GENERAL AUTHORITY FOR ROADS, BRIDGES AND LAND TRANSPORT
MINISTRY OF TRANSPORT & COMMUNICATIONS
THE GOVERNMENT OF THE ARAB REPUBLIC OF EGYPT

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR CONSTRUCTION
OF
THE SUEZ CANAL BRIDGE
IN
EGYPT

NOVEMBER 1996

JAPAN INTERNATIONAL COOPERATION AGENCY
PACIFIC CONSULTANTS INTERNATIONAL
CHODAI CO., LTD.

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PREFACE

In response to a request from the Government of the Arab Republic of Egypt the Government of Japan decided to conduct a basic design study on the Project for Construction of The Suez Canal Bridge in the Arab Republic of Egypt and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Egypt a study team from August 9 to 18, 1996.

The team held discussions with the officials concerned of the Government of Egypt and conducted the field studies at the study area. After the team returned to Japan, further studies were made. Then a mission was sent to Egypt from September 9 to 18, 1996 in order to discuss a draft basic design and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Arab Republic of Egypt for their close cooperation extended to the teams.

November, 1996

Kimio Fujita
President
Japan International Cooperation Agency

November, 1996

Letter of Transmittal

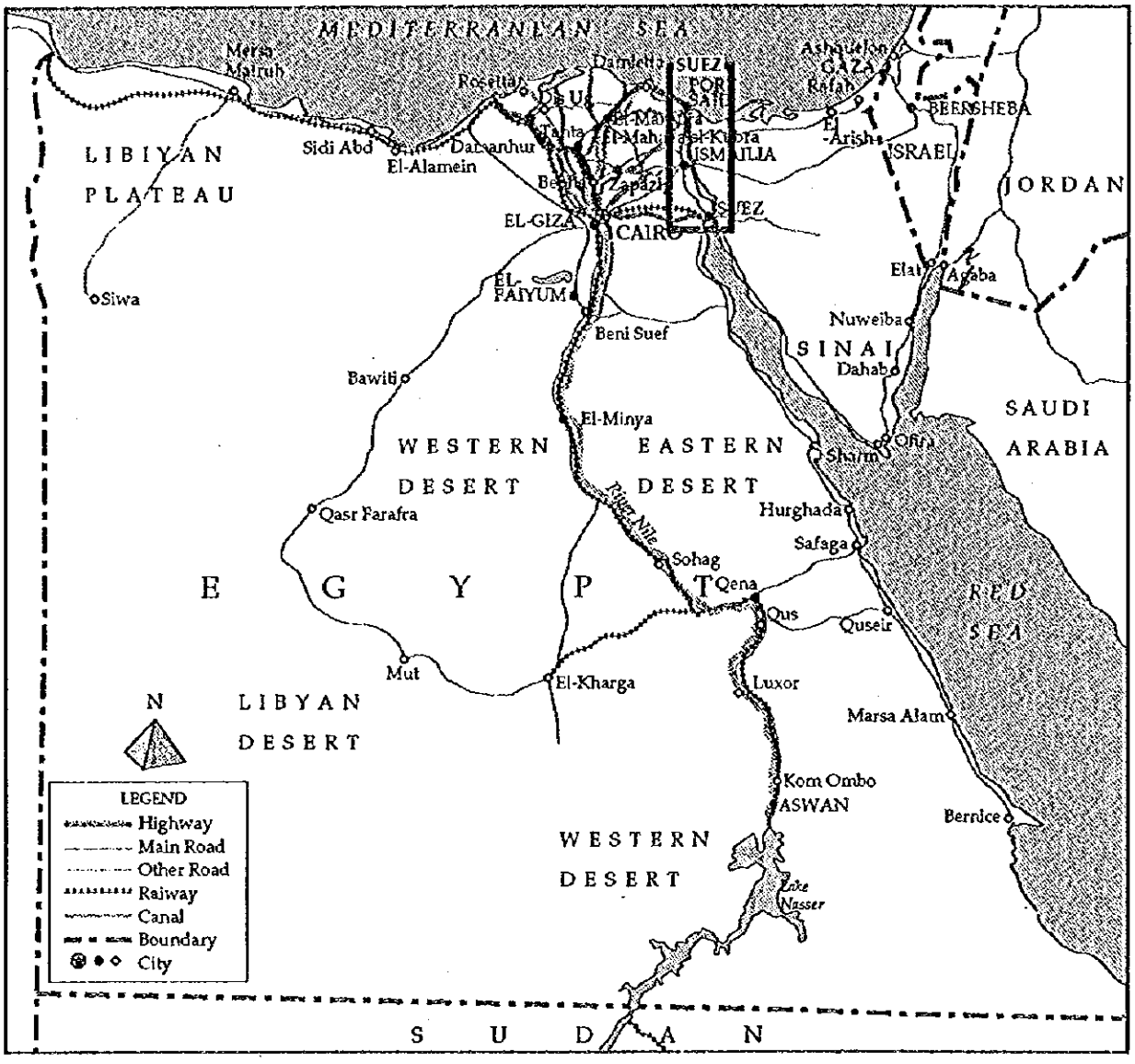
We are pleased to submit to you the basic design study report on the Project for the Construction of the Suez Canal Bridge in the Arab Republic of Egypt.

This Study was conducted by Pacific Consultants International and Chodai Co., Ltd. under a contract to JICA, during the period from July 24, 1996 to November 24, 1996. In conducting the study we have examined the feasibility and rationale of the project with due consideration to the present situation of Egypt and formulated the most appropriate basic design for the project under Japan' grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the Project.

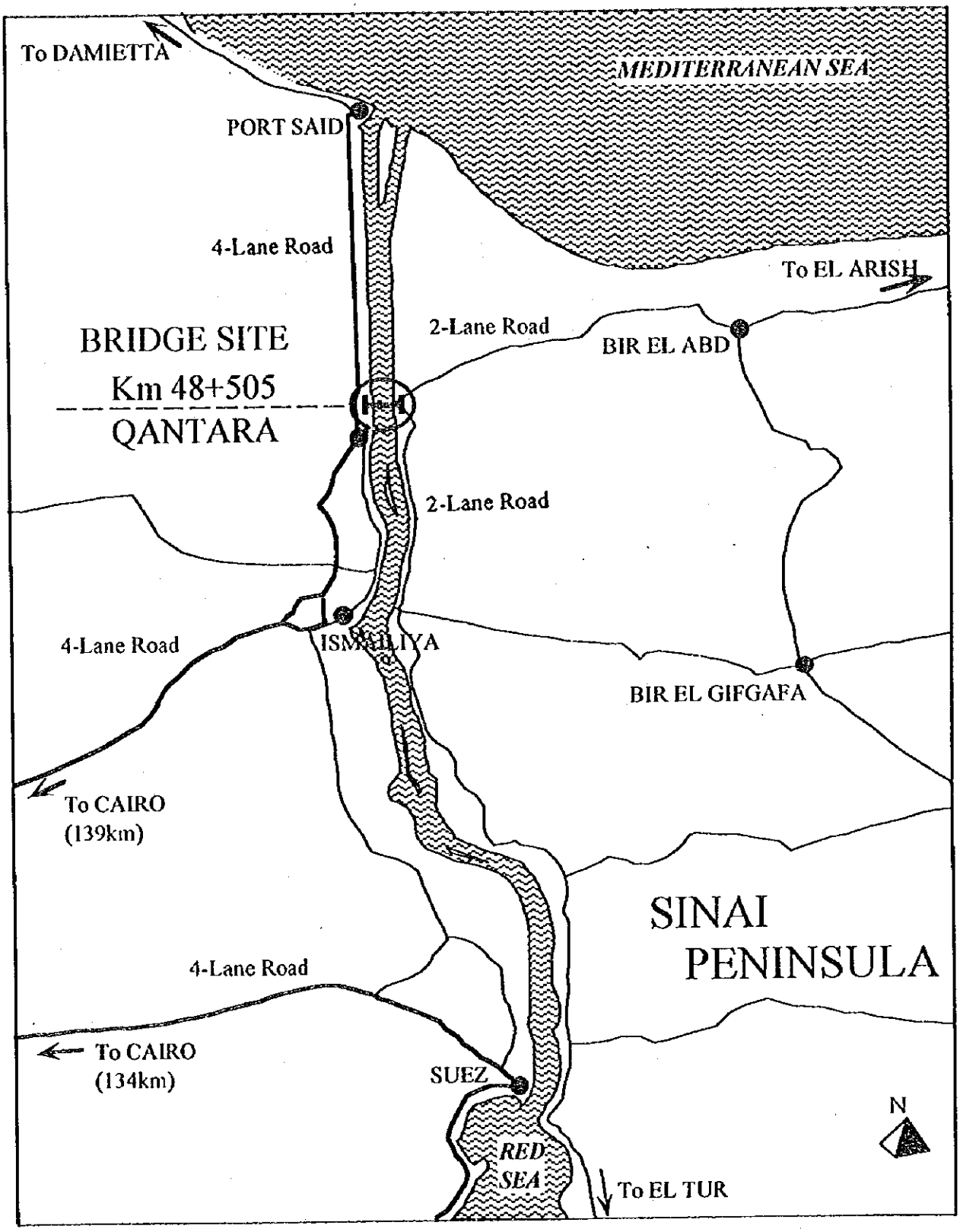
Very truly yours,

Hiroyuki ENDO
Project Manager
Basic Design Study Team on the Project
for Construction of the Suez Canal Bridge
in the Arab Republic of Egypt
Pacific Consultants International
Chodai Co., Ltd.

