 | 42.0 | 12.0 | 30.0 | - | 25.0 | Clay with gravel | 22-25 | | -9.60 |
| NGHE AN | (6) | QUYNH BANG | 81 | * | 19° 10'.576 | 105° 42'.758 | 1.1 | BH-1 | R/S | 14.60 | 35.0 | 7.0 | 19.0 | 9.0 | 24.0 | Sandstone | >50 | 13.38 | -1.20 |
| | | | 93 | | | | | BH-2 | L/S | 14.80 | 45.0 | 8.4 | 17.1 | 19.5 | 25.0 | Sandstone | Rock | | -1.40 |
| HA TINH | (11) | MY SON | 105 | * | 18° 00'.308 | 106° 10'.895 | 35.6 | BH-1 | L/S | 60.00 | 25.0 | - | 7.5 | 17.5 | 7.5 | Granite | Rock | 47.00 | -13.00 |
| | | | | | | | | BH-2 | R/S | 50.60 | 25.0 | - | 4.6 | 20.4 | 3.0 | Granite | Rock | | -3.60 |
| | (12) | CUA TRAI | 54 | ** | 18° 29'.609 | 105° 42'.784 | 10.1 | BH-1 | R/S | 8.00 | 30.0 | 7.5 | 9.5 | 13.0 | 17.0 | Clay with gravel | >50 | 3.45 | -4.50 |
| QUANG BINH | (18) | LAC THIEN | 66 | * | 17° 46'.612 | 106° 00'.065 | 171 | BH-1 | R/S | 37.20 | 21.0 | 9.6 | 2.9 | 8.5 | 12.5 | Limestone | Rock | 30.36 | -6.80 |
| | | | | | | | | BH-2 | L/S | 39.50 | 21.0 | - | 2.0 | 19.0 | 2.0 | Limestone | Rock | | -9.10 |
| QUANG TRI | (22) | PA NHO | 30 | * | 16° 36'.810 | 106° 44'.242 | 310 | BH-1 | R/S | 81.00 | 30.0 | - | 11.0 | 19.0 | 11.0 | Clayey Sand - Sandstone | >50 | 75.70 | -5.20 |
| | | | | | | | | BH-2 | L/S | 79.70 | 30.0 | 3.5 | 9.0 | 17.5 | 6.7 | Clayey Sand - Sandstone | >50 | | -4.00 |
| THUA THIEN | (26) | KHE DUONG | 42 | * | 16° 15'.401 | 107° 59'.074 | 13.2 | BH-1 | L/S | 119.50 | 30.0 | 10.0 | 11.4 | 8.6 | 22.0 | Coarse Sand with Gravel | 32～71 | 119.00 | -0.50 |
| | | | | | | | | BH-2 | R/S | 119.50 | 35.0 | 8.8 | 13.2 | 13.0 | 22.0 | Coarse Sand with Gravel | >50 | | -0.50 |
| DA NANG CITY | (27) | HOI PHUOC | 63 | * | 15° 59'.826 | 108° 04'.442 | 5.1 | BH-1 | R/S | 48.80 | 25.0 | - | 13.0 | 12.0 | 13.0 | Weathered Granite | Rock | 45.50 | -3.30 |
| | | | | | | | | BH-2 | L/S | 46.20 | 25.0 | - | 14.2 | 10.8 | 14.2 | Weathered Granite | Rock | | -0.70 |
| QUANG NAM | (35) | DAI LOI | 63 | * | 15° 53'.558 | 108° 06'.100 | 13.8 | BH-1 | R/S | 50.00 | 45.0 | 19.5 | 5.3 | 20.2 | 24.8 | Weathered Granite | Rock | 46.00 | -4.00 |
| | | | | | | | | BH-2 | L/S | 49.20 | 45.0 | 23.0 | - | 22.0 | 23.0 | Gravel-Granit | >50 | | -3.20 |
| BINH THUAN | (36) | DA DUNG | 90 | * | 10° 40'.923 | 107° 45'.945 | 18.0 | BH-1 | L/S | 13.50 | 22.3 | - | 4.6 | 17.7 | 4.6 | Rhyolite | Rock | 5.97 | -7.50 |
| | | | | | | | | BH-2 | R/S | 11.25 | 22.8 | - | 7.4 | 15.4 | 7.4 | Rhyolite | Rock | | -5.20 |
| | (37) | TRANG | 33 | * | 11° 01'.321 | 108° 09'.605 | 22.5 | BH-1 | L/S | 59.09 | 24.6 | - | 6.6 | 18.0 | 6.6 | Granite | Rock | 55.86 | -3.20 |
| | | | | | | | | BH-2 | R/S | 58.70 | 24.0 | - | 7.2 | 16.8 | 7.2 | Granite | Rock | | -2.80 |
| NINH THUAN | (42) | TUAN TU | 63 | ** | 11° 31'.847 | 109° 00'.032 | 7.6 | BH-1 | L/S | 10.30 | 54.5 | 36.6 | 10.7 | 7.2 | 47.3 | Granite | Rock | 7.70 | -2.60 |
| | (43) | TAM NGAN | 80 | * | 11° 50'.395 | 108° 43'.731 | 166 | BH-1 | L/S | 126.79 | 27.6 | - | 7.0 | 20.6 | 7.0 | Granite | Rock | 125.05 | -1.70 |
| | | | | | | | | BH-2 | R/S | 129.80 | 21.8 | - | 2.0 | 19.8 | 2.0 | Granite | Rock | | -4.70 |
| LAM DONG | (46) | TAM VAN | 78 | * | 11° 47'.342 | 108° 14'.307 | 849 | BH-1 | L/S | 748.31 | 25.9 | - | 5.5 | 20.4 | 5.5 | Rhyolite | Rock | 745.49 | -2.60 |
| | | | | | | | | BH-2 | R/S | 747.74 | 28.4 | 3.7 | - | 24.7 | 3.7 | Rhyolite | Rock | | -1.00 |
| DAC LAC | (52) | EA SOUP | 51 | * | 13° 04'.569 | 107° 53'.697 | 192 | BH-1 | L/S | 17.50 | 14.7 | - | 2.0 | 12.7 | 2.0 | Claystone | Rock | 10.42 | -6.80 |
| | | | | | | | | BH-2 | R/S | 15.60 | 19.0 | 5.0 | - | 14.0 | 5.0 | Coarse Gravel | >50 | | -5.08 |
| | (56) | KRONG KMAR | 69 | * | 12° 30'.736 | 108° 20'.837 | 438 | BH-1 | L/S | 8.60 | 38.0 | 7.0 | 15.0 | 16.0 | 22.0 | Granite | Rock | 5.33 | -3.20 |
| | | | | | | | | BH-2 | R/S | 7.40 | 26.4 | 8.0 | 7.3 | 11.1 | 15.3 | Granite | Rock | | -2.05 |
| GIA LAI | (58) | DAK PO TO | 60 | ** | 13° 37'.672 | 108° 24'.386 | 192 | BH-1 | R/S | 6.50 | 46.0 | 6.6 | - | 39.4 | 6.6 | Sandstone - Granite | Rock | 5.00 | -1.50 |
| | (59) | IA DRANG | 55 | * | 13° 44'.524 | 107° 51'.347 | 438 | BH-1 | L/S | 9.72 | 10.5 | - | 1.8 | 8.7 | 1.8 | Basalt | Rock | 7.10 | -2.62 |
| | | | | | | | | BH-2 | R/S | 9.82 | 10.2 | - | 1.2 | 9.0 | 1.2 | Basalt | Rock | | -2.70 |
| KON TOM | (66) | NGOC TU | 60 | * | 14° 43'.359 | 107° 46'.418 | 633 | BH-1 | L/S | 5.42 | 25.0 | - | 4.8 | 20.2 | 4.8 | Weathered Schists-Granite | >50 | 3.45 | -1.90 |
| | | | | | | | | BH-2 | R/S | 7.40 | 25.0 | - | 5.1 | 19.9 | 5.1 | Weathered Schists-Granite | >50 | | -3.90 |
| QUANG NGAI | (67) | XA CAI | 80 | * | 15° 01'.161 | 108° 49'.196 | 1.5 | BH-1 | L/S | 60.00 | 19.0 | 2.9 | 10.6 | 5.5 | 13.6 | Granite | Rock | 58.20 | -1.80 |
| | | | | | | | | BH-2 | R/S | 60.20 | 32.5 | 3.5 | 13.4 | 15.6 | 16.9 | Granite | Rock | | -1.80 |
| | (70) | DO | 80 | * | 15° 15'.618 | 108° 30'.014 | 51.4 | BH-1 | L/S | 58.95 | 25.3 | - | 9.8 | 15.5 | 9.8 | Mica schist | Rock | 57.54 | -1.40 |
| | | | | | | | | BH-2 | R/S | 63.57 | 22.5 | - | 2.0 | 20.5 | 2.0 | Mica schist | Rock | | -6.00 |
| | (72) | SONG SAU | 63 | ** | 15° 15'.847 | 108° 39'.739 | 16.8 | BH-1 | L/S | 40.00 | 13.2 | 7.7 | - | 5.5 | 7.7 | Granite | Rock | 37.40 | -2.60 |
| BINH DIINH | (74) | BALE | 42 | * | 14° 04'.301 | 108° 59'.984 | 35.3 | BH-1 | L/S | 10.50 | 11.0 | 4.0 | 1.5 | 5.5 | 5.5 | Granite | Rock | 8.53 | -1.97 |
| | | | | | | | | BH-2 | R/S | 10.50 | 11.0 | 6.6 | - | 4.4 | 6.6 | Granite | Rock | | -1.90 |
| PHU YEN | (78) | TRA O | 33 | * | 13° 26'.037 | 109° 04'.522 | 26.3 | BH-1 | L/S | 11.15 | 30.7 | - | 12.6 | 18.1 | 11.0 | Granite | Rock | 9.09 | -2.06 |
| | | | | | | | | BH-2 | R/S | 11.31 | 28.7 | - | 4.0 | 24.7 | 4.0 | Granite | Rock | | -2.20 |
| | (79) | TRA BUONG | 63 | * | 13° 18'.400 | 109° 03'.418 | 23.7 | BH-1 | L/S | 8.52 | 16.5 | - | 8.8 | 7.7 | 7.7 | Granite | Rock | 7.30 | -1.20 |
| | | | | | | | | BH-2 | R/S | 8.03 | 15.1 | - | 5.0 | 10.1 | 5.0 | Granite | Rock | | -0.70 |
| KHANH HOA | (83) | NGOI NGAN | 48 | * | 12° 45'.493 | 109° 17'.991 | 4.5 | BH-1 | L/S | 9.69 | 43.2 | 4.8 | 23.2 | 15.2 | 13.0 | Granite | Rock | 7.93 | -1.70 |
| | | | | | | | | BH-2 | R/S | 8.50 | 44.0 | 5.6 | 27.5 | 10.9 | 15.0 | Granite | Rock | | -0.57 |
| TOTAL | | | | (22+5) | | | | (44+5) | | | 49 | | | | | | | | |
| | 27 | | | 27 | | | | 49 | | | 1,348.4 | 227.3 | 397.7 | 723.4 | | | | | |

## 2-2 Survey Area Geology

### (1) Outline of Survey Area Geology

The geological strata of the Central Area are composed of granite of all ages, crystalline schists, basalt of the Pliocene Epoch, sedimentary rocks of the Mesozoic Era mainly consisting of shale, slate and limestone, all overlain by Quaternary formations, which consist of Alluvial and Diluvial formations.

Geological Formations in the Central Area

| Geological Age | | Formation | Description |
|---|---|---|---|
| Quaternary | Holocene | Alluvium | - Soft to firm cohesive soil<br>- Loose sandy soil |
| | Pleistocene | Diluvium | - Stiff to hard cohesive soil<br>- Medium dense to dense sand and gravel |
| Tertiary<br>Cretaceous<br>Triassic | Pliocene | Igneous rock<br>Igneous rock<br>Igneous rock<br>Sedimentary rock | - Basalt<br>- Granite, Basalt<br>- Dacites, Rhyolites<br>- Shale, Slate, Limestone |

1) Alluvial Deposits

Alluviul deposits are extensively distributed in North and South Central Coastal Area, and are mainly composed of dark, yellowish, brownish and blackish gray very soft clay, sandy clay to organic clay(Ac), and loose fine to medium sand (As). The thickness of the clayey deposit is about 4.9 to 8.0 m with SPT blow counts of 0 to 4 recorded.

Sandy soil is interbedded with clayey soil or with lenses and consists of yellowish, brownish, blackish and whitish grey fine to coarse sand. The thickness of sandy soil is about 3.5 70 8.9 m with SPT blow counts of 2 to 10 recorded. Maximum depth of alluvial deposit from ground surface is 30.3 m of bridge NO. 42B.

2) Diluvial Deposits

The Diluvium is composed of cohesive soil (Dc) and sandy soil (Ds). The top of stratum at coastal plain is located at a depth from 3.5 to 8.9 meters from ground surface.

i) Cohesive Soil (Dc-stratum)

Cohesive soil (Dc) is distributed throughout the project area and is composed of brown to yellowish-brown, yellowish to greenish grey clay to clayey silt. The Dc soil top of stratum is located 5.8 to 30.0 meters from ground surface.

Confirmed thickness of the Dc-stratum is from 4.5 to 29.2 meters and the stratum is formed of stiff to hard clay, silty clay and sandy clay with sand lenses. SPT blowcount is 9 to 38.

ii) Sandy Soil (Ds-stratum)

The Sandy Soil is composed of yellowish brown to greenish gray silty fine sand to coarse sand with gravel. The Ds soil top of stratum is located 0 to 23.5 meters from ground surface.

Confirmed thickness of the Ds-stratum ranges from 4.0 to 27.6 meters with SPT blowcounts of 11 to 50.

Total depth of the alluvium and diluvium deposit from ground surface is 15.3 to 42.0 meters and maximum depth is 47.3 meters of bridge NO.42B. And base rock is overlain above-mentioned strata.

3) Base Rock

Base rock of central area is composed of granite, crystalline schists (gneiss, micaschiste, amphibolites, cipoline, chlorite-schist, phyllite etc.) of all ages, basalt of the Pliocene Epoch, igneous rock (dacite, rhyolite etc.) of the middle Triassic period and sedimentary rock of the Mesozoic Era, which consists mainly of shale, sandstone and limestone.

North part of the foot of the Truong Son (Annam) range of the north central area, limestone of the Mesozoic Era, is widely distributed and is used as factory of cement production.

Plaku of north part to Buon Ma Thuot in the Mountain and highland region of south central area, basalt flow of the Pliocene Epoch, is widely distributed in this area, its extension is north to south about 100 km, east to west about 80 km in north part and is north to south about 90 km, east to west 70 km in south part.

(2) Geology of the Bridge Sites

1) Founding Strata for Bridge Design

The load bearing capacity of strata is assessed depending on the importance of the structure and the lateral loads imposed by the structure.

In general, the required bearing capacity for spread or piled foundations of bridge abutment and piers is defined by the following N-values:

Sandy and cohesive soil…………………….N > 50

Weathered rock…………………………...N > 50

And for the case of small and lightly-loaded bridges

Sandy soil………………………….….…..N > 30

Cohesive soil……………………………..N > 20

2) Bearing Strata of Bridges

Boreholes were drilled at both abutments at all bridge sites except B Type Bridge.

Soil suitable as a founding material for bridge abutment loads is found in the diluvial deposits and base rock. These are cohesive soil, fine to coarse sand and base rock that is described last section.

Top of strata of the diluvium in coastal area are located at a depth from 11.0 to 25.0 meters from ground surface, and has SPT blowcounts ranging from 22 to 50.

Base rock that is described last section, is located 1.2 to 25.0 meters from ground surface.

The results of the borehole investigation are shown as Table 8-2, and based on the findings, recommended design soil parameters for use in the Central Area are shown as Table 8-3.

Table 8-3 Design Soil Parameters

| Stratum | Average SPT Blowcount | Wet Density $\gamma t$ (t/m$^3$) | Cohesion of Initial Condition C (t/m$^2$) | Internal Angle of Friction Φ (degree) | Unconfined Test, Modulus of Deformation $E_{50}$ (Kg/cm$^2$) |
|---|---|---|---|---|---|
| **Ac** | 0 | 1.70 | 1.00 | -- | 5.75 (Note 1) |
| **As** | 11 | 1.70 | | Fig.10-2-11a | 28N |
| **Ag** | 25 | 1.90 | - | Fig 10-2-11a | 28N |
| **Dc** | 31 | 1.80 | 19.0 | - | 28N |
| **Ds** | 41 | 1.90 | | Fig. 10-2-11a | 28N |

Note 1: $Eo= E_{50} = 24.202\ qu + 0.907$ for Ac soil

## 2-3 Soil Test Results

### (1) General

The soils analyzed for embankment and foundation design are Alluvial and Diluvial deposits of which a total of 135 samples were taken by undisturbed and disturbed sampling. The following samples were analyzed:

| | | | |
|---|---|---|---|
| Undisturbed Samples | Alluvium (Ac) ...............42 Samples | | |
| “ | Diluvium (Dc) .................8 Samples | Sub Total 50 | |
| Disturbed Samples | Alluvium (Ac) ...............42 Samples | | |
| “ | (As)................28 Samples | | |
| “ | (Ag) ...............27 Samples | | |
| “ | Diluvium (Dc) ...............13 Samples | | |
| “ | (Ds)................12 Samples | Sub Total 85 | |
| Total | ......................................................135 Samples | | |

The type and quantity of tests and applicable standards are shown in Table 8-1. Based on the results of these soil tests, physical and mechanical properties of the Ac, As, Ag, Dc and Ds soils were determined and suitable bearing strata for bridge foundations decided.

### (2) Laboratory Soil Test Results

1) Physical Properties

a) Particle Size Grading

The gradings of three soil categories are shown in the following Table 8-4.

Cohesive deposits (Ac and Dc) contain fines fraction, silt (60.1〜48.5%) and clay (17.5〜19.1%) total 67.6〜77.6% by weight.

The Ds soil contains coarse sand and gravel over 82.3 % by weight.

