9.2.2 Bridge Design Criteria

(1) General

Subsequent to the selection of the Qantara location for the preliminary design of the Canal crossing bridge, the design requirements and criteria have been reviewed, and any necessary supplementary design criteria for the preliminary design have been determined

For the design criteria other than items specified in this chapter, the design requirements and criteria described previously in section 6.1 will be used for the preliminary design.

(2) Geometric Requirements

1) Number of Lanes

Separated 4 lanes will be adopted for the bridge as shown in Fig. 9.2.1.

2) Vertical Grade

The maximum vertical grade of 3.3 % will be adopted for the bridge and road

3) Horizontal Alignment

The horizontal alignment for main bridge and approach viaducts will be straight.

4) Reference Point of Canal

The reference point of the cross section of the channel is the crest of the stone pitshing on the west bank of the Suez Canal as shown in Fig.9.2.3.

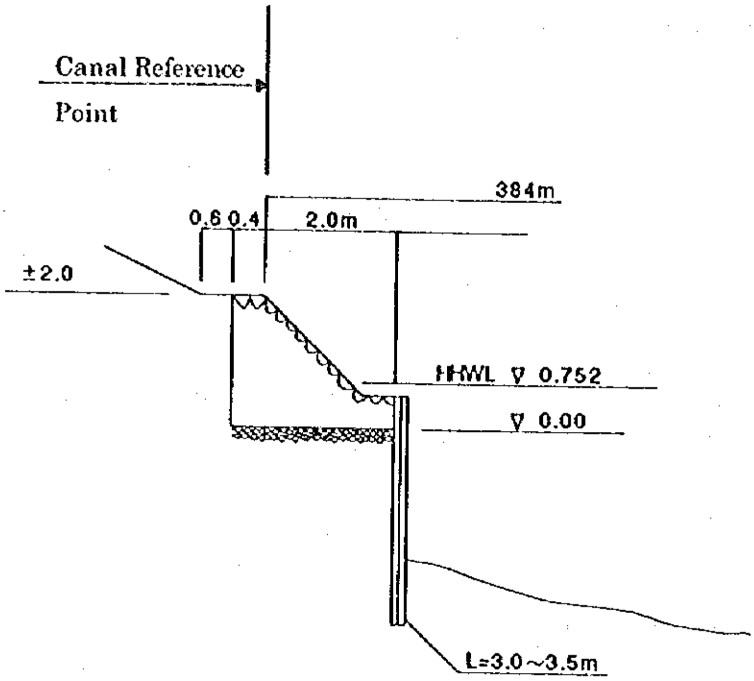


Fig. 9.2.3 Retaining Wall of the Suez Canal at Qantara

5) Center Line of Channel

The center line of the channel is to be 192.0 meters from the crest.

6) Height of Embankment

The height of the embankment for the access road on the West Bank is to be generally 3 meters above the existing ground level.

7) Connecting Road

The access road will connect directly to the Ismailiya-Port Said Road on the West bank, and the New Central Highway on the East bank.

(3) Bridge Design Requirement and Criteria

1) Pavement

An asphalt concrete pavement of the following thickness is to be used:

8 cm for steel deck slab, and

7 cm for a concrete deck slab

2) Structural Design

-Seismic Effect

For the design of the bridge crossing the Suez Canal, 125 gal of ground acceleration will be used for basic seismic design intensity.
(Refer to Paragraph 6.1.3 6))

-Settlement

The differential settlement of the pylon foundations is not to exceed 2.5 cm.

The maximum differential settlement for the piers is to be as follows:

1.5 cm for elastic condition, and
2.5 cm for creep condition.

-Ship Collision

For the calculation of the ship collision force, a 500,000 DWT tanker will be used.

-Structural Steel Plate

The minimum thickness of steel plate for the steel deck girder is to as follows:

- 12 mm for steel deck plate
- 10 mm for bottom frange plate
- 9 mm for web plate

CHAPTER 10

GEOMETRIC DESIGN

CHAPTER 10 GEOMETRIC DESIGN

10.1 General

The geometric design of the road crossing the Suez Canal at Qantara has been carried out based on the geometric design criteria which have been determined in Chapter 9.

The following items have been studied in this chapter.

- Horizontal and Vertical Alignment
- Plan and Profile
- Embankment
- Pavement Design
- Slope Protection
- Drainage
- Lighting System
- Traffic Safety Facilities
- Traffic Management Facilities
- Miscellaneous

10.2 Horizontal and Vertical Alignment

10.2.1 Horizontal Alignment

The horizontal alignment of the road crossing the Canal has been determined based on the criteria selected and policies for the horizontal alignment in Chapter 6.

(1) Connecting Roads

In principle, the road crossing the Canal will connect directly into the Cairo - Ismailiya - Port Said Road on the West Bank and the New Central Road on the East Bank.

1) West Bank

The alternative methods of connecting the Canal road crossing into the Cairo - Ismailiya - Port Said Road on the West Bank are studied in this sub-section. In addition, the possibility of connecting into the Abou Souwer - Qantara Road on the West Bank is also examined as one of the alternatives.

As a result of this study, the Canal road crossing will be connected into the Cairo - Ismailiya - Port Said Road 300m north of the intersection of the Cairo - Ismailiya - Port Said Road with the Abou Souwer - Qantara Road on the West Bank, for the following reasons.

- This is the most economical construction because it is the shortest road crossing.
- The radius of the curve is adequate to maintain safe and smooth traffic operation. (The radius of the curve is 450m)
- The distance between these the two intersections i.e. the Canal road crossing and Canal and the Cairo - Ismailiya - Port Said Road, and the Cairo - Ismailiya - Port Said Road and the Abou Souwer - Qantara Road junctions will be adequate to ensure safe and uninterrupted traffic flows. (The distance between the two intersections : L = 300 m)
- The land acquisition area is the smallest.

Refer to the Appendix A10.1.1 for the details of this study.

2) East Bank

The New Central Road is the only existing main road close to the Suez Canal on the East Bank. Therefore, the Canal road crossing will have to connect directly into the New Central Road to provide the preferred horizontal alignment.

(2) Crossing Location

1) GARBLT Requirement

The GARBLT required that the crossing be located at Qantara between SCA km 48 + 460 and km 48 + 530. If the Canal road crossing is located to the north of SCA km 48 + 460, this location will be close to a community area of Qantara and there are many obstacles in this area. If the crossing is south of SCA km 48 + 530, the bridge will cross at a curved section of the Suez Canal.

2) SCA Requirement

The SCA require that the crossing be located to the north of SCA km 48 + 650 because the SCA demands a minimum distance of 3 km between the bridge and the north end of the island in the Ballah by-pass channel of the Canal.

3) Local Constraints

There are some local constraints in the area which will limit the selection of the most appropriate route for the Canal road crossing as shown in Fig. 10.2.1 to Fig. 10.2.4. It will not be possible to avoid all of these constraints. However, the route will be selected to avoid passing over the most sensitive institutions such as military areas and public facilities including, the schools and irrigation canal office as far as possible. In addition, minimizing the demolition of private houses in the village to the west of the irrigation canal is taking into account in determining the crossing location.

4) Crossing Location Alternatives

The following three alternatives for crossing locations have been selected and compared in order to determine the best crossing alignment.

- Altemative 1 : SCA km 48 + 450

  In order to avoid the military area, the crossing location should be to the north of SCA km 48 + 490.
  SCA km 48 + 450 is the best crossing location for avoiding the important public institutions, of the military area, irrigation canal office and schools. However, the removal of some private houses is necessary at this location.

- Altemative 2 : SCA km 48 + 517.5

  SCA km 48 + 517.5 is the best crossing location for avoiding the demolition of private houses to the west of the irrigation canal. However, the road will pass through the important public institutions, of the military area, irrigation canal office and schools at this location.

- Altemative 3 : SCA km 48 + 505

  SCA km 48 + 450 is a compromise between the Alternative 1 and 2. The road will pass through the important public institutions, of the military area, irrigation canal office and schools and also some private houses at this crossing location. However, the intrusion into the military area by the road and number of demolished houses will be less than the Altemative 1 or 2.

The horizontal alignment of the crossing location alternatives is shown in Fig. 10.2.5 to Fig. 10.2.9 and the relationship between the roads and these constraints is shown in Fig. 10.2.10 and Fig. 10.2.11.
The results of the comparison are shown in Table 10.2.1.

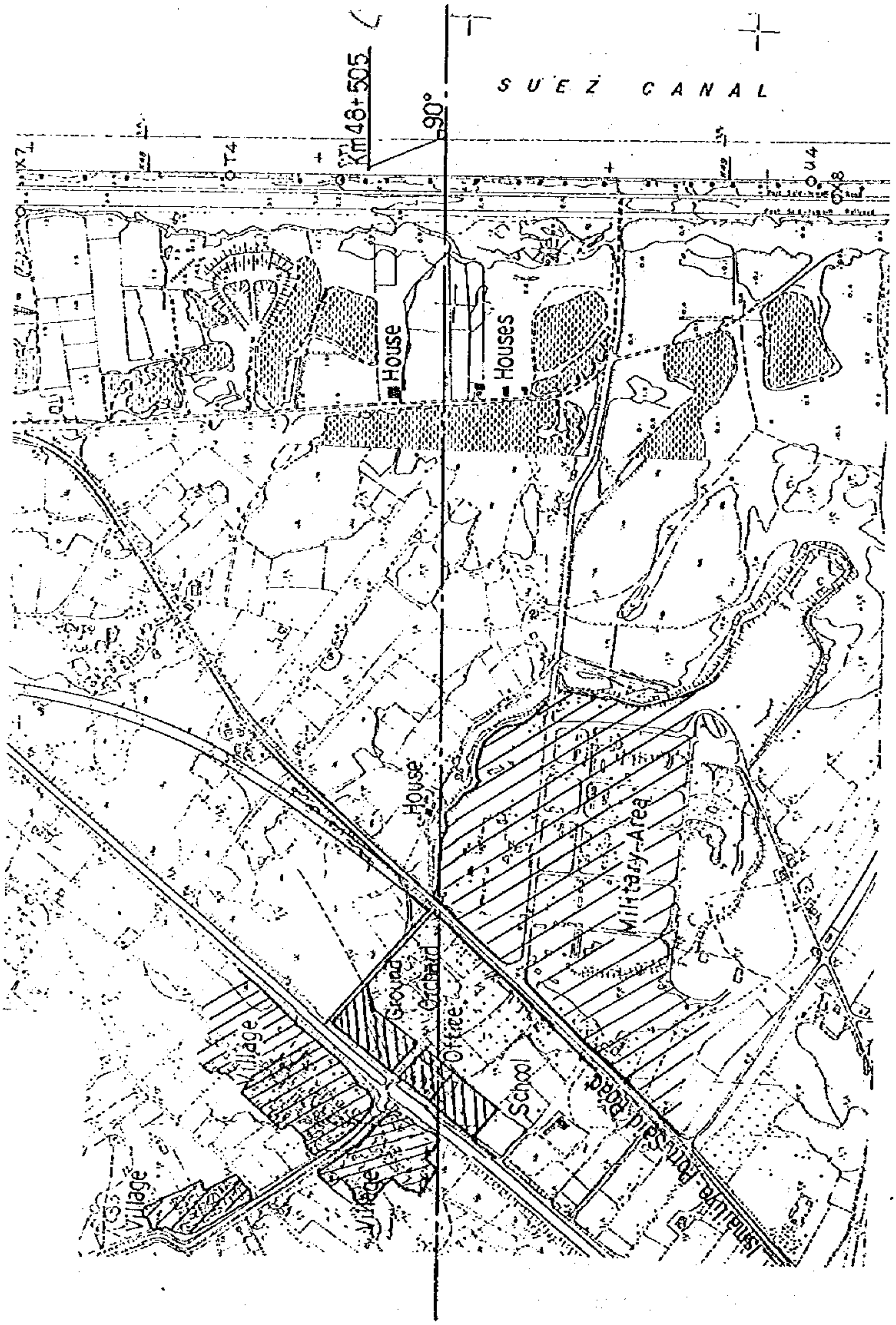


Fig. 10.2.1 **Constraints Affecting Horizontal Alignment (1)**

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

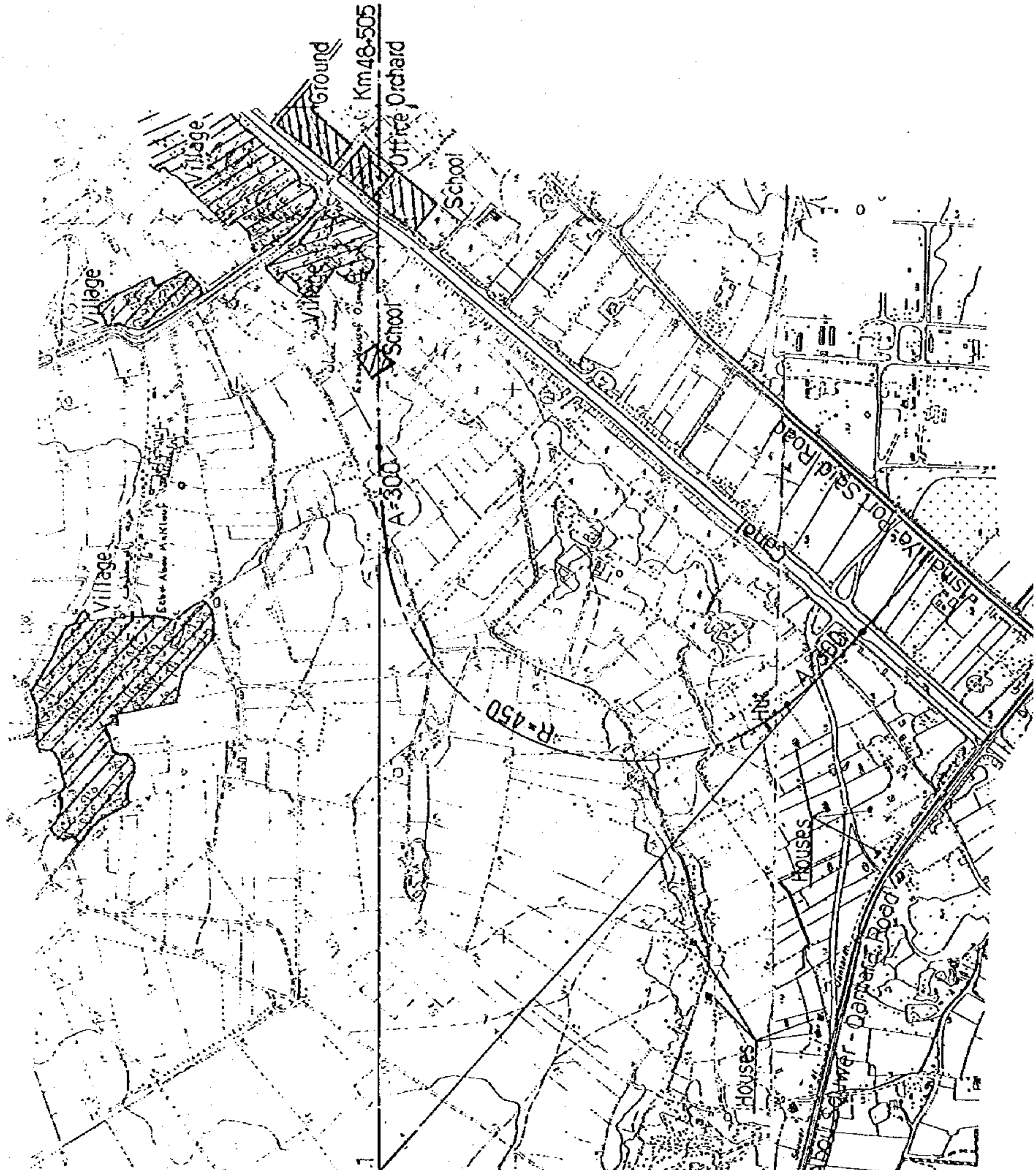


Fig. 10.2.2 **Constraints Affecting Horizontal Alignment (2)**

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

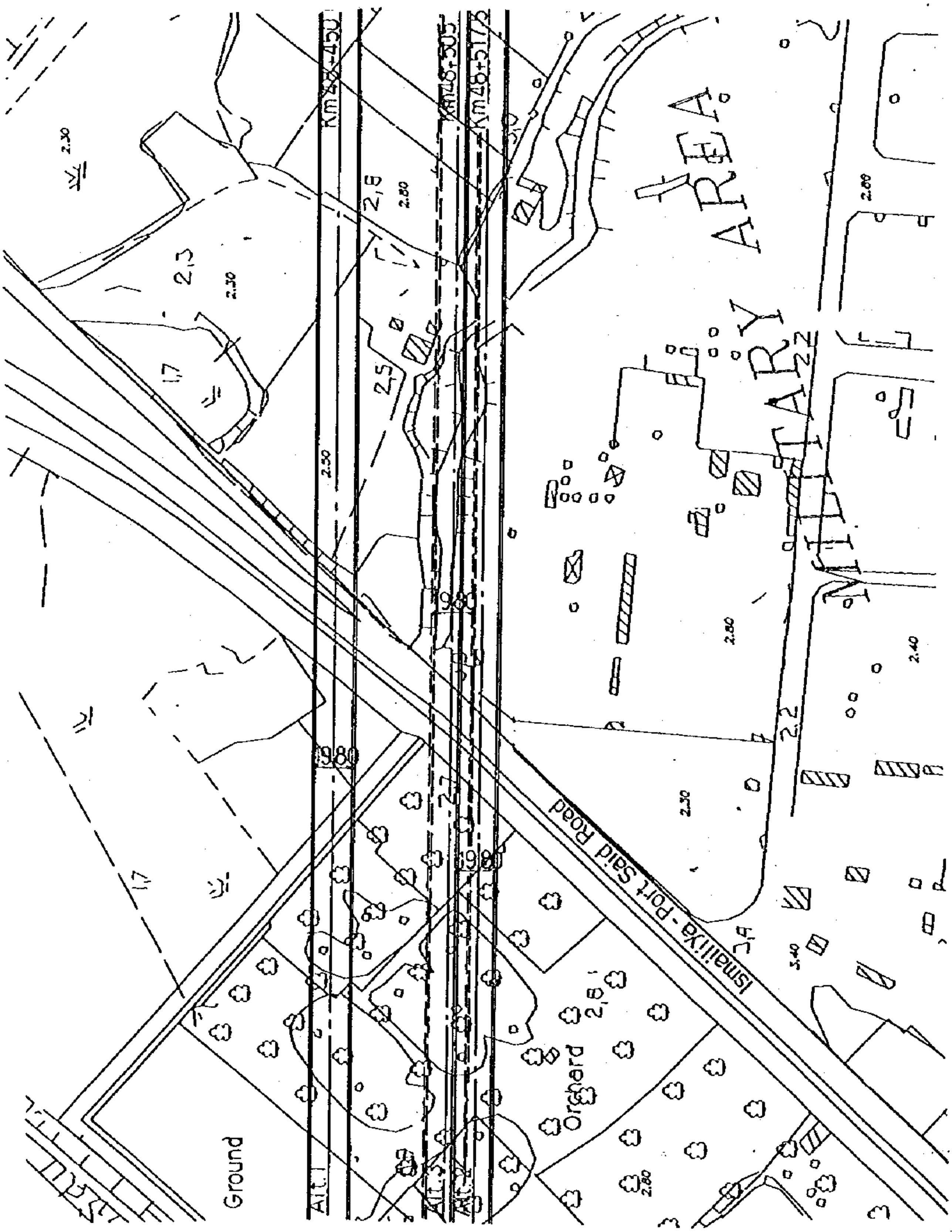


Fig. 10.2.3 **Constraints Affecting Horizontal Alignment (3)**

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

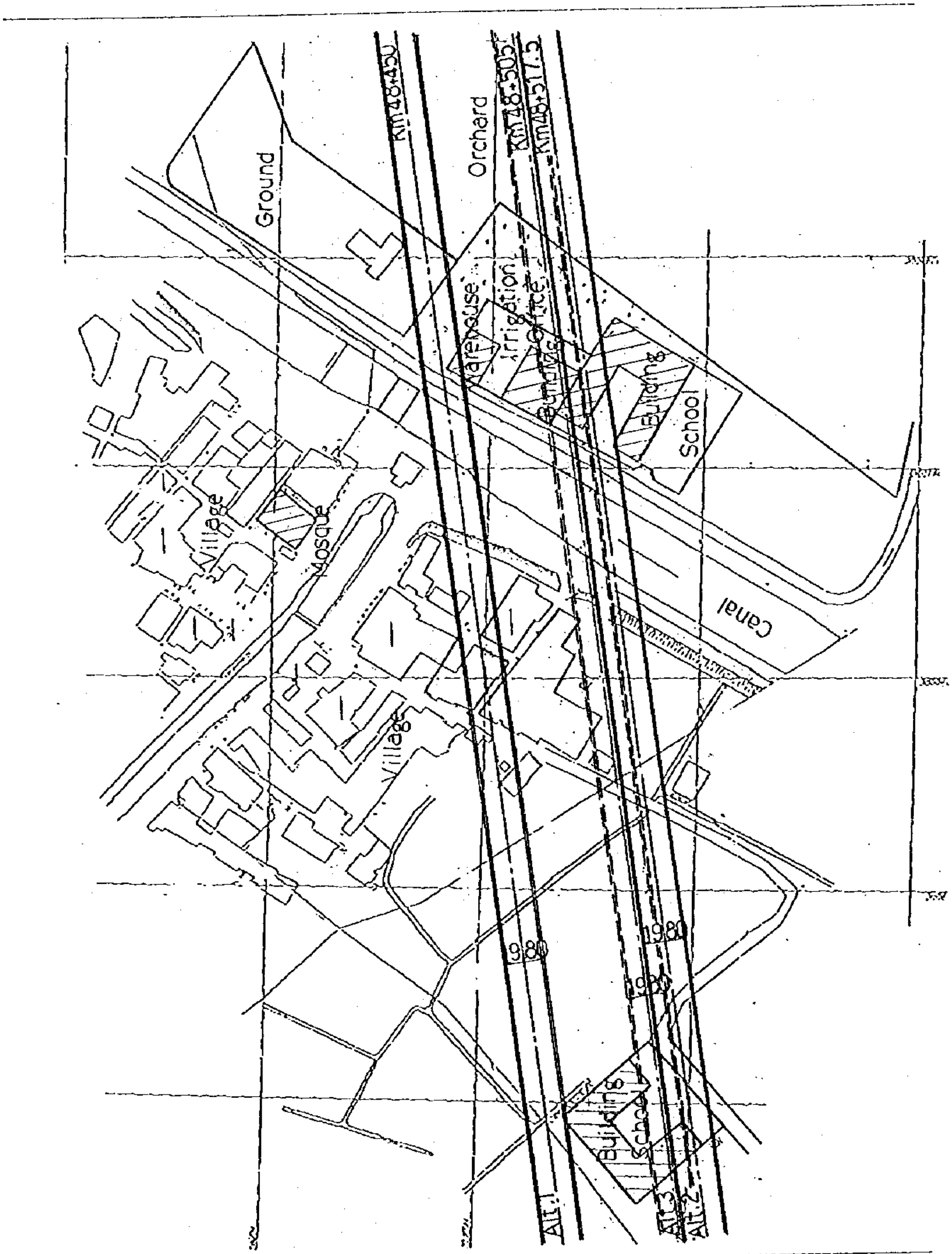


Fig. 10.2.4 **Constraints Affecting Horizontal Alignment (4)**

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

As a results of this study, SCA km 48 + 505 is considered to be the best crossing location for the following reasons.

- To avoid intruding into the military area and demolishing private houses are the most important factors to be considered.
- The military area where the road will cross is small and relatively unimportant. The number of demolished houses will be small, and the removal or interference with public institutions is less sensitive than that of private houses.
- The span arrangement of the approach viaduct crossing crossing over Cairo - Ismailiya - Port said Road is simolified.

Refer to the Appendix A10.1.2 for other possible crossing locations.

(3) Factors Dictating Horizontal Alignment

The horizontal alignment will be determined by the following factors.

1) The road crossing the Canal is to connect at the straight sections of the New Central Road and the Cairo - Ismailiya - Port Said Road.

2) The crossing road is to be straight on the bridge section.

3) The radius of curves for the road crossing are to be as large as possible. If possible, a radius of 2,000m or more which will not require a transition curve will be provided.

4) The road must cross over the Suez Canal at right angles and at a point where the alignment of the Suez Canal is straight.

5) The following very important institutions are to be avoided by the road crossing as far as possible;

- Military Area
- Irrigation Canal Office
- Schools
- Fish Feeding Area (On the East Bank)

(4) Horizontal Alignment

The horizontal alignment of the Canal road crossing was studied and selected as shown on the plan in the section 10.3. (Refer to the Appendix A10.1.3)

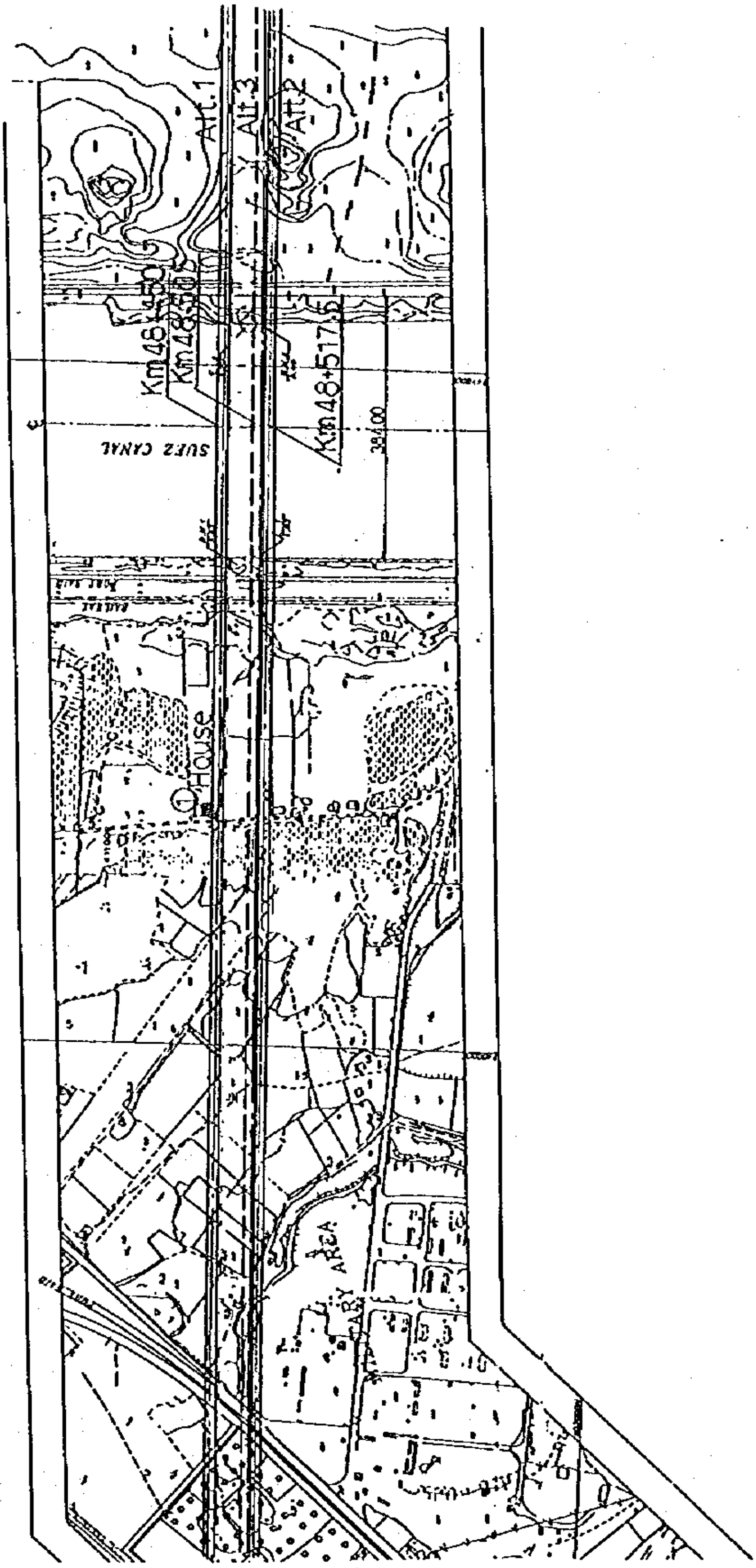


Fig. 10.2.5 Alternative Crossing Location (1)