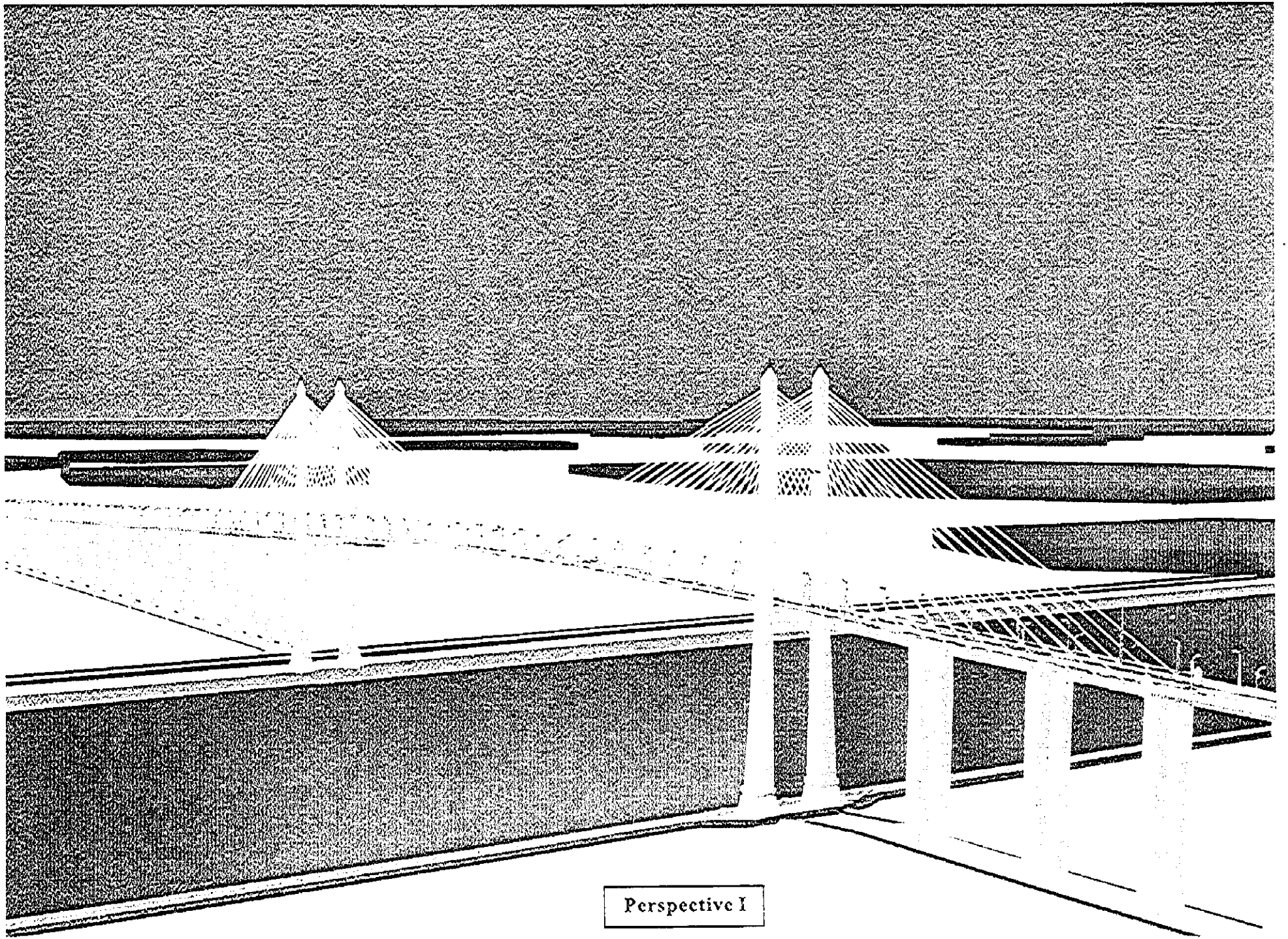


Whole Egypt and Project Area

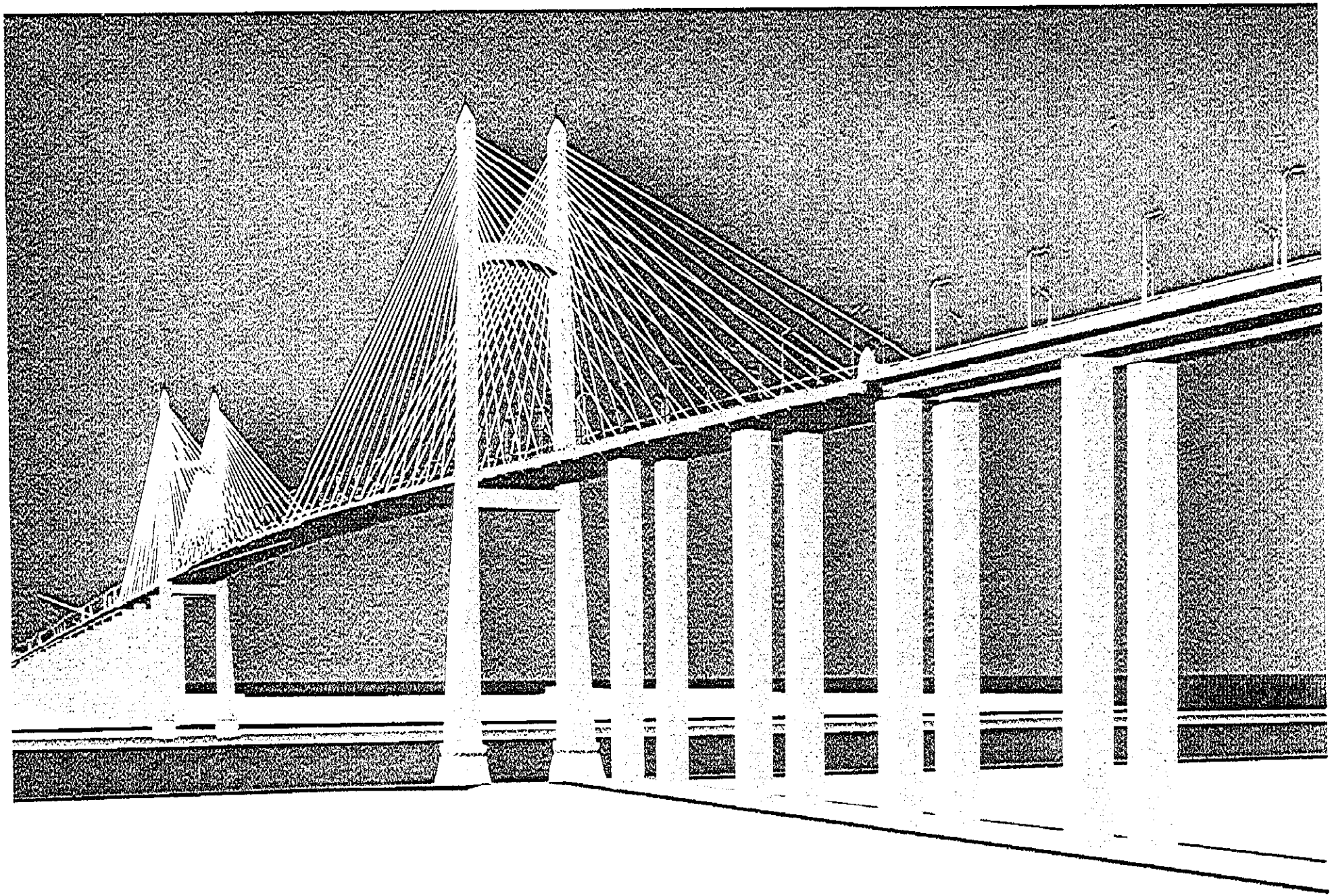
: Project Area



Project Location Map



Perspective I



Perspective II

Abbreviations

A. Authorities and Agencies

AASHTO	:	American Association of State Highway and Transportation Officials
GARBLT	:	General Authority of Roads, Bridges and Land Transport
GOOP	:	General Organization for Physical Planning
JICA	:	Japan International Cooperation Agency
MOP	:	Ministry of Planning
MOS	:	Ministry of State
MOTC	:	Ministry of Transport and Communications
SCA	:	Suez Canal Authority
UNDP	:	United Nations Development Program
USAID	:	Unites States Agency for International Development

B. Other Abbreviations

A	:	Ampere
ave.	:	Average
A/P	:	Authorization to Pay
B	:	Breadth
Br	:	Bridge
cm	:	Centimeter
CBR	:	California Bearing Ratio
H	:	Height
HP	:	Horse Power
k*l*	:	Kilolitre
km	:	Kilometre
km^2 or sq. km	:	Square Kilometre
km/h	:	Kilometre per Hour
kvA	:	Kilovolt-Ampere
kw	:	Kilowatt
l	:	Litre
LE	:	Egypt Pound
Min.	:	Minimum

Max.	:	Maximum
m, M	:	Metre
m^2	:	SQ. M : Square Metre
m^3 or cu. m	:	Cubic Metre
min.	:	Minute
mm	:	Milimetre
mm^2	:	Square Millimetre
No.	:	Numbers
sub-str.	:	Substructure
sup-str.	:	Superstructure
t	:	Ton
t/h	:	Ton per Hour
t/m^2	:	Ton per Square Metre
veh.	:	Vehicles
VpD or VPD	:	Vehicles per Day
W	:	Width
%	:	Percent
ø	:	Diametre
$	:	Dollar
¥	:	Yen

Summary

Summary

SUMMARY

Much of the residential and cultivated land in Egypt lies in the area north of Cairo, which is less than 4 % of the total land area. The country is faced with problems caused by concentration of population in this region. The increase in agricultural production has caused the soils to become overworked, and the heavy demand for the water has caused environmental, economical and food shortage problems. To ease these problems and further adverse economic developments, the Government of the Arab Republic of Egypt set out the "National Project for the Development of Sinai" (NPDS) in September 1994. The NPDS proposes to develop the Sinai Peninsula by the year 2017 to accept 3.2 million residents and to create a labour opportunity of 0.8 million people and this was approved and first prioritized under the Implementation Clause of the National Project in 1995. The total appropriation to be invested for this project was estimated at approximately EL 75 billion to be disbursed from 1994 to 2017; EL 20.8 billion for housing and town development, EL 12.8 billion for agriculture and EL 10 billion for industry.

As the principal development projects of agriculture, mining and tourism of NPDS, highly prioritized by the Government move forward, the increase in road traffic over the Suez Canal has started to become evident. It is therefore becoming urgent to provide the means for road transport across the Suez Canal, to access the Sinai Peninsula. The Suez Canal, which was built in 1869, and extends from Port Said to Suez for a total length of 195 km, dividing the greater Cairo metropolitan area from the Sinai Peninsula. In order to cross the Suez Canal, it is necessary to utilize one tunnel or seven ferry boat systems.

It is forecasted that by the year 2017, the daily road traffic over the Suez Canal would reach 50,000 to 60,000 vehicles/day, and would exceed the present allowable road traffic capacity of approximately 22,000 vehicles/day. In order to cope with this increase of the traffic, it is evident that some means of crossing facility is required. The present ferry boat system is providing this service by making use of the intervals provided by the breaks in the convoys, but there is a limit to how much more this system can be allowed. The safe travel of the ships transiting the Suez Canal will be endangered with this system of crossing, and the ferry system cannot be considered to cater to any future increases in the road traffic. It has become necessary to provide a crossing facility of either a road bridge or a tunnel.

Prior to the setting out of the NPDS in June 1994, the Government of Egypt requested the Government of Japan to study the feasibility of constructing a structure to cross the Suez Canal. After conducting a preliminary survey in October 1994 and preparatory study (scope of works

mission) in January 1995, a full scale study was commenced in May 1995. In March 1996 as an Interim Report the most suitable proposal of a 4 lane bridge crossing with a total length of 3,960 m was submitted by the Study Team.

Then, major points such as bridge structure types, project location and vertical grade of approach bridges were agreed between the Japanese side and the Egyptian side.

The objective of the Project is to construct a bridge across the Suez Canal to cope with increased traffic demand in the near future, which was forecasted in the NPDS. This Project for construction of the Suez Canal Bridge is already fixed as a part of the development scheme, and has large political importance. This bridge project will be a symbol of progress for the Middle East peace process and is also expected to contribute to the development of not only Egypt but also the whole North Africa and Mediterranean Area, and it will connect the two major continents of Africa and Asia with a bridge.

The road bridge crossing the Suez Canal was confirmed between the two countries deciding on a share for Japan of 60 % and for Egypt of 40 %, in a conference of the Grant Aid Contact Mission held in June 1996.

The Government of Japan decided to conduct a basic design study and entrusted the study to the Japan International Cooperation Agency (JICA). JICA dispatched to Egypt a study team from August 9 to 18, 1996. The team held discussions and signed the minutes of discussion with the officials concerned of the Government of Egypt.

The basic design study team held discussions with the officials of the Government of Egypt, conducted field surveys of the proposed bridge site, survey of procurement of materials and equipment and also supplemental costs and implementation organization, etc. and obtained and confirmed the present state of the concerned sector, the state of the region around the project site, background of the project, contents of the project, implementation organizations and maintenance and management organization, and collected data and information necessary for the study.

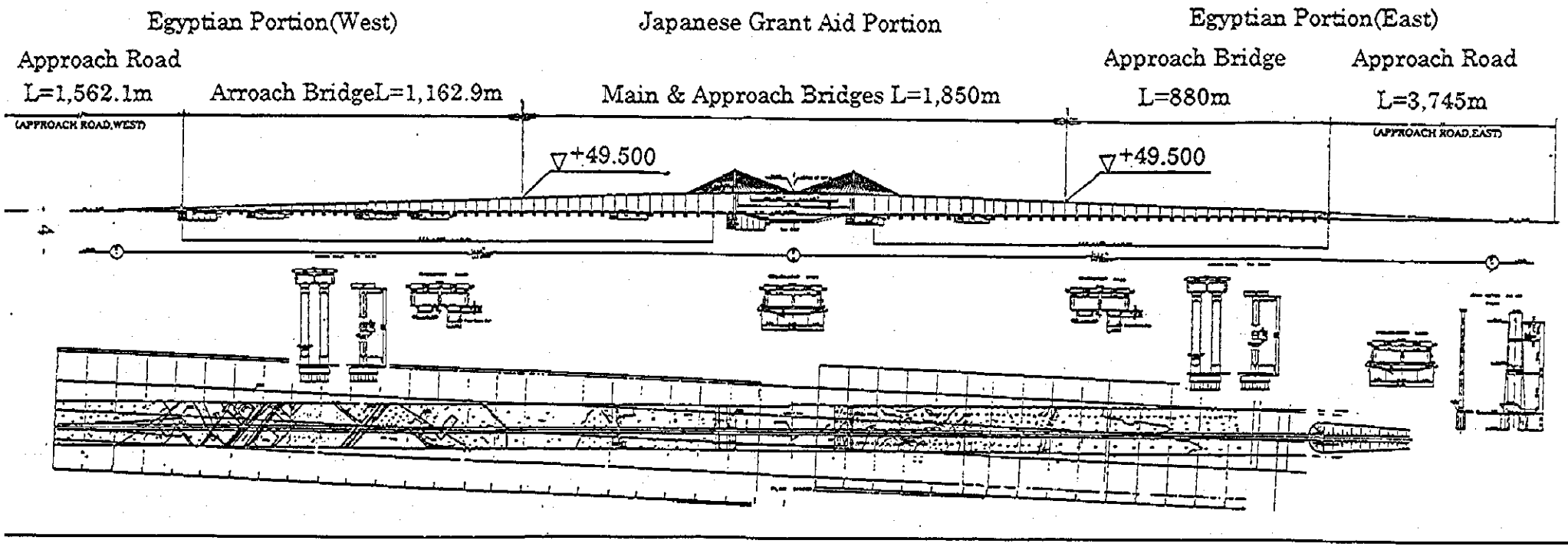
With the results of the surveys and studies in Egypt, after their return to Japan the study team carried out analysis and examination of data and information, clarification of appropriate project and its effect, and examined the most appropriate project size and details, and performed basic plan, construction plan and project cost estimates. After the studies were performed, the study team completed the Draft "Basic Design Report".

JICA dispatched to Egypt the 2nd study team to submit and discuss the draft basic design from September 9 to 17,1996, and they signed the minutes of discussion.