Table 8-4 Soil Grading Results

| Soil Fraction / Stratum | | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | No.10 (2.00) (%) | No.40 (0.425) (%) | No.200 (0.075) (%) |
|---|---|---|---|---|---|---|---|---|
| | | Average | Average | Average | Average | Average | Average | Average |
| | | Range of recorded values | Range of recorded values | Range of recorded values | Range of recorded values | Range of recorded values | Range of recorded values | Range of recorded values |
| Ac-cohesive Soil | Average | 0.8 | 21.6 | 60.1 | 17.5 | 99.2 | 94.8 | 77.6 |
| | Range | 0-3.4 | 1.0 ~12.4 | 46.5~73.6 | 10.0~25.6 | 96.6-100 | 86.5~100.0 | 61.7~93.4 |
| As-Sandy Soil | Average | 5.6 | 74.3 | 16.8 | 3.7 | 94.5 | 54.3 | 20.2 |
| | Range | 0-12.8 | 56.5~92.2 | 3.0~30.5 | 0~8.9 | 87.4~100 | 28.7~79.9 | 3.7~36.6 |
| Ag-Gravelly Soil | Average | 56.2 | 37.4 | 5.8 | 0.6 | 43.8 | 13.8 | 6.5 |
| | Range | 36.6~75.7 | 19.3~55.4 | 2.0~13.3 | 0~2.5 | 24.3~63.4 | 1.5~26.2 | 0.2~15.4 |
| Dc-Cohesive Soil | Average | 4.2 | 28.2 | 48.5 | 19.1 | 95.8 | 87.0 | 67.6 |
| | Range | 0~11.5 | 13.2~43.2 | 36.4~60.7 | 10.6~27.6 | 88.5~100 | 75.6~98.5 | 52.3~83.0 |
| Ds-Sandy Soil | Average | 33.9 | 48.4 | 14.0 | 3.7 | 66.1 | 38.0 | 17.8 |
| | Range | 8.4~59.3 | 29.1~67.6 | 0.7~28.3 | 0~9.5 | 40.7~91.6 | 6.1~69.8 | 0.7~37.4 |

b) Consistency Test Results

The moisture content and index test results are summarized in Table 8-5.

Ac Soil

- Ac soil: No variation in strength, moisture content or plasticity with depth was observed.
- According to the classification chart, Ac-soil is classified as CL-ML: 80.6 % CH: 11.1%  MH-OH: 5.6%  ML-OL: 2.8%
- Colloidal activity

  Ac-soil is classified as follows:

  - Non-active clay (mainly Kaolinite) A< 0.75……………………..16.7 %

  - Ordinary clay (mainly Illite) A=0.75~1.25……………………… 55.6%

  - Active-clay (including organic colloid) A= 1.25~ 2.00…………..27.8 %

Ac soil is classified as being in an unstable condition since Wn=<Wl,

Ic= -0.2~0.9 and average Ic= 0.3

Dc Soil

Dc soil: No variation in strength, moisture content or plasticity with depth was observed.

- According to the classification chart, Dc soil is classified as CL: 76.2% CH: 23.8 %
- Colloidal activity

Dc soil is classified as follows:

- Non active clay (mainly Kaolinite) A<0.75…………………..26.7%

- Ordinary clay (mainly Illite) A=0.75~1.25……………………46.7%

- Active clay (including organic colloid) A=1.25~2.00…….. …26.6%

- Dc soil is classified as being in a stable condition with Wn< Wl, Ic=0.91~1.21 and average Ic=1.06

Table 8-5 Moisture Content and Plasticity Test Results

| Test/Index \ Stratum | Wn (%) | Wl (%) | Ip | If | It | Ic | Activity Ratio |
|---|---|---|---|---|---|---|---|
| | Average | Average | Average | Average | Average | Average | Average |
| | Range of recorded values | Range of recorded values | Range of recorded values | Range of recorded values | Range of recorded values | Range of recorded values | Range of recorded values |
| Ac-Cohesive Soil | 34.3 | 40.5 | 17.7 | 11.8 | 1.6 | 0.3 | 1.1 |
| | 19.7~48.9 | 28.7~52.3 | 10.6~24.8 | 8.5~15.1 | 0.9~2.2 | - 0.2~0.9 | 0.7~1.6 |
| Dc-Cohesive Soil | 19.5 | 41.4 | 20.7 | 15.5 | 1.4 | 1.06 | 2.2 |
| | 16.2~22.7 | 33.4~49.5 | 14.9~26.5 | 12.4~18.6 | 1.0~1.8 | 0.91~1.21 | 0.6~5.2 |

Note

ML: Inorganic silt, very fine sand, rock flour, silty or clayey fine sand

CL: Inorganic clay of low to medium plasticity, gravely clay, sandy clay, silty clay, low cohesive clay

OL: Organic silt and organic silty-clay of low plasticity

MH: Inorganic silt, micaceous or diatomaceous fine sand or silt and plastic silt

CH: Inorganic clay of high plasticity, high cohesive clay

OH: Organic clay of medium to high plasticity

Wn: Natural water content

Wl: Liquid limit

Ip: Plasticity index

If: Flow index

If: Toughness index (It = Ip/If)

Degree of shear strength at plastic limit

Ic: Consistency index (toughness and stability of cohesive soil)

$$Ic = (Wl-Wn)/Ip$$

$Ic \geq 1$ Stable condition

$Ic = 0$ Unstable condition (liquefies when disturbed)

Colloidal activity: Colloidal activity has deep ties with clay mineral and geological condition of sediment, and is defined by Skempton.

Clay is classified into four groups from non-active clay to high-activity clay (activity >2). It is shown as the following formula.

$$\text{Colloidal activity} = \frac{\text{Plasticity index Ip}}{\text{Soil particle (\%) of less than 2 } \mu\text{m}}$$

Table 8-6 Classification by Colloidal Activity

| Activity Ratio | Description | Main Clay Mineral | Deposition Conditions |
|---|---|---|---|
| A < 0.75 | Non-active clay | Kaolinite | • Fresh water sediments<br>• Marine deposits which have been leached |
| A=0.75 - 1.25 | Ordinary clay | Illite | Marine and estuarine deposits |
| A > 1.25 | Active clay | •Including organic colloid<br>• A ≥ 2 includes Montmorillonite | |

c) Specific Gravity, Bulk Density and Voids Ratio

Measured values of specific gravity, bulk density and voids ratio are summarized in Table 8-7 and shown on graphs in Figure 8-2 and Figure 8-3.

- Specific Gravity (Gs)

The test results yield consistent values with a standard deviation of 0.023~0.036

- Wet Density (γt)

The tests show consistent values. The relationship between γt and other parameters is shown by the following formula:

$$gt = \frac{1 + \frac{Wn}{100}}{\frac{1}{Gs} + \frac{\frac{Wn}{100}}{\frac{Sr}{100}}} * gw$$

Where:

γt : Bulk density of soil ($t/m^3$)

Wn : Natural moisture content (%)

Sr : Degree of saturation (%)

Gs : Specific gravity

If the soil samples are fully saturated by high ground water at the project site, Sr=100% is applied to the above formula. The formula becomes the function of natural moisture content (Gs= constant).

$$gt = \frac{1 + \frac{Wn}{100}}{\frac{1}{Gs} + \frac{Wn}{100}}$$

Table 8-7 Results of Gs, γt and e

| Soil Properties / Stratum | Specific Gravity Gs | Wet Density γt | Voids Ratio e |
|---|---|---|---|
| | Average | Average | Average |
| | Range of recorded values | Range of recorded values | Range of recorded values |
| Ac- Cohesive Soil | 2.691 | 1.698 | 1.400 |
| | 2.666~ 2.716 | 1.570~1.770 | 1.160~1.640 |
| As-Sandy Soil | 2.674 | - | - |
| | 2.651~ 2.694 | - | - |
| Ag-Gravelly Soil | 2.672 | - | - |
| | 2.637~ 2.708 | - | - |
| Dc-Cohesive Soil | 2.685 | 1.865 | 0.634 |
| | 2.653~2.717 | 1.568~2.163 | 0.575~0.693 |
| Ds-Sandy Soil | 2.720 | | |
| | 2.684~2.756 | | |

The values of Gs and Wn are plotted in Appendix- .The values of wet density adopted for design are as follows:

Ac $\gamma t = 1.700\ t / m^3$

As $\gamma t = 1.700\ t / m^3$

Ag $\gamma t = 1.900\ t / m^3$

Dc $\gamma t = 1.800\ t / m^3$

Ds $\gamma t = 1.900\ t / m^3$

- Voids Ratio (e)

The voids ratio of the Ac and Dc soils has a strong correlation with natural moisture content with follows:

Ac- soil

e = 0.025Wn + 0.114

Variance = 4.959

Correlation coefficient = 0.993

2) Mechanical Properties

Mechanical tests (Unconfined compression and consolidation tests) were carried out on undisturbed samples of Ac and Dc soils from each bridge site.

a) Unconfined Compression Test

Unconfined compressive test results are shown in Table 8-8 and Figure 8-4 and Figure 8-5. The relationships between qu (kg/cm$^2$) and $E_{50}$ (kg/cm$^2$) for the Ac soils are shown by the following:

Ac soil

$E_{50}$ = 24.202qu + 0.907

Variance = 27.885

Correlation coefficient = 0.878

Again, the relationships between qu (kg/cm$^2$) and the natural moisture content (Wn) for the Ac soils are shown by the following:

Ac soil

qu = - 0.078Wn + 3.381

Variance = -10.871

Correlation coefficient = -0.849

b) Consolidation Test

Consolidation test results are shown in Table 8-8 and in the following figures.

Figure 8-6 e-logP Design Curve (Ac and Dc soils)

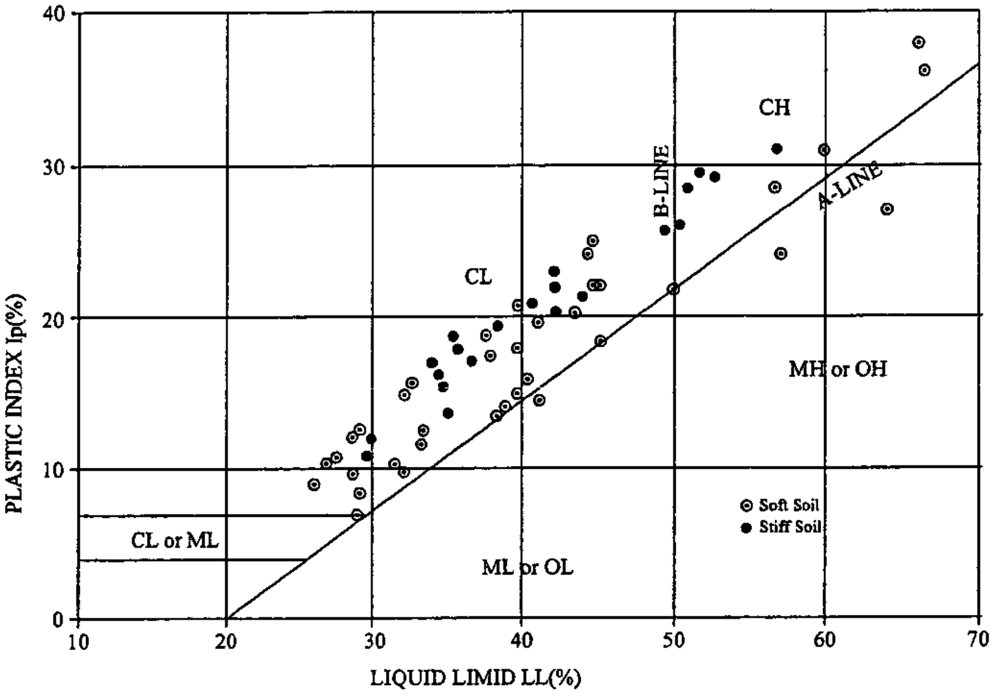
Figure 8-7 log Cv - logP Design Curve (Ac and Dc soils)

According to the test results, the Ac soil is in a state of incomplete consolidation.

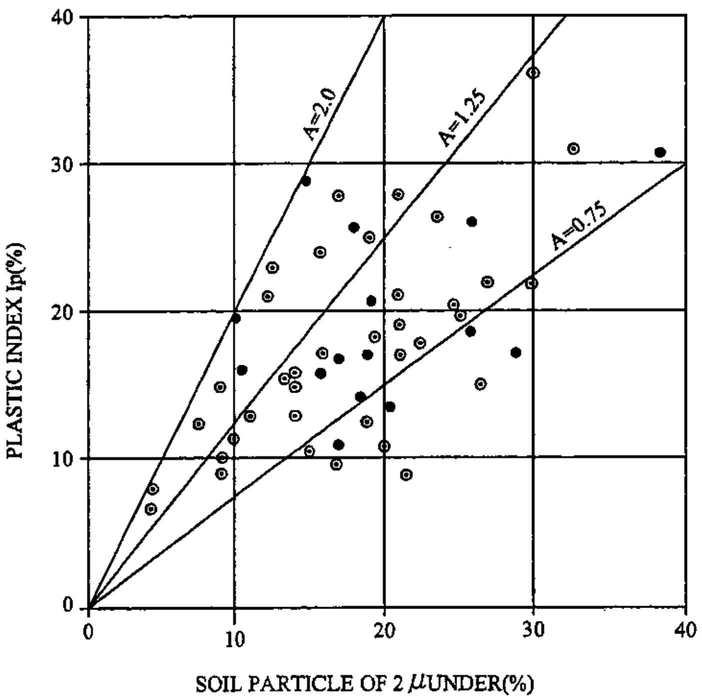
Table 8-8 Mechanical Test Results

| Test / Stratum | Unconfined Triaxial Compression qu , E50 and ε | | | Consolidation Pc Cc | |
|---|---|---|---|---|---|
| | qu (kg/cm$^2$) | E50 (kg/cm$^2$) | ε (%) | Pc (kg/cm$^2$) | *Cc* |
| | Average | Average | Average | Average | Average |
| | Range of recorded values | Range of recorded values | Range of recorded values | Range of recorded values | Range of recorded values |
| Ac-Soft Cohesive Soil | 0.250 | 37.2 | 4.90 | 0.46 | 0.466 |
| | 0.140 ~0.360 | 9.60 ~64.7 | 3.50 ~6.20 | 0.32 ~0.60 | 0.323 ～0.608 |