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

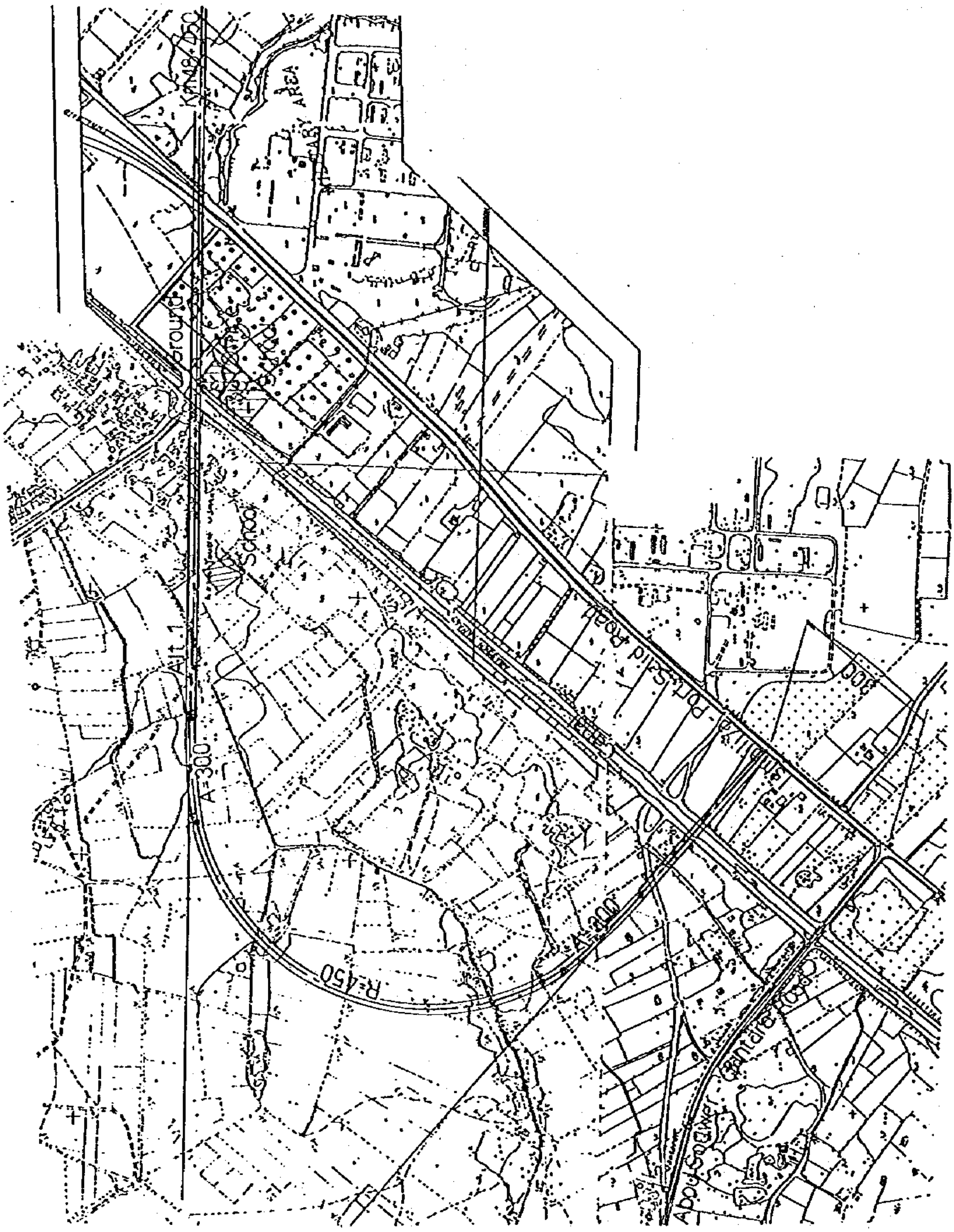


Fig. 10.2.6 Alternative Crossing Location (2)

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

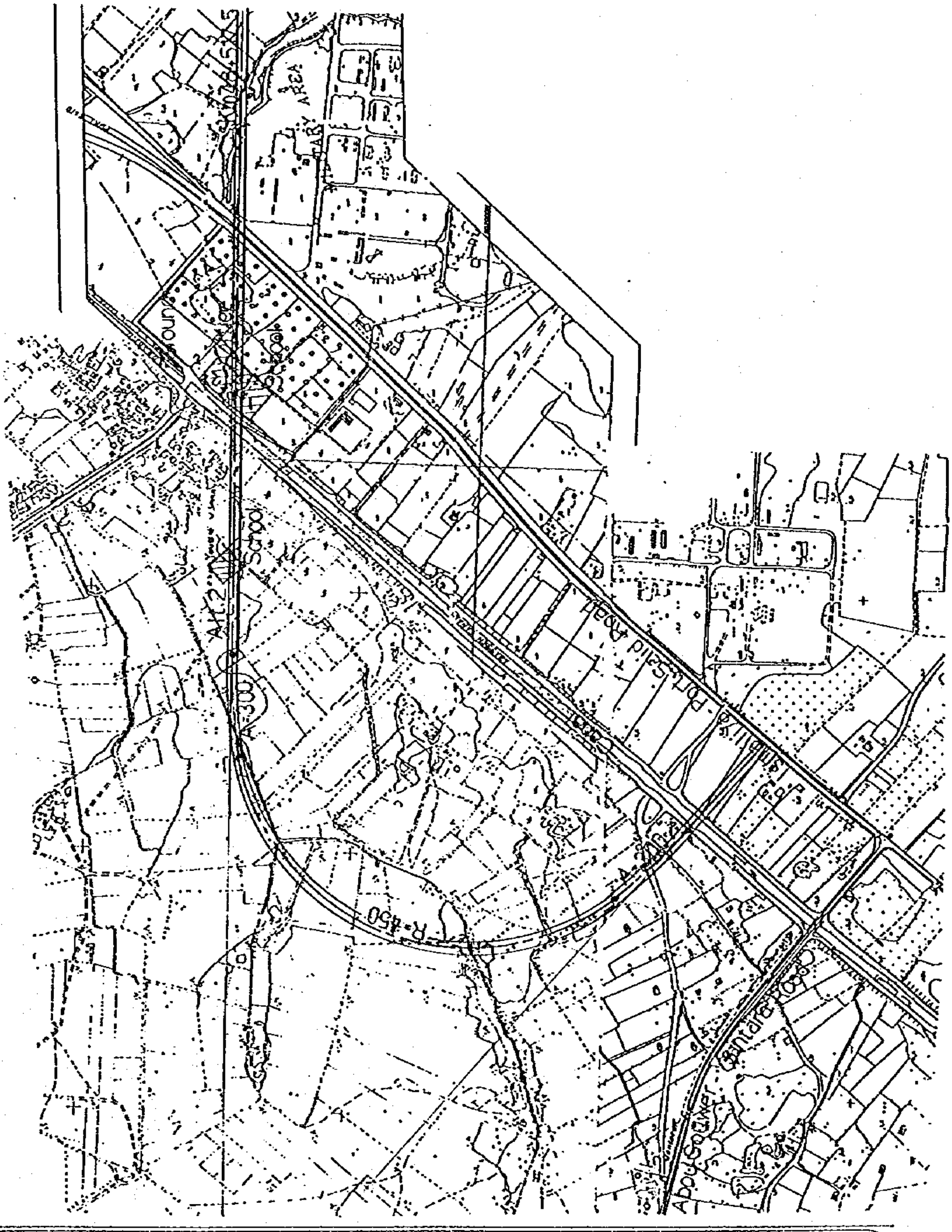


Fig. 10.2.7 Alternative Crossing Location (3)

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

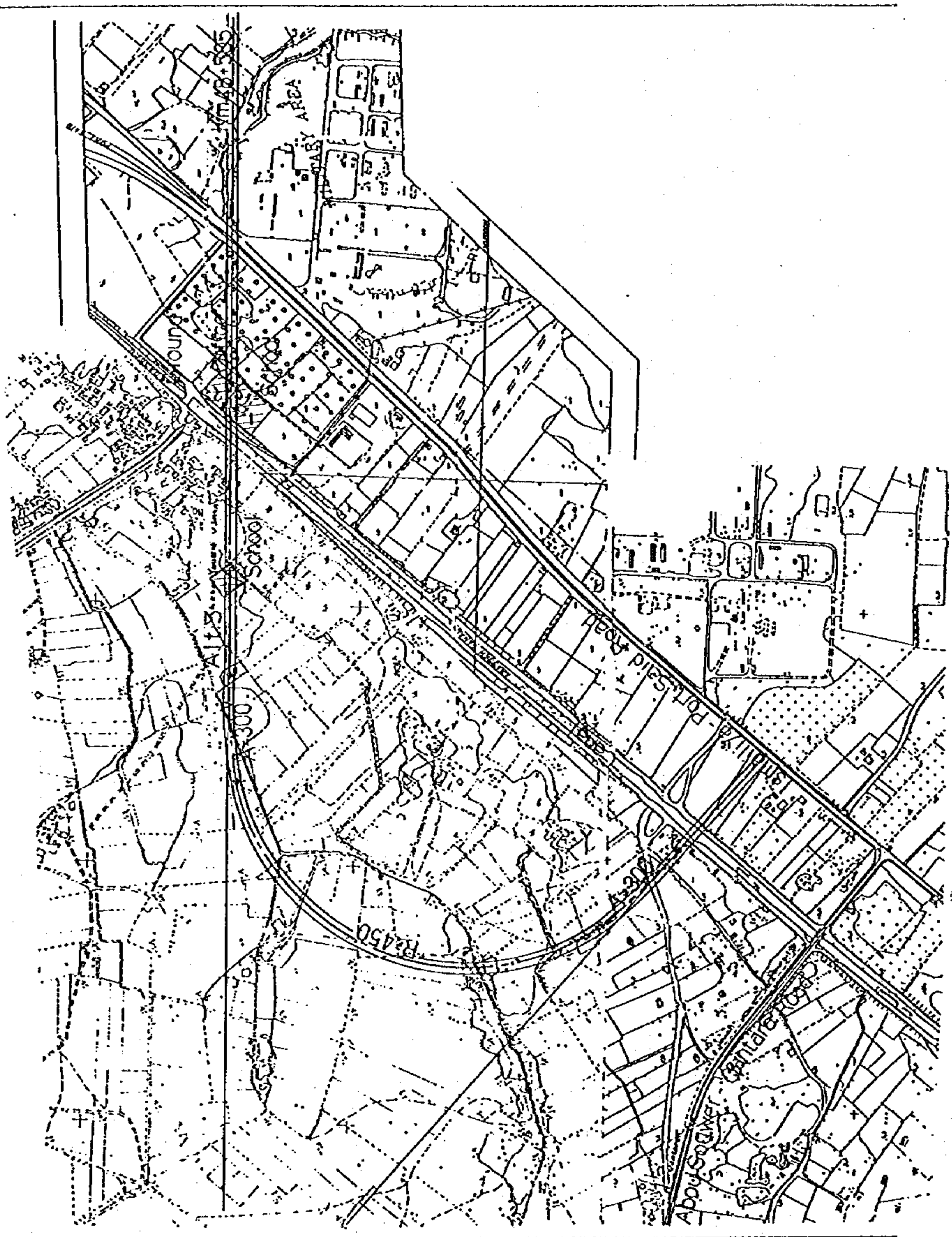


Fig. 10.2.8 Alternative Crossing Location (4)

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

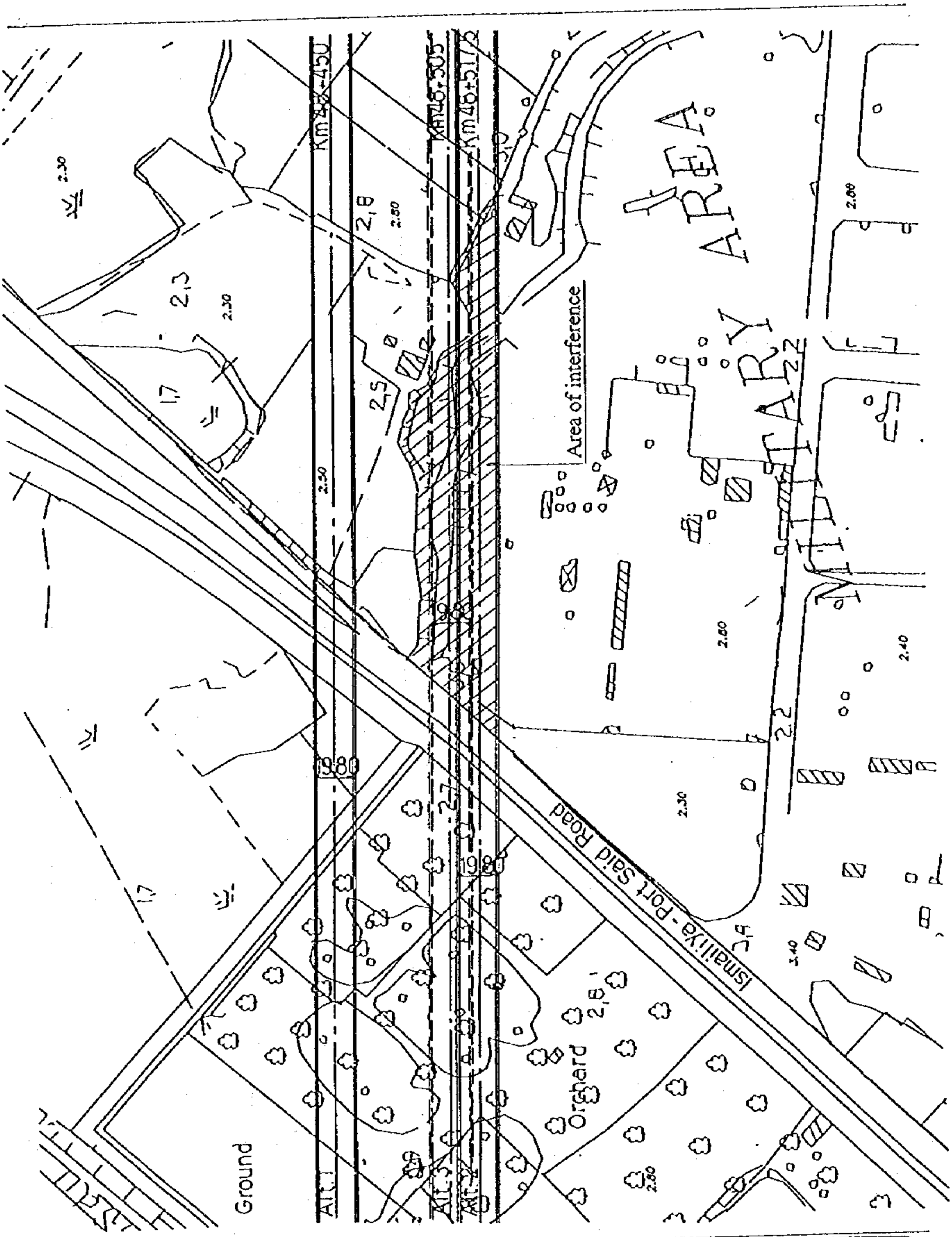


Fig. 10.2.9 Relationship between Road and Constraints (1)

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

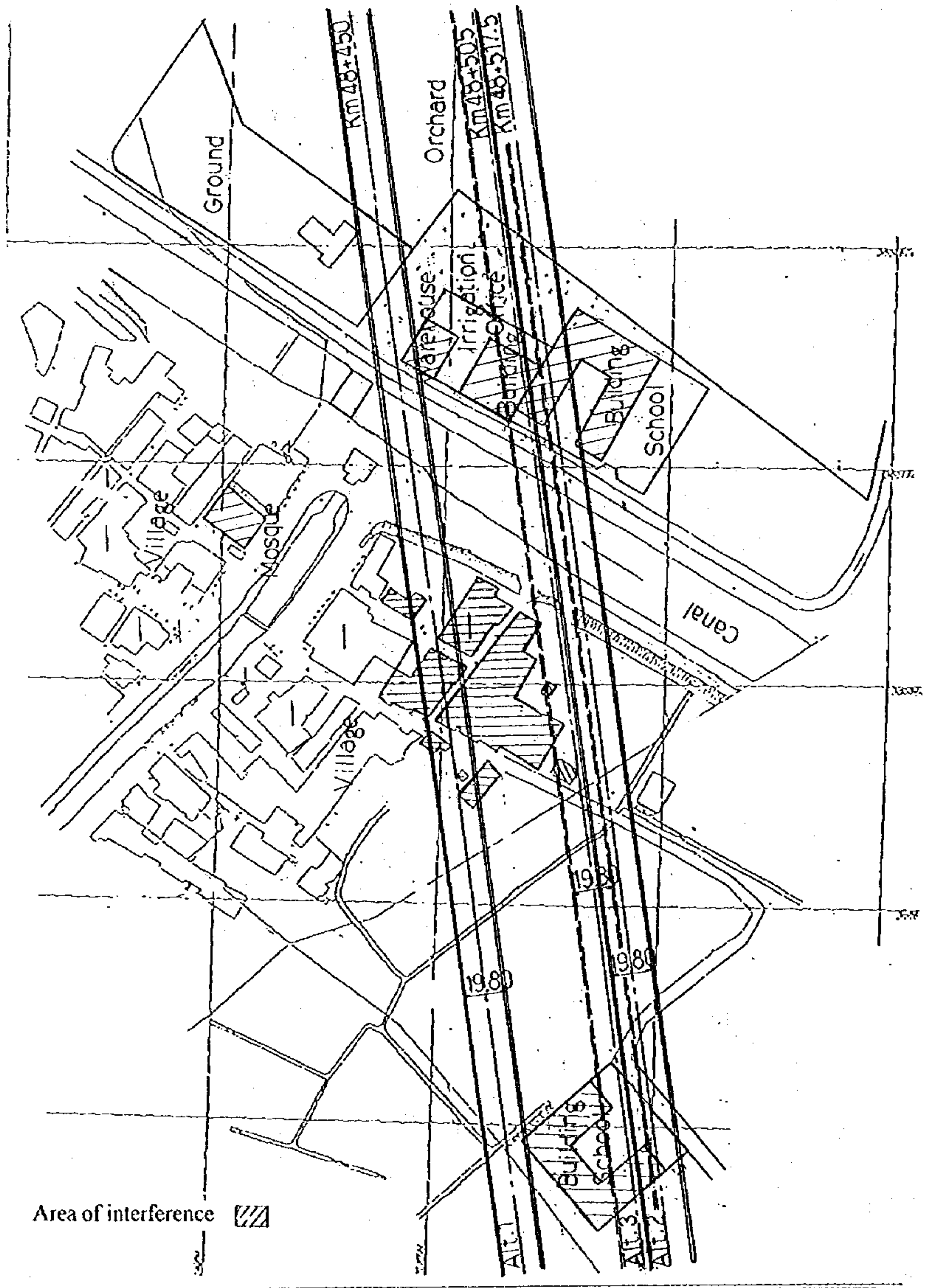
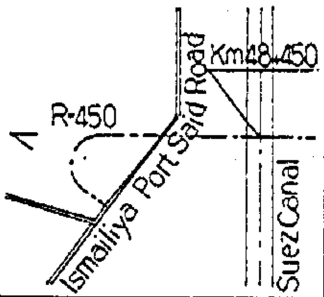
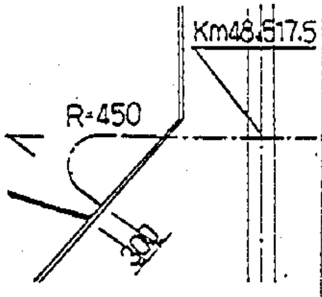
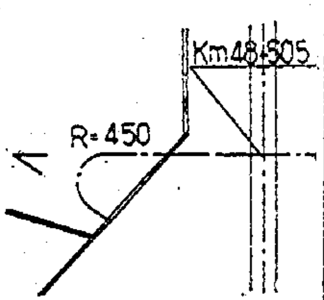


Fig. 10.2.10 **Relationship between Road and Constraints (2)**

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

Table 10.2.1 Comparison of Alternatives for Road Crossing

Alternatives	Horizontal Alignment	Length of Road (m)	Comments	Evaluation: Horizontal Alignment	Evaluation: Constraints: School West	School beside Canal	Irrigation Office	Orchard	Village	Ground	Irrigation Canal	Military Area	Priority
Alternative 1 Km. 48 + 450 (Straight)		3,750	The road crossing the Canal will cross the Suez Canal at SCA Km. 46 + 450. Passing over the important public institutions is avoided at this location. The road crossing is straight in the approach viaduct section.	Good 450m Radius	Good	Good	Medium	Medium	Poor (Demolish 7 houses)	Medium	medium (Close to a bridge and gate)	Good	Medium
Alternative 2 Km. 48 + 517.5 (Straight)		3,600	The road crossing the Canal will cross the Suez Canal at SCA Km. 46 + 517.5 to avoid the demolition of private houses on the west of the irrigation canal. The road crossing is straight in the approach viaduct section.	Good 450m Radius	Poor	Poor	Poor	Poor	Good	Good	Good	Poor	Medium
Alternative 3 Km. 48 + 505 (Straight)		3,650	The road crossing the Canal will cross the Suez Canal at SCA Km. 46 + 505 to minimize the military area crossing by the road and demolition of private houses. The road crossing is straight in the approach viaduct section.	Good 450m Radius	Poor	Poor	Poor	Poor	medium (Demolish 2 houses)	Good	Good	Medium	High

Source : JICA Study Team

(shaded) : Critical Factors

10.2.2 Vertical Alignment

(1) Critical Height

1) Height of Crest

The clearance provided between the proposed elevation of the road and the outer limit of the navigation clearance envelope of the Suez Canal will be about 3.0 m taking into consideration the girder depth and the deflection of the main bridge. The elevation of the crest of the road will be decided by the above clearance and the vertical grade. (Refer to Fig. 10.2.11)

The proposed elevation at the outer limit of the navigation clearance envelope

PHo = 73.752 m

The proposed elevaiton of the crest PHc = 80.088 m → PHc = 80.100 m

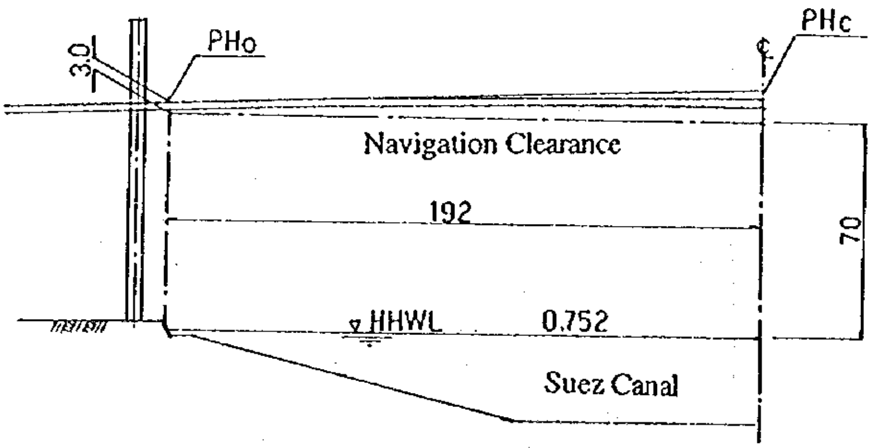


Fig. 10.2.11 Relationship between Proposed Elevation and Navigation Clearance

2) Height of Access Road

The elevation of the access roads will be decided taking into consideration the following factors.

- The height of the connecting roads which are the Cairo - Ismailiya - Port Said Road on the West Bank and the New Central Road on the East Bank is about 1.5m above the ground level.
- The height of the access road embankment will be 2.0m to 3.0m above the ground level taking account of crossing structures for pedestrians and irrigation.

Therefore the proposed elevation of the access road are 4.0m on the West Bank and 2.5m on the East Bank.

(2) Vertical Grade

A constant vertical grade will be adopted for both sides of the elevated sections of the Canal road crossing based on the results of the studies for the vertical grade in Paragraph 6.5.1.

Vertical grades of 3.3 % and 4.0 % have been studied in order to determine the appropriate grade of the Canal road crossing. (Refer to the Appendix A10.1.4)

As a result of this study, a vertical grade of 3.3% was selected because of the resultant smoother traffic flows taking account of the characteristics of Egyptian vehicles. In addition when considering the heavy vehicle ratio about 1 in 5 on the road crossing, and the environmental issues of the road, including noise and air pollution, a vertical grade of 3.3% is preferable. (Refer to Paragraph 4.1.3 and 15.3.3)

10.3 Plan and Profile

The plan and profiles of the road crossing the Suez Canal have been determined based on the studies in Paragraphs 10.1 and 10.2, and the proposed plan and profiles are shown in Fig. 10.3.1 and Fig. 10.3.2.

10.4 Embankment

10.4.1 Maximum Height

The maximum height of the approach embankments will be determined by the two key factors of stability and the site conditions along the approach embankment alignment on each side of the Canal.

(1) Stability of Embankment

The two conditions controlling stability of embankments which have been studied are slope failure and bearing capacity of the ground.

Refer to the Appendix A10.2 for details of this study.