The major objective is to estimate the project cost for the Japanese Grant Aid portion and to plan the project share allotment between the Japanese Grant Aid portion and the Egyptian portion and its project implementation based on the preliminary design results provided under the Feasibility Study. The results of the preliminary study proposes a road crossing over the Suez Canal in the Qantara area. The bridge should provide adequate clearance and cause no adverse effects to vessels transiting the Suez Canal, and furthermore guarantee their safe passage during the construction period and after completion of all of the bridge works. The project has been divided into two parts, with the points of formation level (FL) of +49.5 m as the point of demarcation of the two parts. The portion with elevation higher than FL +49.5 m will be implemented under the Japanese Grant Aid, and the portion lower than +49.5 m by the Egyptian side.

To cope with these special project conditions, Japanese consultant firm will be employed for the whole project implementation and to provide construction supervision, quality control and construction programming for the whole Project. The work Allotment is shown in page 4.

Egyptian standards are used as design standards. In the construction planning, local or third countries' materials and plant and equipment are proposed to be used basically.



Work Allotment

The outline of the basic plan is summarized as follows:

Main Bridge

Type of Bridge	:	Cable-stayed bridge with steel box girder
Main Pylon	:	H-type, reinforced concrete (RC)
Main Pylon Base	:	Caisson foundation/Diaphragm wall
Main Girder	:	Steel box girder, steel deck
Stay Cable	:	Freyssinet cable
Side Span Bridge Piers	:	Reinforced concrete, 2 Nos.
Side Span Foundation	:	Cast-in-place concrete piling, ϕ1.5 m
Bridge Length	:	L = 730 m
Span Arrangement	:	163 m + 404 m + 163 m
Effective Width	:	B = 16.3 m
Pavement	:	Asphalt concrete, 8 cm thick

Approach Bridge

Bridge Type	:	PC box girder, continuous rigid frame type and continuous girder type
Superstructure	:	Continuous girder, 3 ~ 7 spans
Substructure	:	Reinforced concrete structure
Foundation	:	Cast-in-place concrete pile, ϕ1.5 m
Bridge Length	:	1,440 m (east bank), 1,722.9 m (west bank)
Span Spacing	:	40 m (standard)
Effective Width	:	B = 16.3 m
Pavement	:	Asphalt concrete, 7 cm thick

Approach Roads

Road Lengths	:	3,745 m (east bank), 1,562 m (west bank)
Effective Width	:	19.6 m
Max. Embankment Height	:	Approx. 20 m (east bank), approx. 10 m (west bank)
Embankment Slopes	:	2:1, benched approx. every 5 m
Embankment Protect	:	Slope protection applied

The total period necessary for the bridge construction is 3 year and 9 months (45 months).

The National Project for the Development of Sinai (NPDS) is a part of the whole national land development for each industrial and each area, and is deemed as a main objective of the national growth. Through the course of implementation of development plans, traffic demands to cross the proposed bridge site is expected to increase, and the traffic volume of the bridge is forecast as 28,000 vehicles/ day in the year 2017.

In Qantara, where the proposed bridge will cross the Suez Canal, the west bank has been developed already. However on the east bank at present development is proceeding. Therefore the development of the whole region of east and west banks will be advanced more, when the Suez Canal Bridge is completed, and it will contribute greatly to the regional development.

As mentioned above, construction of the bridge will provide a big effect to the region and the country. Therefore, it is considered that implementation of this project under the Japanese Grant Aid Scheme is appropriate.

The existing organization of GARBLT is capable of handling the management and operation of this project, due to the evidence, which develop the road increasing by 40 % for the last 10 years and achieve 39,000 km paved road. It is expected that the existing organization of General Authority for Roads, Bridges and Land Transport (GARBLT) will manage fully operation and maintenance of the bridge.

The construction supervision for this project is not the same as for the ordinary Japanese Grant Aid Project, and it will cover also the Egyptian portion, which is funded by the Egyptian Government. Both the Japanese Grant Aid portion and the Egyptian portion will have to be completed simultaneously, therefore it is very important to organize the supervision management system with careful planning.

Table of Contents

Appendices

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List of Tables

Chapter 1 Background of the Project

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Much of the residential and cultivated land in Egypt lies in the delta region near the Mediterranean Sea north of Cairo and along the River Nile, and that area is only 4 % of the whole area of Egypt (1.002 million square km^2). Presently almost all of the population of Egypt (58.27 million, in 1995) is living in this delta region, and the country is facing problems caused by the population concentration in this region. The increase in agricultural production has caused the soils to become overworked, and the heavy demand for water has caused environmental, economical and food problems. To ease these problems and facilitate further economic developments, the Government of the Arab Republic of Egypt set out the "National Project for the Development of Sinai" (NPDS) in September 1994.

As the principal development projects of agriculture, mining and tourism of NPDS, highly prioritized by the Government, move forward, the increase in road traffic over the Suez Canal has started to become evident. It is therefore becoming urgent to provide the means for road transport across the Suez Canal, to access the Sinai Peninsula.

Prior to the setting out of NPDS in June 1994, the Government of Egypt requested the Government of Japan to study the feasibility of constructing a structure to cross the Suez Canal. After conducting a preliminary survey and preparatory study (scope of works mission), a full scale study was commenced in May 1995. In March 1996 as an Interim Report the most suitable proposal of a 4 lane bridge crossing with a total length of 3,960 m was submitted by the Study Team.

The objective of the Project is to construct a bridge across the Suez Canal to cope with increased traffic demand in near future, which was forecast in above NPDS. This Project for construction of the Suez Canal Bridge is already fixed as a part of the development scheme, and has large political importance. This bridge project will be a symbol of progress for the Middle East peace process and is also expected to contribute to the development of not only Egypt but also the whole North Africa and Mediterranean Area, and it connects the two major continents of Africa and Asia with a bridge.

Major points such as bridge structure types, project location and vertical grade of approach bridges were agreed between Japanese Government and Egyptian Government. The road bridge crossing the Suez Canal was announced as a "Joint Egyptian - Japan Project" in a conference of the Grant Aid Contract Mission held in June 1996, and a Joint Project was confirmed between the two countries deciding on a share for Japan of 60 % and for Egypt of 40 %.

Chapter 2 Contents of the Project

Chapter 2 Contents of the Project

Chapter 2 Contents of the Project

2-1 Objective of the Project

The objective of the Project is to construct the bridge over the Suez Canal to cope with the traffic volume, which will be increased due to the process of the "National Project for the Development of Sinai" (NPDS).

2-2 Basic Concept of the Project

The major objective is to estimate the project costs and plan the project implementation based on the preliminary design results provided under the Feasibility Study. The project is divided into a Japanese Grant Aid portion and an Egyptian portion. The results of the Preliminary Design proposes a road crossing over the Suez Canal at the Qantara area. The bridge should have adequate clearances and no adverse effects to vessels transiting the Suez Canal, and furthermore guarantee their safe passage during the construction period and after completion of all of the bridge works. The project has been divided into two parts, with the points of formation level (FL) of +49.5 m as the border. The portion with elevation higher than FL +49.5 m will be implemented under the Japanese Grant Aid, and the portion lower than +49.5 m by the Egyptian side.

To cope with these special project conditions, a Japanese consultant will be employed for the whole project implementation and provide construction supervision, quality control and construction programming for whole Project.

2-3 Basic Plan

2-3-1 Design Conditions

Design conditions and the bridge plan studied and selected in the Feasibility Study were adopted in this Study.

1) Applicable Standards

As a general rule, the design standards of Egypt will be used. For other standards not covered by the Egyptian criteria, the standards of the U.S., (American Association of State Highway and Transportation Officials (AASHTO), Japan (Japan Road Association, Honshu-Shikoku Bridge Authority and Japan Highway Corporation), and European standards, will be used.

- Road Alignment Design

  Design Speed: 80 km/hr
  Geometric design conditions will be as described in Table 2-1
  and road widths will be as described in Figure 2-1.

- Navigation Limits

  The navigation limits at Qantara will be as shown in Figure 2-2, and will be 384 m x 70 m. The navigation clearance for the Suez Canal during construction, as required by SCA, will be 270 m x 70 m. The height clearance at both end spans are required to be 68 m.

- Construction Limits

  The construction limits for roads and railways are for a height limit of 5.5 m.

- Bridge Design Standards

  a) Design Load:

  Vehicle Load

  The Japan Road Association Specification will be used, and the Egyptian requirement of special vehicle load of 60 tons will be checked. (Refer to Figure 2-3)

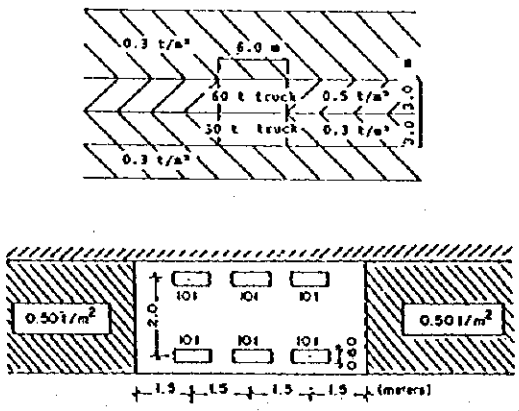

Figure 2-3 Live Load for Roadway Bridges

Table 2-1 Geometrical Design Conditions

Item	Unit	Figure	Remarks
Design Speed	km/hr	80	Primary Rolling Desert Road
Lane Width	m	3.65	
Shoulder Widths for ;			
1) Bridge or Tunnel Section : 4 Lanes	m	0.60	
2) Earthwork Section : Elevated	m	1.25	Approach Section
3) Earthwork Section : Level	m	2.25	Access Road
Hard Strip Width	m	0.25	
Median Width	m	1.50	
Crossfall	%	2.0	
Maximum Superelevation	%	4.0	
Maximum Vertical Grade	%	3.3	Rolling Desert Road
Stopping Sight Distance	m	100	
Minimum Horizontal Curve Radius	m	250	
Minimum Horizontal Curve Radius not Requiring Transition Curve	m	2,000	
Minimum Vertical Curve Radius for ;			
1) Crest Curve	m	3,000	
2) Sag Curve	m	2,000	