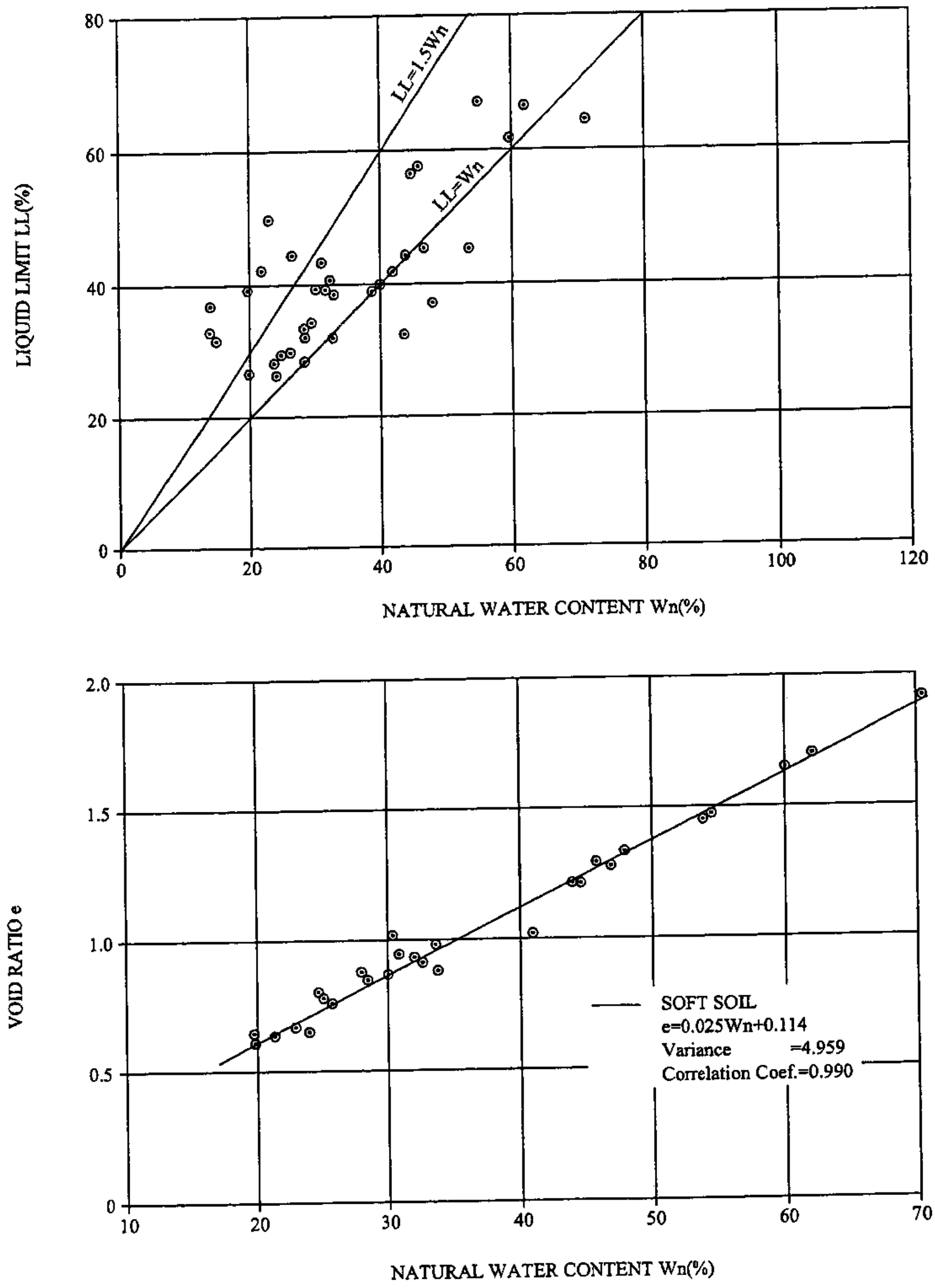
PLASTICITY CHART



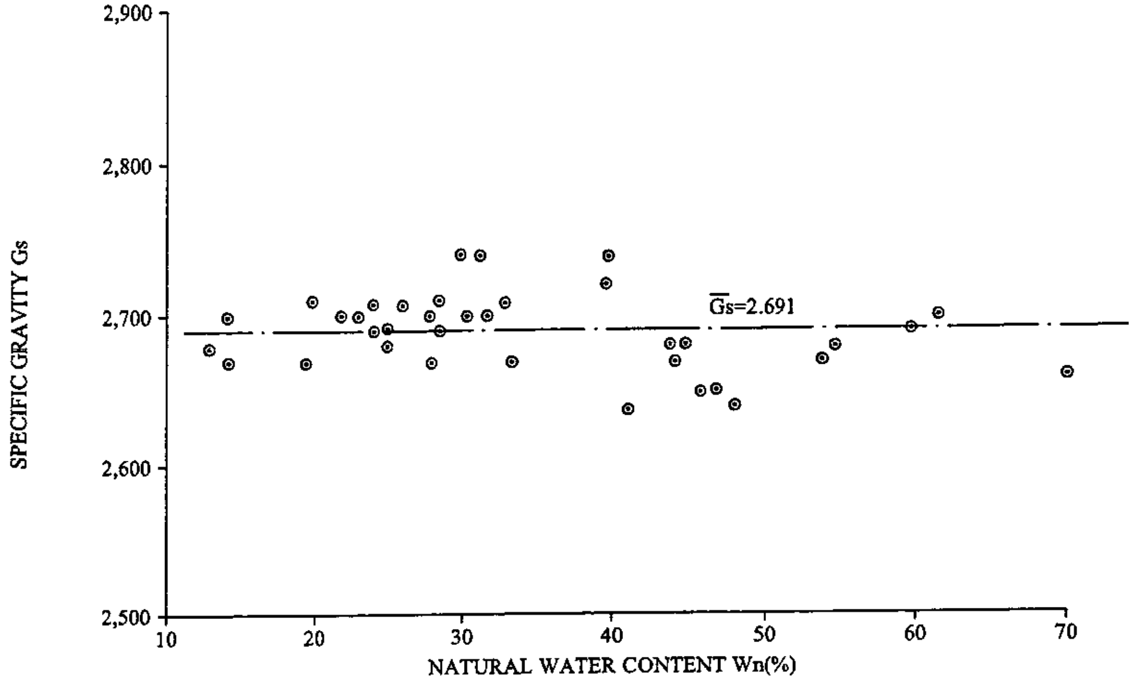

COLLOIDIAL ACTIVITY

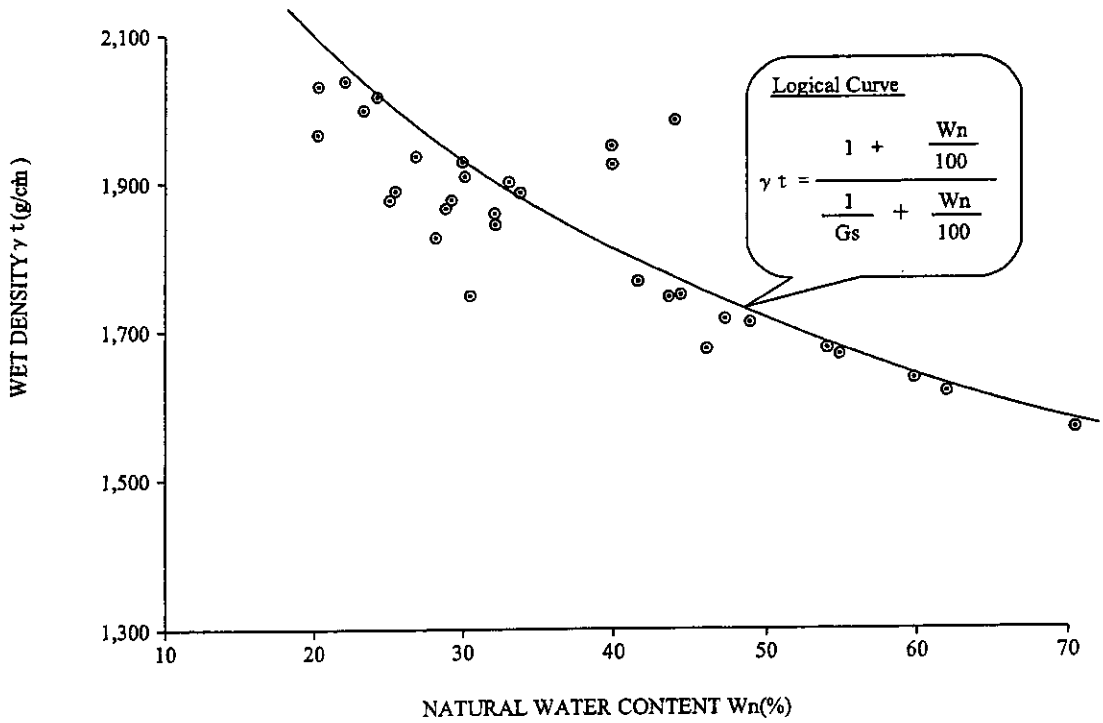



| Figure 8-1 | CONSISTENCY CHART<br>(soft soil) |
|---|---|
| BASIC DESIGN STUDY ON THE PROJECT FOR<br>RECONSTRUCTION OF BRIDGES IN THE CENTRAL AREA | |

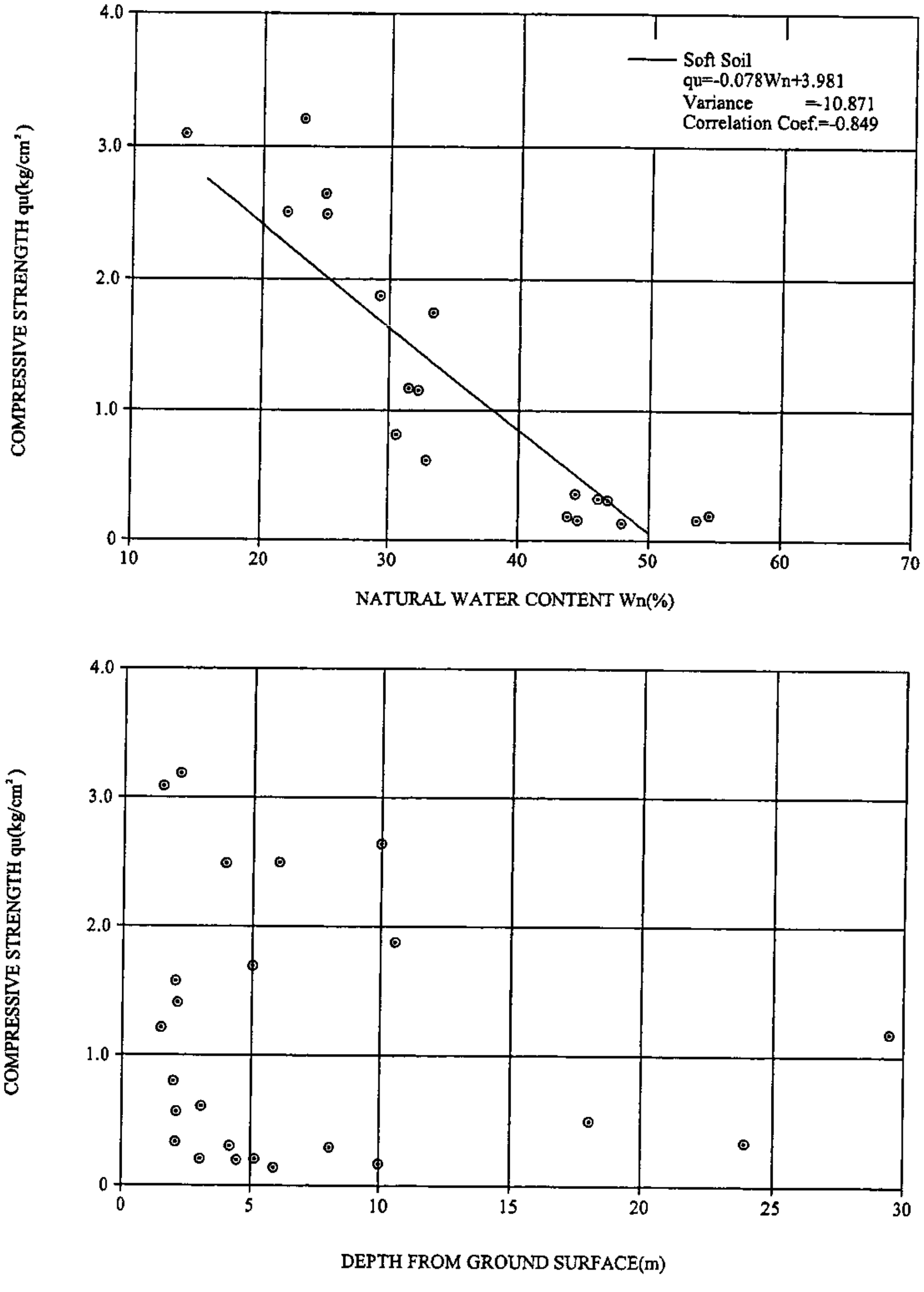



| Figure 8-2 | RELATIVE CHART OF NATURAL WATER CONTENT (Wn)AND LIQUID LIMIT ( LL) VOID RATIO(e) |
|---|---|
| BASIC DESIGN STUDY ON THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN CENTRAL AREA | |

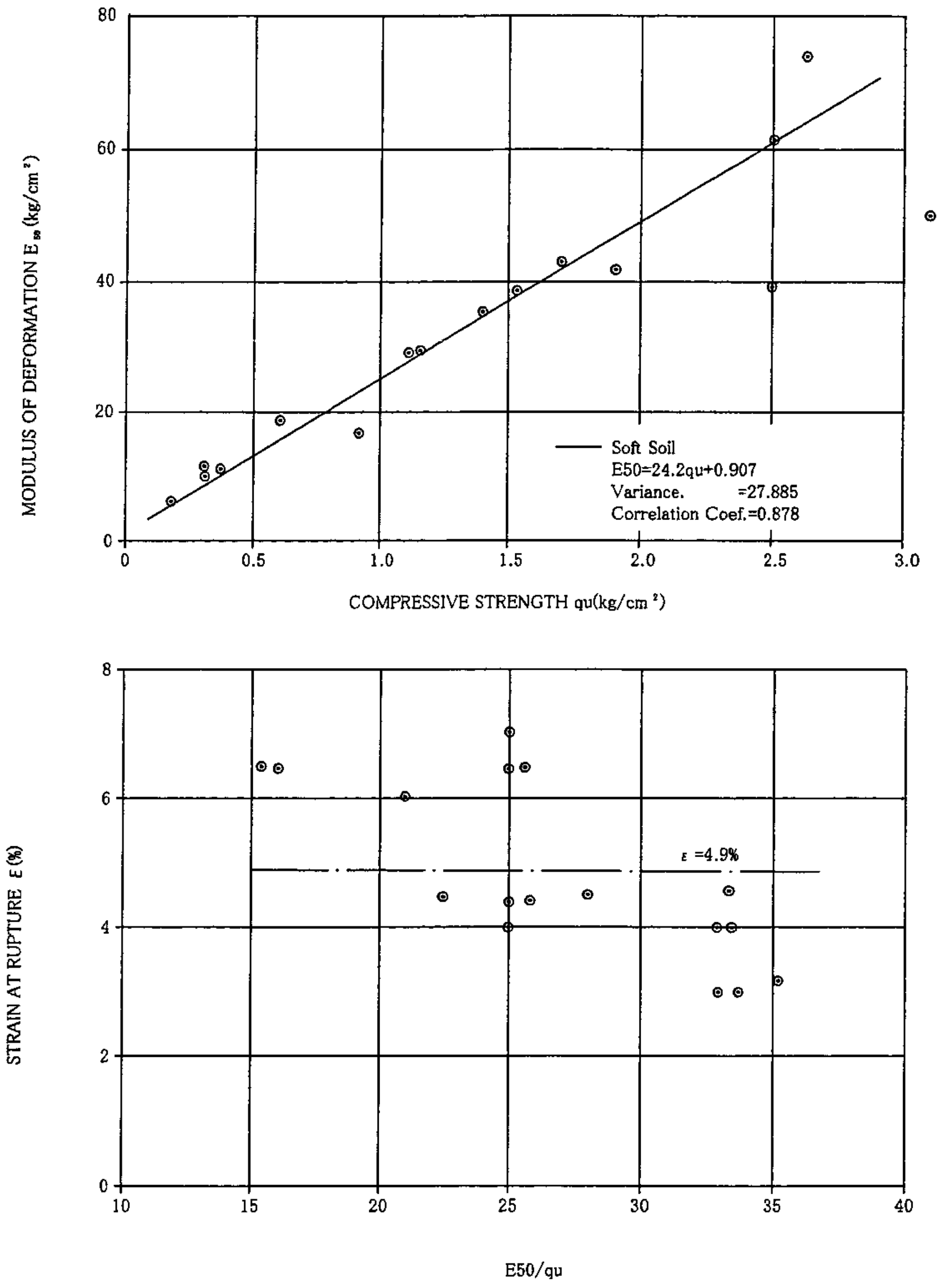



| Figure 8-3 | |
|---|---|
| BASIC DESIGN STUDY ON THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN CENTRAL AREA | RELATIVE CHART OF NATURAL WATER CONTENT (Wn)AND SPECIFIC GRAVITY(Gs),WET DENSITY(γt) (soft soil) |




| Figure 8-4 | RELATIVE CHART OF NATURAL WATER CONTENT (Wn)AND (qu),Depth and (qu) (soft soil) |
|---|---|
| BASIC DESIGN STUDY ON THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN CENTRAL AREA | |




| Figure 8-5 | RELATIVE CHART OF qu AND E50, E50/qu AND ε (soft soil) |
|---|---|
| DETAILED DESIGN STUDY ON THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN CENTRAL AREA | |

## 2-4 Design Soil Parameter

For design purposes, the behavior of the very soft alluvial (N=0) clay when acting as a foundation for high approach embankments must be considered. The stiff clay (ave. N=31 and sandy soil (ave. N=34) of the Diluvial deposits must be considered as a bearing stratum for bridge foundations.

Since the soils have formed in a sedimentary environment, the disposition of soil and its character at each bridge must be examined according to the following procedure, and design soil parameters selected.

- Determine soil profile
- Consider soil test results and select representative values
- Select design soil parameters and cross section

### (1) Classification of Soil Strata

Geological longitudinal profiles were produced based on the borehole logs and laboratory soil test results. In the Ac stratum, the possible presence of intermediate and lower sand strata is significant for its effect on rate of consolidation of the clay. Based on the findings of the borehole logs an appropriate drainage condition, either one or two-directional, may be chosen for design. The ground water level was taken from the geological longitudinal profile.

The soil classification considered for the design is as follow:

Alluvial soil (very soft clay)…………………Ac
Diluvial soil (stiff to very stiff clay)…………Dc
" (medium dense to dense sand)…Ds

### (2) Soil parameters for Ac soil

1) Wet Density

The average values adopted for design are

| Soil | Wet Density $\gamma t$ (t/m$^{3}$) | Number of Tests |
|---|---|---|
| Ac | 1.700 | 31 |

2) Cohesion of initial condition: Co (t/m$^2$)

Angle of internal friction (ϕuu) and shear strength (Cuu) under undrained unconsolidated conditions are as follows:

$$\mathrm{Sin}\phi uu = \frac{\frac{s1}{2}}{\frac{s1}{2} + Cuu \times \cot fuu}$$

$$\therefore Cuu = \frac{s1}{2 \times \tan(45° + \frac{fuu}{2})}$$

Generally ϕuu = 0 ° for soft clay thus Cuu becomes:

$$Cuu = \frac{s1}{2} = \frac{qu}{2}$$

The unconfined compressive strength of the Ac soil is adopted as in sub-section (2)-2) - a)

| Soil | Undrained Shear Strength Co (tf/m$^2$) | No. of Tests |
|---|---|---|
| Ac | 1.00 | 9 |

3) The Rate of Increase in Strength by consolidation pressure

There are three methods to determine the strength / consolidation pressure relationship:

- By the variation with depth of the undrained shear strength
- Based on the plasticity index
- By triaxial compressive strength testing under undrained unconsolidated conditions or by simple shear box testing.

In this case, the plasticity index method is used, since it is recognized that the strength of the soft soil does not increase with depth.

The strength / consolidation pressure relationship can be calculated according to the A. W. Skempton formula:

m = Co/Po=0.11+0.0037*Ip

Where

m: The ratio of shear strength to consolidation pressure

Ip: Plasticity index

Co: Triaxial compressive strength obtained under undrained unconsolidated (UU) conditions.

Po: Vertical Effective Stress

The strength / consolidation pressure relationship calculated using this formula is shown in Table 8-9.

Table 8-9 The Rate of Increase in Strength by the Plasticity Index

| Soil | Plastic Index Ip | The Ratio of Increase in Strength by Consolidation Pressure (m) | No. of Sample N | Calculation Method of Ip |
|---|---|---|---|---|
| Ac | 33.4 | 0.188 | 25 | Average of accumulated values |

Available data on the ratio of Increase in strength by consolidation pressure is shown in Tables 8-10 and 8-11.

Table 8-10 The Rate of Increase in Strength (1)

(Standard of Japan Highway Corporation)

| Soil | Soil Class | Ratio of Strength to Consolidation Pressure m |
|---|---|---|
| Clay | CH, CL, VH | 0.30 ~ 0.44 |
| Silt | MH, ML | 0.25 ~ 0.40 |
| Humid Soil or Black mud | OH, OL, OV, MH | 0.20 ~ 0.35 |
| Peat | Pt | 0.35 ~ 0.50 |

Table 8-11 The Rate of Increase in Strength (2)

(Standard of Japan Highway Corporation)

| Natural Water Content (Wn %) | The Rate of Increase in Strength by Consolidation Pressure (m) | |
|---|---|---|
| | Soil Depth < 10 m | Soil Depth > 10 m |
| > 200 | 0.25 ~ 0.40 | |
| < 200 | 0.45 ~ 50 | 0.25 ~ 0.30 |

The ratio of strength to consolidation pressure of the alluvial deposit Ac is estimated (following Table 3.9) as m= 0.25 ~ 0.40 based on the following available test results.

Ac Soil

Soil classification CL-ML CH, MH-OH

Natural water content, Wn (%) 19.7.~70.8 %

Stratum thickness (m) 6.8 ~ 23.0 (from ground Level

The Rate of Increase in Strength by Consolidation Pressure 0.20 ~ 0.40

Table 8-12 Comparison of the Rate of Increase in Strength by Consolidation Pressure Obtained by Various Methods.

| Method | Soil | Ratio of Strength to Consolidation Pressure, m | |
|---|---|---|---|
| | | Range | Representative Value |
| Plastic Index | Ac | 0.160 ~ 0.245 | 0.20 |
| Based on Table 10-2-10 | | 0.250 ~ 0.400 | |

As result the following value is proposed:

Ac soil, m = 0.25

4) Design e-logP and log Cv-logP Curves

The design curves for the above were obtained after omitting unrepresentative values from the respective tests, and are shown in the following figures:

Figure 8-6 e-logP Design Curve (Ac)

Figure 8-7 logCv-logP Design Curve (Ac)

5) Consolidation Yield Stress Pc ($kg/cm^2$)

The consolidation yield stress of cohesive soil is theoretically the maximum consolidation stress borne in the past and can be estimated by the following three methods: based on consolidation test results, using Pc= 4.Co and using Pc= Po= Co/m.

- Using consolidation test results:

This method estimates the Pc / depth relationship using the least squares method, but is not suitable this case, since an increase in strength with depth was not observed.

- Using Pc= 4.Co:

This formula is empirical based on extensive data obtained for soft ground from which a good correlation between Pc and Co is obtained.

(Source: Standard of Japan Highway Corporation)

$$qu = 2.0\ t/m^2 \text{ -----> } Co = 1.00\ tf/m^2\ (\varphi=0)$$

$$Pc = 2qu = 4.Co = 4.00\ tf/m^2$$

- Using Pc= Po = Co/m

This formula is applicable when the yield stress is equal to the highest consolidation pressure experienced under historic periods of higher ground levels. In this case it is not applicable.