1) Slope Failure

Safety factors for slope failure with embankment heights of 10m on the West Bank and 20m on the East Bank were calculated. The result of these calculations are as follows;

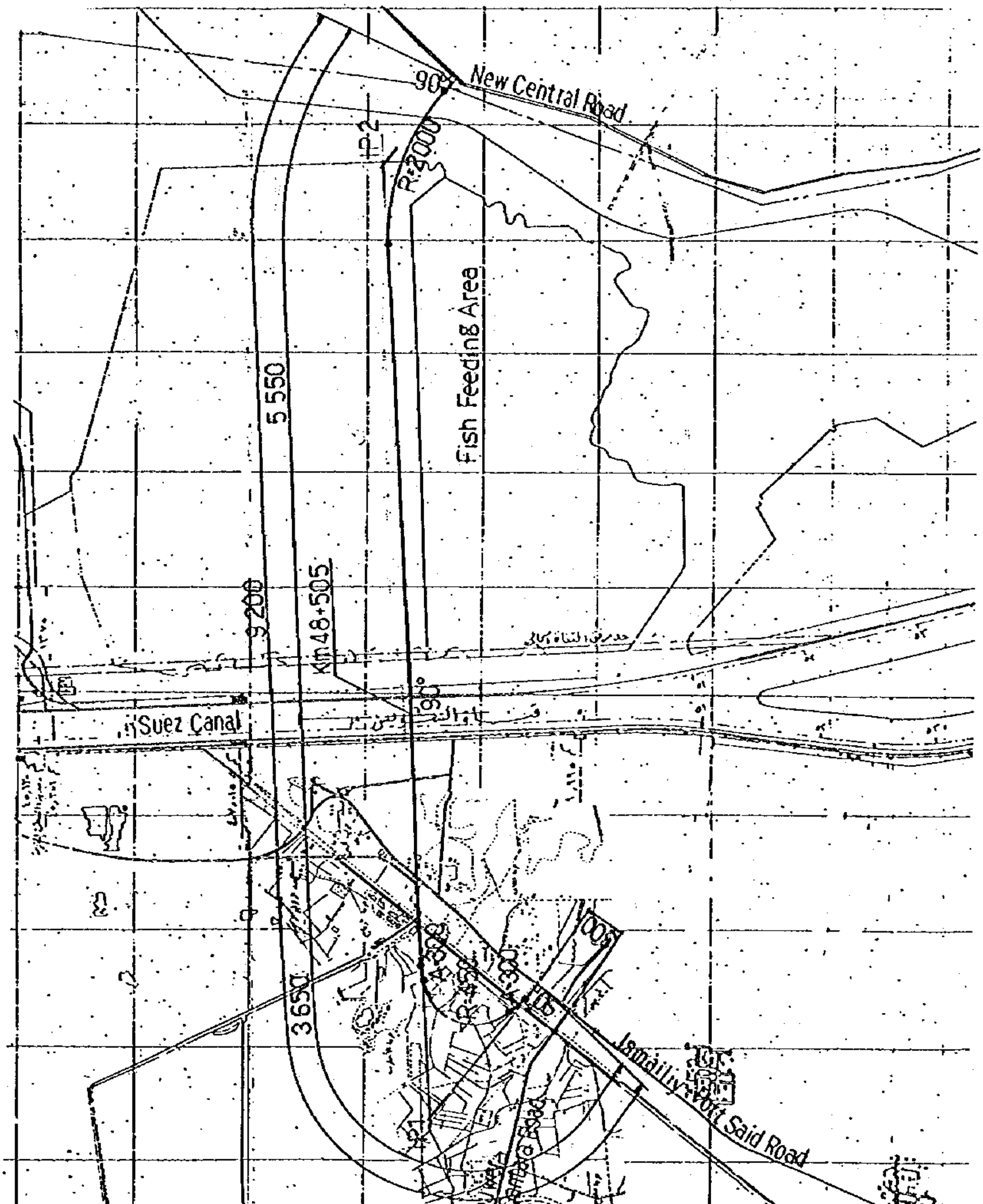


Fig. 10.3.1 Plan of the Canal Road Crossing

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

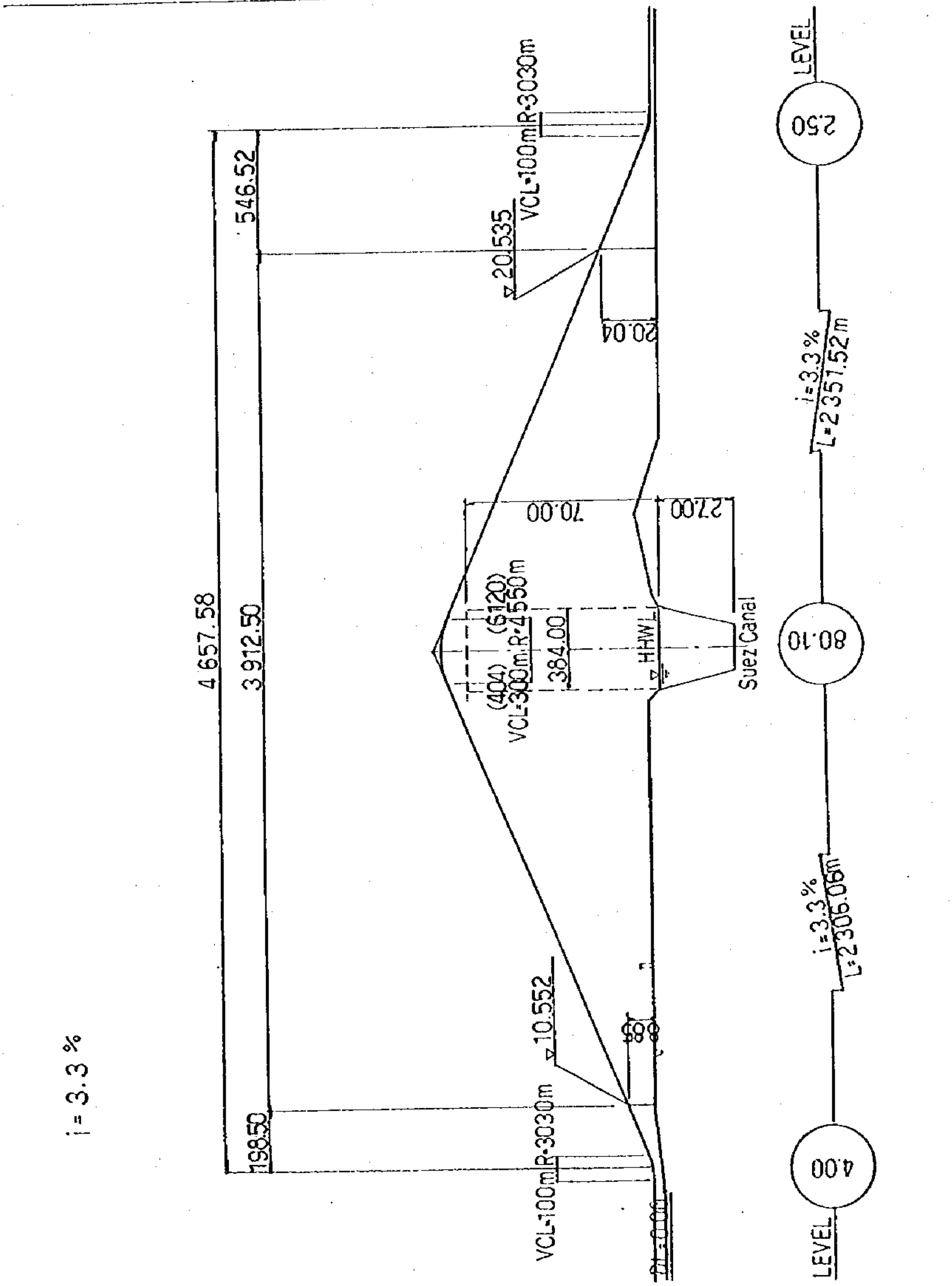


Fig. 10.3.2 **Vertical Grade of the Canal Road Crossing**
(Vertical Grade of 3.3%)

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

- Assuming the internal angle of friction of the embankment is 35 degrees, the safety factor for shallow surface failures is greater than 1.2, and
- The safety factor of failures reaching to the ground is greater than 1.5.

The allowable safety factor is 1.2. Thus, the approach embankment heights of 10m on the West Bank and 20m on the East Bank are stable against slope failures.

2) Bearing Capacity

The bearing capacities required for 10m and 20m height embankments are 19t/m² and 38t/m² respectively. The actual bearing capacities of the ground have been estimated to be 20t/m² on the West Bank and 40t/m² on the East bank based from the data of the geotechnical investigations. Therefore, the approach embankments of these heights are considered to be stable.

3) Maximum Height

As a result of this study, the maximum heights of the approach embankments will be 10m on the West Bank and 20m on the East Bank.

(2) Site Conditions

1) The West Bank

There is an irrigation canal, schools and private houses near the proposed location of the bridge abutment. In order to minimize the demolition of these institutions and buildings, the abutment should be situated to the west of the school or village to the west of the irrigation canal. This will reduce the height of the approach embankment to less than 10m on the West Bank.

Refer to the Appendix A10.2 for further information.

2) The East Bank

There are no facilities which will influence the height of the approach embankment on the East Bank.

(3) Maximum Height

As a result of the study, the maximum heights of the approach embankments will be less than 10m on the West Bank and about 20m on the East Bank.

10.4.2 Material and Structure

(1) Material

In order to ensure the stability of the approach embankments, an internal angle of friction of 35 degrees is required in the shallow surface sections of the embankments. Therefore, unscreened gravel and gravely soil or fine sand from a quarry for the critical sections of the embankment, such as the toes and surfaces of slopes, and sand around the site will be used for the other parts of the embankment.

The materials of the approach embankment will be fully selected after further studies in the detailed design.

(2) Structure

In order to ensure the stability of the approach embankments, the structure of the embankments will be further studied in the detailed design. An example of an embankment structure is shown in Fig. 10.4.1.

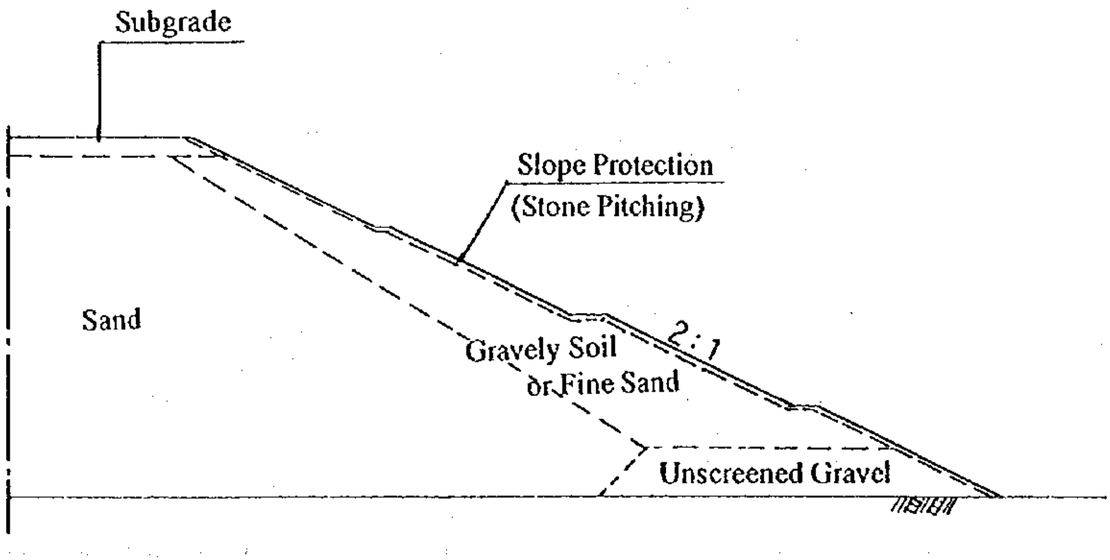


Fig. 10.4.1 Structure of Approach Embankment

10.4.3 Side Slope

As a result of the embankment stability calculations, the inclination of the approach embankment slopes should be 2:1 to ensure the stability of the embankments.

The inclination of 2:1 will also be provided for the slope of the access road of which height is about 2.0m to 3.0m based on the Geometric Design Standards in Egypt.

10.4.4 Slope Protection

A slope protection for preventing the slope surface from erosion and weathering is necessary. A stone pitching shown in Fig. 10.7.8 will be provided to protect the surface of embankment by taking consideration of the climate in Egypt and material of embankment.

10.4.5 Pavement Design

Asphalt concrete pavement which is commonly used, will be provided for the pavements of the approach embankments and access roads.

The standard thickness of pavement in Egypt shown in Fig. 10.4.2 will be used for the pavements of the road crossing the Canal in the feasibility study. The actual thickness of pavement will be determined by further study based on the results of the detailed geotechnical investigation in the detailed design.

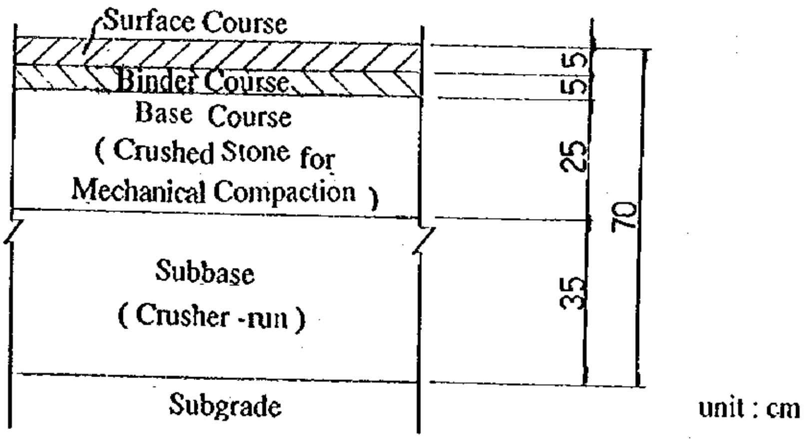


Fig. 10.4.2 Structure of Pavement

This thickness of pavement is for the feasibility study and the actual thickness will be calculated and decided based on the Egyptian standards and American standard (AASHTO) in the detailed design. The thickness designed will be reviewed based on the actual CBR from the field tests during the construction.

10.5 Road Facilities

10.5.1 Drainage

Taking account of the climate in Egypt, full drainage facilities are not required because the precipitation at the site is very low.
However, toe drains will be provided for embankments to drain any rain water, water for road cleaning and any other water. Water on the road surface will be drained via the shoulders. (Refer to Fig. 10.7.4 to Fig. 10.7.6)

10.5.2 Lighting System

A lighting system will be provided for traffic safety and to encourage smooth traffic flows at night. Lighting poles will be installed on both sides of the road at 20m intervals on the approach embankments and access roads.

The necessary level of lighting to maintain safe and smooth traffic flows, and the type and structure of lighting poles will be fully studied and selected in the detailed design.

10.5.3 Traffic Safety Facilities

In order to maintain safe traffic operation and to minimise traffic accidents, traffic safety facilities such as curbstones, traffic islands, traffic barriers and pedestrian subways should be provided for the new road crossing.

The types and details of these facilities will be fully examined and determined in the detailed design.

10.5.4 Traffic Management Facilities

Traffic management facilities including traffic signs, road markings, emergency telephones, road information boards and observation facilities will be provided to encourage smooth and traffic flows and to reduce traffic accidents. Installation of traffic lights at the intersections between the new road crossing and the Cairo - Ismailiya - Port Said Road and the New Central Road are also to be considered.

The types and structures of these facilities will be studied fully and decided in the detailed design.

10.5.5 Toll Collection Facilities

In case of a toll road, toll collection facilities are provided in the access road section of the road crossing the Suez Canal.

The toll collection facilities consist of toll gates, a toll collection office and appended facilities such as an electric room, warehouses, parking lots and others.

A site area of a toll collection office is expected to be 3,000 m² to 5,000 m² in general. Therefore, the toll office will be provided on the East Bank taking into consideration of easier land acquisition. The toll fees of vehicles heading both directions will be collected at this toll office.

The toll collection system, numbers of the toll gates and the size and arrangement of the toll collection facilities will be studied in detail in the detailed design.

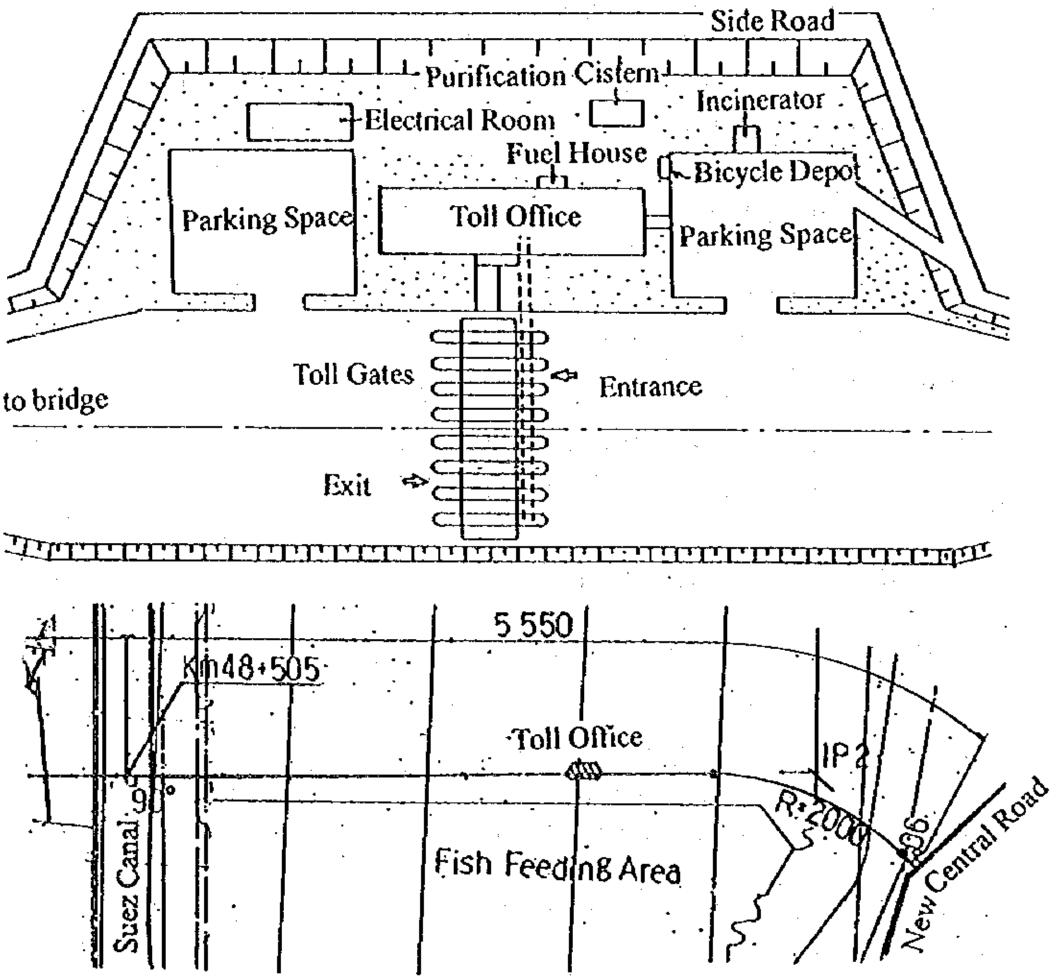


Fig. 10.5.1 Arrangement of Toll Collection Office (Example)

10.6 Miscellaneous

10.6.1 Crossing Structures

In order to maintain waterways for cultivation and access routes for the local people around the new road, pipe culverts for irrigation waterways and box culverts shown in Fig. 10.6.1 for small vehicles and pedestrians will be provided in the approach embankments and access roads on the West Bank.

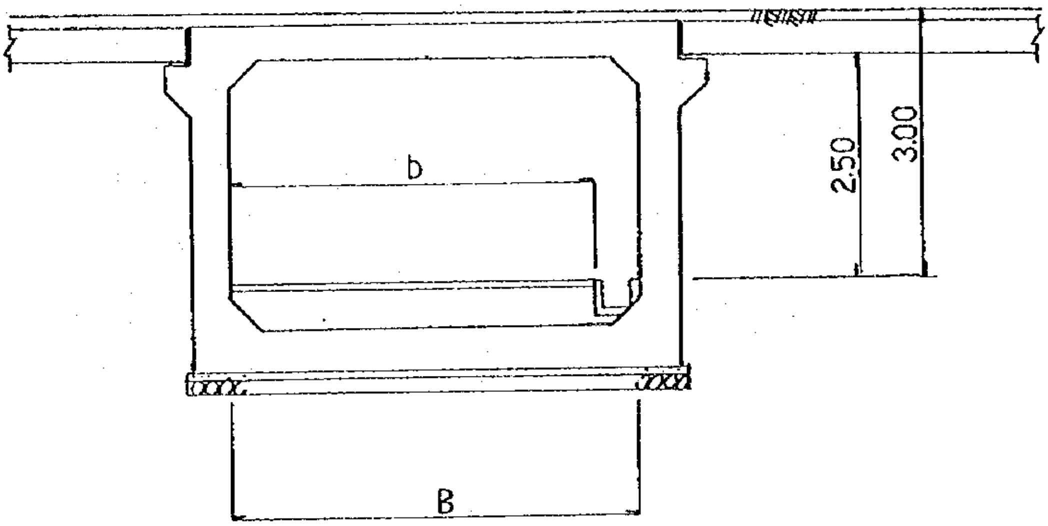


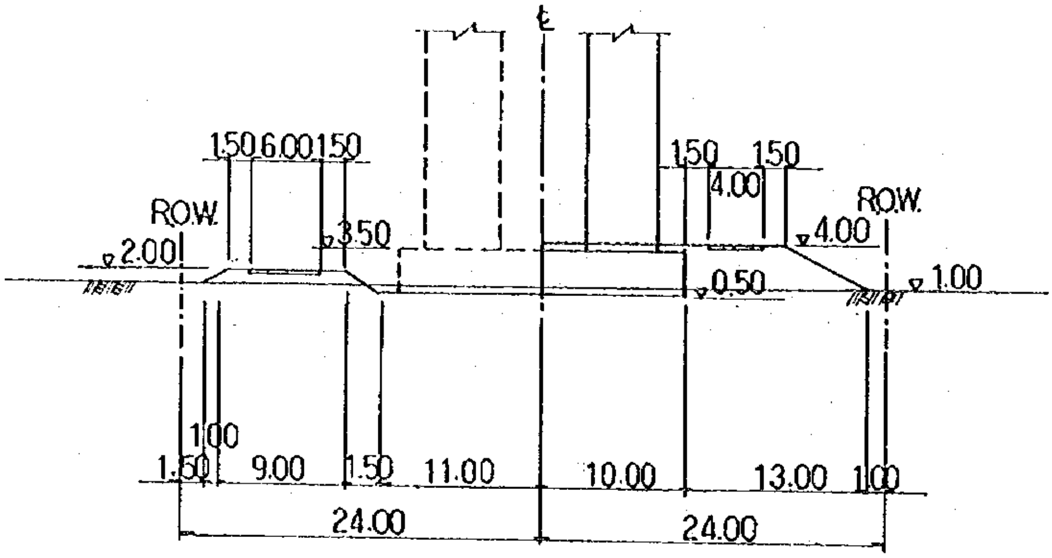
Fig. 10.6.1 Section of Box Culvert

10.6.2 Intersection Planning

The intersections between the new road and the Cairo - Ismailiya - Port Said Road on the West Bank, and the New Central Road on the East Bank will be fully studied to provide smooth and safe traffic flows in the detailed design (refer to Drawings).

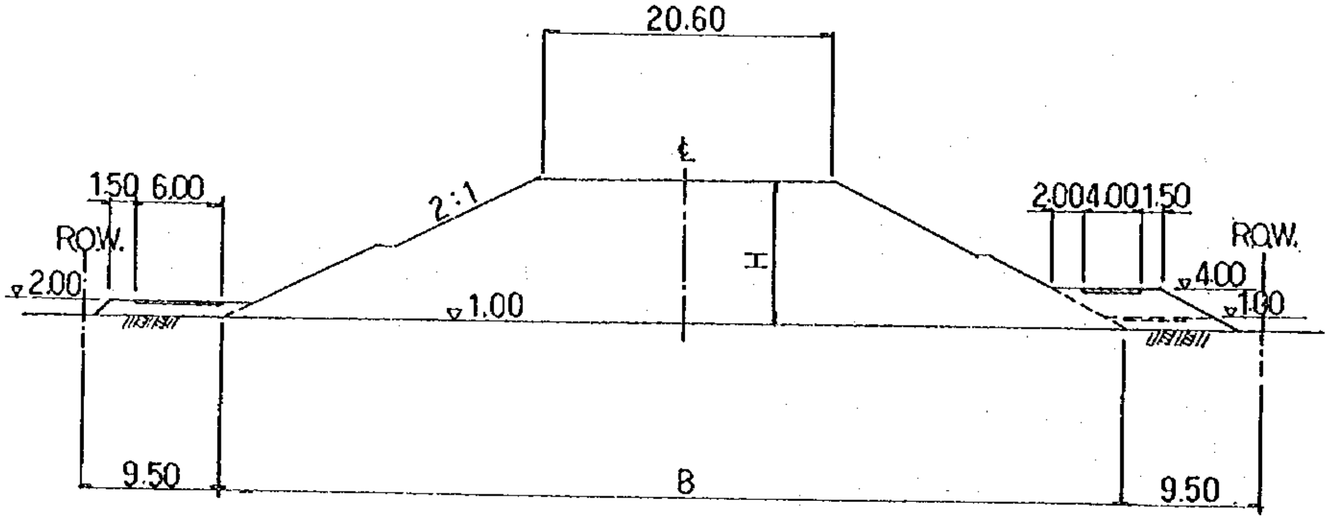
10.6.3 Right-of-Way (R.O.W)

The right-of-way required for the road crossing the Suez Canal is shown in Fig. 10.6.2.