Source: JICA Study Team

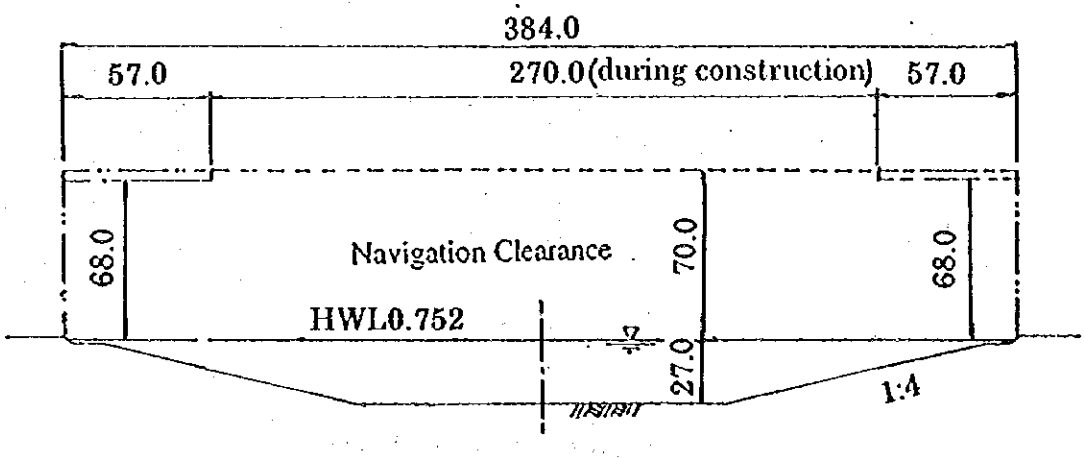

Figure 2-2 Navigation Limit

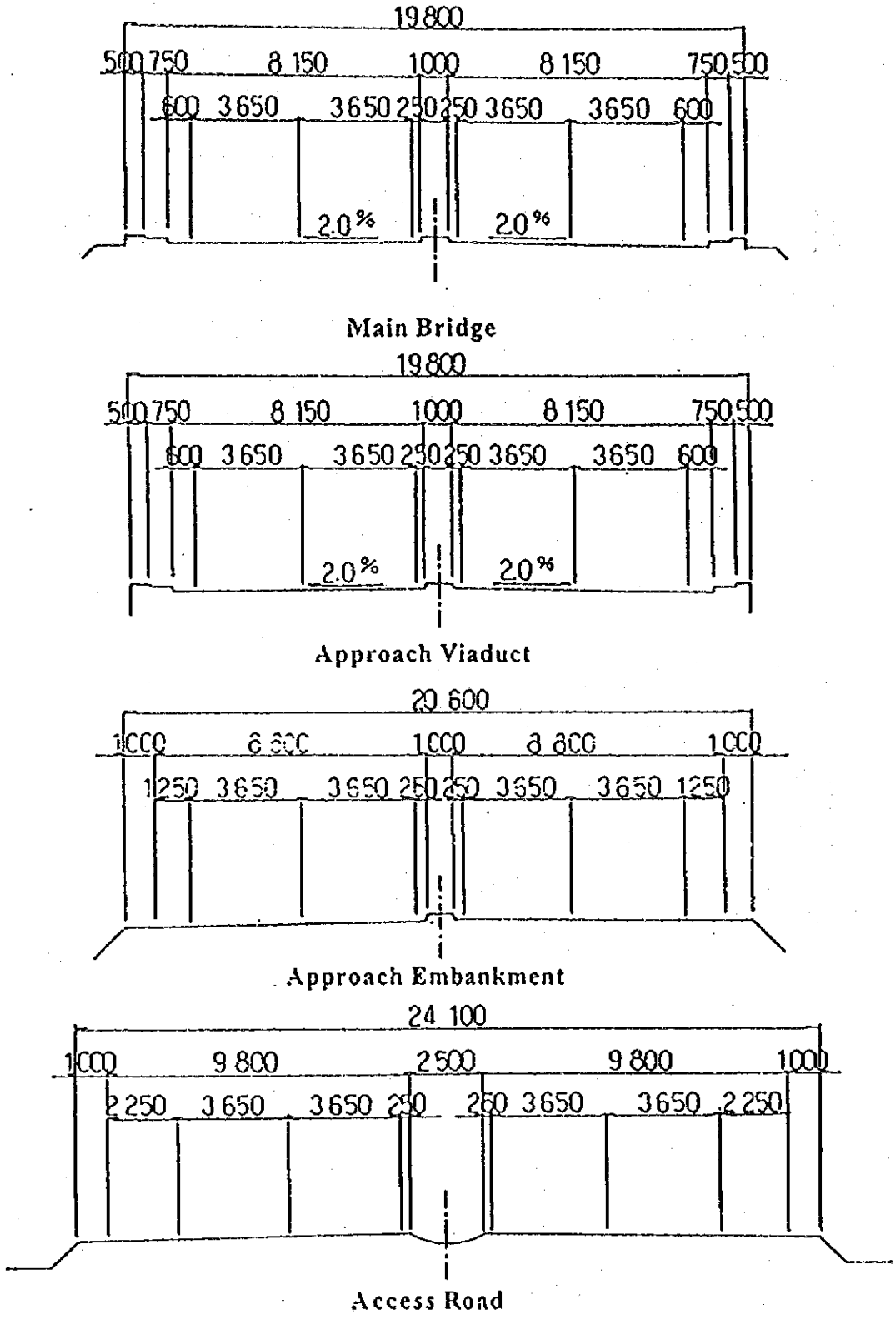

Figure 2-1 Road Widths

Impact Coefficient

$I = 0.4 - 0.008 \times L1 \geq 0.0$

Where: L1: length of load which produces maximum effect

Load on Administrative Access Road

500 kg/m^2

Temperature Changes

Temperature changes:	Structural Steel Structures	20 ± 30 °C
	Concrete Structures	20 ± 20 °C
Temperature Difference between Members:		
	Structural Steel Structures	±15 °C
	Concrete Structures	±5 °C

Wind Loads

The standard wind load is 200 kg/m^2, the correction for height will be in accordance with the Honshu-Shikoku Bridge Authority (Japan) Standard.

Seismic Loads

125 gal in accordance with the modified Seismic Method

Concrete Dry Shrinkage, Creep

At humidity of 50%, in accordance with Japan Road Association Specification

Construction Tolerance

Caisson, Pylon position will consider an error of 5 cm
Pylon tip variation will consider variation 1/1,000 of pylon height

Collision Load (AASHTO)

The effect of collision by 560,000 ton tanker and 10,000 ton, 100,000 ton ships will be considered.

Effects of Differential Settlement

Main Pylon	:	2.5 cm
Adjacent Bridge Piers	:	1.5 cm (in elastic state); 2.5 cm (in creep state)

b) Combination of Loads

To be basically in accordance with Japan Road Association Specification, with adjustment to cope with local conditions

2) Design Methods

To be in accordance with the Japan Bridge Association Specifications, and structures will be designed in accordance with the Allowable Stress Design Method for structures. In addition, for the main crossing sections, to refer to the BS5400 Limit State Design Method.

3) Materials

a) Concrete

Foundation Piles	:	240 kg/cm^2
Caisson/Diaphragm Wall	:	240 kg/cm^2 (base slab will be 300 kg/cm^2)
Substructure	:	240 kg/cm^2
Main Pylon Tower	:	300 kg/cm^2 (350 kg/cm^2 for anchor zone)
PC Structure	:	350 kg/cm^2

b) Reinforcing Steel

ST 37, ST 52 (BS Specification)

c) Structural Steel

SS 400, SM 490, SM 490Y, SM 520

d) PC Tendons

Freyssinet stranded wire, 12T 15.2 mm (SW PR 7B)

e) Stay Cable

Freyssinet stranded wire M15

2-3-2 Basic Plan

The outline of the basic design is generally as follows:

- Main Bridge

Type of Bridge	:	Cable-stayed bridge with steel box girder
Main Pylon	:	H-type, reinforced concrete (RC)
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Pavement	:	Asphalt concrete, 8 cm thick

- Approach Bridge

Bridge Type	:	PC box girder, continuous rigid frame type and continuous girder type
Superstructure	:	Continuous girder, 3 ~ 7 spans
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- Approach Roads

Road Lengths	:	3,745 m (east bank), 1,562 m (west bank)
Effective Width	:	19.6 m
Max. Embankment Height	:	Approx. 20 m (east bank), approx. 10 m (west bank)
Embankment Slopes	:	2 : 1, benched approx. every 5 m
Embankment Protect	:	Slope protection applied

2-3-3 Basic Plan Drawings

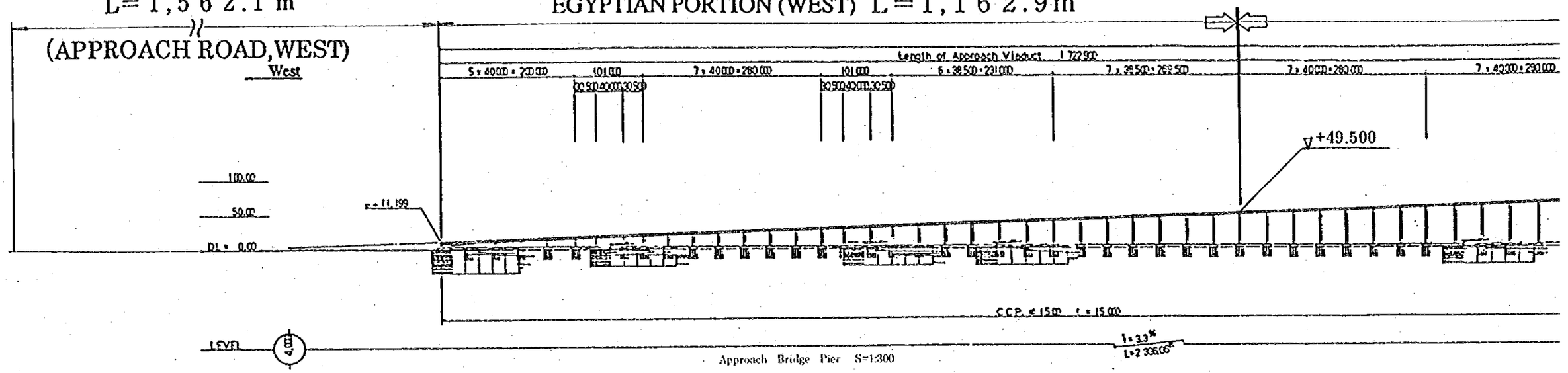
- General View of Main and Approach Bridges (Figure 2-4)
- General View of Main Bridge (Figure 2-5)
- General View of Approach Bridge (Figure 2-6)
- General View of Approach Roads (Figure 2-7)
- Plan of Whole Project Section (Figure 2-8).

L= 1,5 6 2.1 m

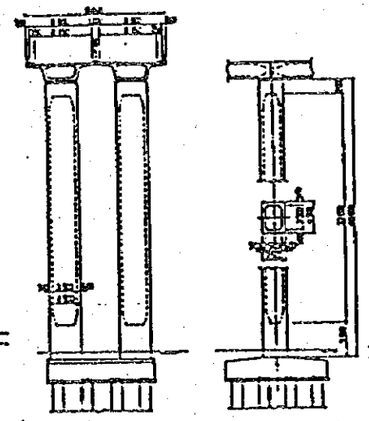
(APPROACH ROAD,WEST)