6) Summary of Design Soil Parameters

The soil parameters for the soft ground Ac soil selected for design are summarized in Table 8-13 and the respective design curves are shown in Figures 8-9 to 8-10.

The soil strata boundaries, ground water level and presence or otherwise of sand strata that can assist with drainage are obtained from the geological longitudinal profile.

Table 8-13 Design Soil Parameters

| Soil | Wet Density $\gamma t$ (t/m$^3$) | Cohesion of Initial Condition Co (tf/m$^2$) | Angle of Internal Friction Ø (Degrees) | e-log p Curve | log –Cv log p Curve | The Rate of Increase in Strength by Consolidation Pressure m | Consolidation Yield Stress Pc (tf/m$^2$) |
|---|---|---|---|---|---|---|---|
| Ac | 1.700 | 1.00 | - | Fig 10-2-9 | Fig. 10-2-10 | 0.25 | 4.00 |

## 3. Earthwork and Foundation Design

In this section treatment of soft ground and examination of strata as formations for carrying bridge foundation loads are investigated based on the analysis of borehole logs, geological longitudinal profiles and laboratory soil tests.

### 3-1 Soft Ground Treatment

(1) General

Areas of soft ground (Ac-deposit) are extensively distributed in the Mekong Delta Area extending up to 19~25 meters below ground level. In order to construct high embankments for approach roads to bridges, improvement of the soft ground is required.

Analysis for improvement of soft ground is carried out as follows:

- Select design soil parameters and Stratigraphy.
- Determine design embankment profile and material.
- Select representative analysis section.
- Decide soft ground design method.
- Decide analysis method.
- Carry out analysis.

(2) Design soil parameters and Stratigraphy

These are discussed in section 2 of this report and the parameters and Stratigraphy used for analysis of the soft ground.

1) Embankment Profile and Material

Embankment profile and fill parameters are as follows:

- Embankment profile: width of road: 8.50m

slope gradient: embankment height less than 6m 1: 1.5

embankment height over 6m 1: 1.75

- Embankment height: see Table 8-2.
- Design soil parameters for embankment fill

- Wet Density……………………..$\gamma t$ = 1.80 t / $m^3$
- Cohesion………………………..…… C = 2.0 tf / $m^2$
- Angle of Internal Friction…………$\phi$ = 10 (degree)
- Rate of Filling…..…………………5 cm / day

2) Representative Sections for Analysis

Sections for analysis will be made for each bridge at detailed design stage. In this report analysis is based on typical sections from BNO.18A, 26A and 35A. The soft ground at these locations extends to about 10〜20 meters below ground level.

(3) Soft Ground Design Method

1) Design Method

Soft ground design methods for high approach road embankments to bridges can be summarized as follows:

① EPS method: Reduction of embankment weight

② Soft ground treatment method: Increase strength of soft ground

③ Piled slab method: Embankment is supported by RC piles

Methods ① and ③ are very expensive, therefore method ② is adopted. There are many possible options included in method ②

The method adopted depends upon various factors such as the nature of the soil (bearing capacity and depth of individual strata), availability of soils, embankment height, and the construction period and cost.

These methods can be classified according to their main purpose, which may be either to prevent embankment slope failure, to accelerate settlement, or both.

Eight methods are summarized in Table 8-14 and 8-15.

Table 8-14 Soft ground treatment method

| | Method | Description |
|---|---|---|
| 1. | Ground surface treatment | - Use of sand, sheet, mat, etc.<br>- Functions as upper discharge layer for consolidation<br>- Prevents upward flowing ground water entering the embankment<br>- Ensures access for construction plant<br>- Cakar Ayam System<br>- EPS method |
| 2. | Replacement of soft ground | - Protects against slope failure and reduces settlement<br>- Replacement depth is limited |
| 3. | Berm (additional embankment) | - Increases resistance to slip circle failure<br>- May be used for environmental reasons. |
| 4. | Slow speed embankment construction | - To increase shear forces over a long period |
| 5. | Surcharge | - To accelerate settlement prior to completion of the embankment and structure. |
| 6. | Vertical drain | - To accelerate consolidation and strength increase<br>- Sand drain, PVD drain (Card board drain) etc |
| 7. | Compaction pile | - To increase strength and stability<br>- Use of compacted sand and crushed stone |
| 8. | Chemical soil stabilization | - To increase bearing strength and stability<br>- Use of lime pile and cement grout, mortar injection |

Table 8-15 Countermeasure for Soft Ground Treatment

| ITEM | METHOD | | | |
|---|---|---|---|---|
| | SAND DRAIN | PBD | SAND COMPACTION | PRE-CAST RC PILE |
| Diameter (mm) | 400 | 65 | 700 | 400×400 |
| Increase in Strength Sub Soil (kg/cm$^2$) | C=0.3⇒1.0 | C=0.3⇒0.5 | C=0.3⇒3.0 | — |
| Characteristic | This method is most popular | Construction Speed is Fast | Range of application is widely | No Settlement |
| Depth for practical application | 30m | 15m | 35m | 30m |
| Minimum Spacing | 1.2m | 0.9m | 1.2m | 1.0m |
| Construction Capacity | 300m/day | 2500m/day | 150m/day | 120m/day |
| Ratio of Cost | 1.0 | 0.2 | 2.4 | 11.0 |
| Other | Many Satisfactory Result | Low depth for practical application | | |

2) Institution of Soil Criteria

General characteristics of the Soft Ground are as in the followings:

(a) Definitions of Soft Ground

General criteria of soft ground are as in following table.

Table 8-16 General Characteristics of Soft Ground

| Soils | Peat or Clayey Soil | | Sandy Soil |
|---|---|---|---|
| Stratum Thickness | Less than 10 m | More than 10 m | ----- |
| SPT Blowcount | Less than 4 | Less than 6 | Less than 10 |
| Unconfined Compressive Strength: qu ( $kgf/cm^2$ ) | Less than 0.6 | Less than 1 | ----- |
| Cone Resistance Dutch Cone Test: qc ( $kgf/cm^2$) | Less than 8 | Less than 12 | Less than 40 |

(b) Classification by thickness of soft ground

The soft ground in the Mekong Delta can be classified in terms of its thickness as follows:

- Very Shallow : soft ground depth : $D < 2.5$ m
- Shallow : soft ground depth : 2.5 m $< D <$ 5.0 m
- Deep : soft ground depth : $D > 5.0$ m

(c) Selection of treatment method

For the selection of treatment methods the following criteria are applied:
- Stable and permanent foundations are required.
- Priority is given to a slow construction rate due to the substantial available time period, and due to the high cost of remedial works in the event of embankment failure.

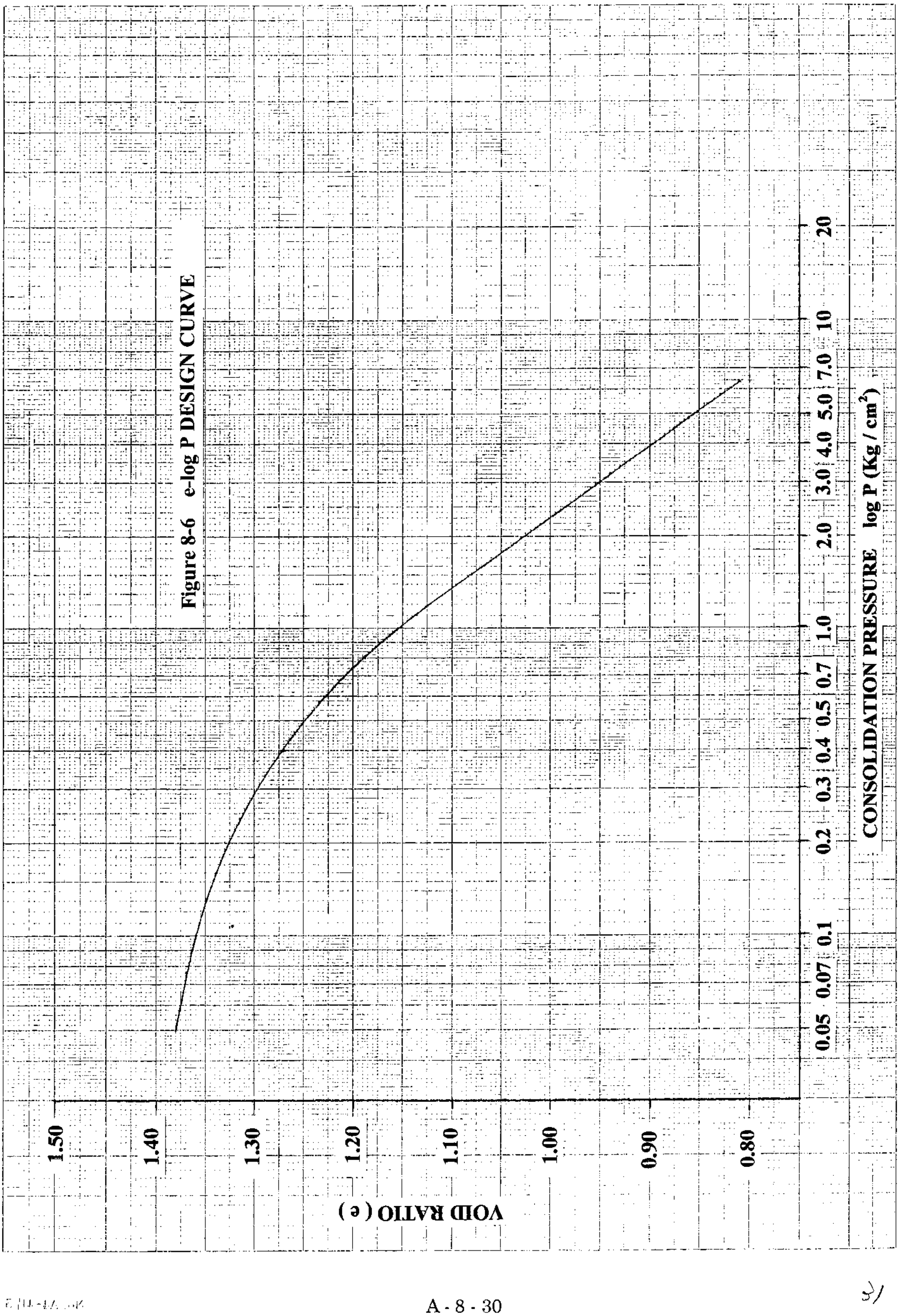



Figure 8-6 e-log P DESIGN CURVE

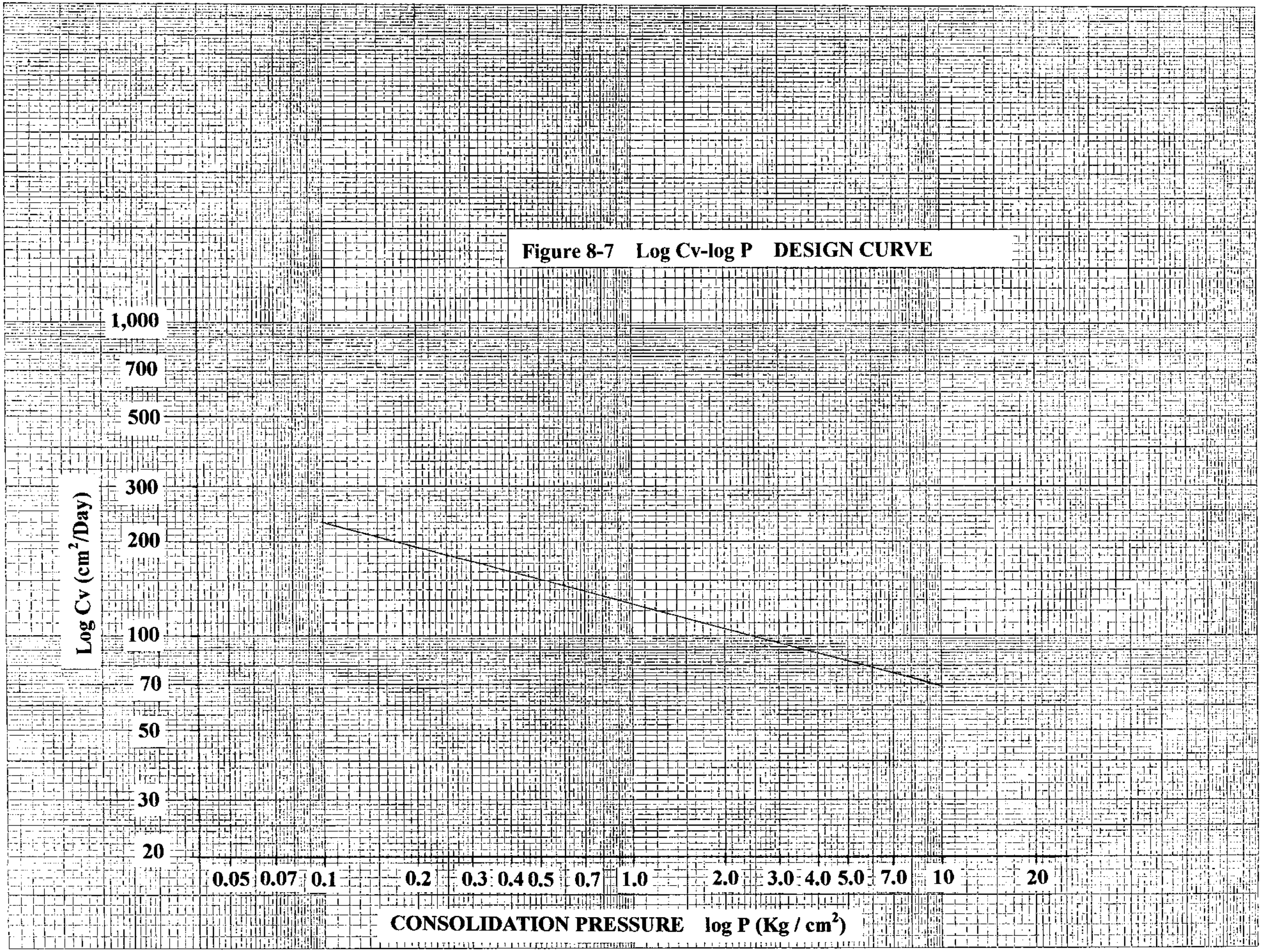
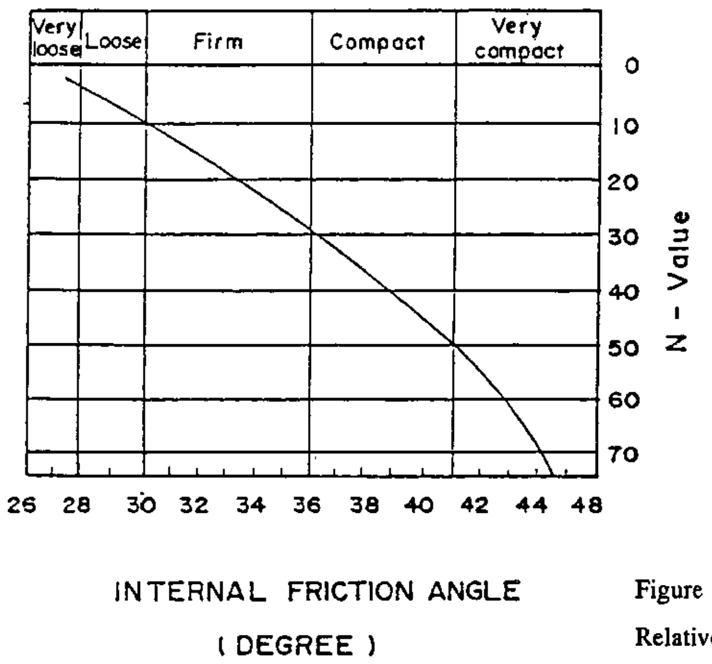
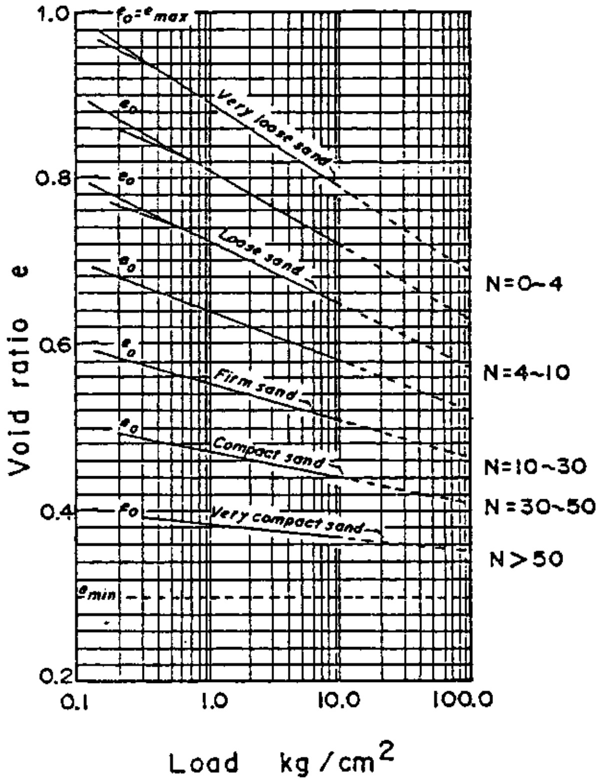


Figure 8-7 Log Cv-log P DESIGN CURVE
Log Cv (cm²/Day)
1,000
700
500
300
200
100
70
50
30
20
0.05 0.07 0.1 0.2 0.3 0.4 0.5 0.7 1.0 2.0 3.0 4.0 5.0 7.0 10 20
CONSOLIDATION PRESSURE log P (Kg / cm²)




Figure

Relative Chart for N-Value and Internal Friction Angle




Figure

Relative Chart for Load and Void Ratio of Sandy Soil

| Figure 8-8 | RELATIVE CHART FOR N-VALUE AND INTERNAL FRICTION ANGLE (Φ), AND VOID RATIO (e) |
| --- | --- |
| **BASIC DESIGN STUDY ON THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN CENTRAL AREA** | |

- Sufficient program time to be allocated for settlement to occur.
- Replacement of soft ground to be limited to 2.5 m for economic reasons but to 5.0m for technical reasons
- Special attention to be paid to prevent heave of the surrounding ground

A number of alternatives have been considered, including vertical sand drains and drainage blanket as set out below.