During Construction **After Completion**

Approach Viaduct



During Construction **After Completion**

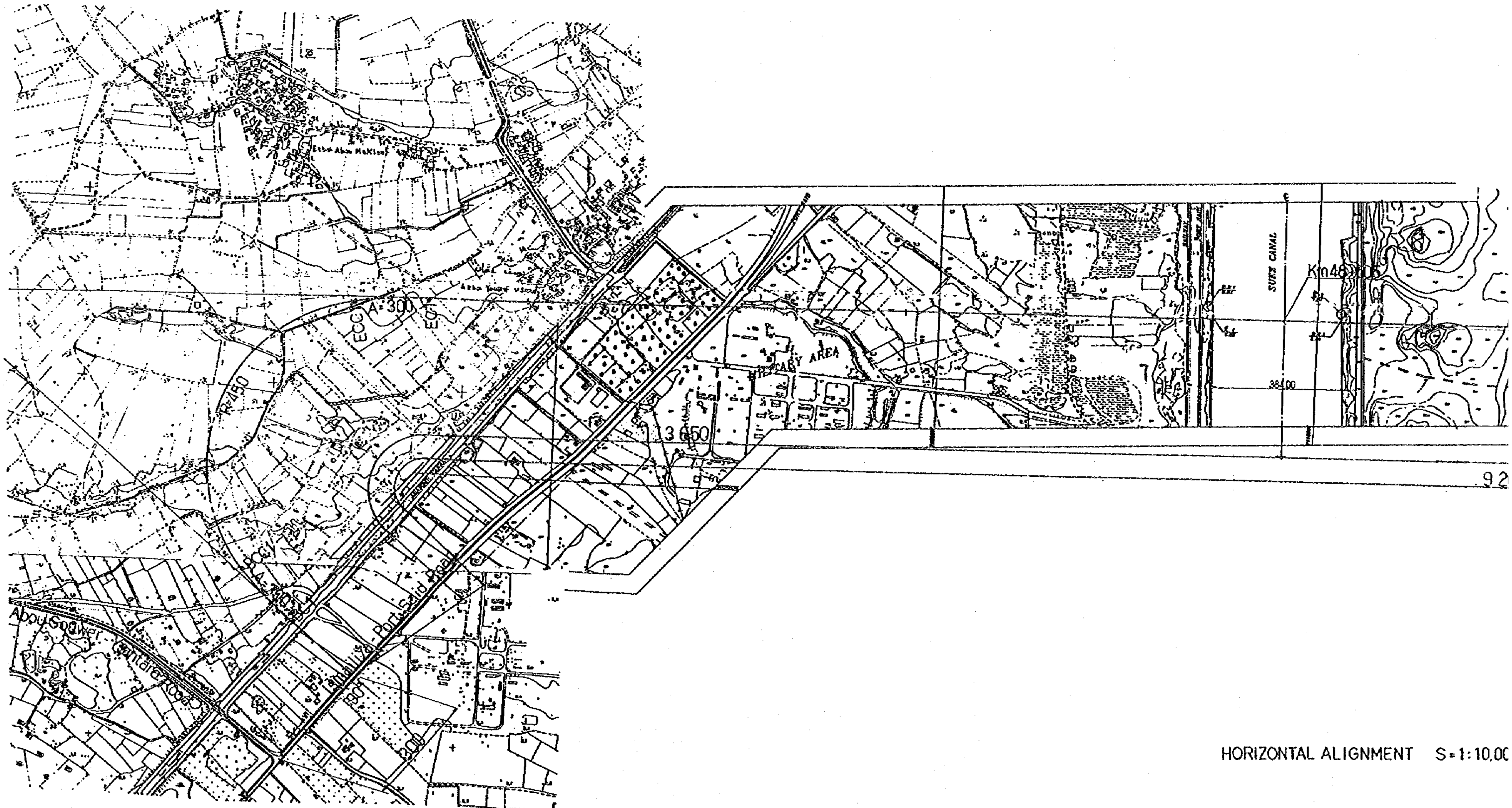
Approach Embankment and Access Road

Fig. 10.6.2 Right-of-Way Required

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

10.7 Drawings and Preliminary Bills of Quantities

10.7.1 Drawings



HORIZONTAL ALIGNMENT S=1:10,0C

Fig. 10.7.1

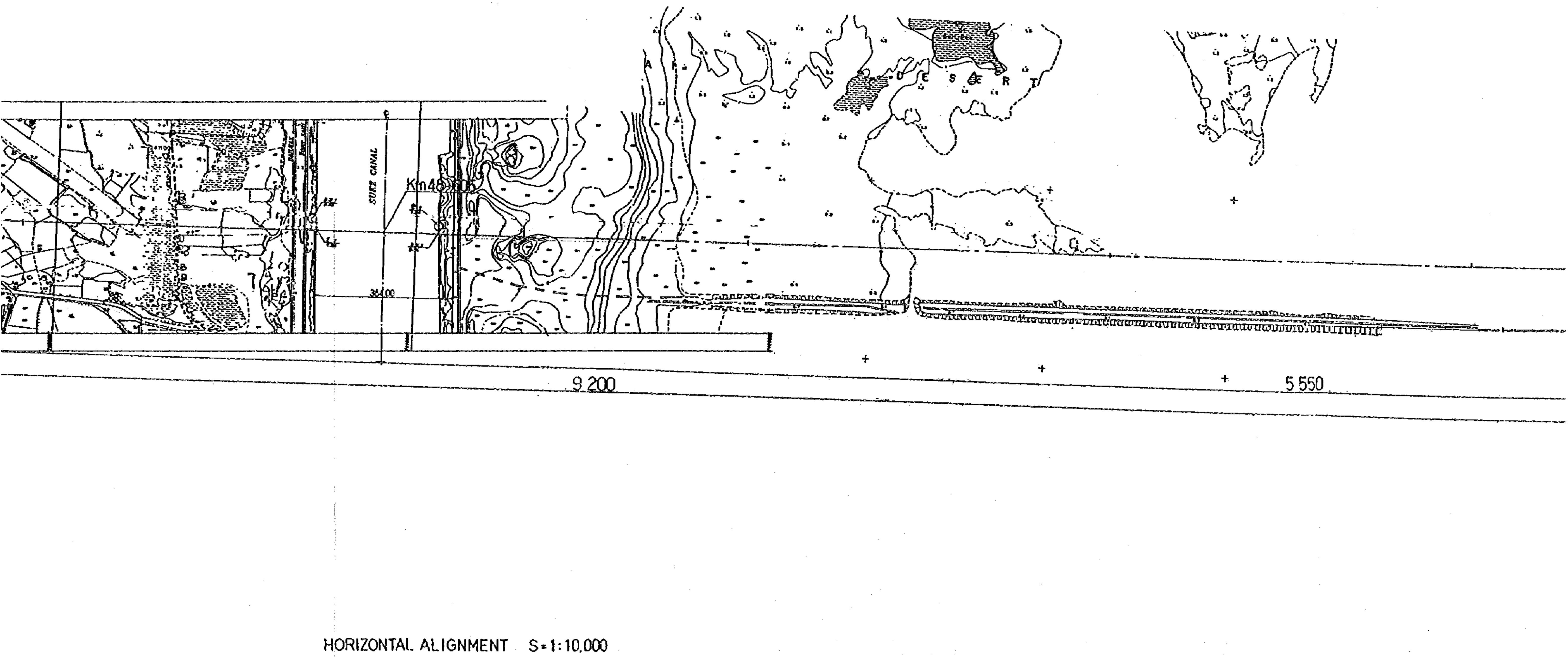
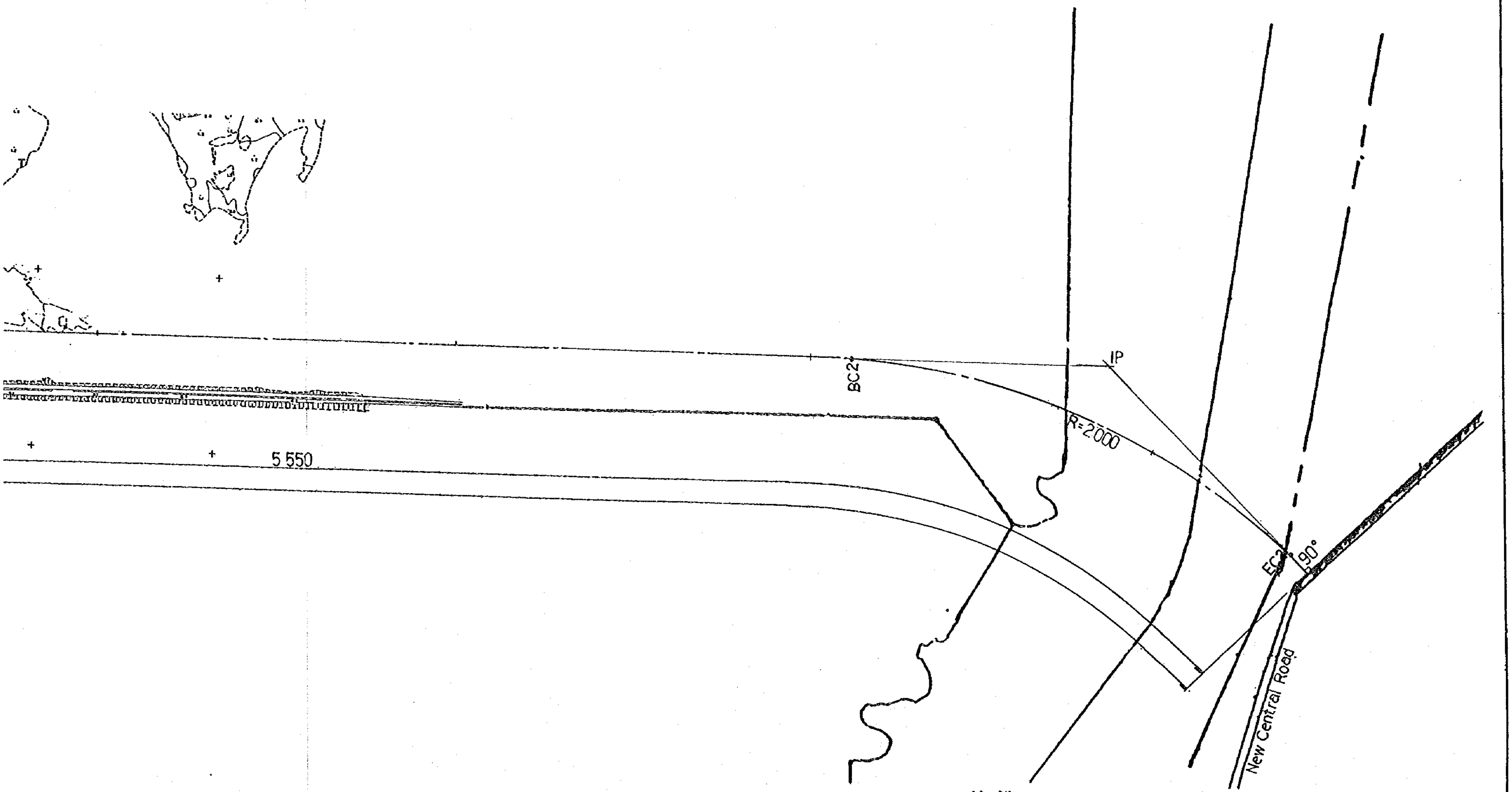
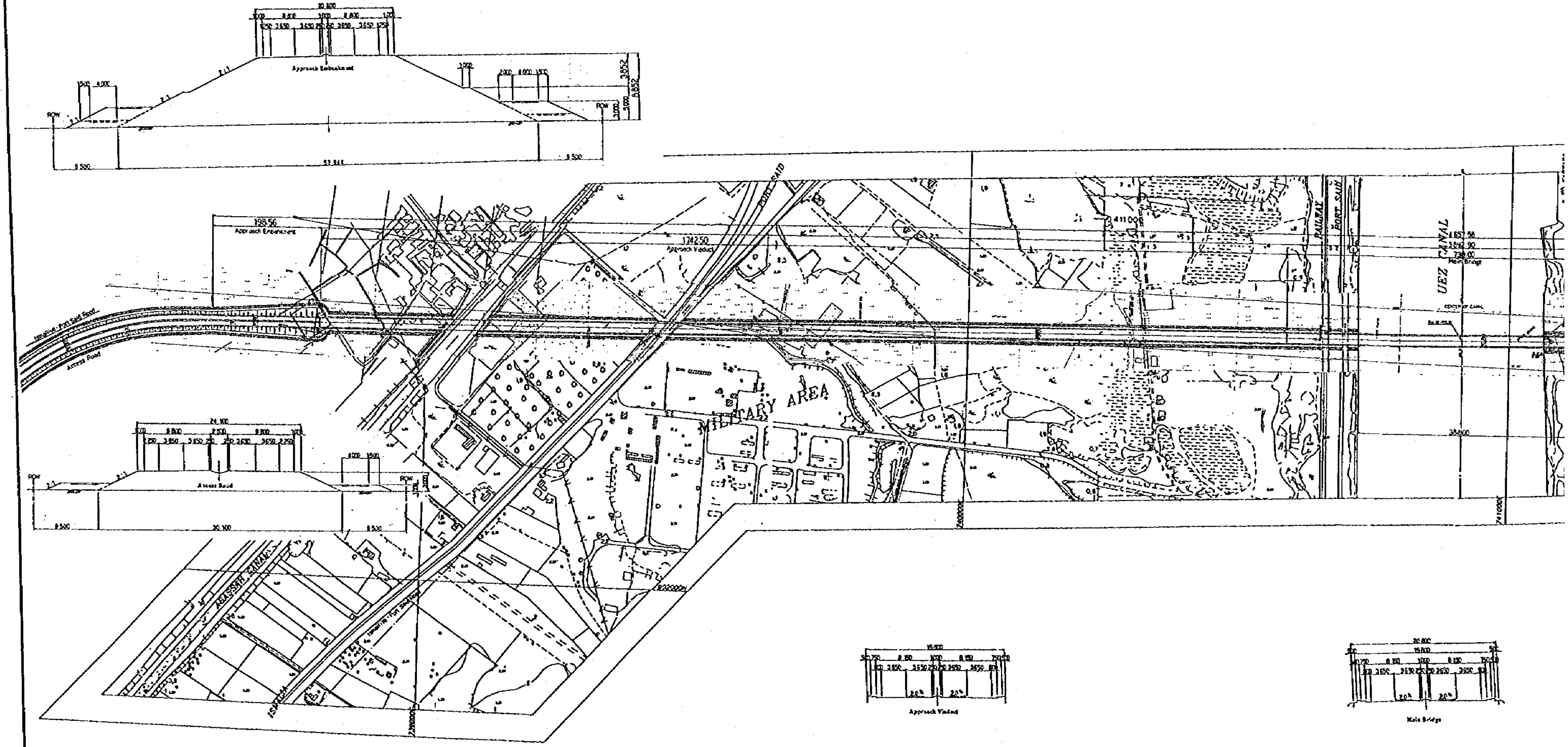


Fig. 10.7.1 Horizontal Alignment

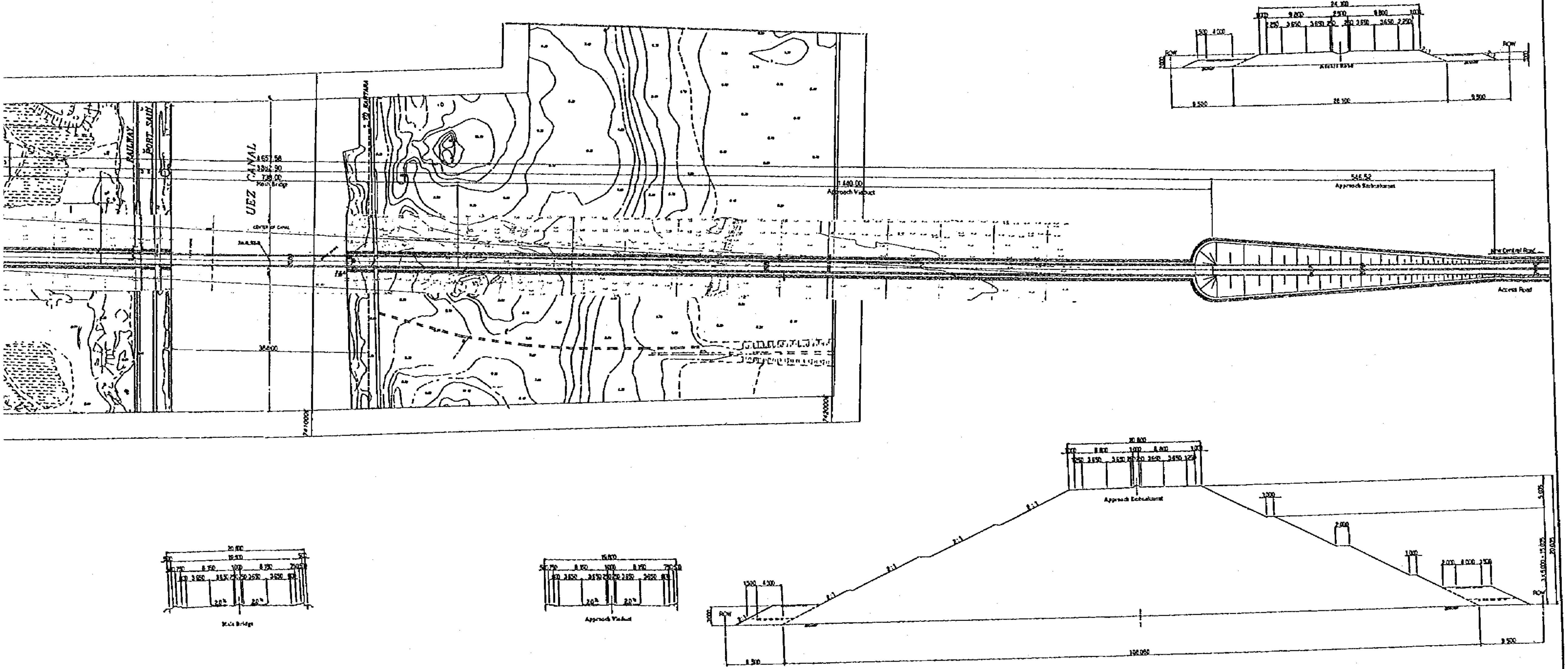


IP
BC2
R=2000
5 550
EC2
90°
New Central Road



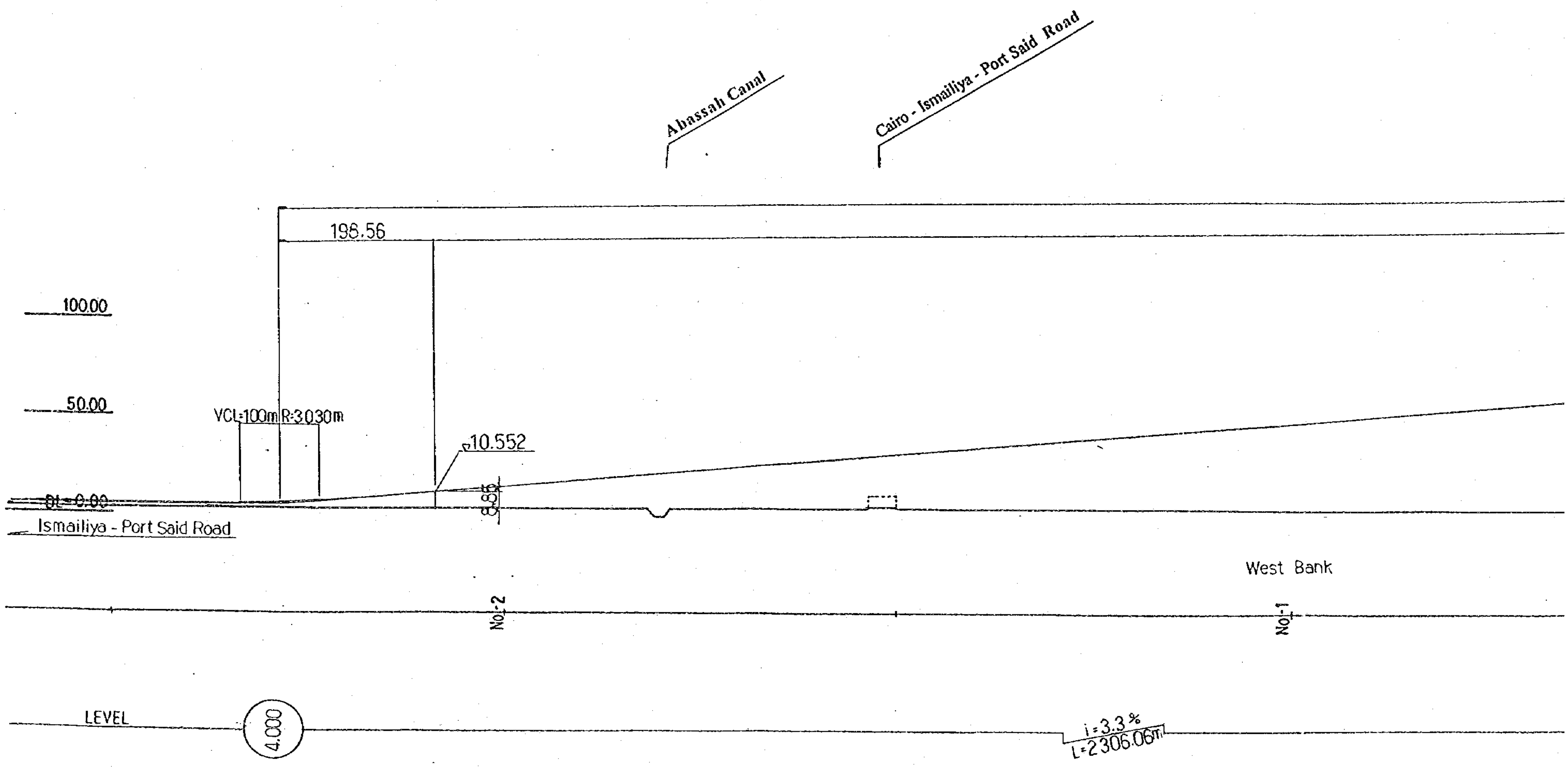
PLAN S=1:2500

Fig. 10.7.2 Plan of Road Crossing t



PLAN s=1:2500

Fig. 10.7.2 Plan of Road Crossing the Canal



Abassah Canal
Cairo - Ismailiya - Port Said Road
196.56
100.00
50.00
VCL=100m R=3030m
▽10.552
DL=0.00
8.85
Ismailiya - Port Said Road
West Bank
No-2
No-1
LEVEL
4.000
i=3.3 %
L=2306.06m

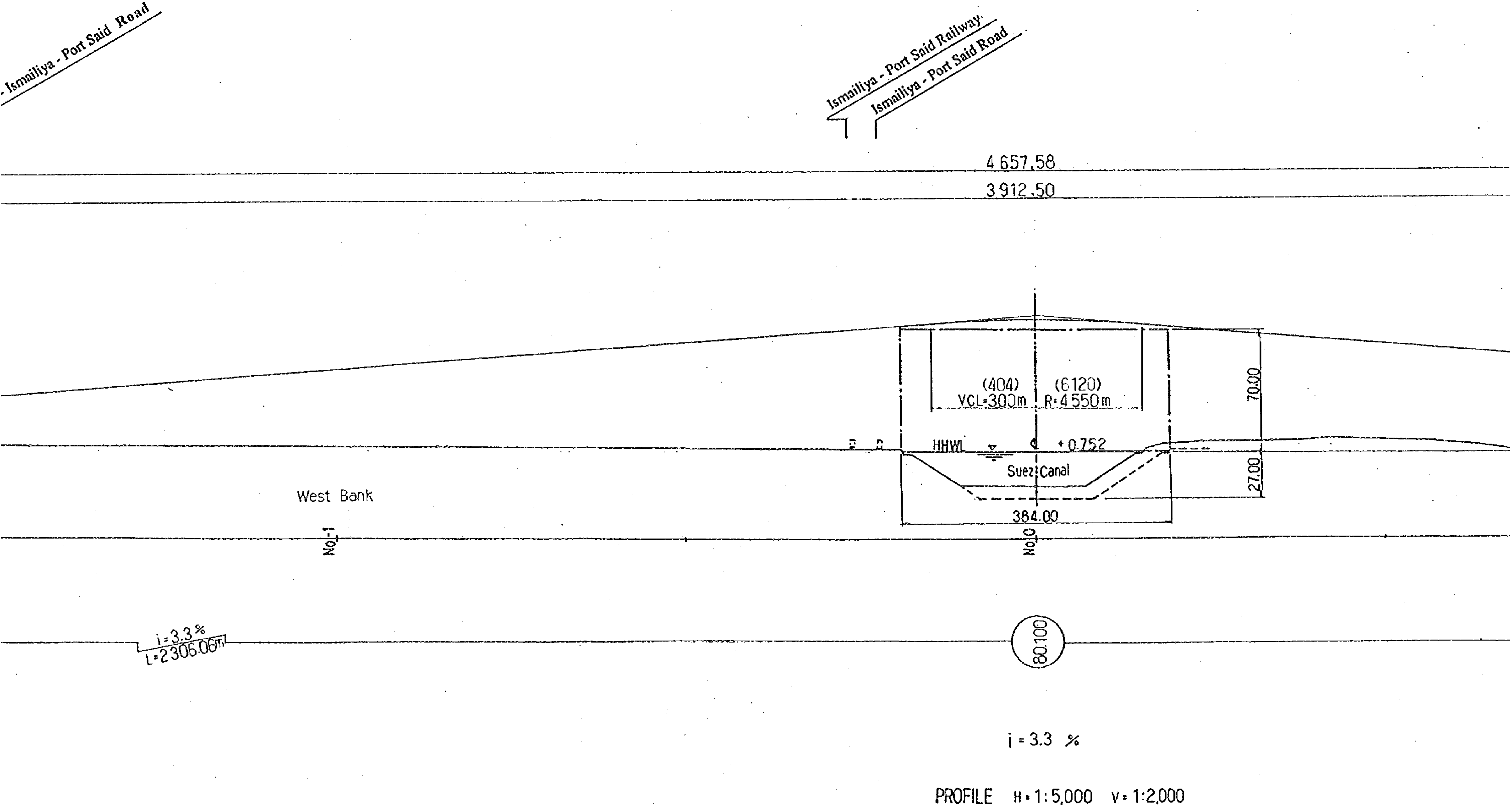
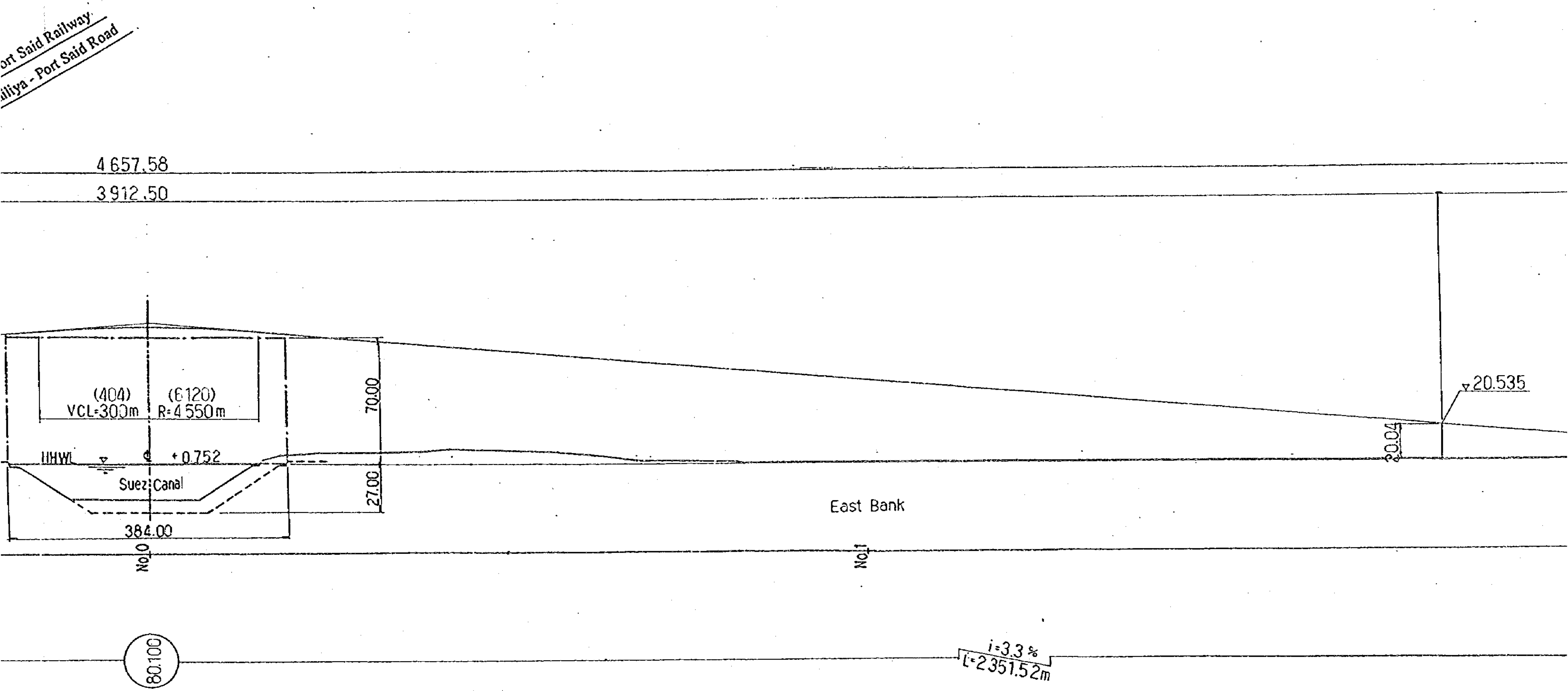


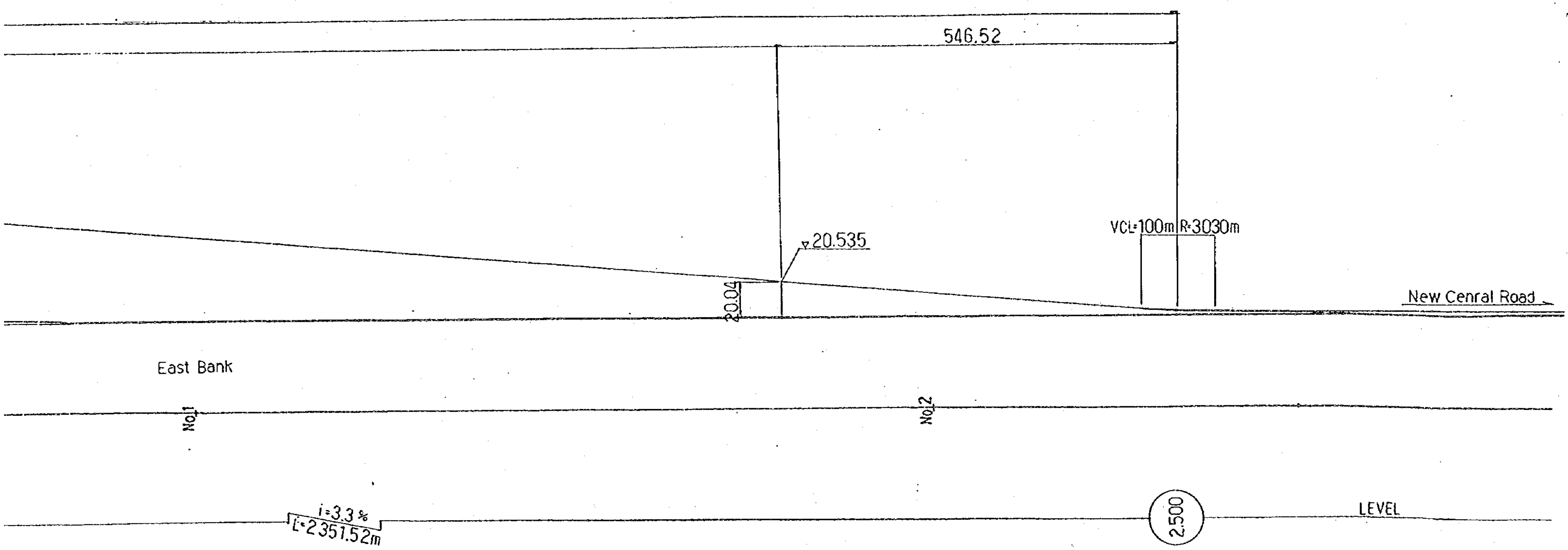
Fig. 10.7.3 Profile of the Road Crossing the Canal