West

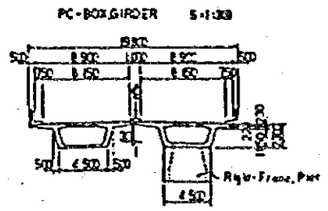
EGYPTIAN PORTION (WEST) L = 1,1 6 2.9 m

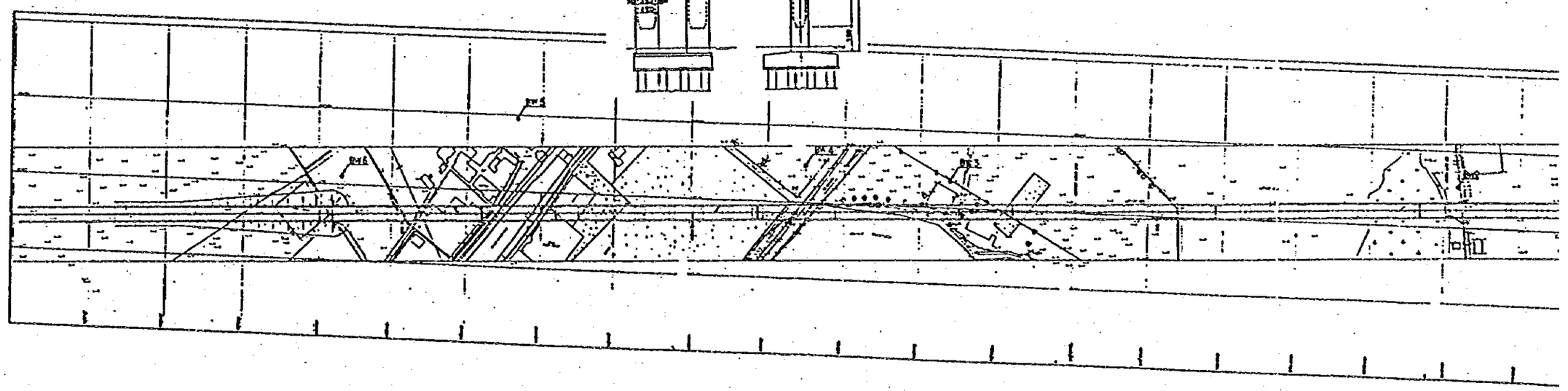


Approach Bridge Pier S=1:300



PC-BOX GIRDER S=1:30





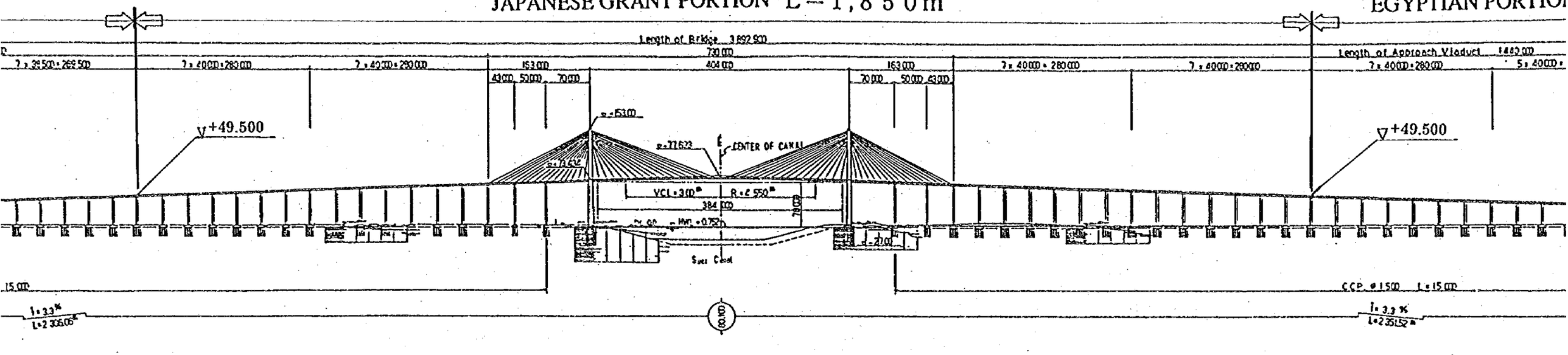
GENERAL VIEW

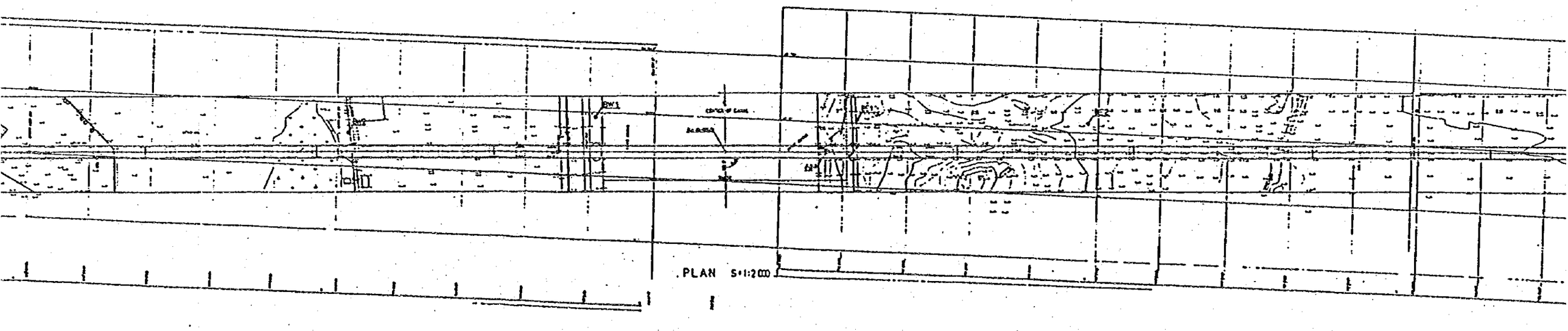
MAIN & APPROACH BRIDGES

PROFILE S=1:2000

JAPANESE GRANT PORTION L = 1,850m

EGYPTIAN PORTIO





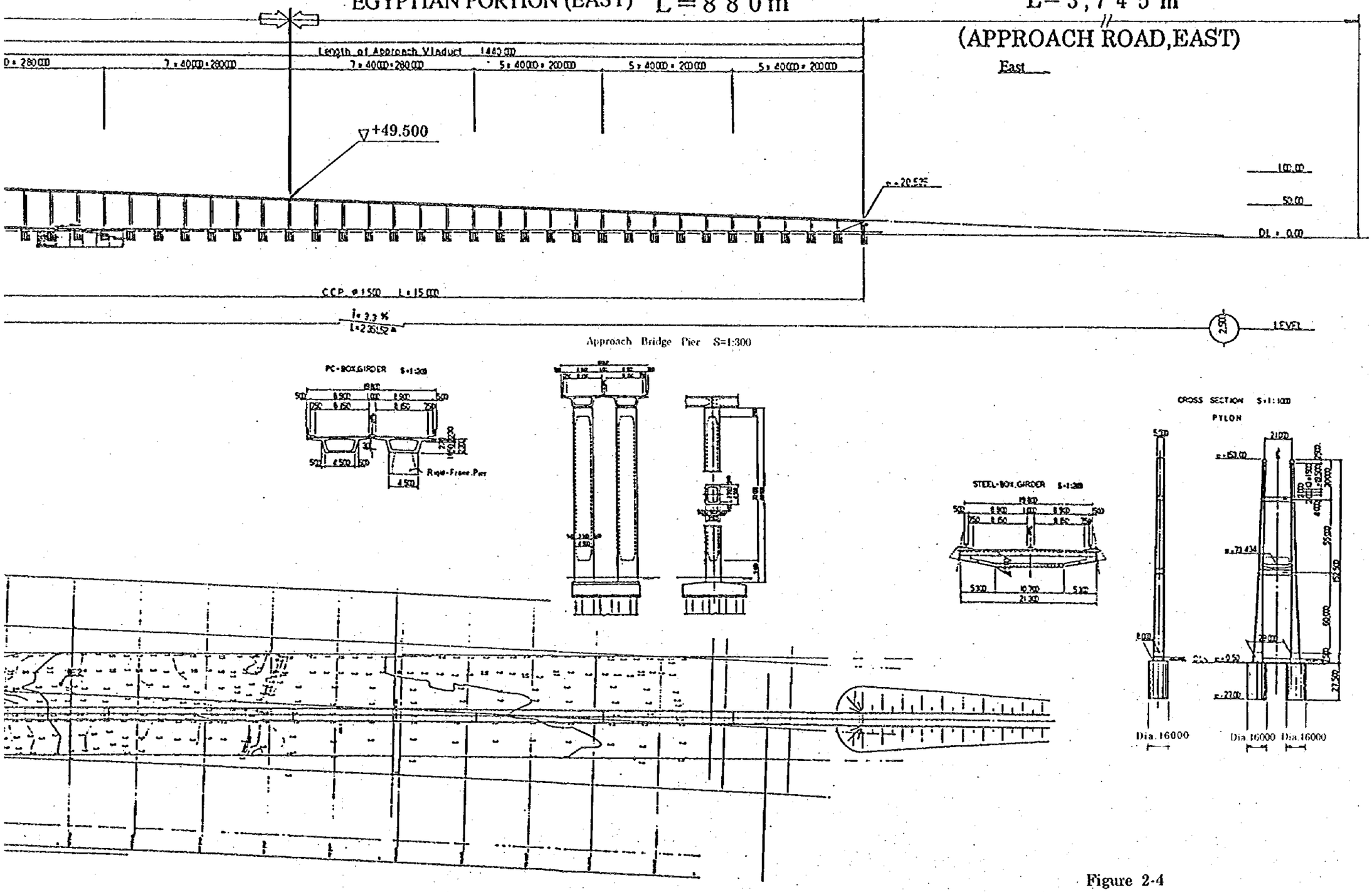


Figure 2-4

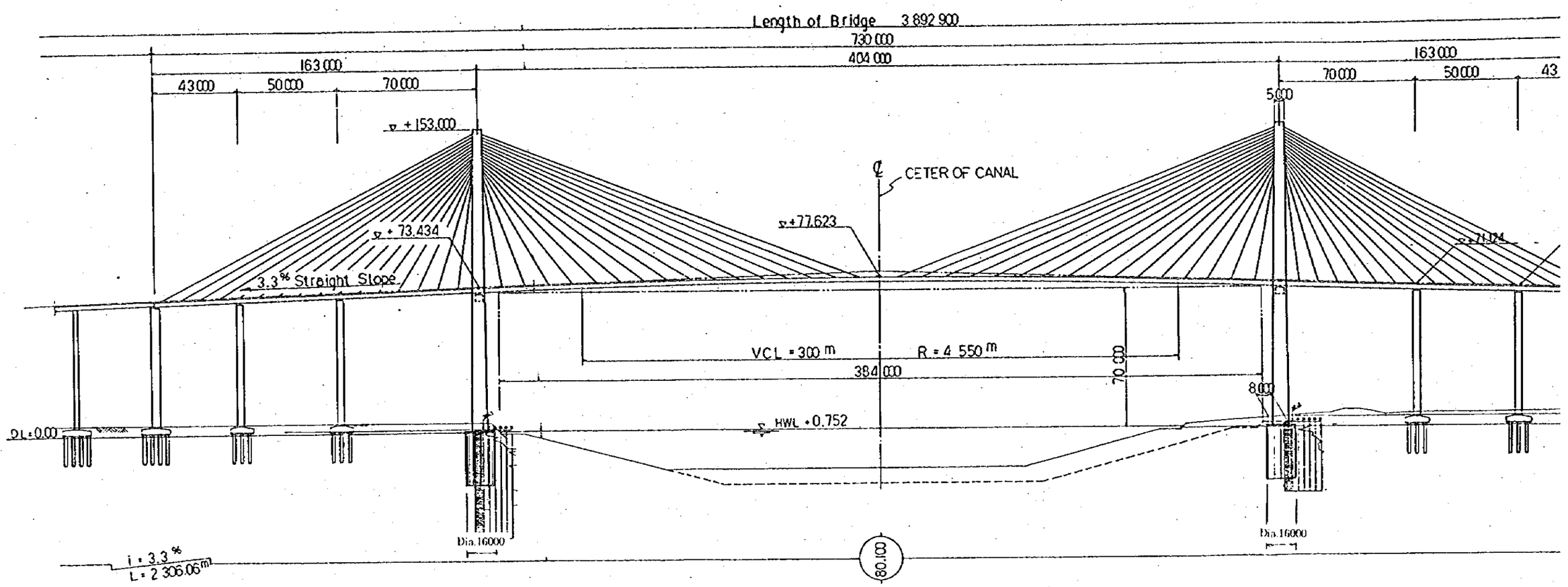
GENERAL VIEW OF MAIN & APPROACH BRIDGES

GENERAL VIEW

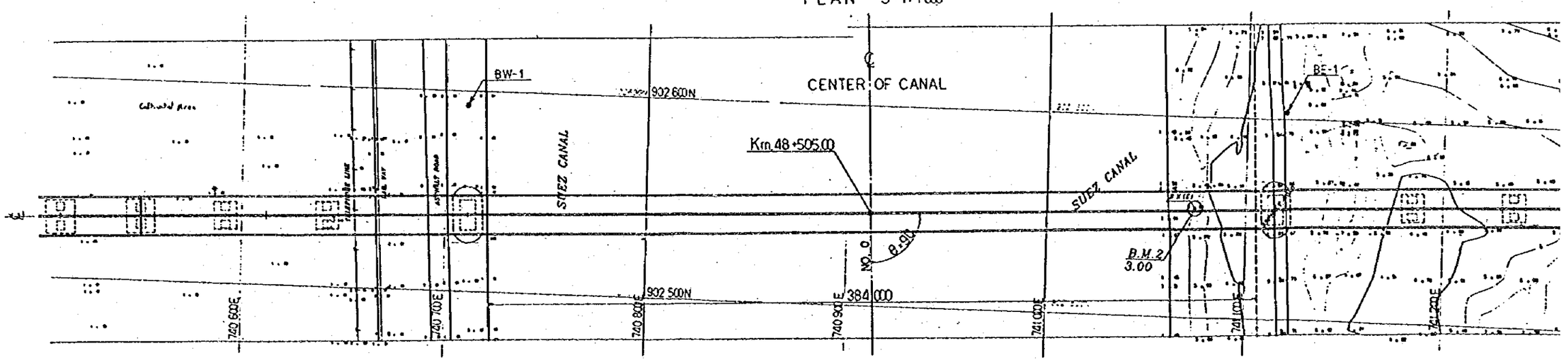
NAIN BRIDGE

PROFILE S=1:1000