3) Method of Analysis

The embankment is analyzed for stability and for settlement. Improvement is calculated by reference to the case of no treatment. Formulae for analysis are as follows:

(a) Ultimate settlement

$$Sc = \frac{eo - e1}{1 + eo} H$$

Where

Sc: Ultimate settlement (cm)

eo: Initial voids ratio

e1: Voids ratio after consolidation

H: Thickness of soil layer to be consolidated (cm)

(b) Consolidation Time

- No Treatment Case

$$t = \frac{d^2 \times T}{Cv}$$

Where

t: Consolidation time (days)

D: Drainage path length (cm)

Cv: Consolidation coefficient ($cm^2$/day)

T: Time factor

- Sand Drain Case

$$t = \frac{De^2 \times T}{Cv}$$

Where

De: Effective drain radius (m) in square arrangement of sand pile, =1.13Dc

Dc: Centre to centre spacing of sand pile (m)

T: Time factor (obtained by n= De/Dw)

Dw: Diameter of sand pile (m)

4) Stability

$$Fs = \frac{\Sigma\{Cl + \tan\phi(W\cos\theta - ul - KW\sin\theta)\}}{\Sigma(W\sin\theta - KW\cos\theta)}$$

Where

C: Cohesion

φ: Angle of internal friction

l: Length of base of slice (embankment and existing ground layers)

W: Weight of soil slice

θ: Angle of base of slice to horizontal

u: Pore water pressure

k: Seismic coefficient

5) Analysis Condition

- The stress distribution in the soil beneath the embankment is obtained from Figures 8-9 and 8-10. The intensity of the distributed embankment load is calculated at points in Figure 8-9.
- The sand pile grid size determined was that where 30 days after completion of the embankment the degree of settlement remaining will be less than 10 cm.

0

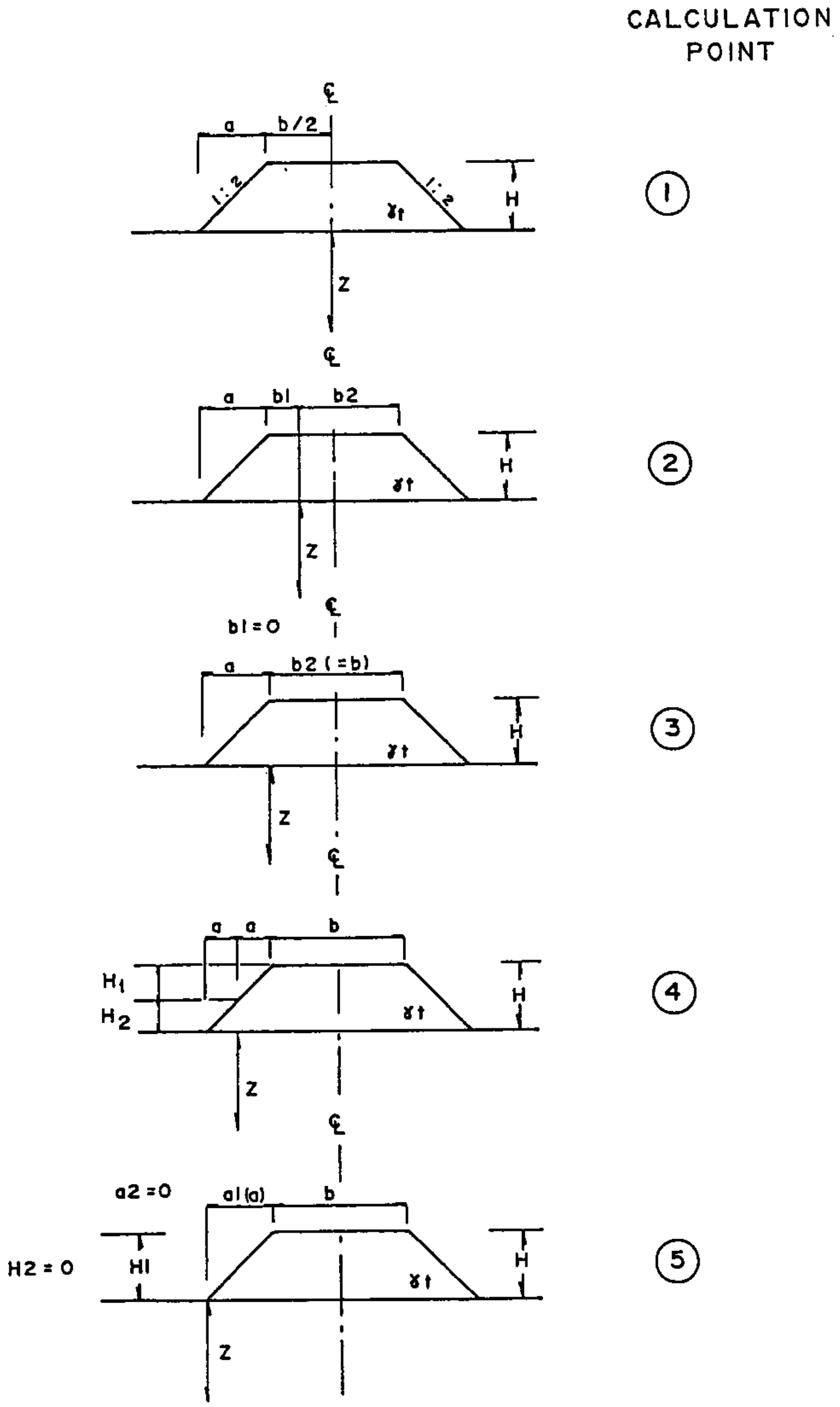



Figure 8-9

**BASIC DESIGN STUDY ON THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE CENTRAL AREA**

**EMBANKMENT LOAD AND CALCULATION POINTS**

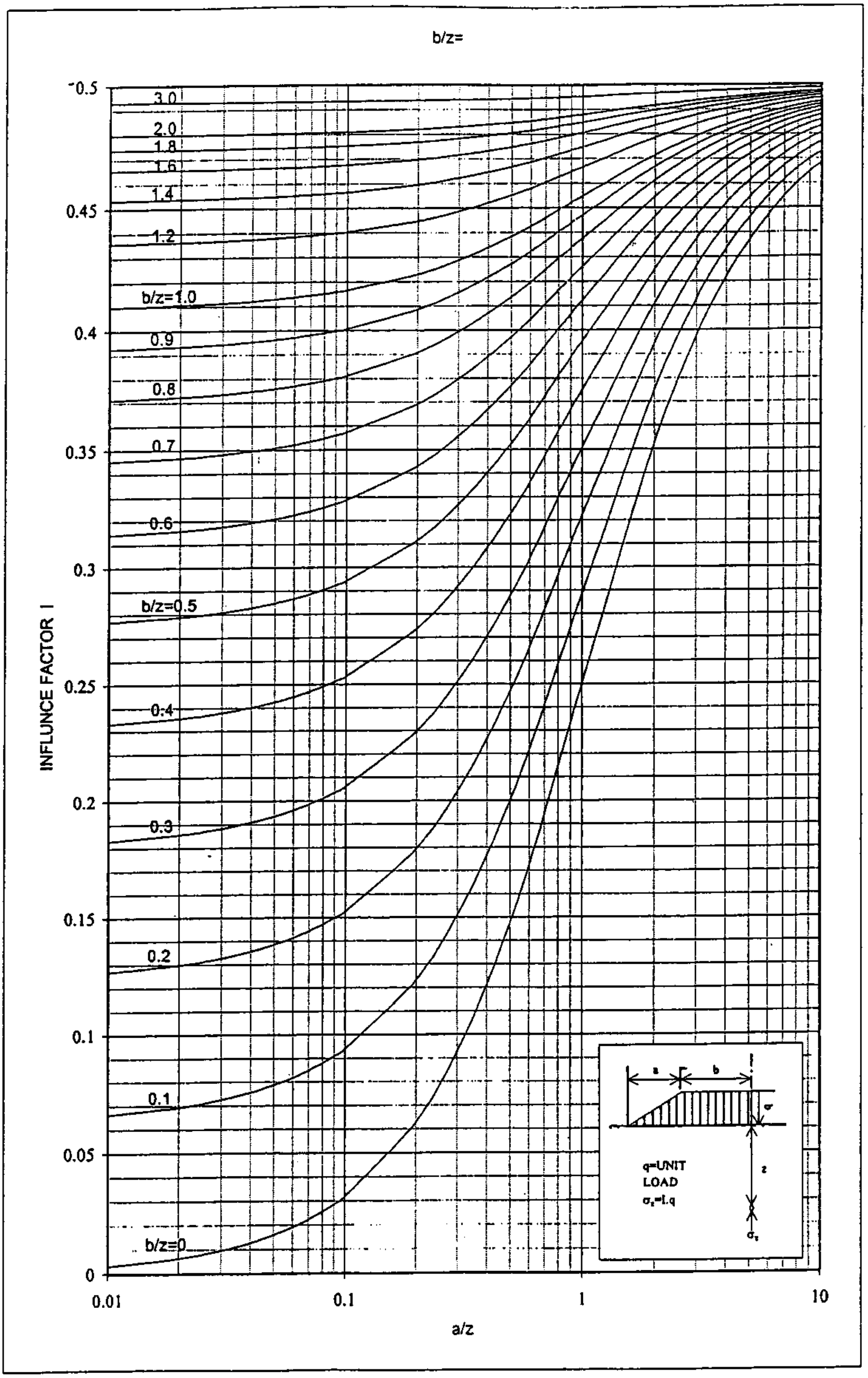



Figure 8-10

BASIC DESIGN STUDY ON THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE CENTRAL AREA

GRAPH OF INFLUNCE LINE (BY OSTERBERG)

- Condition for sand pile.

  Diameter of pile: Dw = 40 cm

  Centre to centre spacing of piles: 1.2 < Dc < 3.0 meters

- Sliding check of existing ground treated by sand pile is carried out for two cases, immediately upon completion of the embankment and at a time thirty days after completion.

6) Target for Settlement and Stability

- 30 days after completion of the embankment remaining settlement is not to exceed 10cm.

- Factor of safety against slip circle failure

  a) Upon completion of the embankment: Fs > 1.10

  b) 30 days after completion of the embankment: Fs > 1.20

  c) when traffic open: Fs > 1.25

7) Degree of Consolidation

Graphs of degree of consolidation and time factors are shown in Figure 8-11.

(Source: Standard of Japan Highway Corporation)

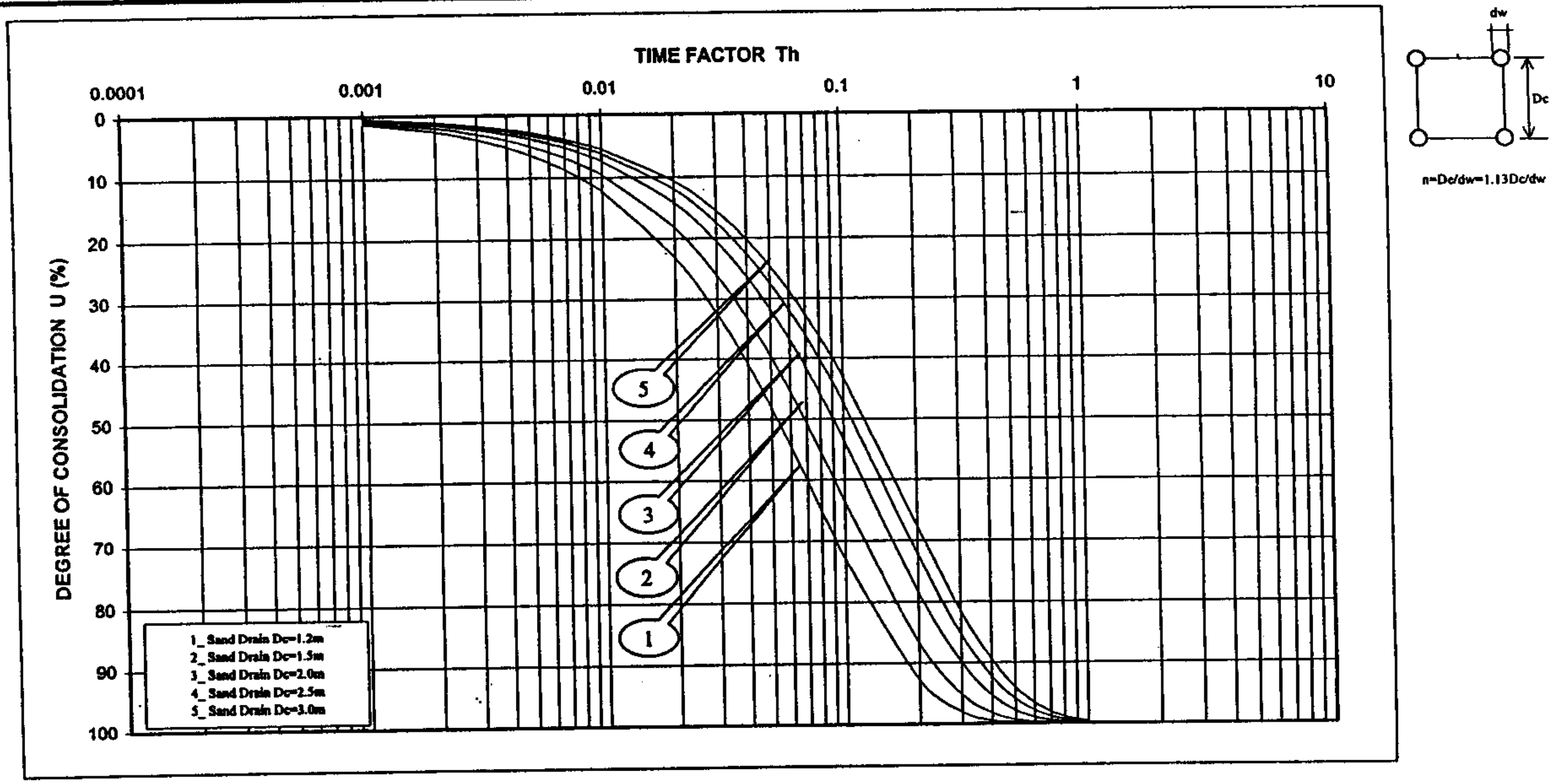



Figure 8-11

BASIC DESIGN STUDY ON THE PROJECT FOR

RECONSTRUCTION OF BRIDGES IN THE CENTRAL AREA

RELATIVE CHART OF

DEGREE OF CONSOLIDATION U(%) AND TIME FACTOR Th

FOR VERTICAL DRAIN METHOD

3-2 Result of Soft Ground Analysis

For a representative case of soft ground in the Central Area in Vietnam, analysis of soft ground by the Plastic Board Drain (PBD) method is given below.

(1) Condition of Soft Ground

1) Extent of soft ground, and ground water level: refer to Table 8-2

2) Design parameters of soft ground

$\gamma t = 1.700$ tf/$m^3$

qu = 2.00 tf/$m^2$

Co = 1.00 tf/$m^2$

Py = 4.00 tf/$m^2$

Ratio of strength to consolidation pressure m = 0.25

Figure 8-6 e-logP Design Curve

Figure 8-7 log Cv-logP Design Curve

3) Embankment Details

Embankment profile and fill parameters are summarized as follows:

- Embankment profile    Width of road: 8.50m

  Slope gradient: embankment height less than 6m 1: 1.5

  embankment height over 6m    1: 1.75

- Embankment height: refer to Table 8-17
- Fill parameters
  - Wet Density…..……………………$\gamma t = 1.80$  t / $m^3$
  - Undrained Shear Strength……….. C = 2.0  tf / $m^2$
  - Angle of Internal Friction …………$\phi = 10$ (degree)
  - Rate of Filling……..………………5 cm / day

(2) Results of Analysis

Representative Embankment Height of approach Road for Bridges, its Safety Factor and when Fs=1.2, Limited Embankment Height are shown as below.

The Bridge to be required soft ground treatment by PBD method are three bridges of BNO.18A, 26A and 35A.

Table 8-17 Safety Factor of Embankment on soft ground
And Limited Embankment Height

| Bridge NO. | Safety Factor (Fs) | Embankment Height (m) | When Fs=1.2, Limited Embankment Height (m) | Thickness of Soft Soil (m) | Note |
|---|---|---|---|---|---|
| BNO.6A BH-1 | 1.510 | 2.20 | - | 7.0 | |
| BH-2 | 1.703 | 2.00 | - | 5.8 | |
| BNO.18A BH-1 | 0.755 | 4.85 | 2.75 | 8.9 | Need treatment |
| BNO.26A BH-1 | 1.031 | 3.00 | 2.40 | 9.8 | “ |
| “ BH-2 | 0.935 | 3.80 | “ | 8.8 | “ |
| BNO.35A BH-1 | 1.003 | 4.60 | 3.50 | 21.8 | “ |
| “ BH-2 | 1.047 | 4.40 | “ | 23.5 | “ |

Results of Analysis for Soft ground treatment by Plastic Board Drain method are shown Table 8-18

Table 8-18 Results of Analysis for Soft ground treatment by PBD method

| Bridge NO. | Planning Embank-ment Height | Necessary Embank-ment Height | Settle. Value Sc | S.Factor (Fs) imm.after completion | S.Factor (Fs) After com.30 days | Remain ing Settle. Value Sr | PBD Interval x Length |
|---|---|---|---|---|---|---|---|
| 18A BH-1 | 4.85 m | 5.45 m | 57.2 cm | 1.276 | 1.346 | 12.9 cm | 1.3m x 10m |
| 26A BH-1 | 3.00 m | 3.40 m | 35.6 cm | 1.278 | 1.345 | 6.9 cm | 1.5m x 10m |
| 26A BH-2 | 3.80 m | 4.30 m | 47.7 cm | 1.159 | 1.222 | 6.1 cm | 1.3m x 10m |
| 35A BH-1 | 4.60 m | 5.20 m | 62.1 cm | 1.261 | 1.331 | 12.3 cm | 1.3m x 21m |

Note: 1) Soft ground (soft clayey soil), which is extensively distributed about Bridge NO.35A is interbedded loose sandy soil with lenses of thickness 8.7m