j = 3.3 %

PROFILE H = 1:5,000 V = 1:2,000

10.7.3 **Profile of the Road Crossing the Canal**


546.52
VCL=100m R=3030m
20.535
20.04
New Cenral Road
East Bank
No.1
No.2
i=3.3 %
L=2351.52m
2.500
LEVEL

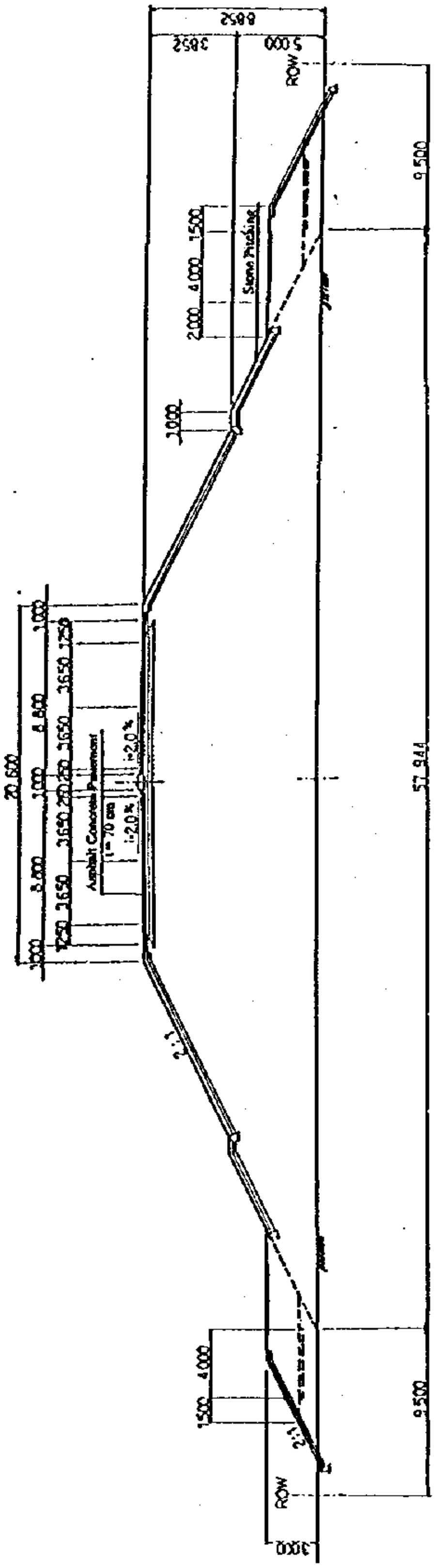


Fig. 10.7.4 **Typical Cross Section of Approach Embankment on the West Bank**

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

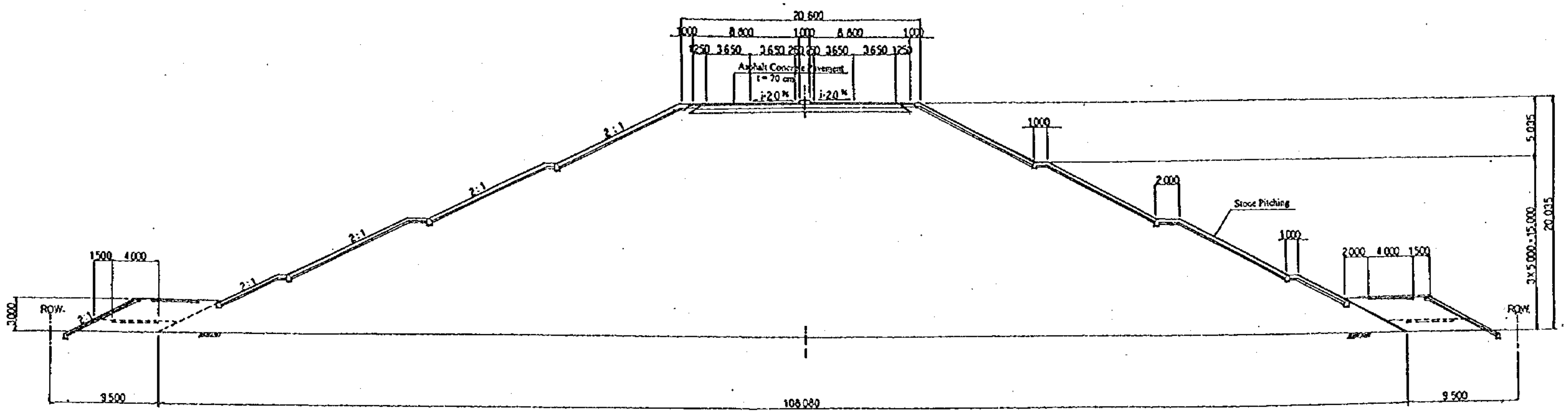


Fig. 10.7.5 Typical Cross Section of Approach Embankment on the East Bank

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

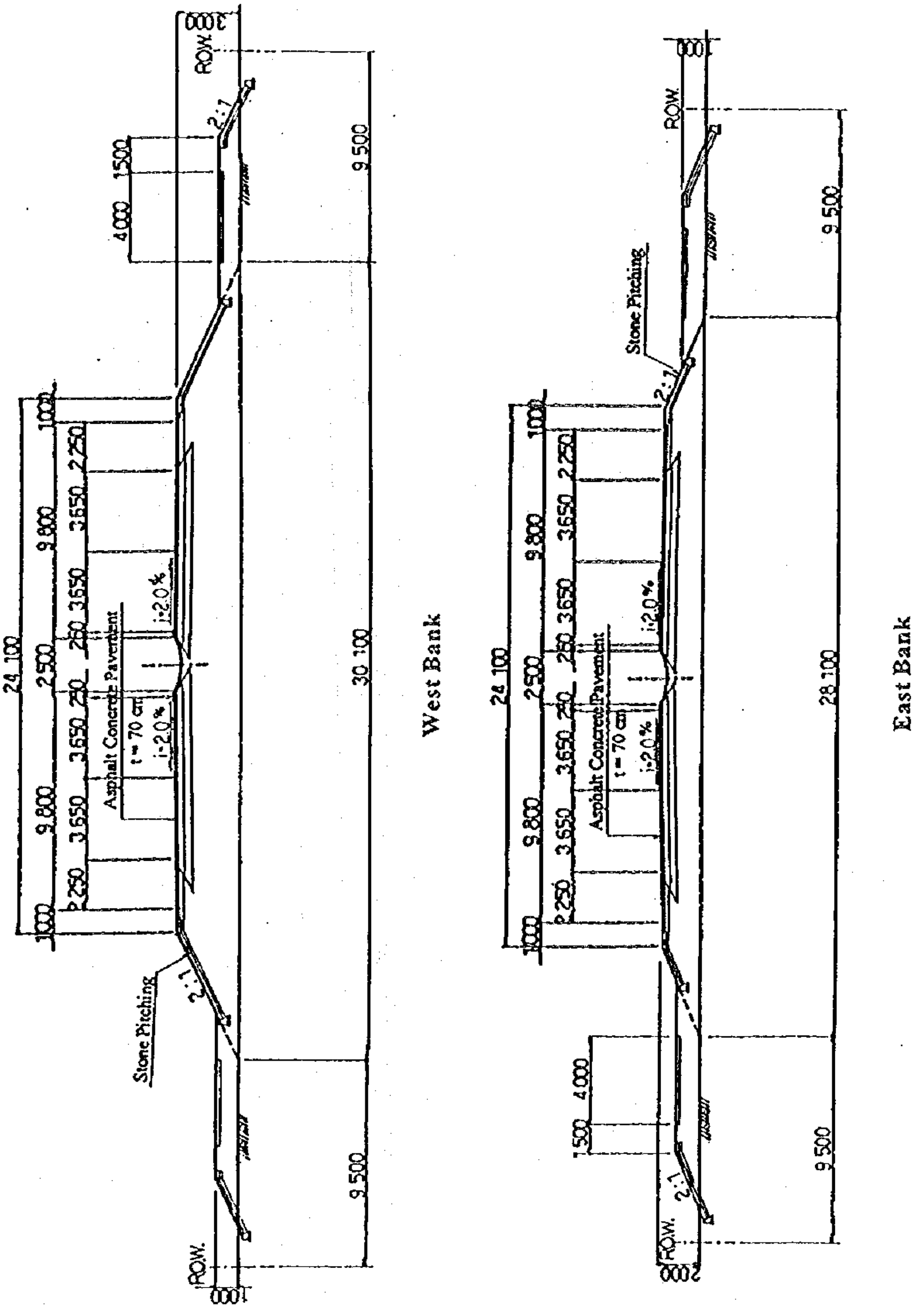


Fig. 10.7.6 Typical Cross Section of Access Road

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

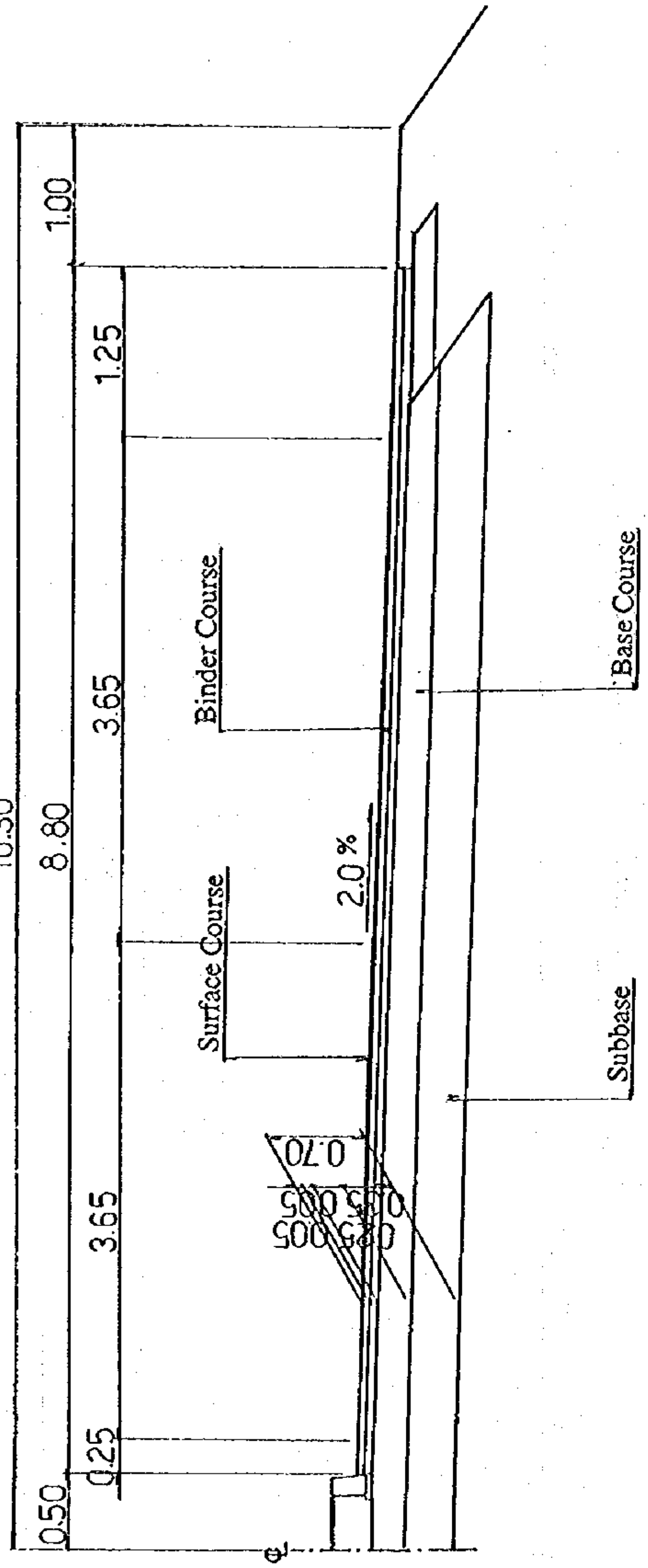


Fig. 10.7.7 Pavement Structure

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

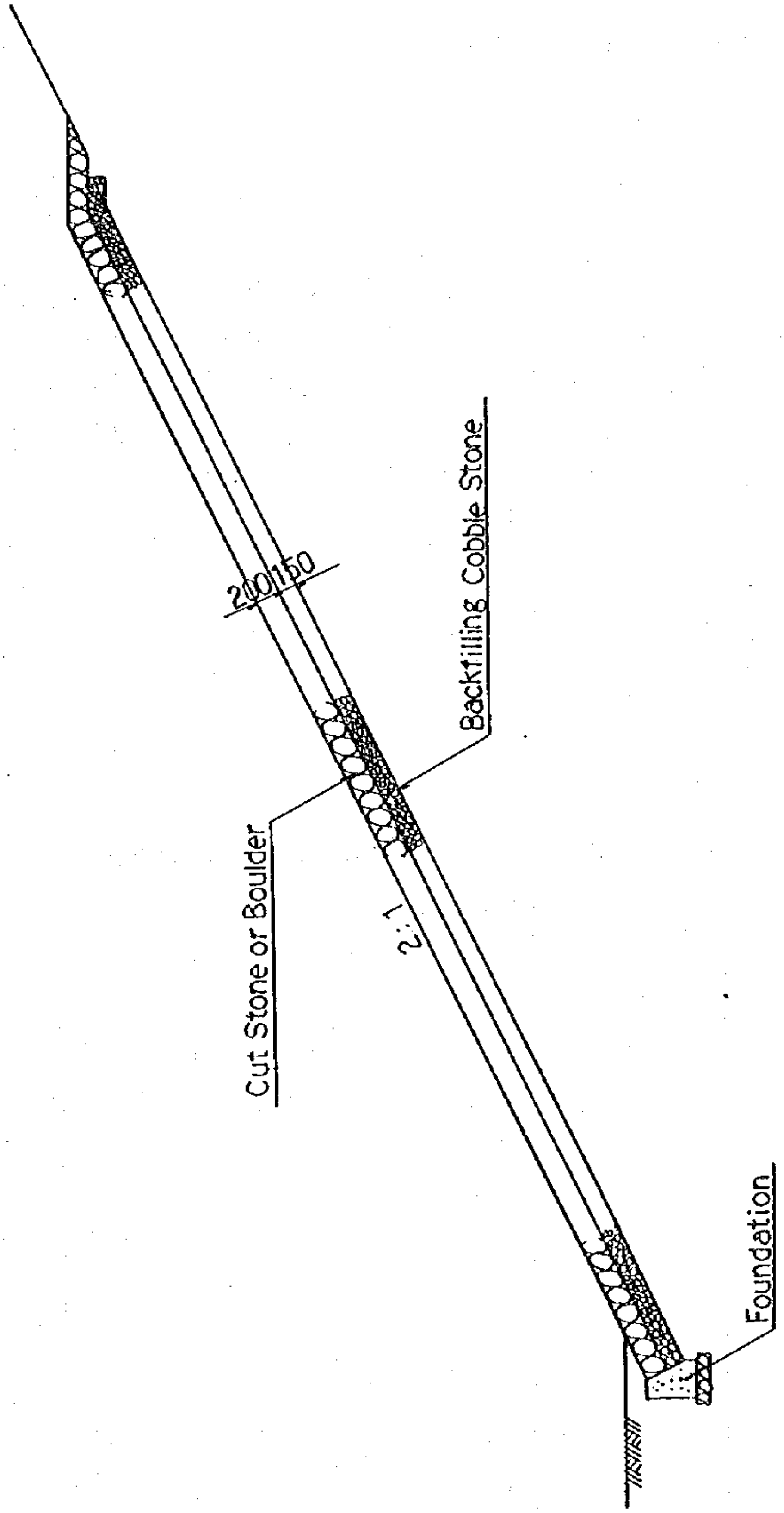


Fig. 10.7.8 Slope Protection (Stone Pitching)

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

10.7.2 Preliminary Tables of Quantities

(1) Approach Embankments

Table 10.7.1 Quantities of Approach Embankments

Items	Description	Unit	Quantities			Remarks
			West Bank	East Bank	Total	
Embankment	Sand and Gravel	m³	47,534.78	394, 974.26	442,509.04	
Slope Protection	Stone Pitching	m³	6,014.84	29,902.15	35916.99	
Pavement	Asphaltic Concrete	m³	3,485.86	9,530.5	13,016.61	T=70cm
Lighting Facility	Lighting Pole	No	22	55	77	20m Interval
Traffic Barrier	Roadside	L-m	436	1,093	1,529	Rigid Type
	Median	L-m	218	547	765	Rigid Type
Drainage	U-gutter	L-m	436	1,093	1,529	Unsupported

Source : Study Team

(2) Access Roads

Table 10.7.2 Quantities of Access Roads

Items	Description	Unit	Quantities			Remarks
			West Bank	East Bank	Total	
Embankment	Sand and Gravel	m³	126,557.95	202,065.20	328,623.115	
Slope Protection	Stone Pitching	m³	16,616.20	25,837.48	42,453.68	
Pavement	Asphaltic Concrete	m³	25,900.40	67,932.60	93,833.00	T=70cm
Bridge	PC Slab Bridge	m³	392.00	-	392.00	B=9.8m×2 L=20.0m
Box Culvert	RC 5.0m×3.0m	m³	799.64	-	799.64	Concrete Vol. : 5 Boxes
Pipe Culvert	RC ϕ1.0m	L-m	600.00	-	600.00	5 Pipes (L=30.0m/each)
Lighting Facility	Lighting Pole	No	135	555	690	20m Interval
Traffic Barrier	Roadside	L-m	2,690	3,100	5,790	Rigid Type
	Median	L-m	2,500	3,100	5,600	Rigid Type
Drainage	U-gutter	L-m	2,650	11,100	13,750	Unsupported
Toll Office	Site Area	m³	-	5,000	5,000	

Source : Study Team

(3) Land Acquisition Area

1) Total Area

West Bank	A_W = 74,073.95 ㎡
East Bank	A_E = 190,772.67 ㎡
Total	A_T = 264846.62 ㎡

2) Important Institution

Military Area	A_M = 7,500.00 ㎡
Orchard	A_O = 8,557.00 ㎡

(4) Demolition

Schools	2 School Buildings	(A = 3,520.00 ㎡)
Irrigation Canal Office	1 Building	(A = 640.00 ㎡)
Private Houses	6 Households	(A = 750.50 ㎡)

CHAPTER 11

BRIDGE DESIGN

CHAPTER 11 BRIDGE DESIGN

11.1 General

As previously described in Chapter 8, the preferred alternative location selected for the bridge was at Qantara. With this site in mind, the supplemental topographic and geological surveys were carried out in order to collect the detailed data for the topography and the sub-surface soils conditions, and to establish the route alignment.

From the results of this survey data, the most appropriate design was selected.

11.2 Selection of Bridge Type

11.2.1 Main Bridge

(1) Superstructure

As stated in Section 6.5.2, a cable-stayed bridge with a steel deck has been selected as the most desirable type for the main bridge of the Suez Canal crossing structure. In this section, the type of deck with structural steel deck girder has been further studied in detail.

In selecting the deck type of the cable-stayed bridge, consideration should be given to structural stability under windy and earthquake conditions as well as economics, aesthetics, safety of construction, and ease of maintenance.

In addition, since this bridge will cross over the Suez Canal, safe transit of the vessels must be ensured at all times during the construction. Use of the Canal for erection and construction of the deck girder will be restricted to certain hour between convey operation. A single enclosed steel box girder has the advantage of ensuring safe construction.

With regard to the seismic behaviour, regardless of the structure type of the deck girder of the proposed bridge, earthquake tremors will have little affect it due to the natural low frequency of the structure, and none the integrity of the structure can be maintained.

However, aerodynamic stability must be considered particularly for the design of a cable-stayed bridge. It is most essential that the aerodynamic stability of a cable-stayed bridge is examined using a rigid sectional model and a full aeroelastic model.

As the requirement for navigational safety is paramount on the Suez Canal, a 2 m heigh screen has to be provided on each edge of the deck girder to prevent falling objects. This create particular problems in the design of the deck structure relative to the aerodynamic behavior. However, the employment of a single-box girder type greatly reduces these effects and is the most suitable option.

According to the results of the initial numerical analysis, there is a possibility that some vibration or vortex induced oscillation may occur at wind speeds around 15 m/sec.
This will need to be taken account of before implementation.

Verification of the aerodynamic stability of the bridge is complicated, and this can not be done, normally, by numerical analysis alone. It can, however, be used effectively for qualitative comparison in certain limited areas of the deck girder. The numerical analysis results for a single-box girder steel deck and a twin-box girder steel deck are given in Annex 11.2.1. An advantage of the single-box girder is that the aerodynamic stability of the many cable-stayed bridges already built has been confirmed in service.

The single-box girder will be aeshtetically attractive with its simple clean structural appearance. The single-box girder will also be easier to maintain.

Taking all these factors into account, it is considered that the single-box girder type is the most suitable for the proposed bridge. However, it is should be noted that the twin box type is the next most suitable in this instance.

It should be noted however that the use of a concrete box girder or composite type with steel deck girder was selected for the deck girder is not considered suitable for the proposed bridge (see Paragraphs 11.2.2 and 11.2.3 in the Appendix).

(2) Type of Stay Cable

In general there are three types of configration of stay cables for cable-stayed bridges as follows:

i) Fan Pattern,
ii) Semi-Fan Pattern, and
iii) Harp Pattern.

With the development in recent years of good fatigue- and corrosion-resistant high-strength stranded cables, multi stayed cables have been used in cable-stayed bridges, and as a result it has become possible to construct cable-stayed bridges with long spans. With the use of multi-strand cables, there is a structural limitation to the fan pattern layout. The semi-fan pattern layout has also generally been called the fan type. The comparison of the fan pattern and the harp pattern is given in Table 11.2.1.

In the fan pattern, the cables in the lower cables in the group are arranged closer to the vertical, and compared to the harp pattern, the bridge will be more rigid in the vertical direction, with smaller deflections from live loads. The constraint in the longitudinal direction, however, will be less. The axial strength of the lower cables can therefore be less, however for the longer lengths of cable required, the total weight of cables will not differ by that much.

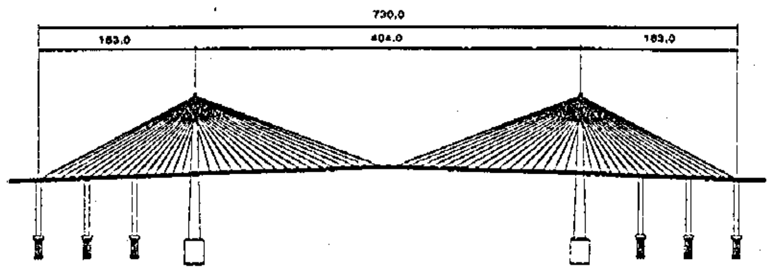
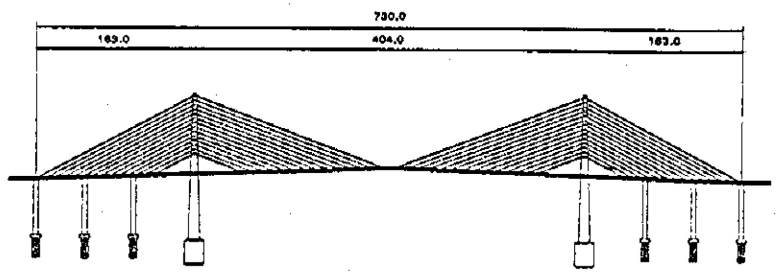
In the harp pattern, the constraint in the longitudinal direction of the bridge will be greater, but the movement of the bridge due to earthquake motion will be in excess of 1 m. Hence for the harp pattern of cable layouts, it will also be necessary to provide means to restrain the movement of the bridge in the longitudinal direction.

The layout of the harp pattern of cable layout is much more simpler, but the final determination of the design of the cables will be one of choice.

At this stage, it can be concluded that the fan pattern of cables is the more suitable when considering the rigidity of the bridge in the vertical direction.

The rubber type bearing will be employed and installed on the cross beams of the pylon. These bearings will be designed to withstand the horizontal and vertical working loads from the deck girder.

Table 11.2.1 Comparison of Cable-stayed Types

	Fan-configuration type	Harp-configuration type
General view		
Structural feature	· The maximum flexural moment in the main girder is 4,500 tfm, and the maximum axial force in the main girder is 3,400 tf. · The maximum thickness of lower flange plate is 25 mm over piers and at some of locations between pylons and piers and 12 mm at all other sections. · The constraint to the movement in the longitudinal direction is lower than the harp type, and constraint members are required similar to the harp type. · The rigidity of the bridge is greater than the harp type, so that the deflection due to live load is smaller.	· The flexural moment in the main girder is the same as the fan type, but the axial force is 30 % larger. · The steel plate thickness of the main girder is thicker than that of the fan type. · The axial forces in the cables range from 400 tf to a maximum of 600 tf, and are larger than for the fan type. · The displacement in longitudinal direction due to earthquakes (kh = 0.1) is more than 1.0 m, and it is necessary to provide members to constrain the movement in the longitudinal direction. · The deflection by live load is greater than that for the fan type.
Constructability	· After the erection of the side spans and the main span girder is constructed alternatively by a cantilever erection.	· Similar erection method to the fan type is adopted.
Weight of steel	Girder 7,166 tf Cables 563 tf Totals 7,729 tf Factor : 1.000	Girder 7,525 tf Cables 563 tf Totals 8,088 tf Factor : 1.046
Rating	Excellent	Good

(3) Pylons

The key functions of the pylons are mainly as follows:

i) The transfer of the loads from the superstructures through the foundation to the bearing strata.

ii) Distribution of the horizontal components of the forces in the stay cables between the side spans and the main span.

iii) To transmit the vertical component of forces in the cables to the bearing strata through the foundation.

The most suitable structural material that can perform these functions in an economical manner is reinforced concrete. As the pylon is required not only to bear the immense vertical loads from the cables, but also to carry the horizontal forces at the connection with the cables, it will additionally be required to be partially prestressed.

The shape of the pylon will have a governing influence on the overall architecture of a cable-stayed bridge. There are cases where the aesthetic design of the pylon can have priority over the required structural behaviour and there are many existing cable-stayed bridges with striking architectural features for which they have become well known. Since only very minor low cost modifications are required for the pylons to be made aesthetically pleasing, it has given rise to freedom in their choice to achieve richness and elegance in their design.

The basic shape of the pylons will be selected for this bridge from 2 types, the H-type or the A-type, as shown in Figs. 11.2.1 and 11.2.2.

Structurally, the difference in the natural frequency of a cable-stayed bridge will be affected whether the H-shaped type or A-shaped type is selected. The deflection frequency of an A-shaped type will be the same as for the H-shaped type, but the torsional frequency will be less than for the H-shaped type pylon. The guideline to determine the wind stability of structures is generally stated that the ratio of deflection frequency to the torsional frequency should be greater than 2.0. On this basis the A-shaped type pylon which has the larger ratio of deflection frequency/torsional frequency, is generally the better. However, this value is not absolute, and vibrations can occur for deflections at 15 m/sec wind velocity. The comparative results of the data are summarized in Table 11.2.2.

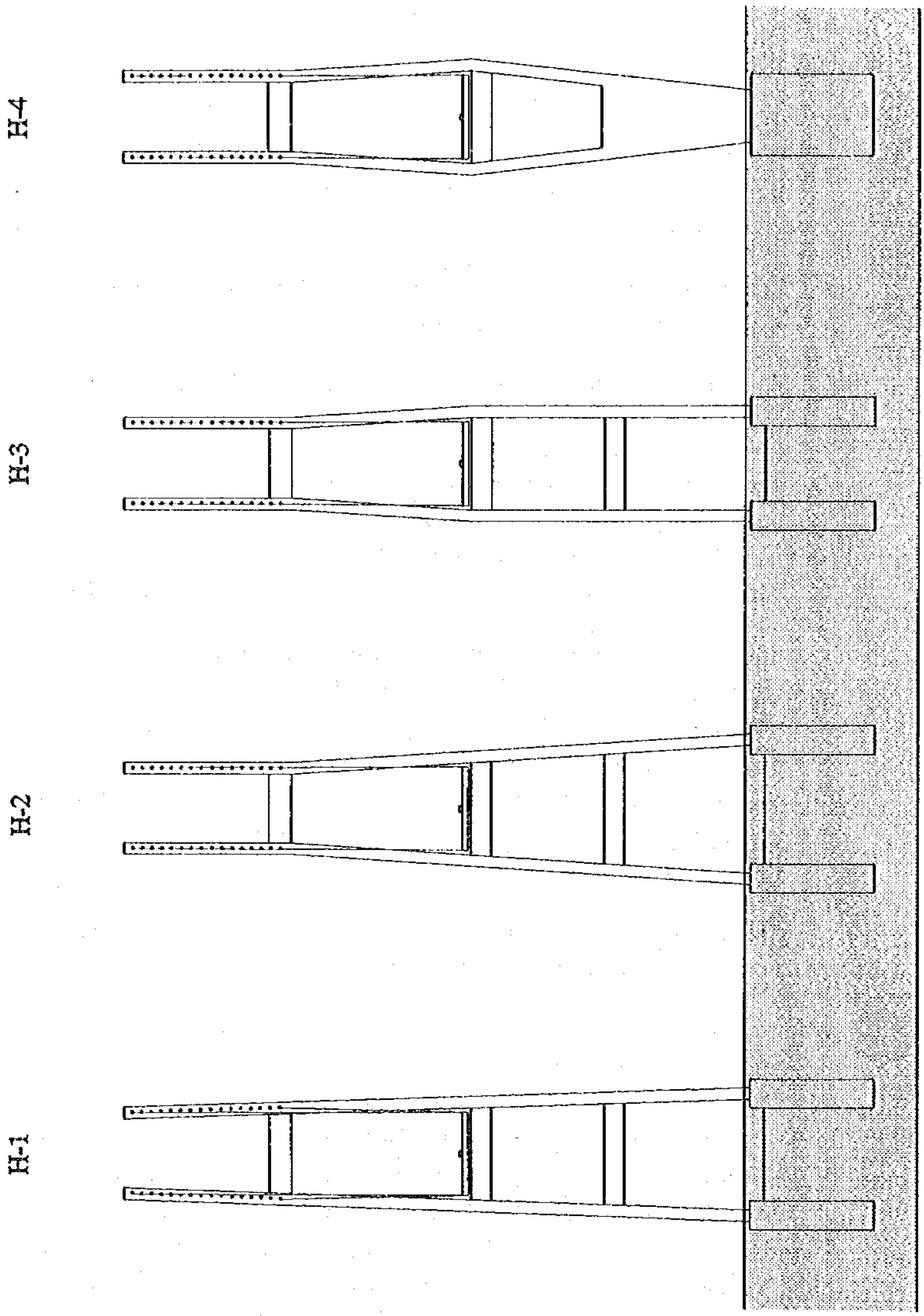


Fig.11.2.1 Types of Pylon (H-Shaped)