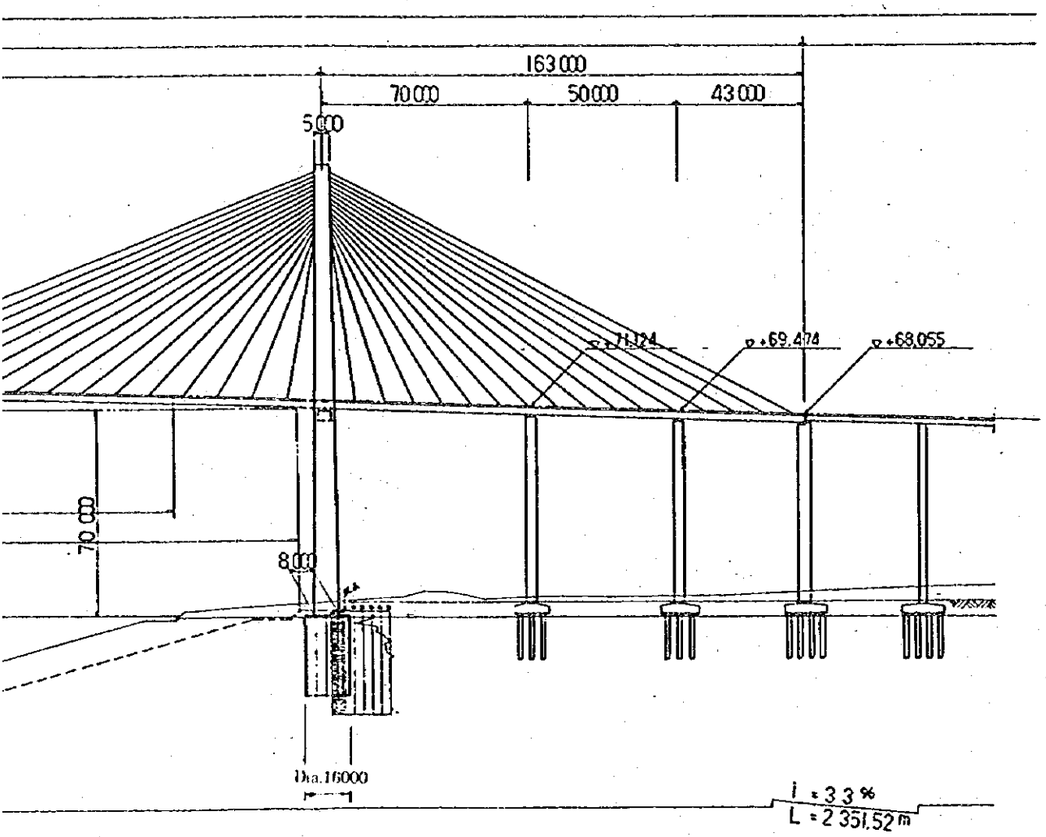
West



PLAN S=1:1000

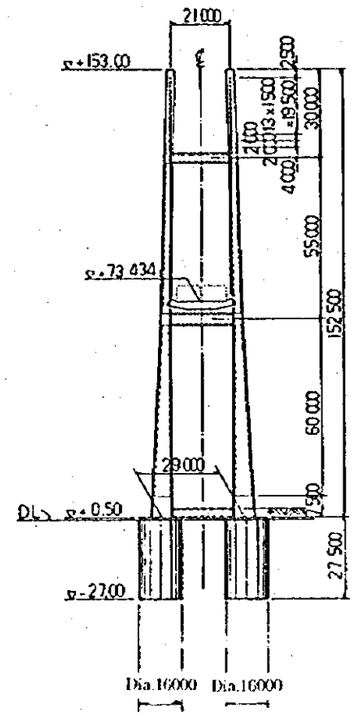


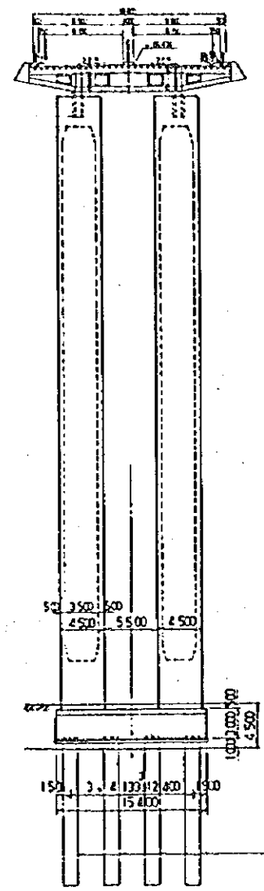
East

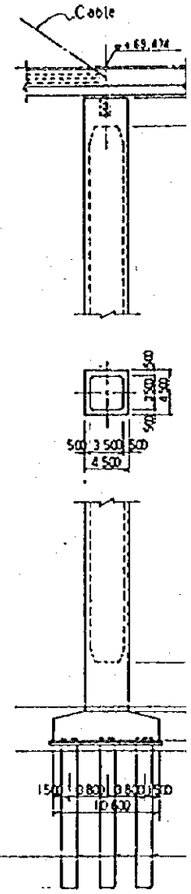


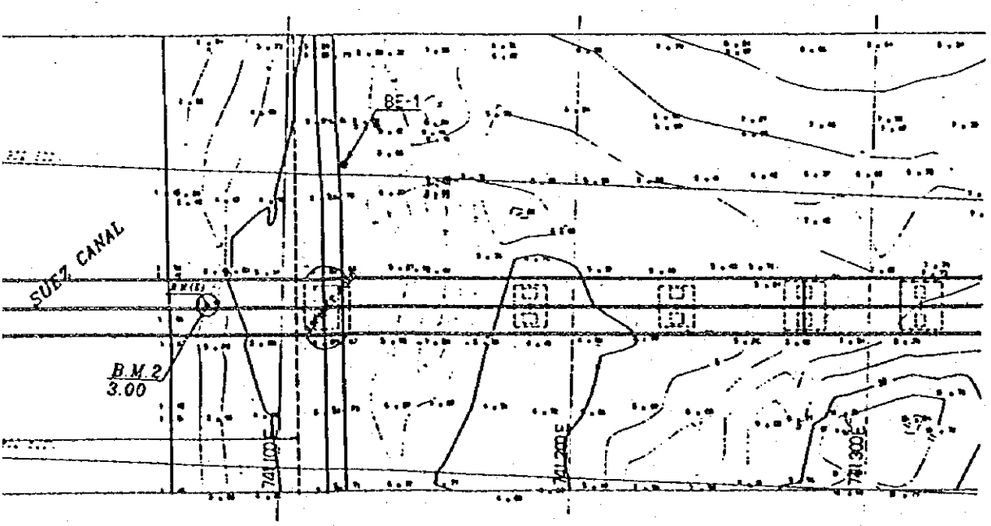
CROSS SECTION S=1:1000

PYLON

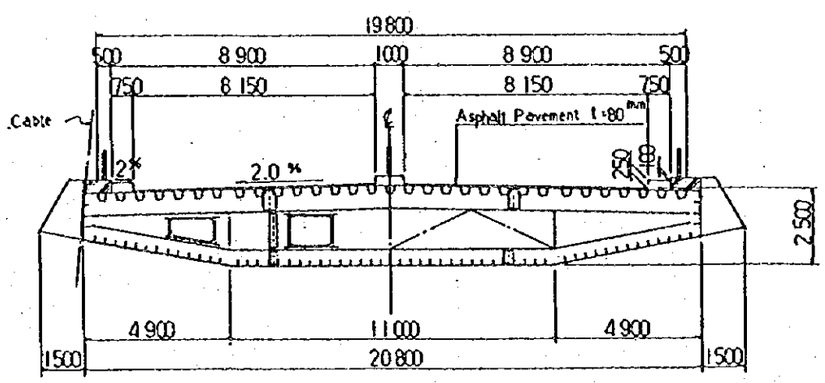




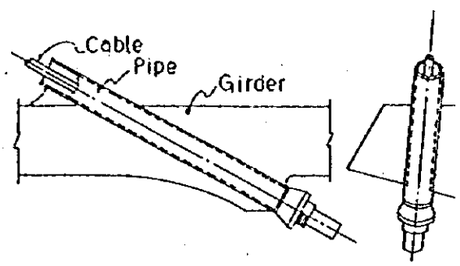




Girder Section S=1:100

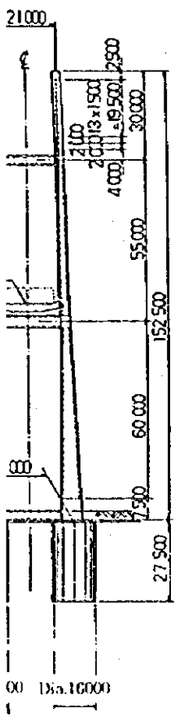


Anchor

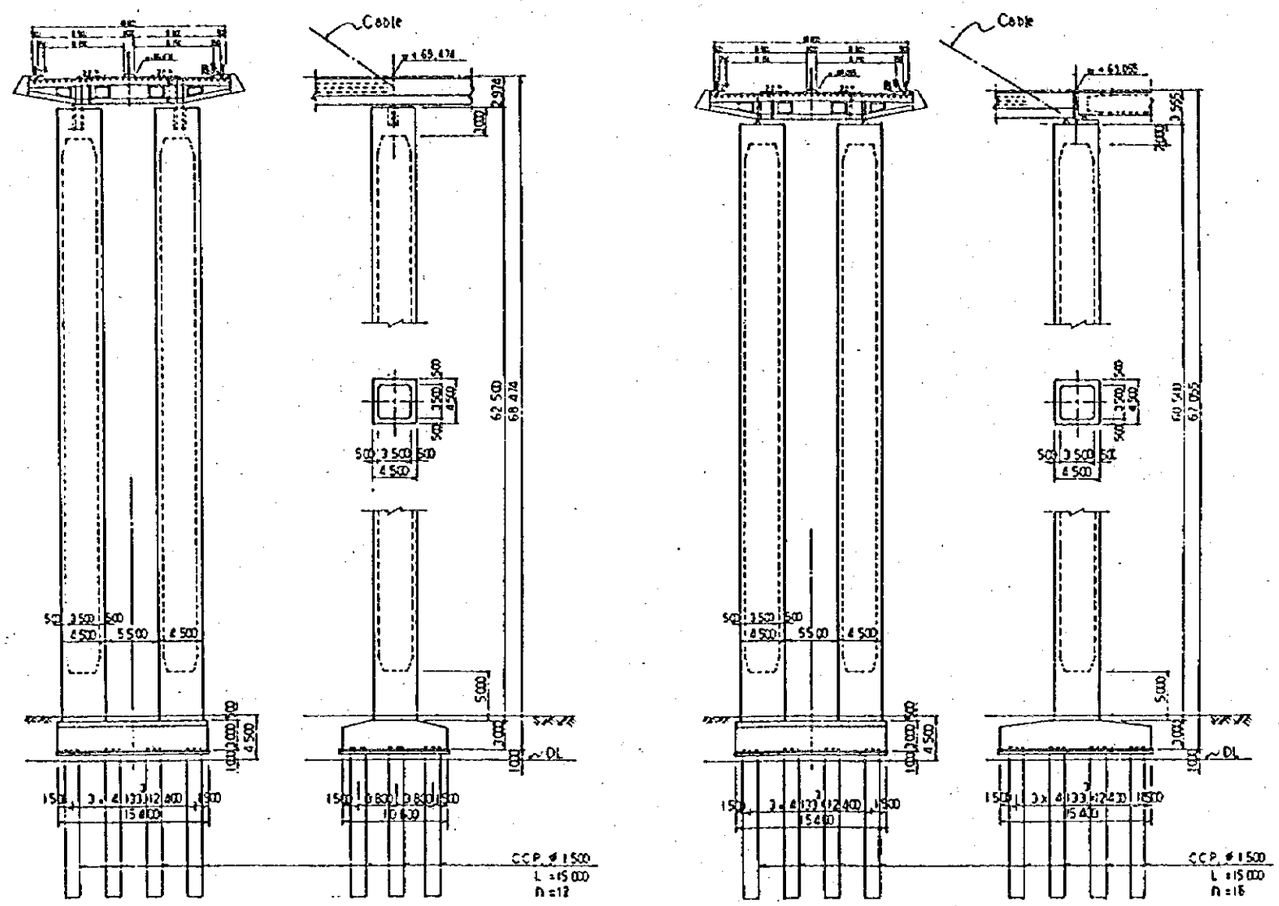


CTION S=1:1000

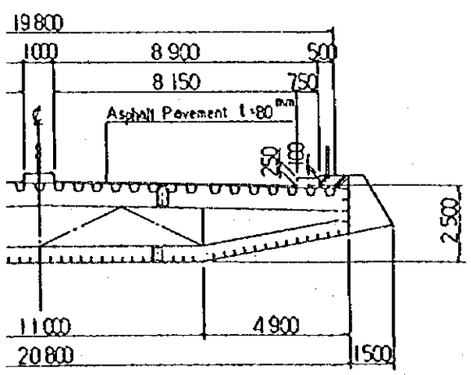
'LON



Pier S=1:300



Section S=1:100



Anchor

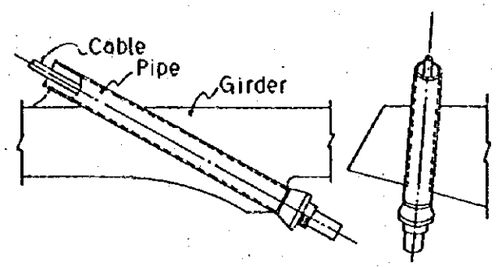


Figure 2-5