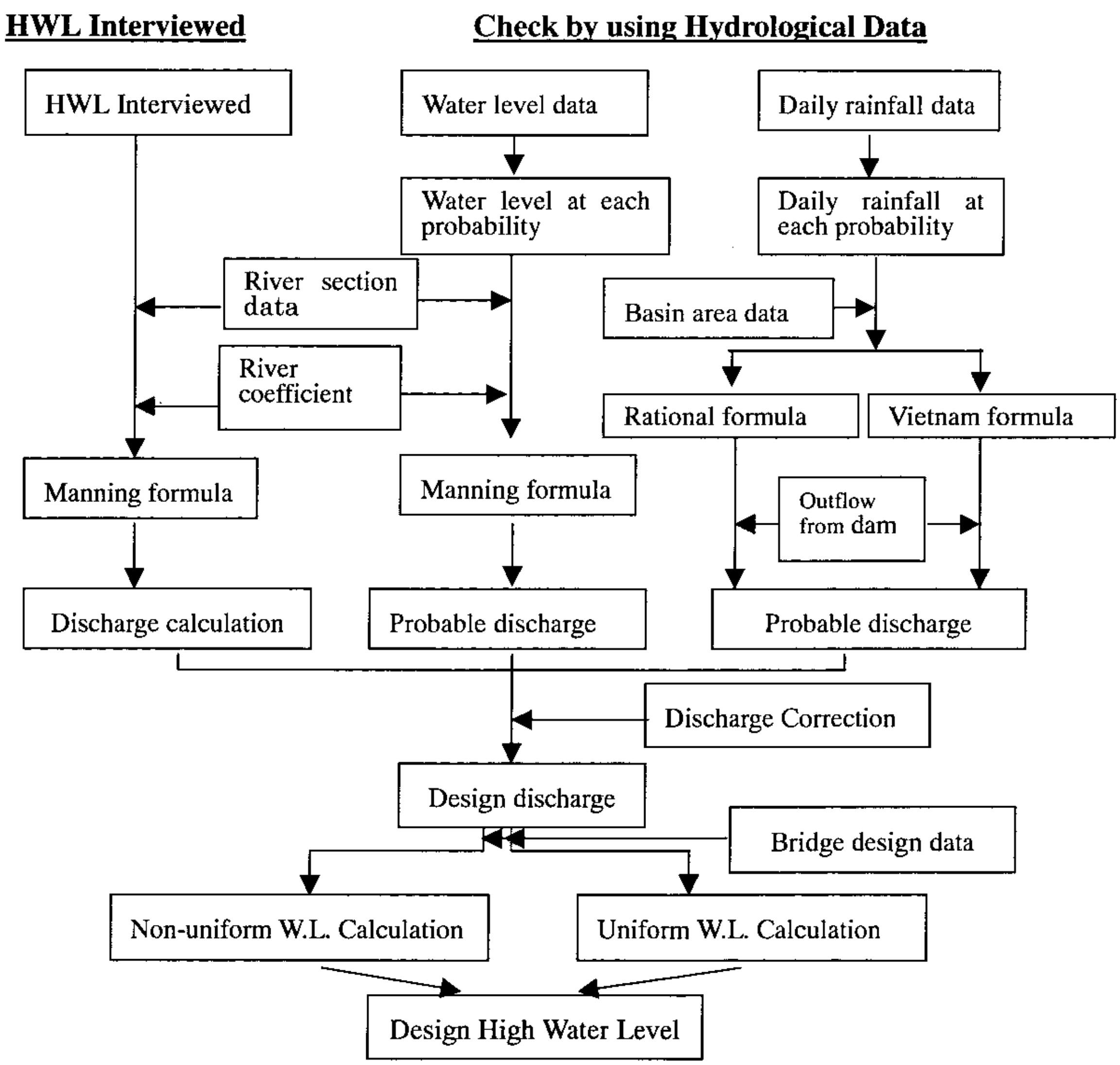
# Appendix 9
# Natural Conditions Survey Results - Hydrological

## APPENDIX - ANALISIS ON DESIGN HIGH WATER LEVEL FOR BRIDGE

### 1. Policy for Determining Design High Water Level for Bridge

The policy and procedure for determining the design high water level at each bridge are shown in the flowchart below. Since the discharge and water level data for the bridges are hardly available, the design high water level for bridges should be determined on the basis of the previous high water level interviewed to local residents near the bridge site. Its appropriateness as a design high water level for the bridges can be justified by checking the high water level at each return period estimated by rainfall data or relevant data such as outflow of dam. Hydrological gauging stations, which are the source of rainfall data, are shown Table A.

**Flowchart for determining design high water level at each bridge site**



## 2. Hydrological Analysis Method

### 2.1 Discharge Estimation

### (1) Discharge Calculation from High Water Level Interviewed

The discharge can be calculated with the following Manning Formula by using a river cross-section and water level date interviewed.

$$Qp = V \times A$$
$$V = 1/n \times R^{2/3} \times I^{1/2}$$

Where,

Qp : Maximum Flood Discharge ($m^3/s$)
V : Flow velocity (m/s)
A :River section area (m2)
R : Hydrological mean depth
I : River slope (obtained from topographical survey data)
N : Roughness coefficient of the river
The following N value can be applied at:
Mountain area : 0.05 or 0.04
Plain area : 0.03
Coastal area : 0.025
Area where many tree exists in the river: 0.09.

### (2) Discharge Calculation from Rainfall Data

The probable daily rainfall is estimated by the maximum daily rainfall data of each year at the neighboring station of the bridge. The discharge will be calculated with both Rational Formula and a formula applied in Vietnam and the average result from two methods will be regarded as a discharge from rainfall data. The Rational Formula for calculating the maximum flood discharge is described as follows:

$$Qp = 1 / 3.6 * f * R * A$$

Where

Qp : Maximum Flood Discharge ($m^3/s$)
f : Runoff coefficient =0.75

R : Hourly rainfall intensity for duration equal to the concentration time(mm/h)
A : Catchment area (km$^2$)

The hourly rainfall intensity and flood concentration time can be calculated with Monobe Formula and a formula proposed by Japanese Public Works Research Institute respectively. Both formulas are shown below.

( Monobe Formula)

$$R = Rt / T \quad (mm/h)$$
$$Rt = R_{24} ( T / 24 )^{K}$$

Where :

Rt : Rainfall intensity for time period corresponding to "T"
$R_{24}$ : daily rainfall in average basin (mm)
T : Flood concentration time (h)
K : Coefficient =0.33

(Public Works Research Institute Formula )

$$T = 1.67 * 10^{-3} \{ L / \sqrt{S} \}^{0.7} + t$$

Where:

T : Flood concentration time (h)
L : Channel length (km)
S : Average slope (h / L )
H : Difference in elevation (m)
T : Inflow time (h) [=0.5 ]

**(3) Discharge Calculation from Water Level Data near Bridge Site.**

For the No.4 and 5 bridges, since the water level data near the bridge is available, it can be utilized to calculate discharge at both bridge sites. The results are shown in Table 2.1.

**Table 2.1 Discharge at No.4 &5 Bridge Calculated by Water Level Data**

| Br. No. | Br. Name | St. Name | Calculated Discharge (m$^3$/s) | | | |
|---|---|---|---|---|---|---|
| | | | 1/100 | 1/50 | 1/25 | 1/2 |
| 4 | THACH QUANG | THACH QUANG | 3000 | 2,600 | 2,300 | 900 |
| 5 | THACH DINH | KIM TAN | 4100 | 4000 | 3900 | 2300 |

### (4) Discharge Estimated from Outflow of Dam Reservoir

For No.37 and 38 bridges, the outflow from a dam reservoir determines the high water level at the bridge sites. There is a Song Quao Dam at approximately16km upstream of No.37 bridge, which was completed in 1997. Although the maximum outflow from dam is recorded 300 $m^3/s$ in 1998, its probability can not be estimated due to limited number of data. Accordingly, the discharge at the bridge site can be calculated by rainfall data.

On the one hand, a Dan Nhin Dam is located at approximately 25km upper-stream of No.48 bridge. Although the maximum outflow of the dam is estimated 4500$m^3/s$ at 200 year return period, the past maximum discharge recorded only 1600 $m^3/s$ at 30 year return period in 1993. The estimation results of the outflow at each probability are shown in Table 2.2.

**Table 2.2 Outflow of Dan Ninh Dam at Each Probability ($m^3/s$)**

| Br.No. | Br. Name | 1/100 | 1/50 | 1/25 | 1/2 | Remarks |
|---|---|---|---|---|---|---|
| 48 | NONG TRUNG BO SUA | 3000 | 2000 | 1300 | 200 | 21years data |

### (5) Results of Discharge Estimation

The discharge estimation from hydrological data mentioned above is shown in Table 3.1.

## 2.2 Water Level Estimation at Each Bridge Site

### (1) Estimation Method of High Water Level from Discharge Results

The high water level at each bridge site can be calculated on the basis of discharge obtained from relevant hydrological data such as rainfall, water level and outflow from dam mentioned above. For component A type bridge, since the river cross-section data at both upstream and downstream sides of the bridge are available, the high water level and flow velocity at each return period can be estimated with the uniform flow calculation. On the other hand, for Component B type bridge, the average longitudinal slope can be estimated from site investigation results and the water level and velocity at each return period can be calculated with the uniform flow calculation.

The estimation results of the high water level and velocity at each return period are shown in Table 3.1.

## 3. Justification of High Water Level Interviewed as Design High Water Level

The high water level interviewed is justified its appropriateness as a design high water level for bridges by comparing the high water level estimated by relevant hydrological data. As a result of the comparison, the return period of the high water level interviewed is confirmed ranging from 1/25 to 1/100 of probability. Consequently, it can be justified the appropriateness of the high water level interviewed as a design high water level in consideration with the scale and importance of bridges for this project.

The comparison results are shown in Table 3-1.

# Table 3.1 Justification of HWL Interviewed

| Br. No | Br. Name | Returen Period | Q (m3) | V (m/s) | H.W.L. Calculated | Com-parison | M.H.W.L. Interveiwed |
|---|---|---|---|---|---|---|---|
| 2 | CHIH DAI | 1/100 | 190 | 1.59 | 12.04 | > | 11.6 |
| | | 1/50 | 170 | 1.53 | 11.79 | > | |
| | | 1/25 | 150 | 1.46 | 11.53 | < | |
| 4 | THACH QUANG | 1/100 | 3630 | 3.57 | 38.00 | > | 37.5 |
| | | 1/50 | 3300 | 3.57 | 37.95 | > | |
| | | 1/25 | 3000 | 3.45 | 37.23 | < | |
| 5 | THACH DINH | 1/100 | 3500 | 4.53 | 30.50 | > | 29.5 |
| | | 1/50 | 3200 | 4.50 | 30.32 | > | |
| | | 1/25 | 2900 | 3.37 | 29.62 | = | |
| 6 | QUYNH BANG | 1/100 | 350 | 1.57 | 15.72 | > | 15.5 |
| | | 1/50 | 320 | 1.53 | 15.55 | = | |
| | | 1/25 | 290 | 1.49 | 15.38 | < | |
| 7 | KE CHIENG | 1/100 | 320 | 2.38 | 79.70 | < | 80.1 |
| | | 1/50 | 290 | 2.31 | 79.40 | < | |
| | | 1/25 | 260 | 2.23 | 79.09 | < | |
| 9 | BAN KHOANG | 1/100 | 1470 | 4.41 | 100.57 | > | 100.4 |
| | | 1/50 | 1340 | 4.25 | 100.33 | < | |
| | | 1/25 | 1210 | 4.09 | 100.09 | < | |
| 11 | MY SON | 1/100 | 1370 | 3.41 | 61.23 | > | 60.6 |
| | | 1/50 | 1240 | 3.32 | 60.54 | = | |
| | | 1/25 | 1130 | 3.23 | 59.92 | < | |
| 12 | CUA TRAI | 1/100 | 470 | 2.39 | 8.58 | > | 8.4 |
| | | 1/50 | 430 | 2.31 | 8.38 | = | |
| | | 1/25 | 390 | 2.23 | 8.17 | < | |
| 15 | PHU VINH | 1/100 | 630 | 2.76 | 21.50 | > | 21.0 |
| | | 1/50 | 570 | 2.70 | 21.29 | > | |
| | | 1/25 | 520 | 2.61 | 21.03 | < | |
| 18 | LAC THIN | 1/100 | 1430 | 3.80 | 40.91 | > | 40.5 |
| | | 1/50 | 1300 | 3.70 | 40.52 | = | |
| | | 1/25 | 1180 | 3.59 | 40.14 | < | |
| 20 | BEN DA | 1/100 | 470 | 1.85 | 50.35 | > | 49.8 |
| | | 1/50 | 430 | 1.80 | 50.07 | > | |
| | | 1/25 | 390 | 1.75 | 49.77 | = | |
| 22 | PA NHO | 1/100 | 490 | 2.54 | 81.62 | > | 81.4 |
| | | 1/50 | 440 | 2.45 | 81.37 | = | |
| | | 1/25 | 400 | 2.37 | 81.17 | < | |
| 24 | NA MAY | 1/100 | 2420 | 3.62 | 80.50 | > | 79.9 |
| | | 1/50 | 2200 | 3.57 | 80.33 | > | |
| | | 1/25 | 2000 | 3.45 | 79.92 | = | |
| 26 | HHE DUONG | 1/100 | 440 | 3.12 | 121.46 | > | 121.2 |
| | | 1/50 | 400 | 3.04 | 121.26 | = | |
| | | 1/25 | 360 | 2.90 | 121.05 | < | |
| 27 | HOI PHOC | 1/100 | 1110 | 4.97 | 51.00 | > | 50.9 |
| | | 1/50 | 1010 | 4.97 | 51.00 | > | |
| | | 1/25 | 920 | 4.86 | 50.86 | = | |
| 34 | SONG QUAN | 1/100 | 300 | 2.34 | 80.76 | > | 80.6 |
| | | 1/50 | 270 | 2.54 | 80.55 | = | |
| | | 1/25 | 240 | 2.16 | 80.34 | < | |
| 35 | DAI LOI | 1/100 | 740 | 1.87 | 52.53 | > | 52.3 |
| | | 1/50 | 670 | 1.81 | 52.15 | < | |
| | | 1/25 | 600 | 1.74 | 51.76 | < | |
| 36 | DA DUNG | 1/100 | 2240 | 2.86 | 15.00 | > | 14.7 |
| | | 1/50 | 2040 | 2.86 | 15.00 | > | |
| | | 1/25 | 1850 | 2.80 | 14.72 | = | |
| 37 | TRNG | 1/100 | 570 | 2.28 | 61.93 | > | 61.4 |
| | | 1/50 | 470 | 2.12 | 61.51 | > | |
| | | 1/25 | 430 | 2.05 | 61.33 | < | |
| 38 | SUOI CAT | 1/100 | 350 | 5.06 | 70.46 | > | 70.2 |
| | | 1/50 | 320 | 4.90 | 70.32 | > | |
| | | 1/25 | 290 | 4.73 | 70.17 | = | |
| 42 | TUAN TU | 1/100 | 350 | 1.63 | 11.26 | > | 10.9 |
| | | 1/50 | 320 | 1.58 | 11.07 | > | |
| | | 1/25 | 290 | 1.52 | 10.87 | = | |
| 43 | TAM NGAN | 1/100 | 270 | 1.80 | 127.95 | > | 127.7 |
| | | 1/50 | 240 | 1.74 | 127.78 | > | |
| | | 1/25 | 220 | 1.69 | 127.66 | < | |
| 45 | CAU GAY | 1/100 | 820 | 3.70 | 120.64 | > | 120.2 |
| | | 1/50 | 730 | 3.54 | 120.39 | > | |
| | | 1/25 | 650 | 3.39 | 120.15 | = | |
| 46 | TAN VAN | 1/100 | 930 | 2.91 | 749.09 | > | 748.7 |
| | | 1/50 | 850 | 2.81 | 748.86 | > | |
| | | 1/25 | 770 | 2.71 | 748.63 | < | |
| 47 | LOC NGAI | 1/100 | 700 | 3.43 | 751.55 | > | 751.1 |
| | | 1/50 | 640 | 3.33 | 751.26 | > | |
| | | 1/25 | 580 | 3.26 | 750.89 | < | |
| 48 | NONG TRUONG BO SUA | 1/100 | 3300 | 6.74 | 900.00 | > | 898.8 |
| | | 1/50 | 2300 | 6.55 | 899.75 | > | |
| | | 1/25 | 1600 | 5.73 | 898.74 | < | |
| 52 | EA SOUP | 1/100 | 1830 | 3.44 | 20.30 | > | 20.0 |
| | | 1/50 | 1660 | 3.33 | 19.72 | < | |
| | | 1/25 | 1500 | 3.22 | 19.15 | < | |
| 55 | ROXY | 1/100 | 590 | 5.44 | 11.50 | > | 11.0 |
| | | 1/50 | 540 | 5.29 | 11.30 | > | |
| | | 1/25 | 490 | 5.11 | 11.07 | = | |
| 56 | KRONG K MAR | 1/100 | 1330 | 3.13 | 12.31 | > | 12.0 |
| | | 1/50 | 1200 | 3.02 | 11.99 | = | |
| | | 1/25 | 1100 | 2.94 | 11.73 | < | |
| 58 | DAK PO TO | 1/100 | 850 | 4.08 | 9.88 | > | 9.3 |
| | | 1/50 | 770 | 3.95 | 9.59 | > | |
| | | 1/25 | 700 | 3.83 | 9.32 | = | |
| 59 | IA DRANG | 1/100 | 500 | 2.96 | 12.33 | > | 11.8 |
| | | 1/50 | 450 | 2.87 | 12.06 | > | |
| | | 1/25 | 400 | 2.77 | 11.77 | = | |
| 62 | NGOC REO | 1/100 | 280 | 3.22 | 9.35 | > | 9.1 |
| | | 1/50 | 250 | 3.08 | 9.21 | > | |
| | | 1/25 | 230 | 2.99 | 9.11 | = | |
| 64 | DAK TO KAN | 1/100 | 280 | 2.32 | 6.17 | > | 6.0 |
| | | 1/50 | 250 | 2.22 | 6.02 | = | |
| | | 1/25 | 230 | 2.16 | 5.92 | < | |
| 66 | NGOC TU | 1/100 | 320 | 2.25 | 8.34 | > | 8.2 |
| | | 1/50 | 290 | 2.17 | 8.22 | = | |
| | | 1/25 | 260 | 2.08 | 8.09 | < | |
| 67 | XA CAI | 1/100 | 930 | 1.70 | 62.00 | < | 62.8 |
| | | 1/50 | 850 | 1.67 | 61.81 | = | |
| | | 1/25 | 770 | 1.64 | 61.62 | < | |
| 70 | DO | 1/100 | 1530 | 3.39 | 62.78 | > | 62.3 |
| | | 1/50 | 1390 | 3.27 | 62.45 | > | |
| | | 1/25 | 1260 | 3.16 | 62.14 | < | |
| 72 | SONG SAU | 1/100 | 1550 | 5.45 | 42.00 | > | 41.7 |
| | | 1/50 | 1400 | 5.35 | 41.84 | > | |
| | | 1/25 | 1280 | 5.16 | 41.55 | < | |
| 74 | BA LE | 1/100 | 390 | 2.93 | 11.77 | > | 11.5 |
| | | 1/50 | 350 | 2.82 | 11.55 | = | |
| | | 1/25 | 320 | 2.74 | 11.37 | < | |
| 76 | DAO LONG | 1/100 | 570 | 2.58 | 99.91 | > | 99.4 |
| | | 1/50 | 520 | 2.50 | 99.72 | > | |
| | | 1/25 | 470 | 2.41 | 99.46 | = | |
| 77 | TRUONG DINH | 1/100 | 490 | 3.69 | 8.65 | > | 8.4 |
| | | 1/50 | 440 | 3.54 | 8.47 | = | |
| | | 1/25 | 400 | 3.43 | 8.31 | < | |
| 78 | TRA O | 1/100 | 510 | 4.25 | 13.96 | > | 13.7 |
| | | 1/50 | 460 | 4.10 | 13.72 | = | |
| | | 1/25 | 420 | 3.97 | 13.51 | < | |
| 79 | TRA BUONG | 1/100 | 1060 | 3.42 | 11.50 | > | 11.2 |
| | | 1/50 | 960 | 3.36 | 11.39 | > | |
| | | 1/25 | 870 | 3.25 | 11.21 | = | |
| 82 | DA LOC | 1/100 | 240 | 1.93 | 9.64 | = | 9.6 |
| | | 1/50 | 220 | 1.87 | 9.44 | < | |
| | | 1/25 | 200 | 1.80 | 9.24 | < | |
| 83 | NGOI NGAN | 1/100 | 110 | 1.15 | 10.01 | > | 9.8 |
| | | 1/50 | 100 | 1.11 | 9.90 | > | |
| | | 1/25 | 90 | 1.06 | 9.77 | = | |
| 86 | TIEN DU | 1/100 | 150 | 1.52 | 11.00 | > | 10.8 |
| | | 1/50 | 130 | 1.49 | 10.90 | > | |
| | | 1/25 | 120 | 1.46 | 10.72 | < | |