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

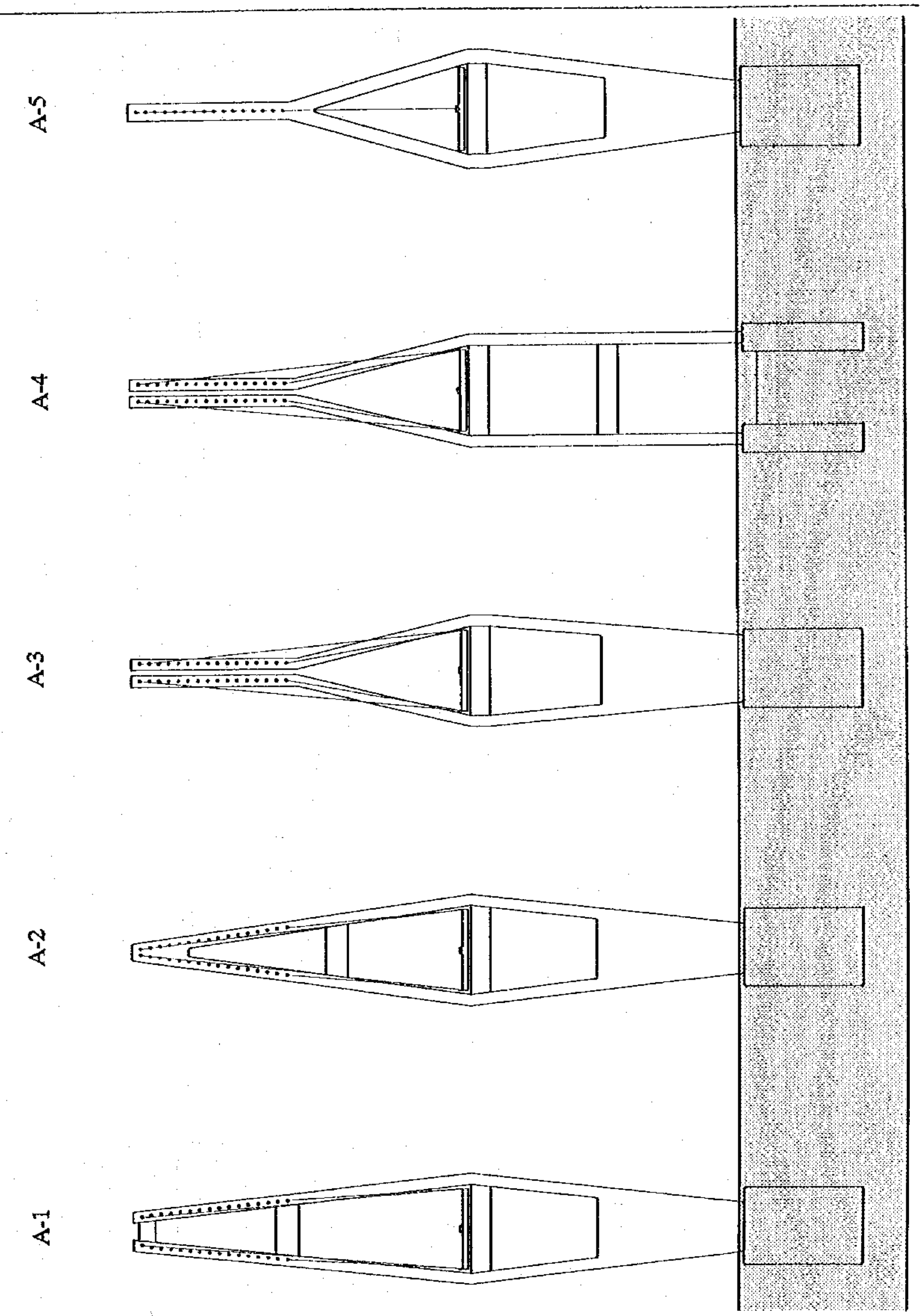
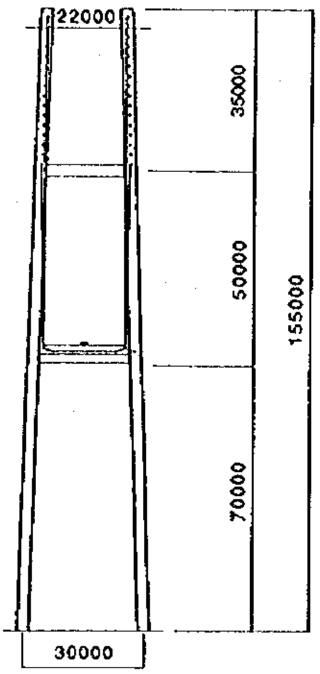
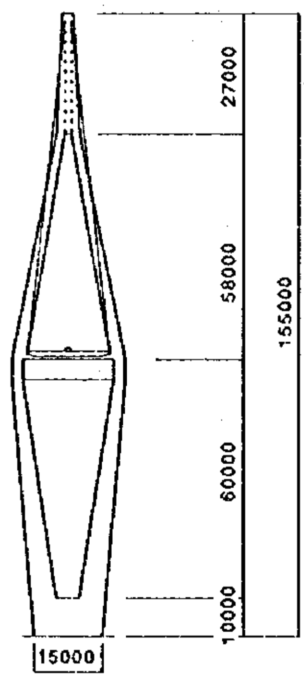


Fig.11.2.2 Types of Pylon (A-Shaped)

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

Table 11.2.2 Comparison of Pylon Types

	Type 1 H-shaped pylon	Type 2 A-shaped pylon
General view		
General description	• H-shaped or A-shaped pylons are generally applicable to the cable-stayed bridges with two sided cables, both types are discussed herein.	
Structural feature	• The cables are inclined near to the vertical since the towers are slightly tapered. The cables offer little resistance against horizontal loads. • The cables are located outside the effective width of the bridge and so do not give an oppressive feeling to bridge users. • As the cables are almost vertical, the connecting arrangement between cables and girder is easier than the A-shaped pylon. • A wide distance between the pylon legs of their base is required to resist the horizontal loads. • The H-shaped pylons offer little resistance to the torsional deflection of the main girder. • The stiffness of the bridge with H-shaped pylons is less than that with A-shaped pylons.	• The A-shaped pylon is more tapered than the H-shaped pylons, and the cable layout appear to enclose the road. The cable resistance against horizontal loads is better than the H-shaped pylons. • The space covered by the cables and the pylon gives an oppressive impression to users on the bridge. • The connecting arrangement between cables and girder is more complicated due to installation at an steeper angle than for the H-shaped pylons. • The short distance between the pylon legs at their base make its resistance against horizontal loads less effective than the H-shaped pylons. • The A-shaped pylons can resist the torsional deflection of the main girder and be stable against horizontal loads.
Wind stability (Vibrational Characteristics)	• Primary natural period of vertical deflection T= 2.86 sec • Primary natural period of torsional deflection T= 1.66 sec • Primary natural period of horizontal deflection T= 2.80 sec • Frequency ratio of deflection to torsion $fh/f\theta = 1.72$ • The natural period of torsional deflection is long, and the divergent flutter generates at a lower wind velocity than the Type 2. • There is the possibility of combined vibration due to low frequency ratio of deflection to torsion ($fh/f\theta$).	• Primary natural period of vertical deflection T= 2.73 sec • Primary natural period of torsional deflection T= 1.27 sec • Primary natural period of horizontal deflection T= 3.20 sec • Frequency ratio of deflection and torsion $fh/f\theta = 2.15$ • The natural period of torsional deflection is shorter than for Type 1, so that the safety factor against generating the divergent amplitude vibration of Type 2 is higher than for Type 1. • There is little possibility of combined vibration since its frequency ratio of deflection to torsion ($fh/f\theta$) is more than 2.
Constructability	• The vertical layout of the pylon simplifies the construction aspects. • The vertical arrangement of the cables makes the girder fabrication and the cable installation easy.	• The taper of the pylon may cause some difficulties in construction, but that is not a major problems. • The shape in the cable plane may make construction difficult, but no special problem is caused.
Aesthetics	• An elegant design of the pylon will improve the overall appearance of the bridge.	• An elegant design of the pylon will improve the overall appearance of the bridge.

The selection of the shape of the pylon can be influenced by the aesthetics and as a propotional histric monument. The shape of the pylon could be based on one of the symbols of Egypt in the form of an obelisk for the bridge.

(4) Substructures

By providing supports to the side spans, the deformation and bending moment of the deck girder, and the tension in the stay cables will be affected. The effects on the side spans of the number of supports will be studied as in the follows.

I) Alternative Plan 1: No auxiliary pier
ii) Alternative Plan 2: 1 auxiliary pier
iii) Alternative Plan 3: 2 auxiliary piers

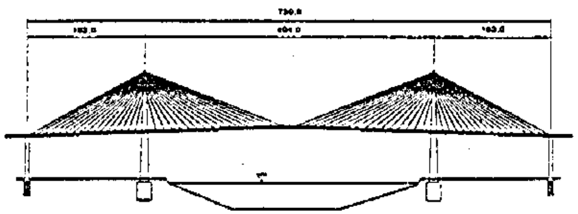
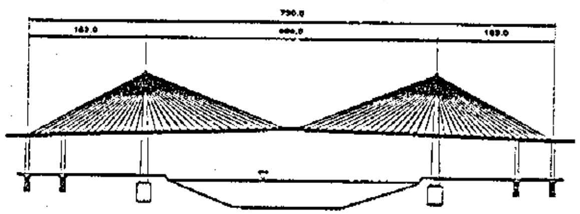
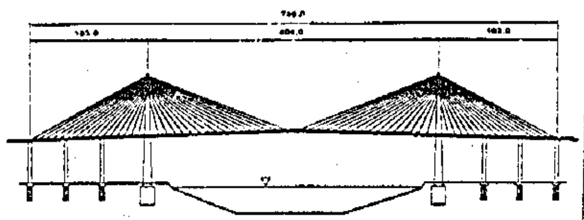
The results of the study are summarized in Table 11.2.4. The bending moment and the deflection characteristics are given in the Appendix Figs. 11.2.1 (1) to 11.2.1 (3).

In alternative Plan 1, with no support, the deflection of the main girder will not only be large and exceed the limit value deflection, but the stresses in the deck girder and stay cables will be concentrated at one point which is not desirable.

In checking the deformation due to deflection for Alternative Plans 2 and 3, there appears to be no significant difference. However the stresses in the deck girder and the bending moments in the side spans in Alternative Plan 3, will be less than in Alternative Plan 2, and will be evenly distributed. Hence the construction cost for the main girders will be lower for the Alternative 3, and the saving will be similar to the cost of constructing temporary supports to the side spans. The net outcome is that the saving in girder costs are used in the construction of auxiliary piers, but a more stable structure is the result.

In comparing the results of the above studies of Alternatives 2 and 3, there is very little difference to choose between them, and hence Alternative 3 has been selected.

Table 11.2.3 Comparison of the Number of Side Span Supports

	Type 1 No auxiliary piers	Type 2 With one auxiliary pier	Type 3 With two auxiliary piers
Sketch diagram			
General description	• No auxiliary pier is provided at either side spans. (so that the effects of providing them can be ampared)	• One auxiliary pier each is provided at each side span in order to increase the rigidity of the entire bridge (improve the deflection and vibration characteristics), and improve the constructability of the bridge.	• Two auxiliary piers each are arranged at each side span in order to increase the rigidity of the entire bridge (improve the deflection and vibration characteristics), and improve the constructability of the bridge.
Static structural feature	• Axial loads in cables : In comparison with the Types 2 and 3, the stresses are concentrated in the top cable, and the cross sectional area of the top cables is large. There is very little differencebetweeen the intermediate cables in this and the Types 2 and 3 arrangement. • Flexural moment: The flexural moments at the center of the main span and the side spans are the largest of the three types. • Deflections due to live load : The deflection is almost double that of the other types. In order to satisfy the allowable live load deflection it is necessary to increase the cable cross sectional area or increase the rigidity of the main girder.	• Axial loads in cables : Compared to the Type 1, the stress distribution is much improved, and there is little difference to that in Type 3. • Flexural moment : There is a high improvement over Type 1 for the flexural moment distribution. - At D+L loading case, flexural moment in side spans is 2 to 3 times than that in Type 3, but the difference at main span is only 10%. - Lateral forces are resisted by the increase of plate thickness. - Additional steel requirements are about 100 t. • Deflections due to live load:The deflection is approximately one-half of that in Type 1 and only 10% greater than that of Type 3.	• Axial loads in cables : In comparison with the Type 1, the stress distribution is much improved, and there is little difference to that in Type 2. • Flexural moment : There is a high improvement over Type 1 for the flexural moment distribution. - Flexural moments at pylons and in side spans are improved due to installing two piers. - In comparison with Type 2, there are no disadvantageous to construction cost since the increased cost for the anchors is offset by the decreased cost of the piers. • Deflections due to live load:The deflection is approximately one-half of that for Type 1, with only an improvement of 10% over that for Type 2.
Rating	Poor	Good	Excellent

(5) Foundations

As described in Section 6.5.2 of this report, pylon foundation of the concrete caisson type will be selected.

For the construction of caisson bases, there are the open caisson method and the pneumatic caisson method. The pneumatic caisson has the benefit that the strength of the bearing strata can be directly confirmed by physical observation. However, depending on the soil conditions at the construction site, there are the risks of air blow out in the pneumatic caisson method, and it may be difficult to make this selection, without more detailed information on the soil grading. It is to be however that in excess of 50 pneumatic caisson shafts have been exccessively constructed in Cairo for the Greater Cairo . These have been in water bearing sands, gravels and silts.

11.2.2 Approach Viaducts

(1) Superstructures

The approach bridge lengths are 1440.0 m on the east side, and 1722.9 m on the west side.

The horizontal alignment of the approach viaducts will be straight, and as the topography of the entire area are is virtually all flat, and there are very few site conditions that will affect the bridge spans. With the exceptions of section on the east side of the bridge where an embankment will be constructed from materials dredged from the Suez Canal, there are unused saltpans which are entirely flat.

On the west side, with the exceptions of the Ismailya-Port Said Highway and the irrigation canal, there are no physical restrictions which will affect the bridge spans.

Therefore, the only topics to be considered in selection of the bridge spans of the approach viaducts are the undulations of approximately 1.0 m to 2.0 m and width of the existing highway and the Canal in the proposed route alignment. As a general rule the economics of the bridge span are dictated by the height of the bridge piers. This means that the span will be longer where the finished road height is high, and shorter where the finished road height is low. Using this logic the appearance would not be uniform and is not recommended. The viaduct type selected will therefore be dependent upon the most suitable length of span.

In this project, a 40 meters long continuous prestressed concrete box girder has been selected for all the approach viaduct spans, and the concrete girder will be constructed using movable scaffolding construction method which is commonly used in Egypt and elsewhere in the world.

The width of the concrete girder has been selected to accommodate two traffic lanes in one direction.

This will make it possible to procure local construction materials, while at the same time permit repeated reuse of one set of formwork, and this will result in economic construction of the approach bridge. This will permit structural standardization and improvement in the quality control standards.

The higher piers are susceptible to bending in the axial direction, and in order to increase the safety factor of the structures, a rigid connection will be provided between the concrete beam and the top of the pier by means of the continuous beam structure.

(2) Bridge Support and Foundation

As the piers and superstructures of the approach viaduct concrete girders are separated ascent and descent carriageways this has made it necessary to twin piers. When the superstructure consist of two separate structures, the use of a single type pier will be uneconomical.

The foundations will be constructed of cast-in-place concrete piles. To ensure the most efficient methods of construction and the most effective layout of foundation piles, the simple combined type of foundation cap is preferred for the twin piers. (see Fig. 6.5.2)

11.3 Design of Main Bridge

The proposed main bridge will be designed using the following criteria:

Type of bridge:	Steel box girder type cable-stayed bridge.
Pylon:	H-type, reinforced concrete.
Deck girder:	Steel deck, box girder with 2.5m depth.
Stay cable:	Freysinnet cable.
Auxiliary pier:	2 Nos.
Length of bridge:	L = 730 m.
Span length:	163 m + 404 m + 163 m.
Effective bridge width:	B = 17.3 m
Pavement type:	Asphaltic concrete pavement, 8 cm thick.

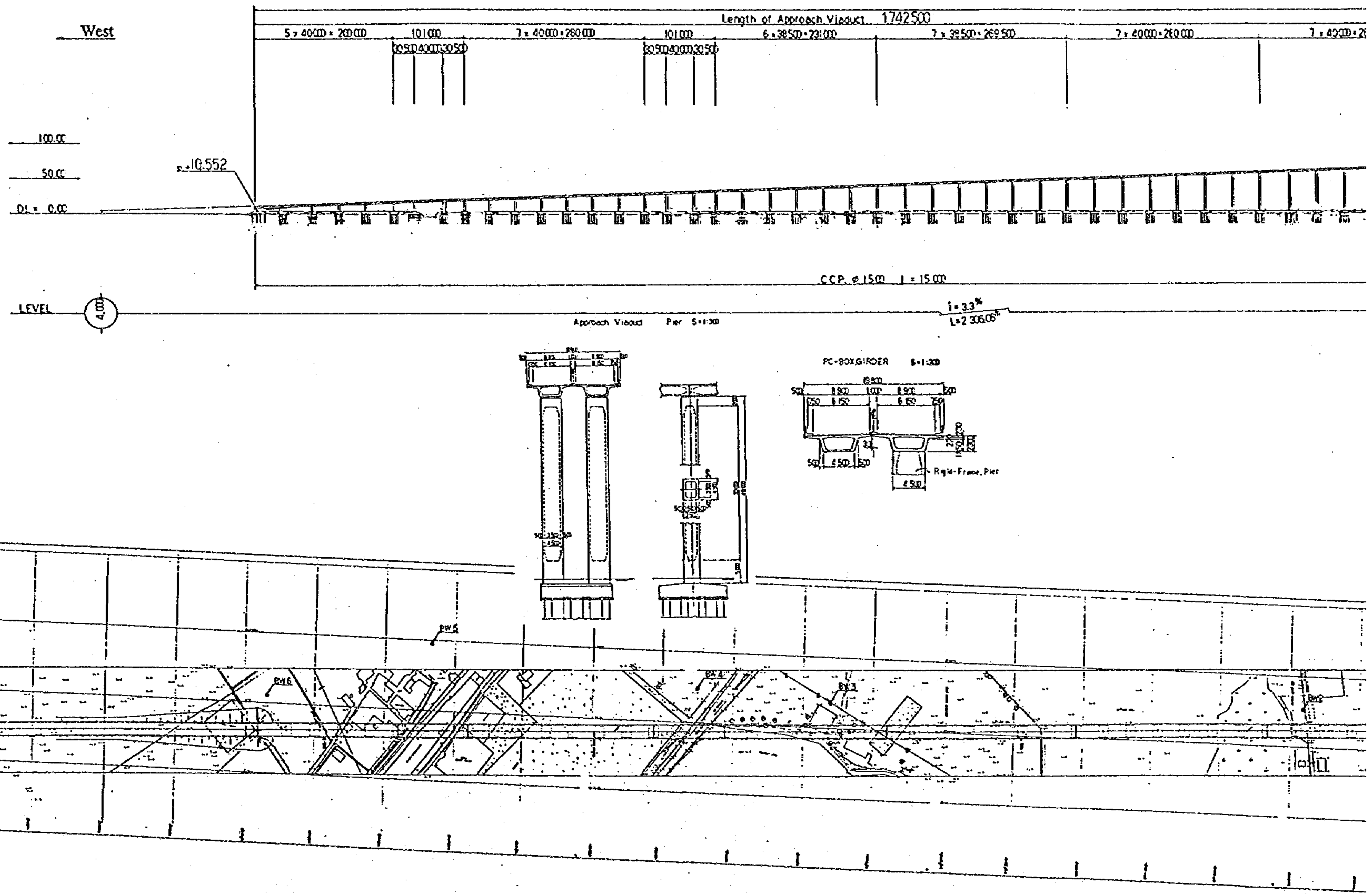
11.3.1 Super-Structure

The deck girder will be of the steel, box girder type, with wind stabilization fairings at both edges of the bridge, for a total width of 23.8 m. The shape of the girder will be streamlined, and the height/width ratio of the girder is 0.1 and it is of flat construction (see Fig. 11.3.1). From past experience it should have good wind stability, but this must be verified by wind tunnel testing.

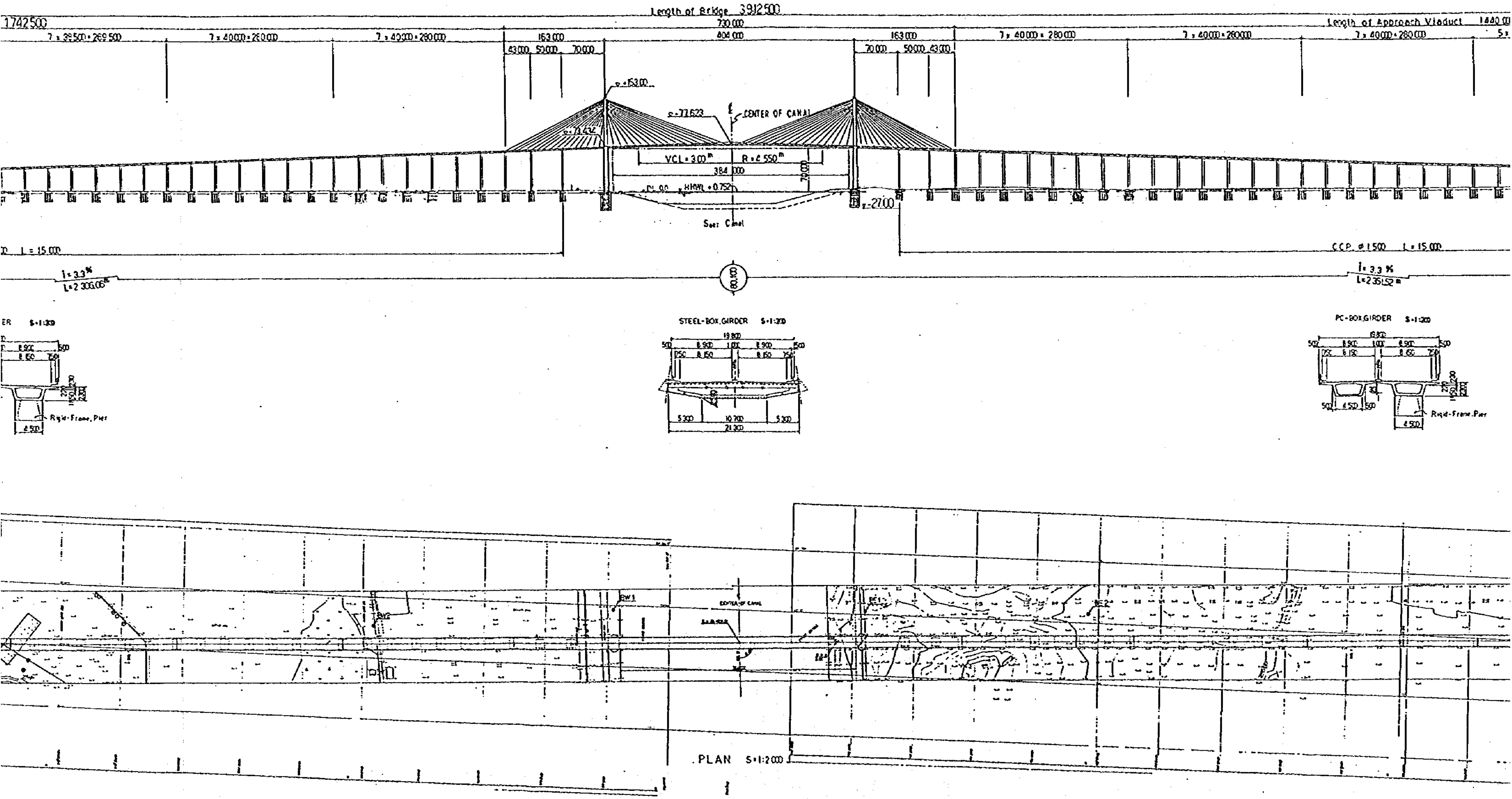
The anchorage spacing of the stay cables on the girder at the side spans and main span are 10.0 m and 12.0 m respectively. At the stay cables anchorage and intermediate points, transverse diaphragms have been placed, to maintain the required rigidity of the girder bridge.

Rubber type deck bearings will be installed at the location of the pylons. Hence the deck girder will be elastically constrained in the vertical and longitudinal directions by the cross beams of the pylons. As for the movements in the longitudinal direction, when there is an earthquake, the elasticity of the rubber bearings will control this movement.

There are inspection walkways on the outside of the traffic lanes, and at the free edge sturdy railings will be placed comprising a traffic fence 2.0 m high from the road surface to prevent objects falling into the canal. It is desirable to make the fence as high as possible, but the wind stability of the bridge must be considered. Therefore, if the allowable height is limited by wind tunnel testing, it may also be necessary to install a protection net on top of the fairing. This too should be confirmed by wind tunnel testing.


West
Length of Approach Viaduct 1742500
5 x 40000 = 200000
101000
7 x 40000 = 280000
6 x 38500 = 231000
7 x 38500 = 269500
7 x 40000 = 280000
100.00
50.00
DL = 0.00
10.552
CCP φ 1500 L = 15000
LEVEL
i = 3.3%
Approach Viaduct Pier S=1:300
PC-BOX GIRDER S=1:300
Rigid-Frame Pier
BW5
BW6
BW4
BW3

GENERAL VIEW
STEEL-BOX, GIRDER ALTERNATIVE
PROFILE S=1:2000



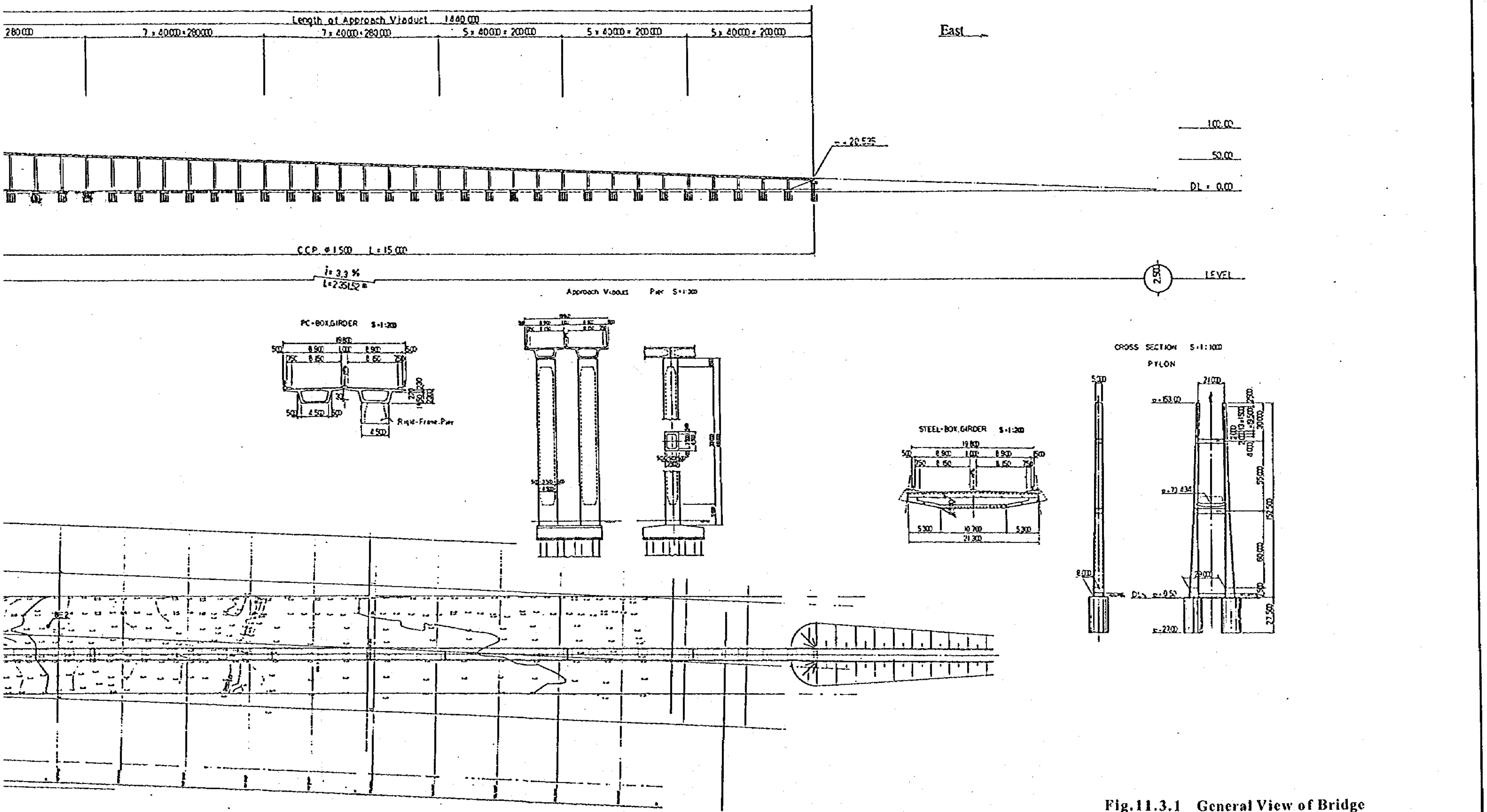


Fig.11.3.1 General View of Bridge

11.3.2 Pylons

The pylon will be of the H-type construction in reinforced concrete. The pylon shaft will be of hollow construction and rectangular in shape, with a dimension of 8.0 m x 7.0 m at the base which will vary with its height.

The pylon must not only be designed bearing in mind working load of the bridge after its completion, but also the temporary loads during construction. Particular provision for pylon in the longitudinal direction must be allowed for during construction of the superstructure.