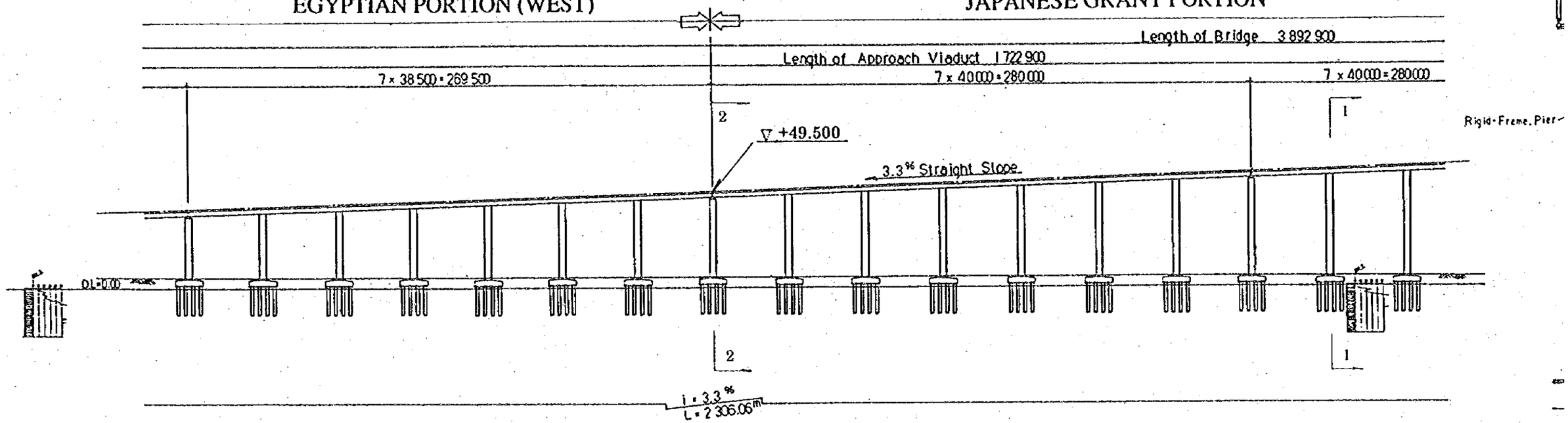
GENERAL VIEW OF MAIN BRIDGE

GENERAL VIEW

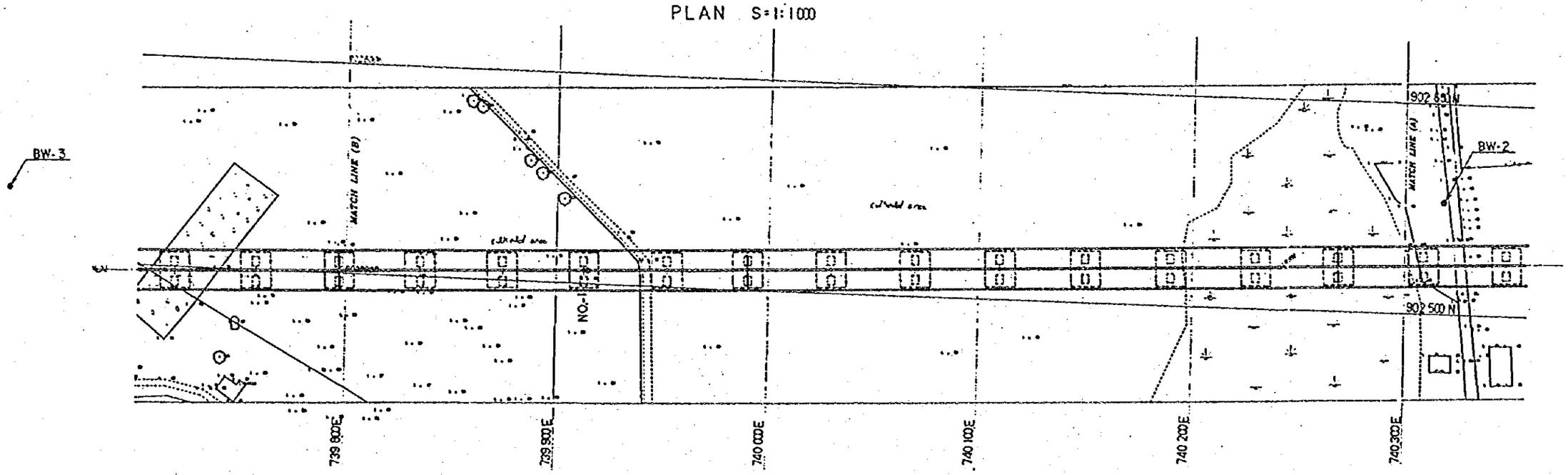
APPROACH BRIDGE

West

PROFILE S=1:1000



PLAN S=1:1000

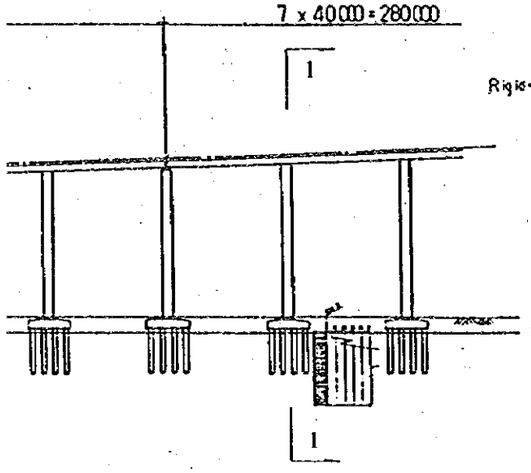


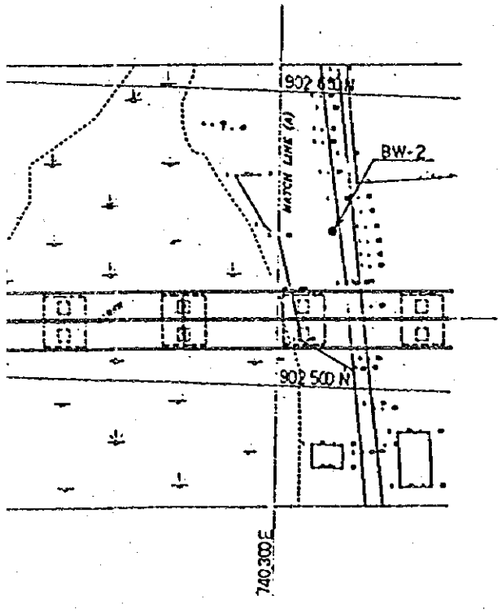
GENERAL VIEW

APPROACH BRIDGE

T PORTION

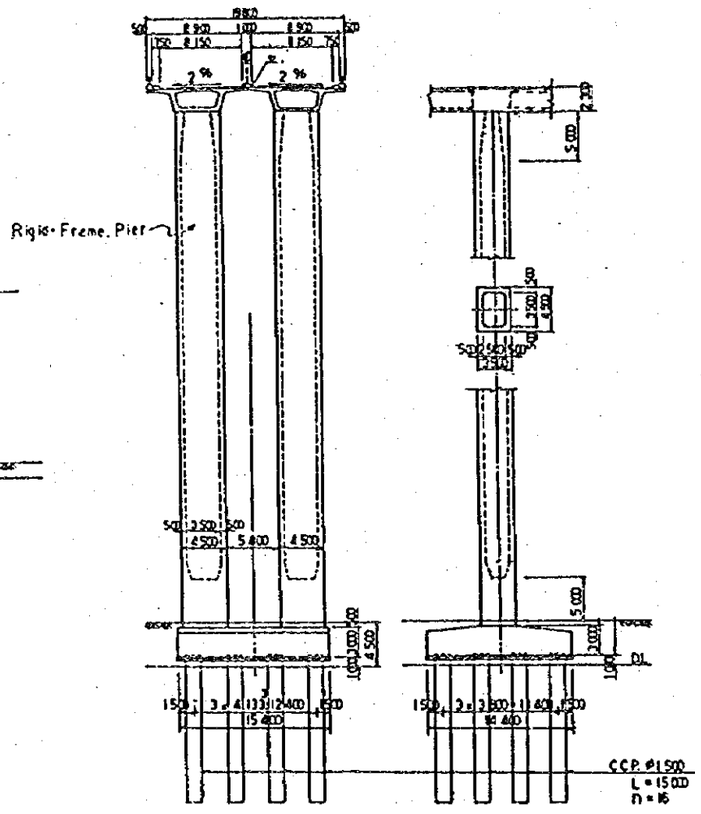
ength of Bridge 3 892 900



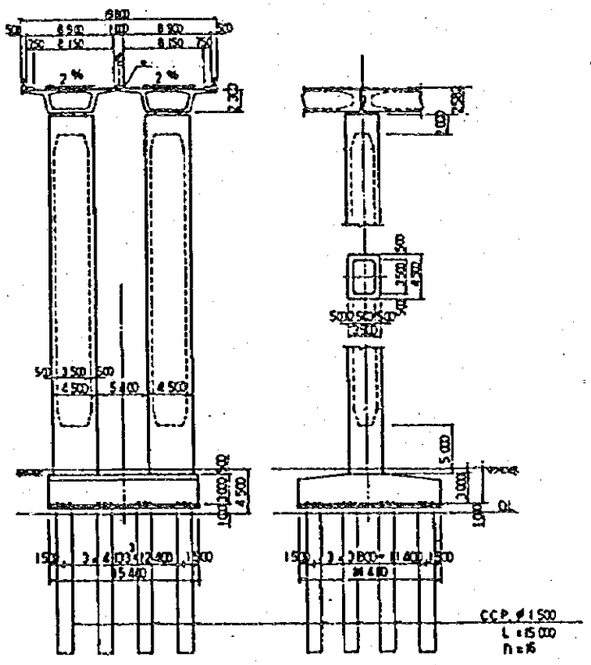


Approach Bridge Pier S=1:300

Section 1- 1



Section 2-2



Girder Section S = 1:50

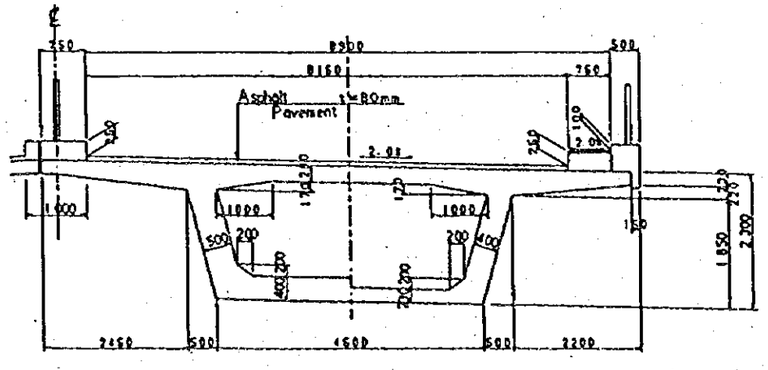
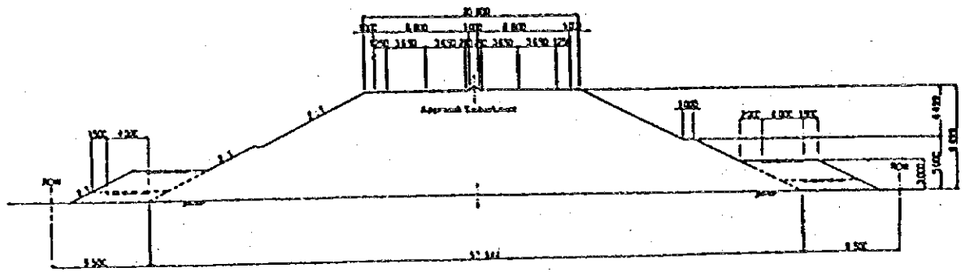
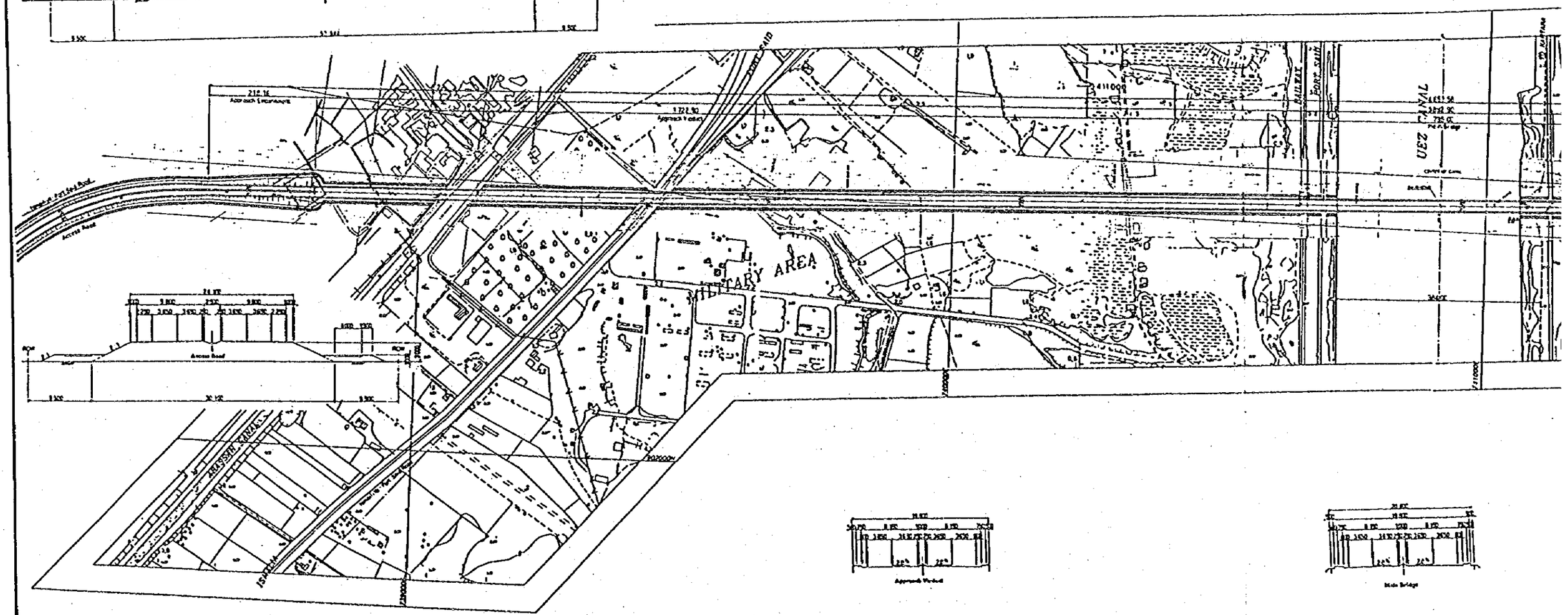