**Table A-1: List of Observatory Gauging Station near Bridge Sites**

| No. | Bridge Name | Longitude | Latitude | Ob.St.-1 Name | Longitude | Latitude | Ob. Year | Ob.St-2. Name | Longitude | Latitude | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | CHINH DAI | | | — | — | — | — | — | — | — | |
| 4 | THACH QUANG | $105^{0}$32’5 | $20^{0}$17’8 | Thach Quang | $105^{0}$32 | $20^{0}$18’ | 24 | — | — | — | Water Level |
| 5 | THACH DINH | $105^{0}$38’9 | $20^{0}$09’9 | Kim Tan | $105^{0}$41 | $20^{0}$06’ | 24 | — | — | — | Water Level |
| 6 | QUYNH BANG | $105^{0}$42’8 | $19^{0}$10’6 | — | — | — | — | — | — | — | |
| 7 | KE CHIENG | $105^{0}$07’ | $19^{0}$07’ | Quy Hop | $105^{0}$07 | $19^{0}$33’ | 39 | Do Luong | $105^{0}$18’ | $18^{0}$58’ | Rainfall |
| 9 | BAN KHOANG | $104^{0}$15’ | $19^{0}$35’ | Quy Chau | $105^{0}$07 | $19^{0}$17’ | 38 | Cua Rao | $104^{0}$17’ | $19^{0}$17’ | Rainfall |
| 11 | MY SON | $106^{0}$11' | $18^{0}$00' | Kú Anh | $106^{0}$17' | $18^{0}$05' | 39 | Ky Giang | $106^{07}$7.8’ | $18^{0}$6.6’ | Rainfall |
| 12 | CUA TRAI | 105 $^{0}$42’8 | $18^{0}$29’6 | — | — | — | — | — | — | — | |
| 15 | PHU VINH | | | — | — | — | — | — | — | — | |
| 18 | LAC THIEN | $106^{0}$00' | $17^{0}$55' | Minh Hoa | $106^{0}$02' | $17^{0}$47' | 39 | Trooc | $106^{0}$16’ | $17^{0}$39’ | Rainfall |
| 20 | BEN DA | $107^{0}$17' | $16^{0}$45' | Thach Han | $107^{0}$14' | $16^{0}$45' | 22 | Dong Ha | $107^{0}$05’ | $16^{0}$50’ | Rainfall |
| 22 | PA NHO | $106^{0}$44' | $16^{0}$37' | Khe Sanh | $106^{0}$50' | $16^{0}$38' | 25 | Dong Ha | $107^{0}$05’ | $16^{0}$50’ | Rainfall |
| 24 | NA MAY | $107^{0}$16'7 | $16^{0}$31'0 | Phuoc | $107^{0}$28' | $16^{0}$32' | 23 | Hue | $107^{0}$41’ | $16^{0}$24’ | Rainfall |
| 26 | KHE DUONG | $107^{0}$59'0 | $16^{0}$15'4 | Nam Dong | $107^{0}$43' | $16^{0}$09' | 23 | Aluoi | $107^{0}$14’ | $16^{0}$05’ | Rainfall |
| 27 | HOI PHUOC | $108^{0}$04'4 | $15^{0}$59'8 | Da Nang | $108^{0}$11' | $16^{0}$02' | 53 | Nong Son | $108^{0}$03’ | $15^{0}$45’ | Rainfall |
| 34 | SONG QUAN | 108 $^{0}$33’3 | 15 $^{0}$22’3 | Tam Ky | $108^{0}$30' | $15^{0}$ 33’ | 21 | Hoi An | $108^{0}$20’ | $15^{0}$20’ | Rainfall |
| 35 | DAI LOI | $108^{0}$06'1 | $15^{0}$53'6 | Ai Nghia | $108^{0}$07' | $15^{0}$53' | 24 | Nong Son | $108^{0}$03’ | $15^{0}$45’ | Rainfall |
| 36 | DA DUNG | $107^{0}$45’9 | $10^{0}$40’9 | — | — | — | — | — | — | — | |
| 37 | TRANG | $108^{0}$09’0 | $11^{0}$01’8 | Phan Thiei | $108^{0}$06’ | $10^{0}$56’ | 39 | Song Luy | $108^{0}$20’ | $11^{0}$12’ | Rainfall,Dam |
| 38 | SUOI CAT | $107^{0}$41’3 | $11^{0}$04’9 | Ta Pao | $107^{0}$43' | $11^{0}$08' | 24 | Ham Tan | $107^{0}$45’ | $10^{0}$41’ | Rainfall |
| 42 | TUAN TU | $109^{0}$00’ | $11^{0}$31’8 | — | — | — | — | — | — | — | Rainfall |
| 43 | TAM NGAN | $108^{0}$ 43’7 | $11^{0}$50’4 | Tan My | $108^{0}$48’ | $11^{0}$41’ | 22 | CaNa | $18^{0}$33’ | $11^{0}$30’ | Rainfall |
| 45 | CAUGAY | $108^{0}$47’0 | $11^{0}$47’3 | Tan My | $108^{0}$48’ | $11^{0}$41’ | 22 | CaNa | $18^{0}$33’ | $11^{0}$30’ | Rainfall |
| 46 | TAN VAN | $108^{0}$14’3 | $11^{0}$47’3 | — | — | — | — | — | — | — | Discharge,Rain |
| 47 | LOC NGAI | $107^{0}$52’3 | $11^{0}$37’0 | Da Lat | $108^{0}$26’ | $11^{0}$57’ | 21 | Di Linh | $108^{0}$04’ | $11^{0}$34’ | Rainfall |

**Table A-2: List of Observatory Gauging Station near Bridge Sites**

| No. | Bridge Name | Longitude | Latitude | Ob.St.-1 Name | Longitude | Latitude | Ob. Year | Ob.St.-2 Name | Longitude | Latitude | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 48 | NT BO SUA | $108^{0}$25'9 | $11^{0}$44'6 | LienKhuong | $108^{0}$23' | $11^{0}$45' | 39 | Than h Binh | $108^{0}$18' | $11^{0}$47' | Rainfall, Dam |
| 52 | EA SOUP | $107^{0}$53'6 | $13^{0}$04'6 | Ea Soup | $107^{0}$52' | $13^{0}$06' | 21 | Cau 14 | $107^{0}$56' | $12^{0}$57' | Rainfall |
| 55 | ROXY | $108^{0}$17'2 | $12^{0}$55'6 | KRong BuK | $108^{0}$22' | $12^{0}$46' | 23 | Buon Ho | $108^{0}$16' | $12^{0}$55' | Rainfall |
| 56 | KRONG K'MAR | $108^{0}$20'9 | $12^{0}$30'7 | KRong Bong | $108^{0}$25' | $12^{0}$32' | 22 | Krong Ma | $108^{0}$12' | $12^{0}$18' | Rainfall |
| 58 | DAK PO TO | $108^{0}$24'4 | $13^{0}$37'7 | Cheo Reo | $108^{0}$25' | $13^{0}$22' | 38 | Phu Tuc | $108^{0}$36' | $13^{0}$22' | Rainfall |
| 59 | IA DRANG | $107^{0}$51'3 | $13^{0}$44'5 | Chu Pron | $107^{0}$56' | $13^{0}$45' | 23 | Chu Pra | $107^{0}$32' | $13^{0}$34' | Rainfall |
| 62 | NGOC REO | $108^{0}$02'7 | $14^{0}$29'4 | Kon Tum | $108^{0}$01' | $14^{0}$21' | 24 | Trung Nghia | $107^{0}$52' | $14^{0}$53' | Rainfall |
| 64 | DAK TO KAN | $107^{0}$52'5 | $14^{0}$50'7 | Dac To | $107^{0}$52' | $14^{0}$40' | 23 | Trung Nghia | $107^{0}$52' | $14^{0}$53' | Rainfall |
| 66 | NGOC TU | $107^{0}$46'4 | $14^{0}$43'4 | Dac Lay | $107^{0}$44' | $15^{0}$05' | 22 | Sa Thay | $107^{0}$50' | $14^{0}$26' | Rainfall |
| 67 | XA CAI | $108^{0}$49'2 | $15^{0}$01'2 | — | — | — | — | — | — | — | |
| 70 | DO | $108^{0}$30'1 | $15^{0}$15'6 | Tra Bong | $108^{0}$32' | $15^{0}$15' | 23 | Quang Ngai | $108^{0}$47' | $15^{0}$08' | Rainfall |
| 72 | SONG SAU | $108^{0}$39'7 | $15^{0}$15'8 | Tra Khuc | $108^{0}$47' | $15^{0}$08' | 23 | Son Giang | $108^{0}$34' | $15^{0}$22' | Rainfall |
| 74 | BA LE | $109^{0}$00'0 | $14^{0}$04'3 | Phu My | $107^{0}$44' | $15^{0}$05' | 24 | Hoai Nhon | $109^{0}$01' | $14^{0}$32' | Rainfall |
| 76 | DAO LONG | $109^{0}$08'6 | $14^{0}$07'9 | — | — | — | — | — | — | — | |
| 77 | TRUONG DINH | $108^{0}$58'4 | $13^{0}$55'8 | Binh Tuong | $108^{0}$52' | $13^{0}$56' | 24 | Quy Nhon | $109^{0}$13' | $13^{0}$46' | Rainfall |
| 78 | TRA O | $109^{0}$04'5 | $13^{0}$26'0 | SongCau | $109^{0}$13' | $13^{0}$13' | 24 | Cung Son | $109^{0}$00' | $13^{0}$04' | Rainfall |
| 79 | TRA BUONG | $109^{0}$03'4 | $13^{0}$18'4 | Ha Bang | $109^{0}$07' | $13^{0}$21' | 24 | Tuy Hoa | $109^{0}$18' | $13^{0}$05' | Rainfall |
| 82 | DA LOC | $109^{0}$04'7 | $13^{0}$32'6 | Cu Mong | $109^{0}$11' | $13^{0}$40' | 23 | Tuy Hoa | $109^{0}$18' | $13^{0}$05' | Rainfall |
| 83 | NGOI NGAN | $109^{0}$18'0 | $12^{0}$45'5 | — | — | — | — | — | — | — | |
| 86 | TIEN DU | $109^{0}$10'4 | $12^{0}$28'4 | — | — | — | — | — | — | — | |

Note:

Ob.Sta.-1 : data from Climate Center (～2000)

Ob.Sta.-2 : data from Standard hydorology book (teddy in Vet Nam)(～1987)

# Appendix 10
# Traffic Volume Survey Results

# Traffic Volume Survey Results

| Province | Bridge No. | Name of Bridge | Comp. A or B | Existing Bridge | Result of Traffic Volume Survey (6:00～18:00 12hours) Trailor Truck | Truck (4 or 6 wheels) | Bus (Big or Small) | 4WD Pick Up Truck | Sedan | Motorcycle | Bicycle | Pedestrian | Special Vehicles (Such as construction equipment) | Wheather | Date | Sum Total of Vehicle (6:00～18:00) (A) | Sum Total of Vehicle (24hours) (A)×1.3* | Road Grade |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| THANH HOA | 2 | CHINH DAI | B | ○ | 0 | 0 | 0 | 0 | 0 | 122 | 362 | 84 | 0 | - | 13/10 | 0 | 0 | VI |
| | 4 | THACH QUANG | B | × | 0 | 0 | 0 | 0 | 0 | 36 | 41 | 46 | 0 | - | 17/10 | 0 | 0 | VI |
| | 5 | THACH DINH | A | ○ | 12 | 33 | 8 | 13 | 4 | 148 | 175 | 50 | 0 | - | 15/10 | 70 | 91 | V |
| NGHE AN | 6 | QUYNH BANG | A | ○ | 0 | 35 | 10 | 0 | 2 | 303 | 788 | 174 | 0 | - | 22/10 | 47 | 61 | V |
| | 7 | KE CHIENG | B | × | 0 | 0 | 0 | 0 | 0 | 38 | 207 | 425 | 0 | - | 29/10 | 0 | 0 | VI |
| | 9 | BAN KHOANG | B | × | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 540 | 0 | - | 27/10 | 0 | 0 | VI |
| HA TINH | 11 | MY SON | A | ○ | 0 | 23 | 0 | 2 | 0 | 559 | 600 | 368 | 0 | - | 1/11 | 25 | 33 | VI |
| | 12 | CUA TRAI | B | ○ | 0 | 0 | 0 | 0 | 0 | 3 | 20 | 23 | 0 | - | 14/10 | 0 | 0 | VI |
| QUANG BINH | 15 | PHU VINH | B | ○ | 0 | 0 | 0 | 0 | 0 | 179 | 335 | 111 | 0 | - | 20/10 | 0 | 0 | VI |
| | 18 | LAC THIEN | A | ○ | 0 | 0 | 0 | 0 | 0 | 226 | 1167 | 166 | 0 | - | 20/10 | 0 | 0 | VI |
| QUANG TRI | 20 | BEN DA | B | × | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Rainy | 13/10 | 0 | 0 | VI |
| | 22 | PA NHO | A | ○ | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 434 | 0 | Sunny | 12/10 | 0 | 0 | VI |
| THUA THIEN HUE | 24 | NA MAY | B | × | 0 | 2 | 0 | 0 | 0 | 0 | 174 | 151 | 0 | Sunny | 15/10 | 2 | 3 | VI |
| | 26 | KHE DUONG | A | × | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 176 | 0 | Sunny | 16/10 | 0 | 0 | VI |
| DA NANG CITY | 27 | HOI PHUOC | A | × | 0 | 4 | 0 | 0 | 0 | 95 | 260 | 392 | 0 | Sunny+Rainy | 17/10 | 4 | 5 | VI |
| QUANG NAM | 34 | SONG QUAN | B | ○ | 0 | 4 | 0 | 0 | 0 | 26 | 108 | 250 | 0 | Rainy+Sunny | 21/10 | 4 | 5 | VI |
| | 35 | DAI LOI | A | ○ | 0 | 0 | 0 | 0 | 0 | 166 | 335 | 1098 | 0 | Rainy+Sunny | 19/10 | 0 | 0 | VI |
| BINH THUAN | 36 | DA DUNG | A | ○ | 204 | 180 | 47 | 9 | 16 | 5838 | 2128 | 144 | 0 | - | 18/10 | 456 | 593 | IV |
| | 37 | TRANG | A | ○ | 21 | 70 | 0 | 7 | 2 | 1345 | 1066 | 11 | 0 | - | 15/10 | 100 | 130 | V |
| | 38 | SUOI CAT | B | ○ | 31 | 43 | 29 | 34 | 25 | 4942 | 3342 | 143 | 0 | - | 21/10 | 162 | 211 | V |
| NINH THUAN | 42 | TUAN TU | B | ○ | 13 | 72 | 2 | 2 | 0 | 1409 | 1008 | 160 | 0 | - | 31/10 | 89 | 116 | V |
| | 43 | TAM NGAN | A | ○ | 0 | 0 | 0 | 0 | 0 | 103 | 503 | 806 | 0 | - | 28/10 | 0 | 0 | VI |
| | 45 | CAU GAY | B | ○ | 0 | 9 | 0 | 0 | 0 | 262 | 578 | 50 | 0 | - | 30/10 | 9 | 12 | VI |
| LAM DONG | 46 | TAN VAN | A | ○ | 31 | 35 | 43 | 65 | 70 | 3223 | 2127 | 631 | 0 | Sunny | 24/10 | 244 | 317 | IV |
| | 47 | LOC NGAI | B | ○ | 0 | 0 | 0 | 0 | 0 | 180 | 50 | 21 | 0 | Sunny | 23/10 | 0 | 0 | VI |
| | 48 | NONG TRUONG BO SUA | B | ○ | 0 | 133 | 0 | 9 | 10 | 1023 | 156 | 279 | 0 | Rainy | 26/10 | 152 | 198 | V |
| DAC LAC | 52 | EA SOUP | A | ○ | 12 | 40 | 2 | 14 | 0 | 835 | 957 | 223 | 36 | - | 20/10 | 68 | 88 | V |
| | 55 | ROXY | B | ○ | 0 | 80 | 0 | 20 | 14 | 2654 | 252 | 501 | 470 | - | 27/10 | 114 | 148 | V |
| | 56 | KRONG K'MAR | A | ○ | 0 | 20 | 5 | 5 | 0 | 838 | 1080 | 432 | 66 | - | 31/10 | 30 | 39 | VI |
| GIA LAI | 58 | DAK PO TO | B | ○ | 0 | 7 | 0 | 2 | 0 | 26 | 71 | 64 | 0 | Sunny | 24/10 | 9 | 12 | VI |
| | 59 | IA DRANG | A | ○ | 6 | 8 | 0 | 5 | 0 | 403 | 451 | 472 | 25 | Rainy | 25/10 | 19 | 25 | VI |
| KON TUM | 62 | NGOC REO | B | ○ | 0 | 0 | 0 | 0 | 0 | 61 | 23 | 88 | 0 | Sunny | 1/11 | 0 | 0 | VI |
| | 64 | DAK TO KAN | B | ○ | 0 | 3 | 0 | 0 | 0 | 62 | 26 | 110 | 0 | - | 3/11 | 3 | 4 | VI |
| | 66 | NGOC TU | A | ○ | 0 | 0 | 0 | 0 | 0 | 20 | 16 | 58 | 0 | - | 4/11 | 0 | 0 | VI |
| QUANG NGAI | 67 | XA CAI | A | ○ | 0 | 0 | 0 | 0 | 0 | 648 | 1533 | 1163 | 0 | Sunny | 26/10 | 0 | 0 | VI |
| | 70 | DO | A | × | 0 | 0 | 0 | 0 | 0 | 0 | 66 | 273 | 0 | Sunny+Rainy | 24/10 | 0 | 0 | VI |
| | 72 | SONG SAU | B | ○ | 0 | 0 | 0 | 0 | 0 | 255 | 411 | 512 | 0 | Sunny+Rainy | 23/10 | 0 | 0 | VI |
| BINH DINH | 74 | BA LE | A | ○ | 37 | 0 | 0 | 18 | 0 | 572 | 513 | 672 | 33 | - | 15/10 | 55 | 72 | V |
| | 76 | DAO LONG | B | ○ | 0 | 0 | 0 | 0 | 0 | 239 | 798 | 29 | 21 | - | 13/10 | 0 | 0 | VI |
| | 77 | TRUONG DINH | B | ○ | 16 | 15 | 0 | 13 | 2 | 1060 | 1340 | 185 | 27 | - | 17/10 | 46 | 60 | V |
| PHU YEN | 78 | TRA O | A | ○ | 4 | 19 | 2 | 0 | 1 | 319 | 420 | 229 | 4 | - | 20/10 | 26 | 34 | VI |
| | 79 | TRA BUONG | A | × | 0 | 0 | 0 | 0 | 0 | 171 | 213 | 595 | 0 | - | 23/10 | 0 | 0 | VI |
| | 82 | DA LOC | B | ○ | 0 | 0 | 0 | 0 | 0 | 222 | 260 | 395 | 9 | - | 19/10 | 0 | 0 | VI |
| KHANH HOA | 83 | NGOI NGAN | A | ○ | 0 | 8 | 0 | 0 | 0 | 1139 | 1177 | 240 | 0 | - | 5/11 | 8 | 10 | VI |
| | 86 | TIEN DU | B | ○ | 0 | 11 | 0 | 1 | 0 | 881 | 929 | 55 | 0 | - | 2/11 | 12 | 16 | VI |