Manholes for entry into the pylon interior should be provided above the deck level of the deck girder, and inspection platforms will be provided for entry into the pylon as well as for the inspection on the entire bridge deck.

11.3.3 Sub-Structure

The sub-structure of the main bridge will consist of the two auxiliary piers in the side spans. The functions of these sub-structures will be to support the main girder and the anchorage for the cable stays.

These piers will be of the hollow rectangular shaft. With the sub-structure acting as a cable anchorage, it will require sufficient mass to withstand the uplift forces due to the cable tension. The auxiliary piers are very high, and will therefore provide sufficient mass even with a hollow cross-section.

11.3.4 Foundations

The foundations for the main pylon will consist of two open caisson foundations for each pylon. The shape of each caisson will be circular of 16 m in diameter. The depth of the caisson has been established at -27.0 m with due consideration given for the future planned deepening of the Suez Canal

As it will be difficult to sink the caisson under its own weight, the caisson has been designed to be sunk using ground anchors and hydraulic jacks.

For the auxiliary pier foundations, 1.5 m diameter concrete piles with 15 m effective length will be used.

11.4 Design of Approach Viaducts

11.4.1 Super-Structure

The main girders of the approach viaducts will be 40.0 m long prestressed concrete box girder. The girder will be designed to be constructed as cast-in-situ concrete. There will be no transverse PSC tendons installed.

For crossing over the Ismailiya-Port Said Highway and the Abassah Canal the span length will conform to the needs of the terrain. The exterior profile of the girders will be made the same as the 40 m long girders to give matching aesthetics.

A rigid connection, with no flexible bearings will be provided between the main girders and the piers. Also to improve the load capacity of the approach viaduct and the mobility of the structure, the spans will be of continuous over five to seven spans.

11.4.2 Sub-Structure

Each pier will consist of twin rectangular reinforced concrete columns, and will be of the same type fthroughout. The cross sectional dimension of the pier will match the full dimension of the lower flange of the main girder, with a constant dimension of 4.5 m transversely and be from 2.5 m to 4.5 m longitudinally.

11.4.3 Foundations

All foundations will consist of all be provided with cast-in-situ reinforced concrete piles. The piles will be of a constant diameter of 1.5 m, and the number of piles to be installed will depend on the foundation depth and their reactions. This will simplify the quality control and achieve a reduction of in cost due to the economy of .

The top of the piles will be connected by a reinforced concrete pile cap, which will be provided with an earth cover 0.5 m from the finished ground surface.

11.5 Accessories

11.5.1 Effects on Suez Canal VTMS and Countermeasures

(1) Effects on SC VTMS

A bridge within the area of a Suez Canal Vessel Traffic Management System (VTMS) will usually cause some kind of problems. The proposed bridge will be located at Km.48.505, between the Ismailia radar and Qantara radar. This will probably affect the coverage area of the Qantara radar, located at Km.45.100, and the Ismailia radar, located at Km.73.680 (see Fig.6.5.7). The discussion on the effects and consequences will be cover this senario.

The Ismailia radar covers the area north up to the Qantara radar. The Qantara radar covers the area down to the Ismailia radar. These radars thus provide an overlapping coverage in the bridge area. The Ballah bypass, an area used for anchoring the vessels, is especially dependent on an overlapping radar coverage.

The effects of the bridge will be radar shadows caused by the structure as follows:

- For the Ismailia radar, in the area north of the bridge
- For the Qantara radar, in the area south of the bridge

The consequence of these shaded areas will be a loss of reflected image on the Suez Canal and thus a reduction in the reliability of the SC VTMS System.

(2) Countermeasures

1) Requirements for Countermeasure

In order to eliminate the shadow areas on the Ismailia radar and the Qantara radar due to the bridge construction, additional radar(s) and or modifications to the existing system are required. The requirements of these countermeasures are:

- To eliminate the shadow area for the Qantara radar south of the bridge
- To eliminate the shadow area for the Ismailia radar north of the bridge
- To secure radar coverage from 2 radars in the affected areas.

These requirements are based on technical considerations and do not include other considerations such as e.g. interruptions in the operation of the SC VTMS.

The following three alternatives have been examined as countermeasures;

- Alternative 1 — Move the existing radar from the Qantara radar site to the bridge
- Alternative 2 — Install a new radar on the bridge, and move the existing radar in Qantara to El Cap Signal Station
- Alternative 3 — Install 2 new radars, one in the vicinity of Ballah Signal Station and one at El Cap Signal Station.

In calculating the most applicable solution, not only compliance with the countermeasure requirements mentioned above should be taken into account, but also the avoidance of interruption in operation of SC VTMS will be considered from the navigation safety point of view.

2) Evaluation of Alternatives

Alternative 1

- Move the existing radar from the Qantara radar site to the bridge -

With this solution the shadow area for the existing Qantara will be reduced. The shadow from the Ismailia radar will also be reduced. However the automatic tracking beneath and close to the bridge will be unreliable. The tracking range of the new radar location will also be decreased. There may also be problems for the Ismailia radar to track targets in the area below and close to the bridge.

There will be an interruption in the operation of the SC VTMS for at least 1 - 2 months which is the time allowed for dismounting, installation and re-integration of the radar into the system.

Alternative 2

- Install a new radar on the bridge, and move the existing radar in Qantara to El Cap Signal Station -

The new radar at the bridge, will eliminate the shadow area for the Qantara radar (south of bridge) and thus provide good radar coverage in the area between the Ismailia radar and the bridge.

The new radar location at El Cap Signal Station will provide good radar coverage in the area north of the bridge. The combination of the new radar location at El Cap and the Iamailia radar will provide radar coverage below the bridge.

The solution will cause an interruption in the operation of the SC VTMS for at least 1 - 2 months which is the time allowed for dismounting, re-installation and re-integration of the Qantara radar into the system.

Alternative 3

- Install 2 new radars, one in the vicinity of Ballah Signal Station and one at El Cap Signal Station -

The new radar in the vicinity of Ballah Signal Station will eliminate the shadow area for the Qantara radar (south of the bridge) and thus provide an excellent radar coverage in the area between the Ismailia radar and the bridge.

The new radar at El Cap will eliminate the shadow area for the Ismailia radar (north of the bridge) and provide an excellent radar coverage for tracking in the area north of the bridge.

The new radars at Ballah and El Cap will work together in providing a tracking in the area below the bridge.

3) Suitable Countermeasure

- It is considered that navigation safety is the most important factor in the selection of the required facilities for the bridge crossing over the Suez Canal.

- Alternative 1 is the most economical solution but not recommended, because this solution will not meet the requirements due to the tracking problems described above.

- The requirement for radar coverage is met by both alternatives 2 and 3. Alternative 2 will result in an interruption in the operation of the SC VTMS and alternative 3 will require more additional radar equipment.

- The choice of alternative 2 or 3 depends on what is acceptable to the involved parties, both in terms of interruption in operation and additional costs. Taking all these factors into account, it was concluded that Alternative 3, provision of 2 new additional radars, is the most suitable solution to eliminate the problems of the radar shadows. It would be possible to install 2 more radars into the SC VTMS without increasing the number of trucker shelves of the computer system.

11.5.2 Navigational Hazards

(1) Introduction

In the construction of bridges over the Suez Canal, it is most important to prevent hazards to vessels navigating its waters. There should be no objects falling from the bridge into the Canal, whether by chance or intent. Any parking or stopping of vehicles on the bridge, or any unlawful act by vehicle passengers should be actively prevented and immediately stopped. Bridges crossing the Suez Canal appear as a curved structure over the channel, obstructing the view and creating an inclined obstacle 2.2 km long on both the east and west sides, which may cause vehicle breakdowns and accidents due to collisions.

Accident prevention and monitoring of incidents, will require countermeasures to be taken , and close watching to prevent the falling of objects from the bridge.

(2) Accident Prevention

The prevention of accidents is desirable not only from the human side but also to maintain the safe navigation of vessels along and the efficient operation of vehicles traffic over the canal.

The following measures will be required.

- high mount curb and high railings (fencing).
- painting of curb.
- traffic lane markings.
- installation of delineators on curb

(3) Measures to Prevent Falling Objects

In order to prevent the falling of objects from the bridge, in addition to the installation of high railings at both edges of the bridge, fencing should be provided. The height of fencing is planned to be 2.0 m from the road surface. A higher fence would help to prevent objects from being thrown over the fencing, but in order to ensure for wind stability, in the case of cable-stayed bridges, as described previously, it will be necessary to check the integrity of the bridge by wind tunnel tests.

(4) Installation of Watch Tower

In order to prevent any unlawful action from taking place on the bridge, and assist in the early detection of vehicle accidents, watch towers should be provided on one edge at both ends of the bridge and center of span. The watch tower will be set 1.5 m above the finished road surface so that 3/4 of the main span of the cable-stayed bridge can be observed for any object 1 m above than the surface of the bridge

It will be necessary to station a breakdown vehicle at the Bridge Administration Office to move away any breakdown or damaged.

11.5.3 Other Bridge Fixings

(1) Navigation Lights

On the lower side of the main girder of the cable-stayed bridge, there will be navigation lights which indicate the center of the Suez Canal and the limits of the navigation channel. Until such time as the canal widening takes place, the bridge center and the canal center will be identical. Hence the navigation lights of the canal should be installed bearing in mind that the water course characteristics may be altered with the changes in the cross section due to the widening of the channel.

(2) Aviation Lights

Hazard lights should be installed on top of the bridge pylons indicating the location of both the east and west pylons. For the H-type pylons, hazard lights shall be installed on both towers with one light blinking.

(3) Lightning conductors

Lightning conductors should be installed on both the east and west pylons.

(4) Road Lighting

Road lights should be provided on both sides of the roadway. The light fixtures should be installed 29 m apart in general, with a luminance of 5.0 lux. On the main girder for cable-stayed bridges, the light fixtures should be installed at 18 m centres.

(5) Inspection Trolley

As inspection trolley should be provided under the main girder for inspection and bridge painting.

The trolley should be installed on rail track mounted on the lower flange of the deck girder, and should be capable of traveling in the longitudinal direction. It must be provided with full safety eqipment, radio, and be enclosed to prevent

11.6 Preliminary Quantities

The results of estimating of the main construction materials is summarized in Tables 11.6.1 and 11.6.2.

Table 11.6.1 Material Quantities for Main Bridge

Items	Description	Unit	Quantities	Remarks
Foundation for Pylons	- Concrete	m^3	12,600	for 2 foundations
	- Form	m^2	10,100	
	- Reinforcing Bars	ton	700	
Pylons	- Concrete	m^3	9,600	for 2 pylons
	- Forms	m^2	222,000	
	- Reinforcing Bars	ton	2,400	
	- PSC Tendons	ton	10	
Deck Girder	- Structural Steel	ton	7,370	
	- Pavement	m^2	13,360	
Auxiliary Piers	- Concrete Piles	Nos.	72	
	- Concrete	m^3	6,300	
	- Forms	m^2	14,700	
	- Reinforcing Steel	ton	800	
Stay Cable	- Steel Strands	ton	560	
Miscellaneous	- Handrail	m	1,460	
	- Expansion Joint	ton	70	

Table 11.6.2 Material Quantities for Approach Viaducts

Viaducts on West Bank

Items	Description	Unit	Quantities	Remarks
Substructure	- Concrete Pile	Nos.	650	1.5 m ϕ x 15 m
	- Concrete	m^3	47,100	
	- Forms	m^3	85,800	
	- Reinforcing Bar	ton	5,400	
Superstructure	- Concrete	m^3	23,500	
	- Reiforcing Bar	ton	3,400	
	- PSC Tendons	ton	750	
	- Forms	m^2	75,200	
	- Pavement	m^2	28,200	7 cm thick
Miscellaneous	- Handrail	m	3,470	
	- Expansion Joint	unit	8	

Viaducts on East Bank

Items	Description	Unit	Quantities	Remarks
Substructure	- Concrete Pile	Nos.	550	1.5 m ϕ x 15 m
	- Concrete	m^3	43,000	
	- Forms	m^3	81,800	
	- Reinforcing Bar	ton	5,000	
Superstructure	- Concrete	m^3	19,600	
	- Reiforcing Bar	ton	2,800	
	- PSC Tendons	ton	610	
	- Forms	m^2	62,800	
	- Pavement	m^2	26,400	7 cm thick
Miscellaneous	- Handrail	m	2,880	
	- Expansion Joint	unit	6	

A breakdown of the total quantity can be found in Appendix 11.

CHAPTER 12

CONSTRUCTION PLANS AND COST

CHAPTER 12 CONSTRUCTION PLANS AND COST

12.1 General

There is a very big difference in the topography for the construction of crossing facilities on the east side and the west side of the Canal. On the west side of the Suez Canal there are roads and railroads running parallel to the Suez Canal with the Trunk Highway of Ismailiya-Port Said Highway crossing and the Abassah irrigation canal. There are developed areas along the proposed route alignment with farm lands and scattered residences. This will restrict entry into the construction site areas and the establishment of work areas. In contrast to this, on the east side of the Canal, the area is covered by desert land and idle salt flats with restrict on the establishment of work site areas.

An existing crossing facilities over the Canal near the proposed site is the Qantara Ferry approximately 1.5 km to the north which transports light vehicles and pedestrians but would not be suitable for construction vehicles. To transport any general construction materials and major equipment would be necessary to use the Ferdan Ferry 18 km to the south of the planned crossing point. However in order to undertake any major construction, it would be essential to use a dedicated vessel to transport the materials and equipment across together with the project personnel and to establish the berthing facilities on both sides of the Canal.

Large volumes of water will also be required for the project, and it should be possible to supply this from the existing water mains on both banks.

12.2 Temporary Works

It will be necessary to construct temporary work site facilities on both sides of the Canal for the bridge construction. As described previously, there will be restrictions to establishing any such facilities on the West bank of the Canal and so it is recommended to set up the principal work site facility on the East bank with a secondary site facility on the West bank.

12.2.1 Work Facilities on the East Side

The temporary work site facilities will have to be set up at the beginning of the project. Access to the East Side Office Facilities will be from the New Central Highway and the Canal Road. The main access from the existing New Central Highway to the East Side Works Facilities should be planned to become the Temporary Access Road. All temporary work yards and work shops would be near the canal.

The temporary works site facility will be divided into three separate areas:

- Bridge materials temporary storage yard and preliminary assembly yard
- Works and materials storage yard
- Site Management and Welfare Administration Office

All site facilities will be provided with fencing for security and safety, and will be provided with security guards around the clock.

The temporary works site will consist of the following main items. The total area to be provided for temporary works on the East Bank has been estimated to be 97,500 m^2, and a plan of the proposed layout are shown in Figs.12.2.1(1) and 12.2.1(3).

- Temporary storage yard for bridge components, assembly and ship out
- Construction equipment storage yard
- Industrial water storage facilities
- Concrete and mortar batching plant yard
- Storage yard for sand and washed gravel
- Construction materials storage yard and shed
- Electric generator and air compressor shed
- Equipment repair shops and fuel storage facilities
- Site office and parking lots worker's camps, recreation facilities, first aid station
- Ferry pier and jetty

12.2.2 West Side Temporary Office Facilities

The West Side Temporary Facilities will be located between the Ismailiya-Port Said Highway and the Irrigation Canal. Access roads to the Temporary Works Facilities and Project Site can be made by utilizing the Highways, Irrigation Monitoring Roads, and the local roads.

The temporary facilities will be generally similar to the East Side facilities, but there will be no equipment/material storage facilities, site office, repair shop facilities, and recreational facilities provided.

The total temporary site facility is estimated to be 30,000 m^2, as shown in Fig. 12.1.1 (2).

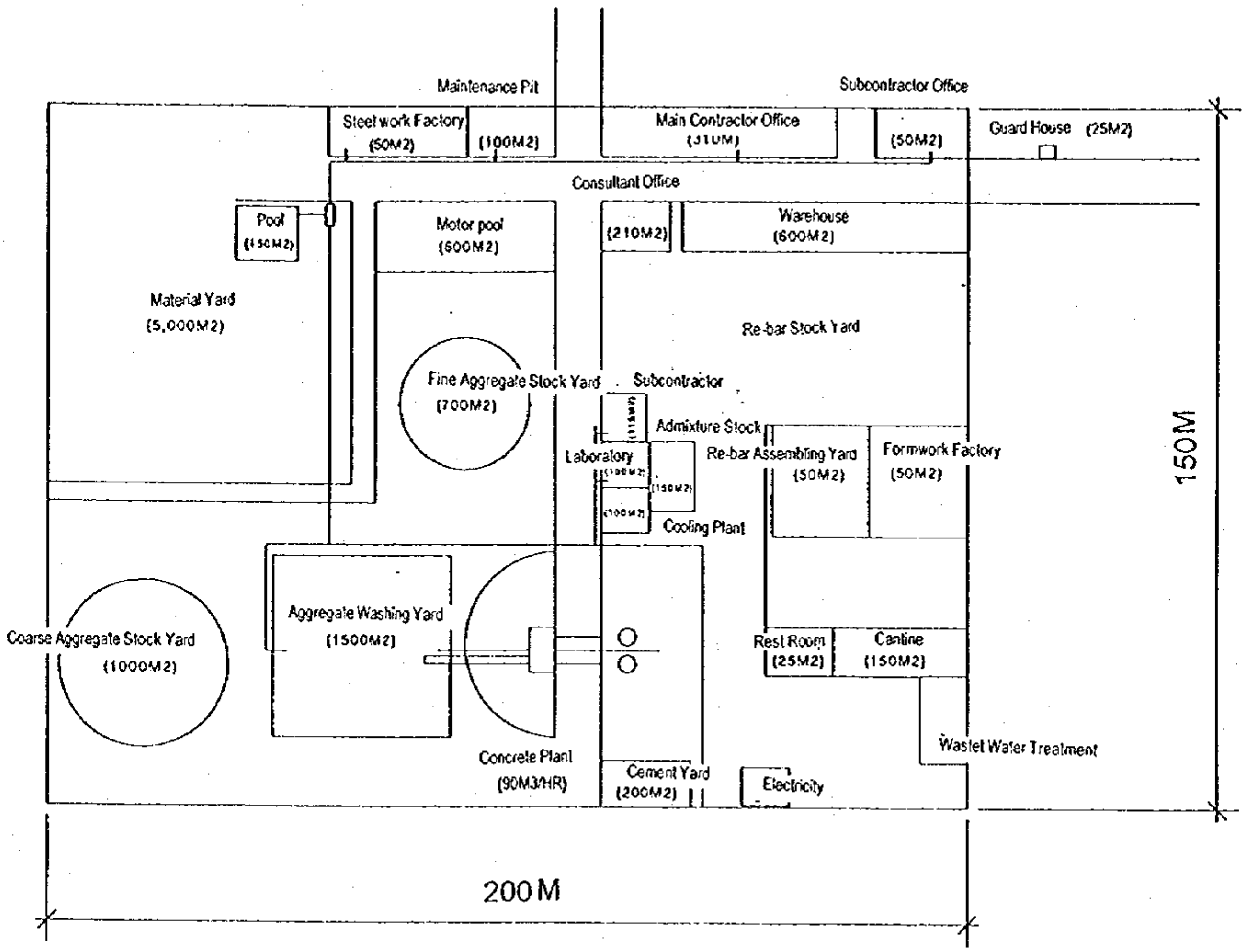


Fig.12.2.1(1) Site Work Yard (East Bnak)

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

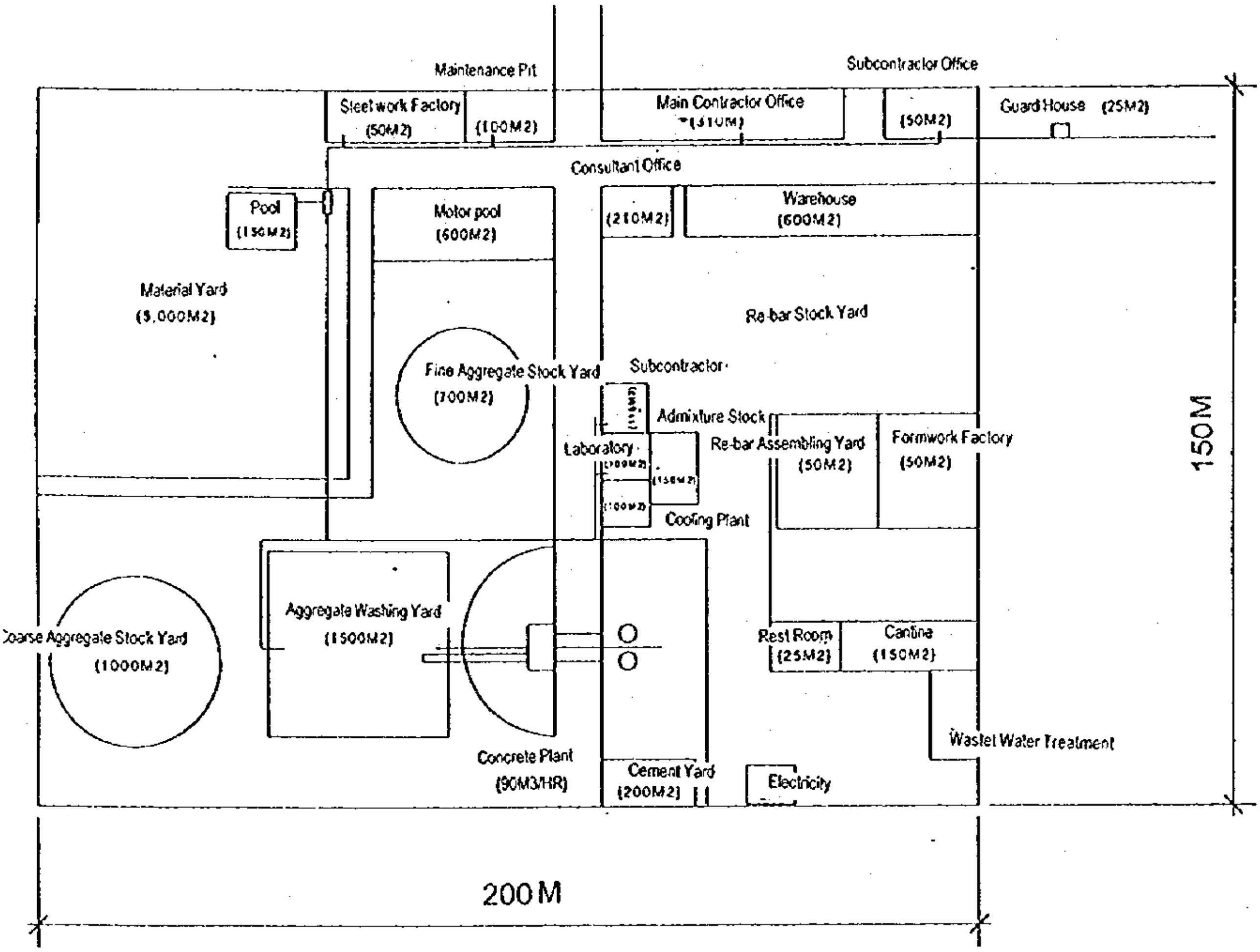


Fig.12.2.2(2) Site Work Yard (West Bnak)

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL

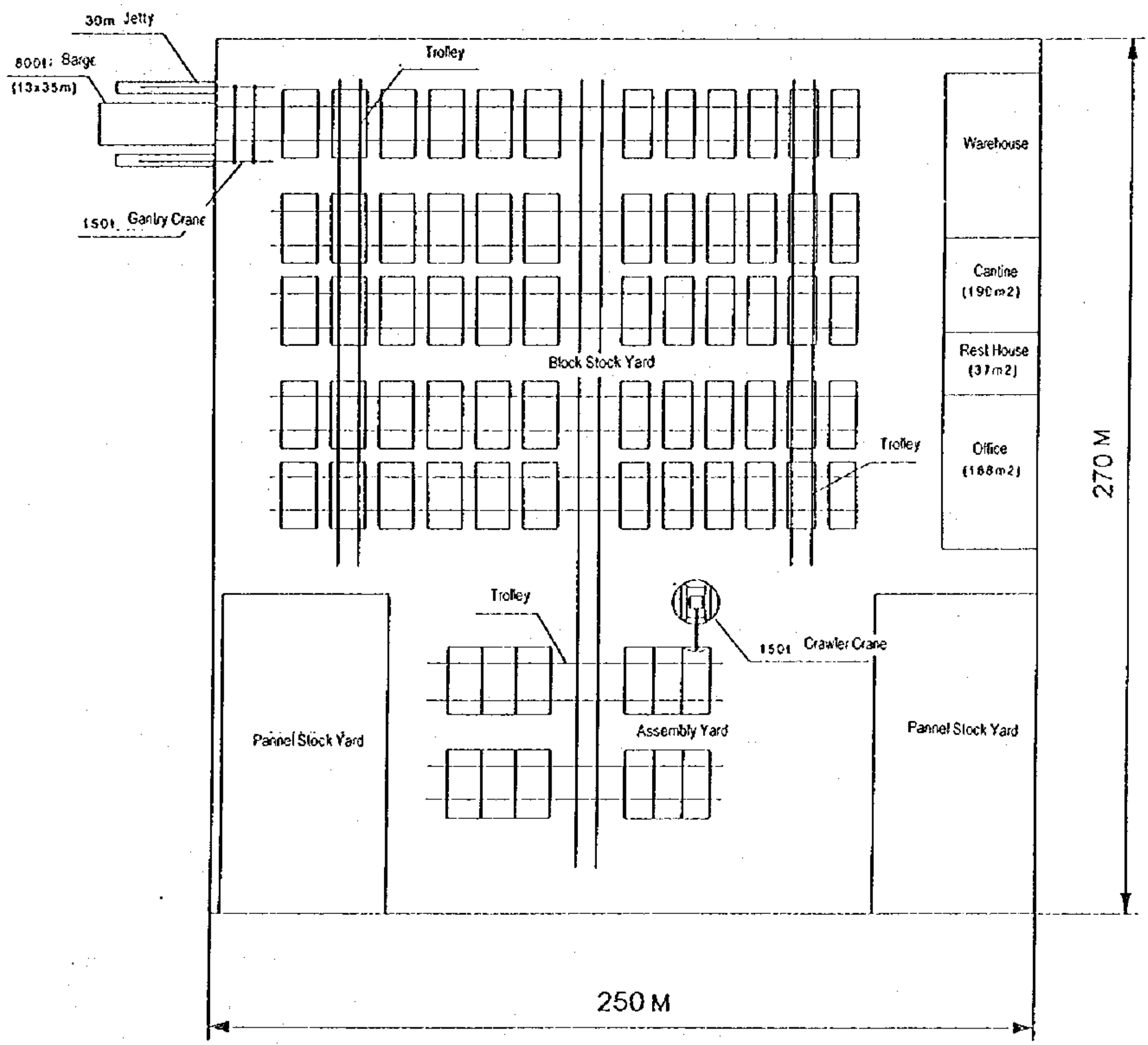


Fig.12.2.2(3) Site Work Yard (Assemble Yard)

12.3 Main Bridge

12.3.1 Super-Structure

(1) The conditions for Use of the Canal

The cable-stayed bridge should be designed taking full account the method of installing the main girder. The main girder of the bridge will be constructed using the balanced cantilever method. This entails suspending the girder units from stay cable and extending the girder from the pylon on to both the side span and the main span in equal incerements keeping both sides in balance. No temporary supports will be required in this operation.

The canal will be kept in full use during construction under the following conditions as described in Chapter 6, Paragraph 6.1.3.

i) The navigational clearance during construction

The navigational clearance during construction shall be 70 m at Highest High Water Level for the Canal navigational width of 270 m. Byond this width for a further distance of 57 m to the crest of both banks, it shall be 68 m at Highest High Water Level.

ii) Use of the canal water surface during construction periods

During the periods when the shipping convoys are changing from north band to south band, i.e. the four hours between 07:30 - 11:30 and 12:30 - 01:30, the water surface of the canal may be used for construction.

The canal surface over a width of 30 m from the crests on both banks may be used at all times.

The hours of the convoy operation may be changed, and during initial construction stage it will be necessary to hold meetings with the Suez Canal Authority based on actual convoy time and bridge construction schedules.

The east side of the canal will be required to widen at near proposed hindge site for construction temporarily.

(2) Construction Methods for the Main Girder

The main steel box-girder for the bridge will be manufactured overseas. It will be manufactured and divided into 10 sets of cross sections composing 12.0 m or 10.0 m long components for ease of transportation to the site. These component segments will be pre-assembled and welded into segments (approximately 120 tons of one segment) at the assembly yard which will be established on the East Bank only. (See Fig. 12.2.2 (3) and Fig 12.2.(3) and Fig. 12.3.1)

The erection for the main girder and cables will be as follows: (See Fig. 12.3.1)

1 In order to hold the main girder temporarily in place, a working platform and temporary support will be constructed on both sides of the pylon.