Figure 2-6

GENERAL VIEW OF APPROACH BRIDGE





PLAN 1:12500

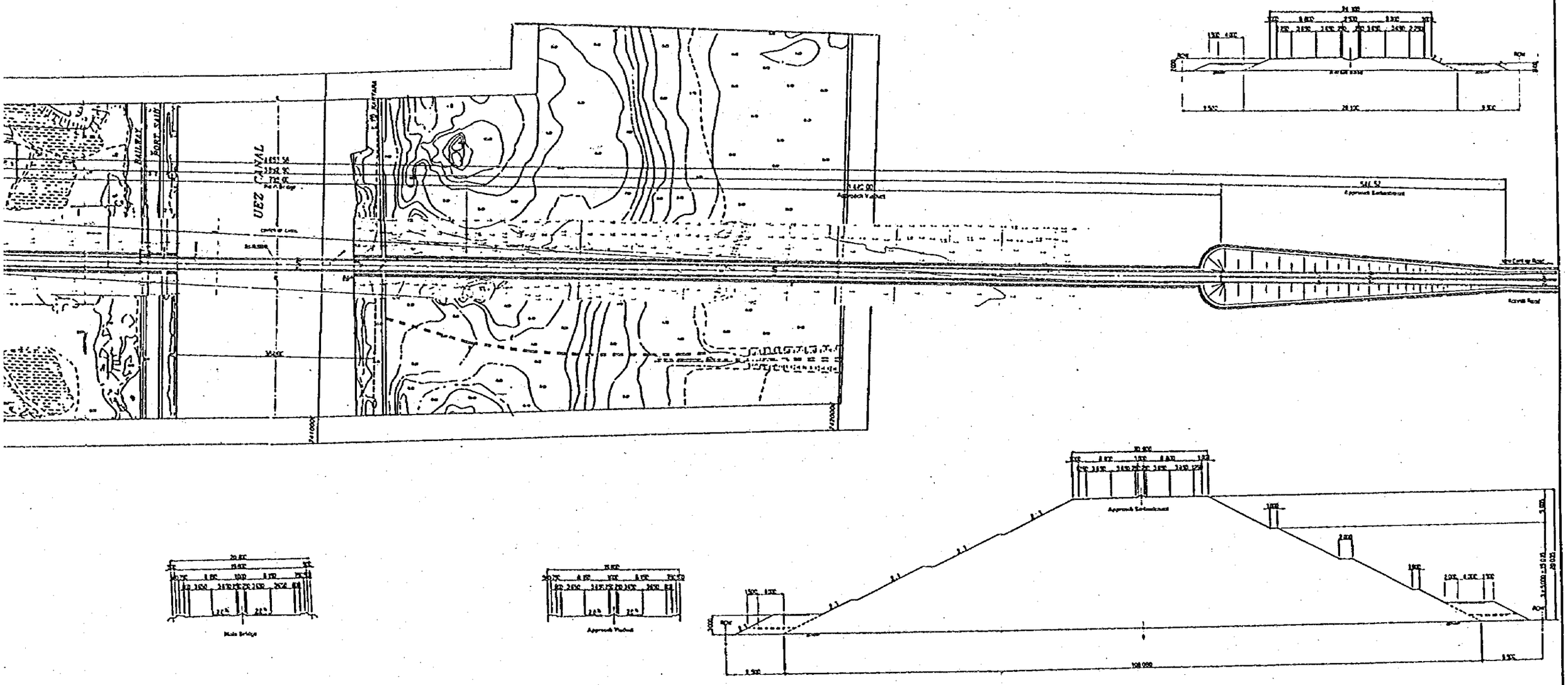
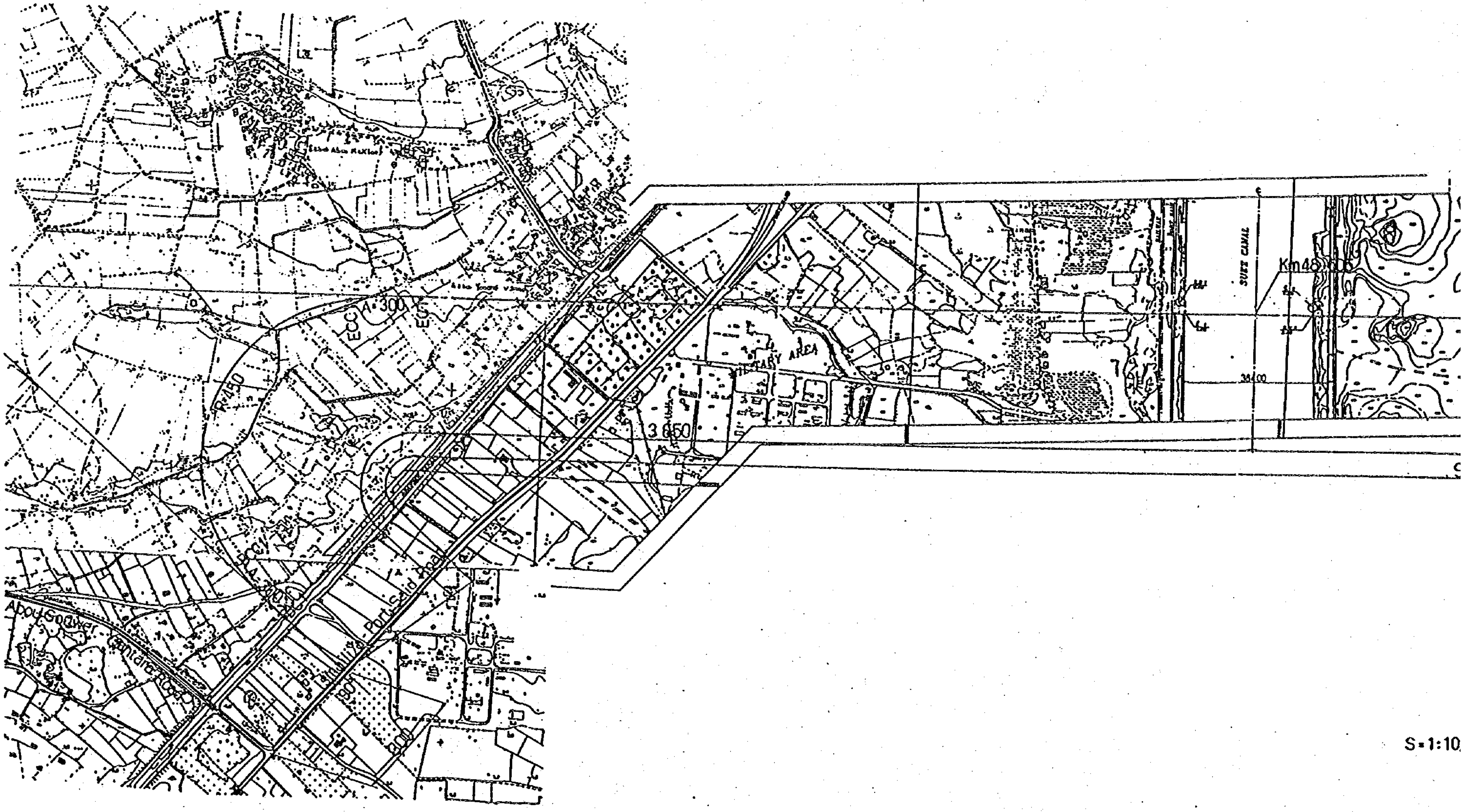
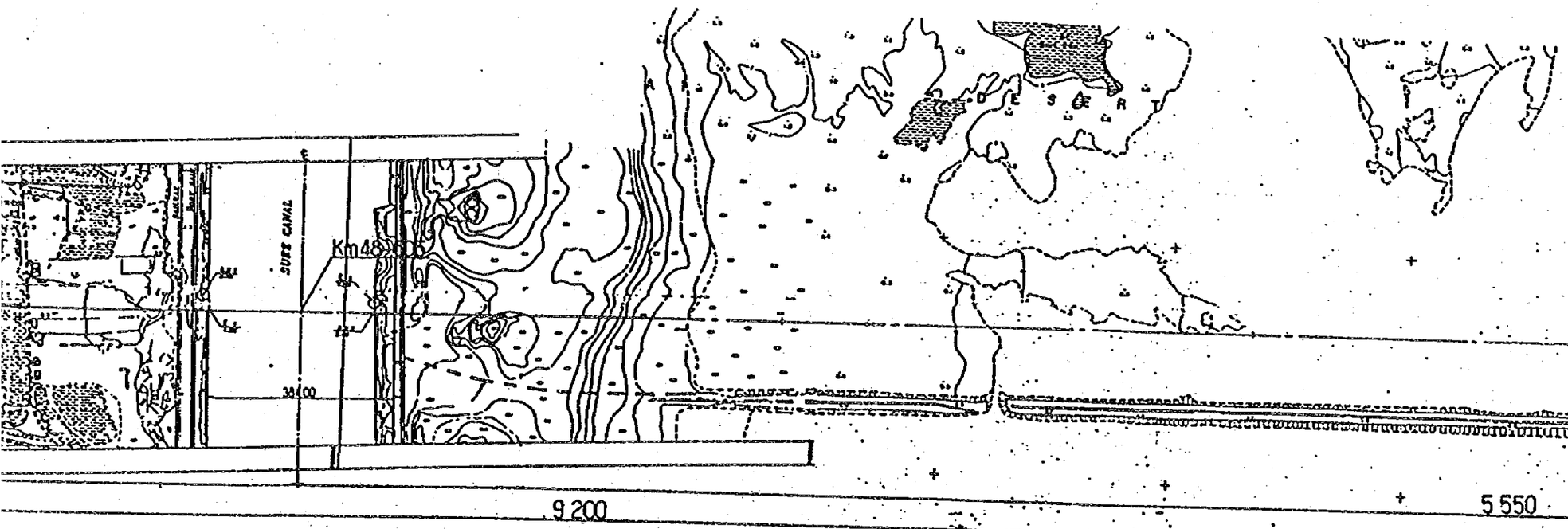


Figure 2-7

GENERAL VIEW OF APPROACH ROAD



ECC A 300
R 450
3 650
MILITARY AREA
SUEZ CANAL
Km48
Port Said Road
Abou Swier
S=1:10



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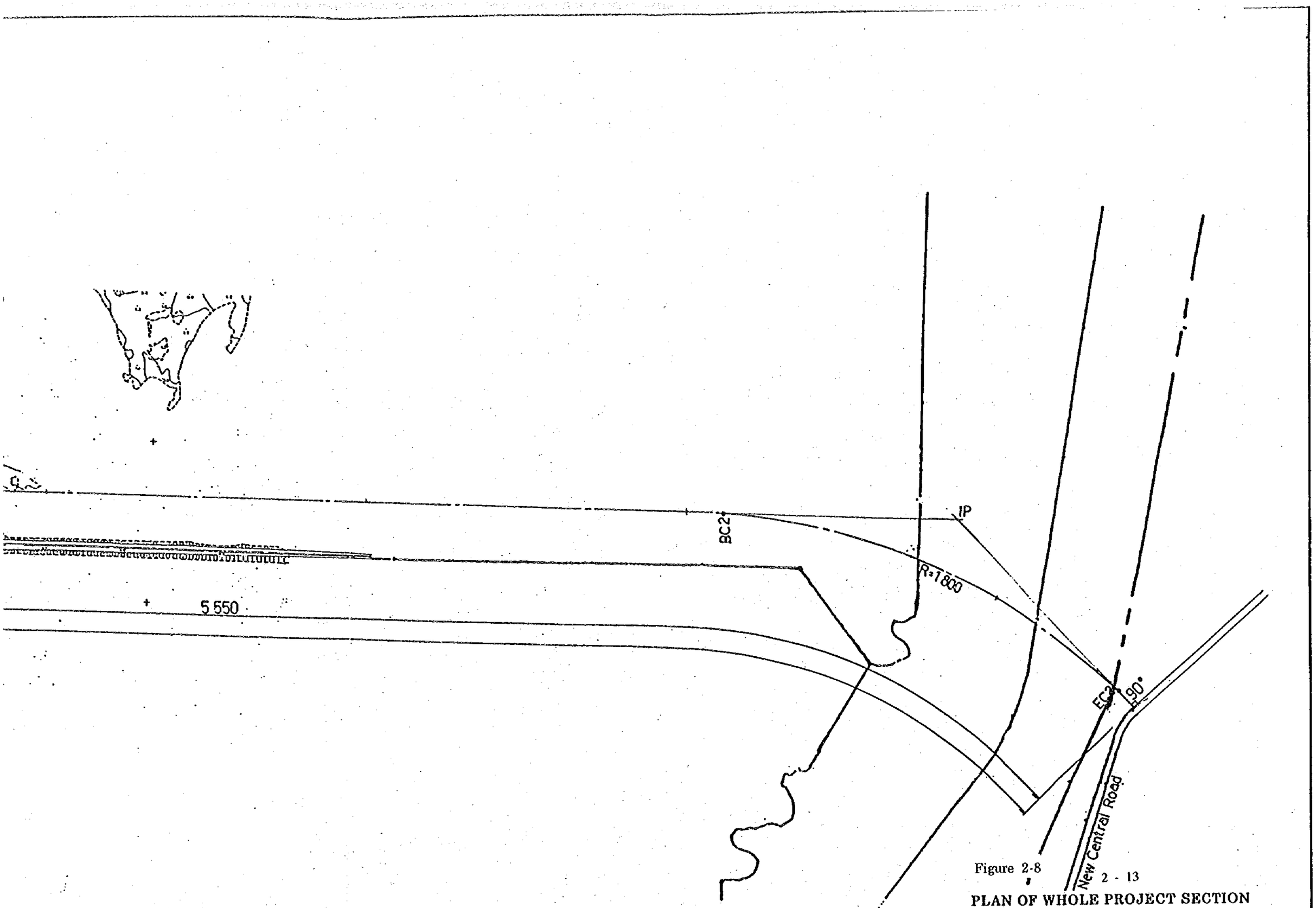

Figure 2-8

PLAN OF WHOLE PROJECT SECTION