＊： 本調査時間は夜間を除くものであり、夜間の交通量は大幅に減少することが予想されるため24時間交通量を×1.3として算出した。

# Appendix 11
# Soft Component

MINISTRY OF TRANSPORT
THE SOCIALIST REPUBLIC OF VIET NAM

# BASIC DESIGN STUDY REPORT
# ON
# THE PROJECT
# FOR
# RECONSTRUCTION OF BRIDGES
# IN
# THE CENTRAL AREA OF VIET NAM

## SOFT COMPONENT

**MARCH 2002**

**PACIFIC CONSULTANTS INTERNATIONAL
IN CONSORTIUM WITH
ORIENTAL CONSULTANTS CO., LTD.**

# Soft Component

## Table of Contents

# 1. Background

## 1.1 Background of the Project

The Socialist Republic of Vietnam has been working on the recovery of the domestic economy since the end of Vietnam War and soon after Doi-Moi Policy started in 1986 the government started investing in many sectors. For the recovery of domestic economy, importance of rehabilitation of infrastructure such as roads and bridges has been widely acknowledged and the high priority has been given to investment in the transportation.

Development of the road network in the provinces of Central Vietnam is at an early stage. This lack of essential infrastructure and poor maintenance condition of existing structures is an important factor restraining development in the area. Improvements have been made to highway bridges since the end of the Vietnam War. Bridges have been rehabilitated or repaired to cope with damages caused by very powerful flood flows. However, inadequate capital budgets leave many structures at best temporary.

The Socialist Republic of Vietnam has requested Grant Aid for the Reconstruction of Bridges in the Central Area by the Government of Japan.

## 1.2 Outline of the Project

Observations during the inspections revealed that many structures are visibly damaged and cannot allow large vehicles to pass. At some locations, even bicycles or pedestrians cannot pass, hence there are locations that are effectively cut off during the rainy season. The lack of suitable river crossings has a detrimental impact on economic development, since agricultural products cannot be shipped to markets, and is thus a key factor of rural poverty. The lack of suitable river crossings also has a negative impact on basic human needs, since access to medical, education, and local administrative services is restricted.

In this project, 45 bridges were selected for new construction or replacement in 18 provinces of the central area. After careful investigation, 23 bridges were selected for steel girder procurement scheme as phase-1 and 22 bridges were selected for facility construction scheme as phase-2. The procurement of steel girders and so called Soft Component are executed by the Japan side. The government of Vietnam will implement the construction of substructure, steel-girder erection, slab concrete and concrete handrails for phase-1.

### 1.3 Need and Effect of Soft Component

In Phase 1 of this project, 23 steel girders are to be prepared by Japan, but substructure construction and girder erection shall be done by Vietnam. Due to lack of experience in steel girder erection for Vietnam, control of schedule and quality may be problem in this phase.

The Soft Component will provide a manual for steel girder erection, monitor the progress of substructure construction and conduct the transfer of steel bridge construction technology from Japan to Vietnam and finally sustain the quality and progress of this project.

## 2. Target of Soft Component

In the Soft Component, three target stages are set up as follows:

<u>Overall Goal</u>

- Sustainable development of steel bridge construction in Vietnam

<u>Goal of Soft Component</u>

- Establishing of technology for steel girder erection and level up of substructure construction

## 3. Direct Result of Soft Component

To achieve the above targets, the following direct result of Soft Component are desired.

(1) Capability of schedule control in steel girder erection
(2) Capability of quality control in steel girder erection
(3) Capability of tolerance control in steel girder erection

(4) Capability of safety control in steel girder erection
(5) Capability of maintenance of steel girder erection

In these direct results of the Soft Component, much more importance should be placed on points (1) to (4) from the standpoint of minimum assistance in this Soft Component. Self effort by Vietnam is anticipated for (5), but occasional support shall be given by manual preparation and discussions with the Vietnamese side in this Soft Component scheme. The manuals and others to be prepared in this Soft Component are as follows:

- Monitoring report for substructure construction
- Schedule control manual for steel girder erection
- Quality control manual for steel girder erection
- Tolerance control manual for steel girder erection
- Safety control manual for steel girder erection
- Maintenance manual for steel girder bridge

## 4. Scope of Works

To achieve the direct results above, the following scope of works are set for each direct result of the Soft Component:

4-1 Capability of schedule control in steel girder erection

- Monitoring of land transportation in Vietnam
- Schedule control manual and monitoring of steel erection
- Monitoring of substructure construction

4-2 Capability of quality control in steel girder erection

- Quality control manual and monitoring of steel erection
- Monitoring of storage for steel girder

4-3 Capability of tolerance control in steel girder erection

- Tolerance control manual in steel girder erection
- Monitoring of tolerance control in steel girder erection

4-4 Capability of safety control in steel girder erection

- Safety control manual in steel girder erection

4-5 Capability of maintenance of steel girder erection

- Maintenance manual for steel girder erection

## 5. Soft Component Activities

The output of the Soft Component is cooperation with counterparts in Vietnam and preparation of manuals for the overall control of schedule, quality, tolerance, safety and maintenance for steel girder erection and the monitoring of substructure construction and steel girder erection, as summarized in Table 1.

## 6. Soft Component Implementation

This Soft Component shall be carried out for 23 steel bridges in the central area of Vietnam. The Implementation of the Soft Component comprises of the mobilization of Japanese experts, the setting up of seminars for the counterparts, advice on the site, and quality check by manual.

6-1 Schedule of Soft Component

Schedule of Soft Component is summarized in Table 1.

6-2 Allocation of experts and counterparts

Because the location of 23 steel girders erection is widely spread in 18 provinces ranging 1300 km in length, three Japanese experts should be dispatched to the construction sites to cooperate with the Vietnamese counterparts in this Soft Component. The roles of the Japanese experts and their Vietnamese counterparts are as follows:

Japanese experts

- Preparation of manuals for overall control of schedule, quality, tolerance, safety and maintenance regarding steel girder erection and conducting of seminars to explain manuals.
- Monitoring and supervision of substructure construction
- Monitoring and supervising of transportation, storage, erection, and painting at the site for steel girder
- Monitoring and supervision of overall construction schedule

Vietnamese counterparts

- Assisting Japanese experts in manuals preparation
- Monitoring and supervision of substructure construction with the Japanese experts
- Monitoring of transportation, storage, erection, and painting for steel girder by using manual checklist
- Monitoring of construction schedule by using manual checklist

## Table.1 Schedule of Soft-Component

| Item | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Preparation of Manual | | | | | | | | | | | | | | |
| Northern Area (6 provinces, 8 bridges) | Substructure | Design Review | | | | | | | | | | | | | |
| | | Monitoring of Construction | | | | | | | | | | | | | |
| | | Construction Safety | | | | | | | | | | | | | |
| | | Schedule and Quality | | | | | | | | | | | | | |
| | | Tolerance and Maintenance | | | | | | | | | | | | | |
| | Steel Girder Erection | Monitoring of Erection | | | | | | | | | | | | | |
| | | Erection Safety | | | | | | | | | | | | | |
| | | Schedule and Quality | | | | | | | | | | | | | |
| | | Tolerance and Maintenance | | | | | | | | | | | | | |
| | Counterpart (one person each) | | | | | | | | | | | | | | |
| Central Area (6 provinces, 8 bridges) | Substructure | Design Review | | | | | | | | | | | | | |
| | | Monitoring of Construction | | | | | | | | | | | | | |
| | | Construction Safety | | | | | | | | | | | | | |
| | | Schedule and Quality | | | | | | | | | | | | | |
| | | Tolerance and Maintenance | | | | | | | | | | | | | |
| | Steel Girder Erection | Monitoring of Erection | | | | | | | | | | | | | |
| | | Erection Safety | | | | | | | | | | | | | |
| | | Schedule and Quality | | | | | | | | | | | | | |
| | | Tolerance and Maintenance | | | | | | | | | | | | | |
| | Counterpart (one person each) | | | | | | | | | | | | | | |
| Southern Area (5 provinces, 7 bridges) | Substructure | Design Review | | | | | | | | | | | | | |
| | | Monitoring of Construction | | | | | | | | | | | | | |
| | | Construction Safety | | | | | | | | | | | | | |
| | | Schedule and Quality | | | | | | | | | | | | | |
| | | Tolerance and Maintenance | | | | | | | | | | | | | |
| | Steel Girder Erection | Monitoring of Erection | | | | | | | | | | | | | |
| | | Erection Safety | | | | | | | | | | | | | |
| | | Schedule and Quality | | | | | | | | | | | | | |
| | | Tolerance and Maintenance | | | | | | | | | | | | | |
| | Counterpart (one person each) | | | | | | | | | | | | | | |

note ; Soft Component will be executed in 3 areas divided

## Appendix.1 Project Design Matrix for Soft Component

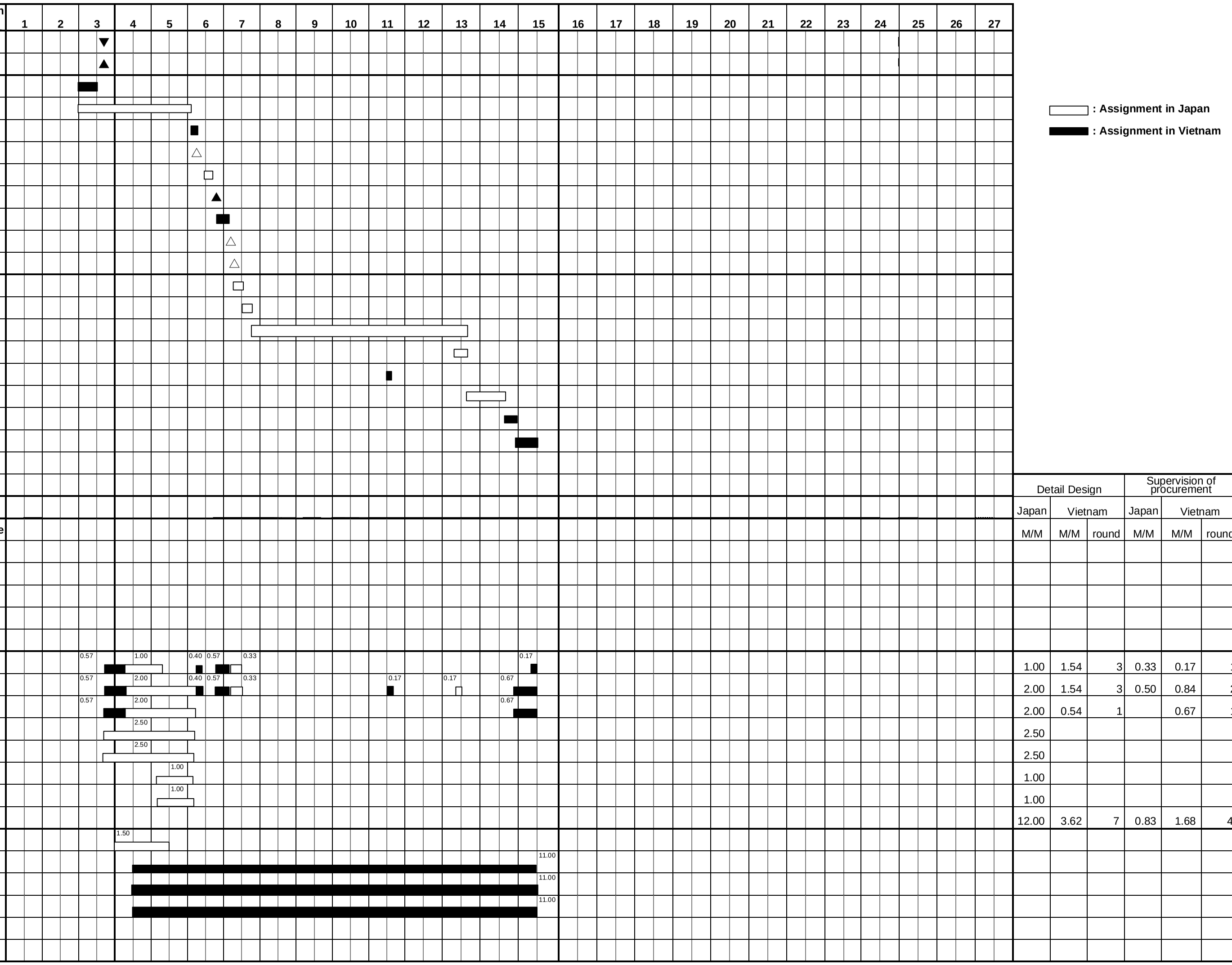
Project ; Reconstruction of Bridges in the Central Area of Vietnam　　Term ; Apr/2002 - Mar/2003

Country ; The Socialist Republic of Vietnam　　Group of target ; PMU18, local engineers

| Item | Objective | Data for Judgment | External conditions |
|---|---|---|---|
| Overall Goal<br>Sustainable development of steel bridge construction in Vietnam | Economic activity in the province<br>Increase of steel girder bridge construction | GDP of each province<br>Bridge construction record | Budget of construction and bridge maintenance |
| Goal of Soft Component<br>Establishing of advanced technology for steel girder bridges erection and level up of substructure construction technology in Vietnam | Increase of steel girder bridge construction<br>Validity of construction by check sheet | Bridge construction record<br>Final report<br>Evidence of completion | Sustainable usage of manual and check sheets<br>Transfer of monitoring technology |
| Output<br>Capability of schedule control in steel girder erection<br>Capability of quality control in steel girder erection<br>Capability of tolerance control in steel girder erection<br>Capability of safety control in steel girder erection<br>Capability of maintenance of steel girder erection | Construction on schedule<br>Proper storage and painting on site<br>Proper maintenance | Schedule report<br>Monthly report<br>As-build drawing | On-time substructure schedule<br>Transportation of steel girders<br>Budget of steel girder erection<br>Selection of local contractor |
| Activity<br>Monitoring of transportation<br>Monitoring of substructures construction<br>Monitoring of steel girder painting<br>Schedule control manual<br>Quality control manual<br>Tolerance control manual<br>Safety control manual<br>Maintenance manual | Input<br>(Japan)<br>Procurement of steel girder<br>Steel bridge experts (11month * 3 person) | (Vietnam)<br>Substructures<br>Approach road<br>Training center<br>Counterparts<br>Project management fee<br>Maintenance fee | Countermeasures for the problems of monitoring<br>Information sharing on site<br><br>(Conditions)<br>Proper counterparts<br>Guarantee of higher priority for bridge construction by the provinces |

## Appendix.2 Schedule of Soft-Component

| | Item |
|---|---|
| Contract | Exchange of note (E/N) |
| | Contract of consultant |
| Detail Design | Investigation on site |
| | Preparation of tender document |
| | Approval of tender document |
| | Announcement of tender |
| | Distribution of drawings |
| | Tender opening |
| | Tender evaluation |
| | Contract sign |
| | (Approval of Japanese government) |
| Procurement of steel girder | Meeting with contractor |
| | Approval of shop drawing |
| | Fabrication of steel girder |
| | Inspection |
| | Meeting on site |
| | Transportation by ship |
| | Transportation by truck |
| | Handover of steel girder |




| | Specialist | Grade | Detail Design Japan M/M | Detail Design Vietnam M/M | Detail Design Vietnam round | Supervision of procurement Japan M/M | Supervision of procurement Vietnam M/M | Supervision of procurement Vietnam round | Soft-Component Japan M/M | Soft-Component Vietnam M/M | Soft-Component Vietnam round | 計 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mobilization of specialist | | | | | | | | | | | | 0.00 |
| | | | | | | | | | | | | 0.00 |
| | | | | | | | | | | | | 0.00 |
| | | | | | | | | | | | | 0.00 |
| | | | | | | | | | | | | 0.00 |
| Assignment of consultant | Project manager | 2 | 1.00 | 1.54 | 3 | 0.33 | 0.17 | 1 | | | | 3.04 |
| | Superstructure-1 | 3 | 2.00 | 1.54 | 3 | 0.50 | 0.84 | 2 | | | | 4.88 |
| | Superstructure-2 | 3 | 2.00 | 0.54 | 1 | | 0.67 | 1 | | | | 3.21 |
| | Superstructure-3 | 4 | 2.50 | | | | | | | | | 2.50 |
| | Superstructure-4 | 4 | 2.50 | | | | | | | | | 2.50 |
| | Cost estimation | 3 | 1.00 | | | | | | | | | 1.00 |
| | Tender document | 3 | 1.00 | | | | | | | | | 1.00 |
| | total | | 12.00 | 3.62 | 7 | 0.83 | 1.68 | 4 | | | | 18.13 |
| | Bridge experts-1 | 3 | | | | | | | 1.50 | | | 1.50 |
| | Bridge experts-2 | 3 | | | | | | | | 11.00 | 1 | 11.00 |
| | Bridge experts-3 | 3 | | | | | | | | 11.00 | 1 | 11.00 |
| | Bridge experts-4 | 3 | | | | | | | | 11.00 | 1 | 11.00 |
| | (soft-Component) | | | | | | | | | | | |
| | total | | | | | | | | 1.50 | 33.00 | 3.00 | 34.50 |