2 A segment of main girder will be temporarily held in place using the truck crane on the temporary support at the cross beam of the pylon.

3 The movable derrick crane for the side span girder will be assembled on the erected main girder. The first segment of the side span will be hoisted in place using this crane.

4 The segment of main span will be erected in a similar manner. The pre-assembled segment can be towed into place with a deck barge under the bridge and then hoisted into place.

5 The next segment for the main span and the side spans can be hoisted into place and connected to the main girder using the stay cables of the pylon to steady them.

6 The next segments can be installed in a similar manner alternately while performing the operation on each side in a similar manner. During these activities, work will continue on the previously installed sections to get them into designated positions.

7 Finally the cantilevered girders from the pylons will be connected at the center of the main span, thus completing the main girder.

During construction the girders will be provided with a camber and the cables lengths will be calculated beforehand so that girders can be positioned in their correct position. For the side spans, when the girder reaches the auxiliary pier, in order to adjust the camber and cable prestressing, the members will be secured temporarily in a higher position but in order to stabilize the structure, connections will be made to the pier.

The most important factor in the construction of cable-stayed bridges is to achieve the final profile of the girder called for in the design, while concurretly ensuring that the design stress in the stay cables and the girder are attained. In order to meet with this requirement, the final position of the girders being installed should not only be calculated but to calculations of the adjustments in the field for any differences made, to ensure full match up is achieved.

Maintaining safe navigation in the Canal during construction operations must be in accordance with the points described in Paragraph 12.3.1(1), and the entire structure must be enclosed with safety netting to prevent objects falling on to the vessels passing on the Canal.

12.3.2 Pylons

The pylon will be constructed with reinforced concrete using climbing forms. Elevators will be provided for materials and prersonnel access. For the lifting of reinforcing steel, concrete and other incidentals, one tower crane with a capacity of 200 tonne will be provided. This crane can be used not only for the construction of the pylon, but can be used to install the stay cables and associated materials.

For the placing of concrete up to the deck level, concrete pumps will be used, but for the placing of concrete at higher levels, cranes with concrete buckets will be employed.

12.3.3 Sub-Structure

The sub-structures will consist of a pair of rectangular boxes which will also be constructed using climbing forms. This work will be performed prior to the installation of the main girder for the bridge, and will use the same construction equipment and where possible the repeated use of the concrete forms. The concrete for the sub-structure will be placed by concrete pumps.

12.3.4 Foundations

(1) Pylon Foundation Work

The foundations will be constructed by caissons as described in Paragraph 6.5.6. The sinking of the caissons into the canal bed will be achieved with 8 hydraulic jacks of 50 tonnes capacity each.

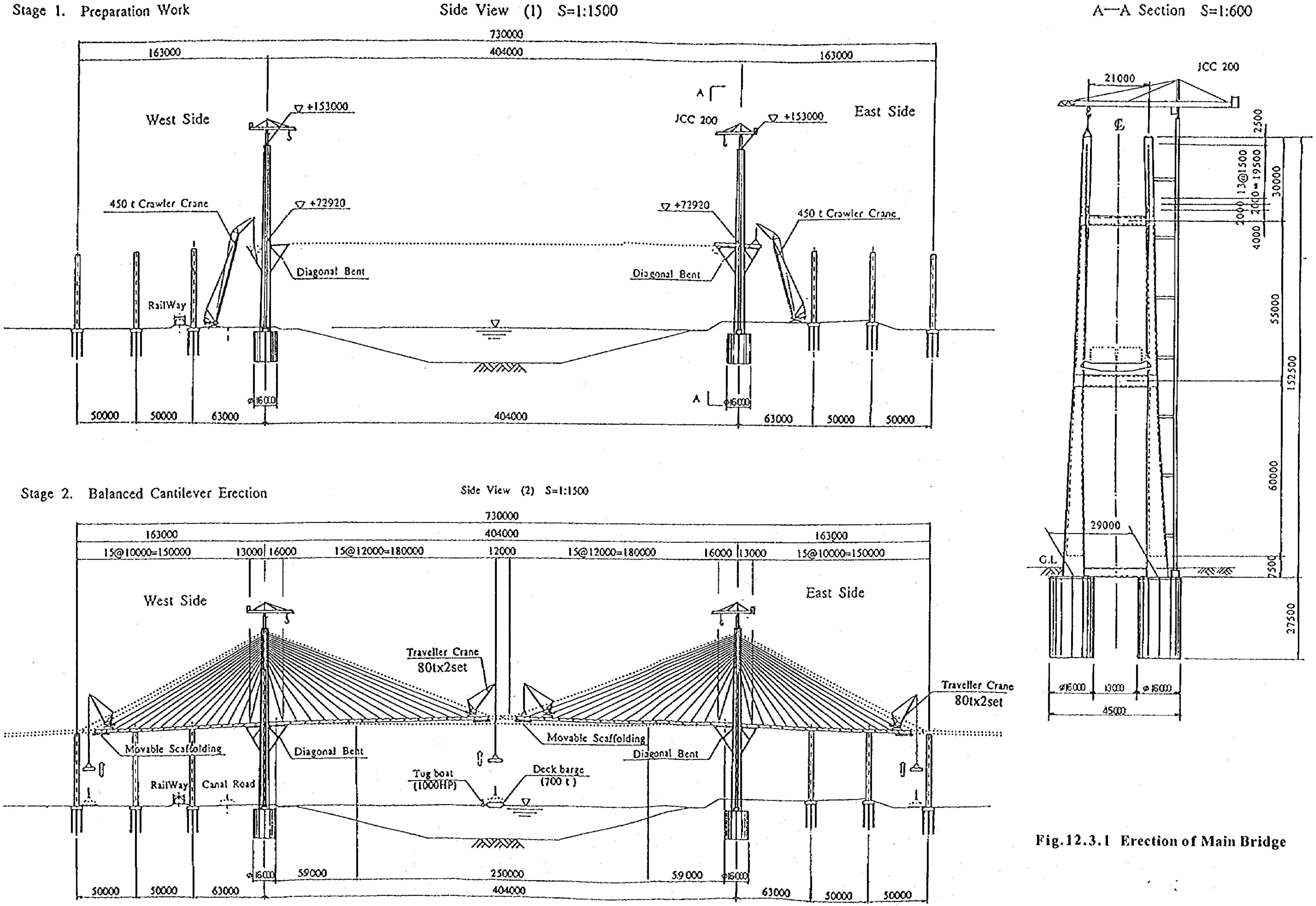


Fig.12.3.1 Erection of Main Bridge

(2) Sub-Structure Foundations

The 1.5 m diameter pile will consist of cast-in-place concrete using steel casings. The boring of the holes will be with an auger boring rig. The augered cast-in-place concrete will be placed by tremie tube while extracting the casing.

Any water in the sub-structure foundation footing pit will be removed with a pump, and the concrete will be placed in the reinforced pile cap.

12.4 Approach Viaducts

12.4.1 Super-Structure

Prestressed concrete box girders with spans of 40 m will be positioned with 4 movable falsework sets on the east side and the west side respectively. The movable falsework will be attached to a cantilevered steel frame (See Fig. 12.4.1).

All upper works will be performed at high levels, and safety measures are to be provided for workmen engaged in the work in all these places including the main girder works.

12.4.2 Sub-Structure

The sub-structure for the approach viaduct will be constructed using climbing forms. This work will be performed ahead of the main girder work.

Eight sets climbing form equipment will be provided for use on the sub-structure of the main bridge, and the east and west side spans.

12.4.3 Foundations

The approach viaduct work will be performed in a similar manner to the main bridge sub-structure work. The piling works shall be sub-contract to a local contractor, and will require 4 teams each on both the east and west side.

For the cofferdam work near the irrigation canal and the pile cap work for the sub-structure, sheet piling will be required.

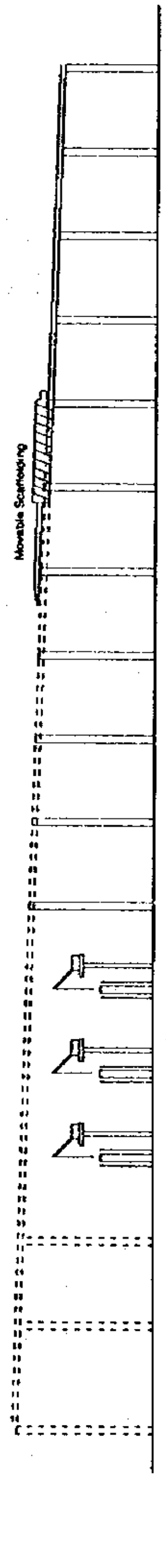


Fig.12.4.1 Erection of Approach Viaduct

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12.5 Approach Embankments and Access Roads

(1) Approach Embankments

For the civil works, the use of conventional earth moving equipment will be adequate. The approach embankments on the east and west banks will consist of earth embankments, and to allow these to stabilize it will be necessary to undertake these works in the early stages. The road base on the approach embankments and the stone pitching protection for the embankment slopes should be completed much earlier than the erection of the main bridge girder as these roads will be used for access to the main bridge and the approach viaducts.

(2) Access Roads

The access roads on the East bank will be used for access to the work shops and yards and work should be started as soon as construction works commence. On the West bank roads there will be sections that cannot be completed until a box culvert for the local road, and a bridge over an irrigation canal have been constructed. These should be started as soon as construction works commence.

12.6 Construction Schedule

The construction schedule for the main bridge and approach viaducts is shown in Figs. 12.6.1(1) to 12.6.1(4). The effective construction time required including the preparatory work is estimated as 48 months.

Main Bridge Construction Schedule

Item	Description	Duration	Remarks
Preparation	Procurement	4m	
	Camp Yard	6m	
	Temporary Road	2m	
	Temporary Wharf	3m	
Foundation	Mounting		
	Ground Anchor	2m	
	Metal Edge Setting	1m	
	Sinking	7m	2sets x 1.7h/10㎡, 7lots
	Bottom Concrete	1m	(under water, clamshell)
	Top Concrete	1m	
	Filling	0.5m	
Pylon	H≦8m	1.5m	
	Shaft(152m,38 segment)	15m	4m/12days
	Cross Beam	2m	
Pier	Foundation(φ 1.5m x 15m)	2m	1pile/day
	Excavation	0.5m	
	Pile Cap	1.5m	
	Shaft(H ≒ 65m)	7m	4m/10days
Deck	Procurement	5m	
	Fabrication	12m	500t/month
	Site Assembly	10m	
	Erection	5m	16blocks(12m long)cantilever-out,
Accessory	Handrail,Drainage,etc	6m	1block/7days
Pavement		2m	
Canal	Excabation	3m	
	Filling	2m	
	Slope Protection	2m	
Site Clearing	Recovering	3m	

Fig.12.6.1(1) Construction Schedule of Main Bridge

Approach Viaduct Construction Schedule(3.3%, West Bank, L= 40m x 45 =1723m)

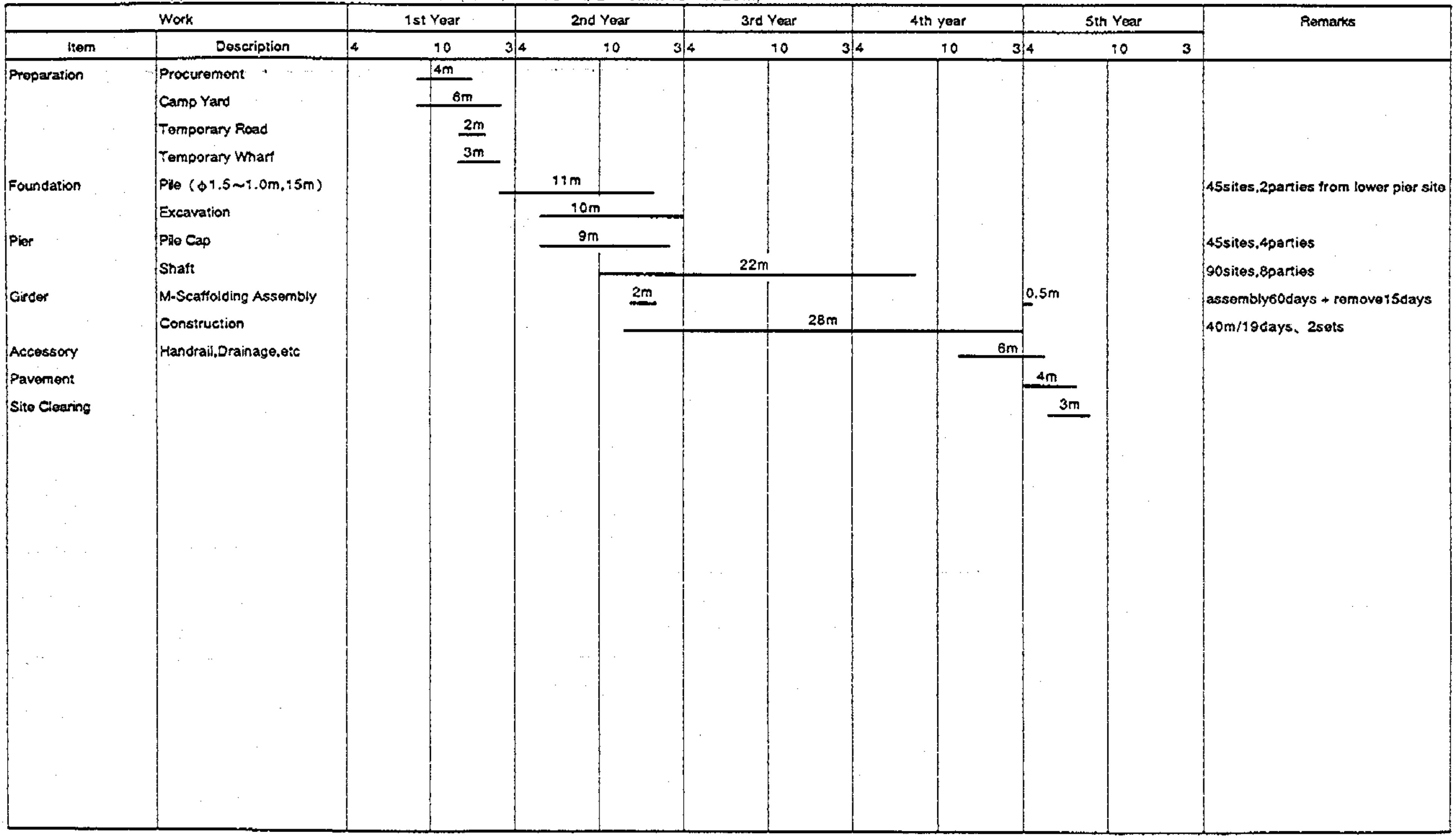

Fig.12.6.1(2) Construction Schedule of Approach Viaduct (West Bank)

Approach Viaduct Construction Schedule(3.3%, East Bank, L= 40m x 36 =1440m)

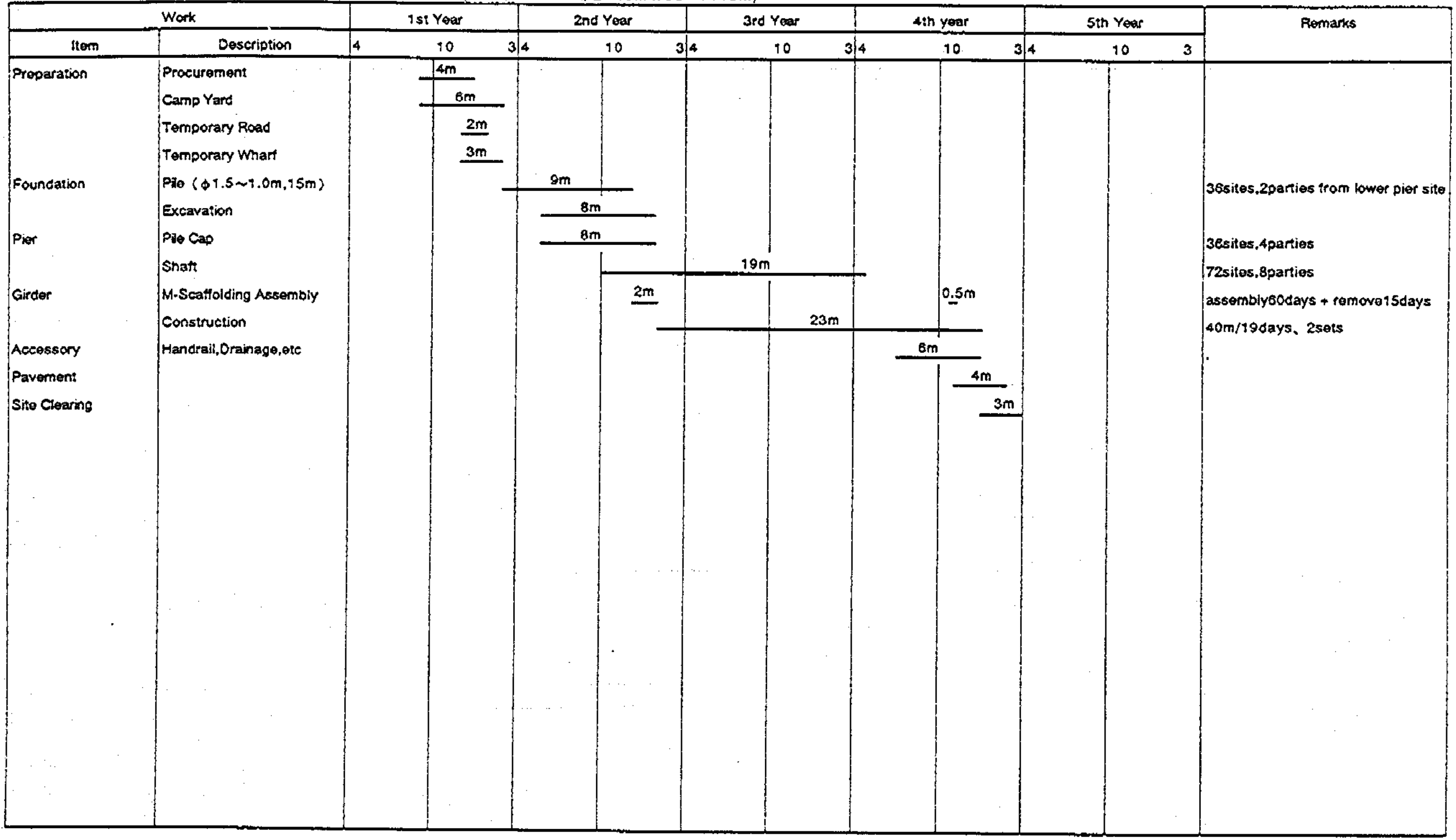

Fig.12.6.1(3) Construction Schedule of Approach Viaduct (East Bank)

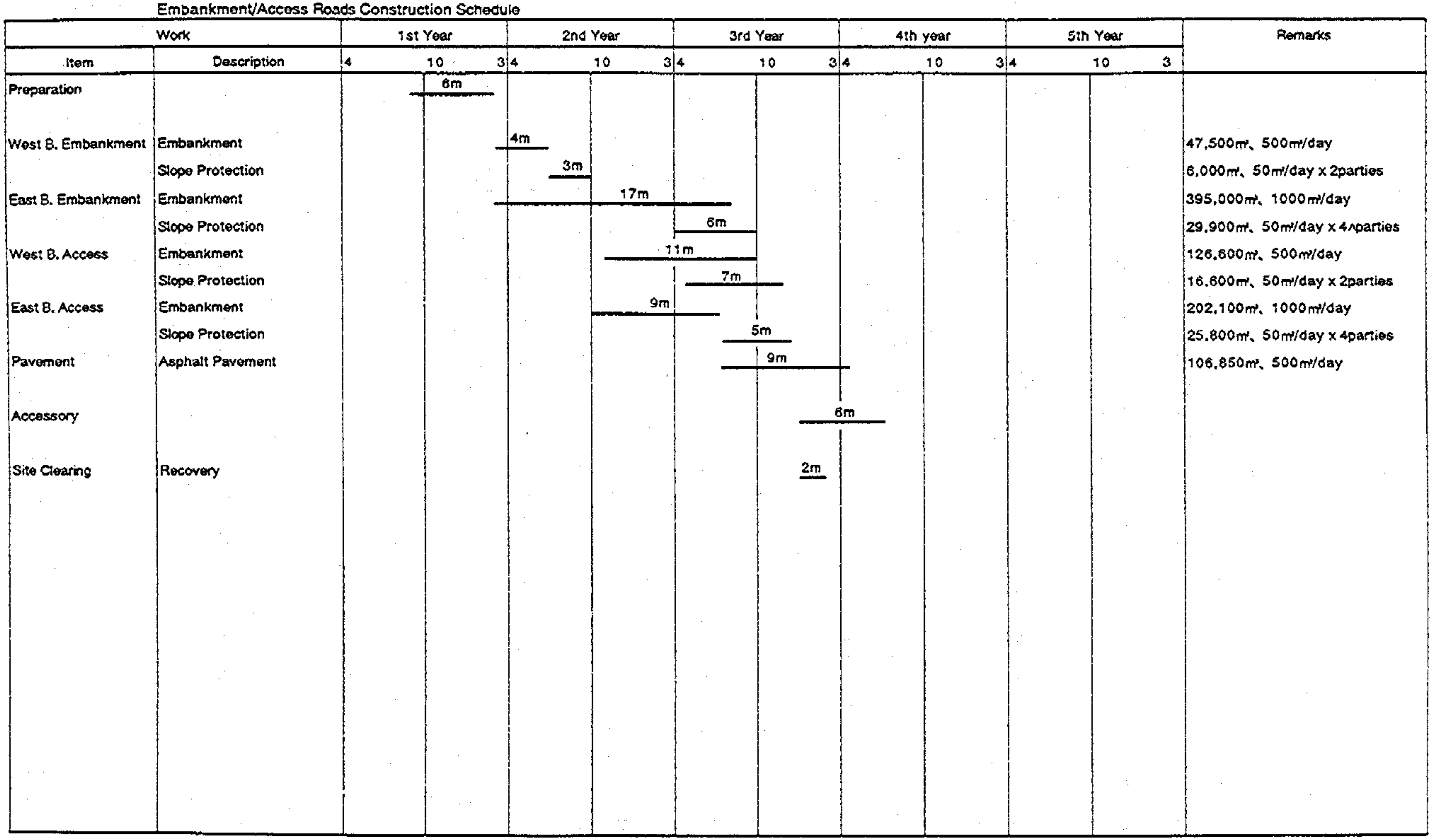

Fig.12.6.1(4) Construction Schedule of Embankment/Access Roads

12.7 New Radar Set

The implementation of the VTMS has been done by SCA and the system is already operating. For the additional two radars, it is anticipated that their installation will be done by SCA. The detailed implementation plan should be discussed with SCA.

The implementation schedule can be divided into the following main areas.

Activity	Estimated duration	Remarks
Procurement of material	4 months	
Implementation preparation	1 months	Based on 4 persons
Assembly and testing at contractors factory	1 months	Based on 3 persons
Shipment	2 months	Custom clearance not included. Custom taxes and duties to be taken care of.
Installation and testing	3 months	Based on 4 engineers
Updated documentation	1 months	Based on 2 engineers

Some of the activities can be conducted simultaneously.

The duration is subject to change, in case of unexpected problems and or waiting time during the installation and testing, to aword distribtion to the operational network.

The site preparation works which include civil work, erection of towers, installation of radar antennas will be conducted simultaneously with the ordering of the equipment.

The work for the radar should be completed prior to commencement of the construction of the pylons for the cable-stayed bridge, to avoid interruption to operation of the VTMS during the bridge construction. It is quite possible that the installation work will be conducted simultaneously with the construction work for the pylon foundations and completed within the required duration.

12.8 Preliminary Cost Estimation

12.8.1 General

Based on the results of the preliminary design and using collected data for costs, a preliminary construction cost for the Canal crossing has been estimated.

The basic assumptions are mentioned previously in Section 6.5.7. The main unit costs such as labor costs, major material costs and depreciation for equipment have been used following the results of the discussions undertaken by representatives of both the Egyptian officials and the Study Team.

12.8.2 Assumptions

(1) Labor

As mentioned previously, the most construction works have been allocated to local labor except for the specialist works.

(2) Materials

The procurement and unit costs for main materials have been used for costing using the following assumptions:

Cement	:	local product, local rate
Re-bars	:	local product, local rate
Aggregates	:	local product, local rate
Sand	:	local product, local rate
Asphalt	:	local product, local rate
Steel girder product	:	imported, price in US currency
Prestress tendon	:	imported, price in US currency
Stay cables	:	imported, price in US currency

(3) Depreciation

Depreciation has been computed using the linear method and the rate which is generally used in Europe for specialist equipment, the rate has been using the following assumptions;

i) An ultra large mobile crane will be procured in Europe.

ii) Movable falswork will be fabricated in Egypt except for special equipment such as electric instrumentation and hydraulic jacks. The depreciation was determined by dividing the depreciation the capital value by the expected normal life of the equipment.

(4) Contingencies

A physical risk contingency of 7% of the estimated construction cost has been assumed. A price escalation of 3% inflation of US currency base has been assumed.

(5) Indirect Cost / Overhead Cost

A figure of 20% of the sum of the basic construction and contingency cost has been assumed for indirect cost / overhead cost.

(6) Engineering Cost

A sum equal to 10% of the basic construction and contingency cost has been estimated as the engineering cost for detailed design and construction supervision by the consultant.

12.8.3 Project Cost

The project cost is summarized in Table 12.8.1.

Table 12.8.1 Project Cost

Unit : million US$
million £E

Section	Cost		Remarks
	Foreign	Local	
Main bridge	25.0	33.8	L=730m, 4 lanes
Approach Viaduct (West)	8.1	70.5	L=1,723m, 4 lanes
Approach Viaduct (East)	6.8	61.6	L=1,440m, 4 lanes
Access road	0	28.6	L=5.4km
Others	3.7	4.1	Road light and safety facilities
Radar system	1.2	1.4	Management facilities
Subtotal	44.8	200.0	
Price contingency	4.0	18.0	9%
Physical contingency	3.1	14.0	7%
Subtotal	51.9	232.0	
Indirect cost	10.4	46.4	20%
Engineering cost	8.4	12.2	10%
Land acquisition, etc.	-	5.1	
Grand total	70.7	295.7	

Exchange Rate : 1 US$ = 3.4 £E (February, 1996)

CHAPTER 13

IMPLEMENTATION PLAN

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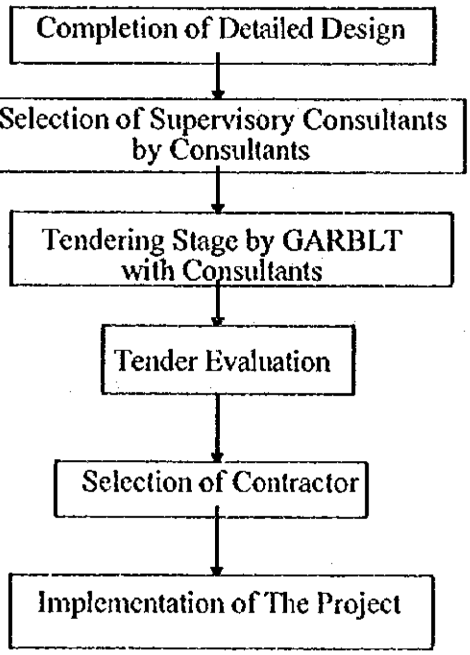
13.1 General

GARBLT (General Authority for Roads and Bridge & Land Transport) is a governmental body subsidiary to the Ministry for Transport & Communications. GARBLT is the only responsible authority for main roads all through the Egyptian roads network (planning, construction, operating, maintenance, safety works, infrastructures, etc.) (manpower : 10,000 in headquarters & 10 districts).

In this paragraph, implementation plan by international tendering is explained as shown in below.



Implementation organization and implementation schedule is as explained in the next paragraph.

13.2 Implementation Organization

13.2.1 GARBLT

GARBLT is a governmental body in the Ministry of Transport and Communication responsible for construction, upgrading and maintenance of inter city and main highway network and its infrastructure.

The organization chart of GARBLT is shown in Fig. 13.2.1.

13.2.2 Consultants Organization

One example of consultants organization for construction supervision is shown in Fig. 13.2.2.

13.2.3 Contractor's Organization

One example of the contractor's organization for construction is shown in the following Fig. 13.2.3.

13.3 Implementation Plan

Implementation plan for construction stage by international tendering is shown in Fig. 13.3.1

Main schedule is :

- Selection of Consultant	3 months after completion of Detailed Design
- Selection of Contractor	9 months after completion of Detailed Design
- Completion Land Acquisition	9 months after completion of Detailed Design
- Commencement of Construction	9 months after completion of Detailed Design
- Completion of Construction	51 months after commencement of Construction

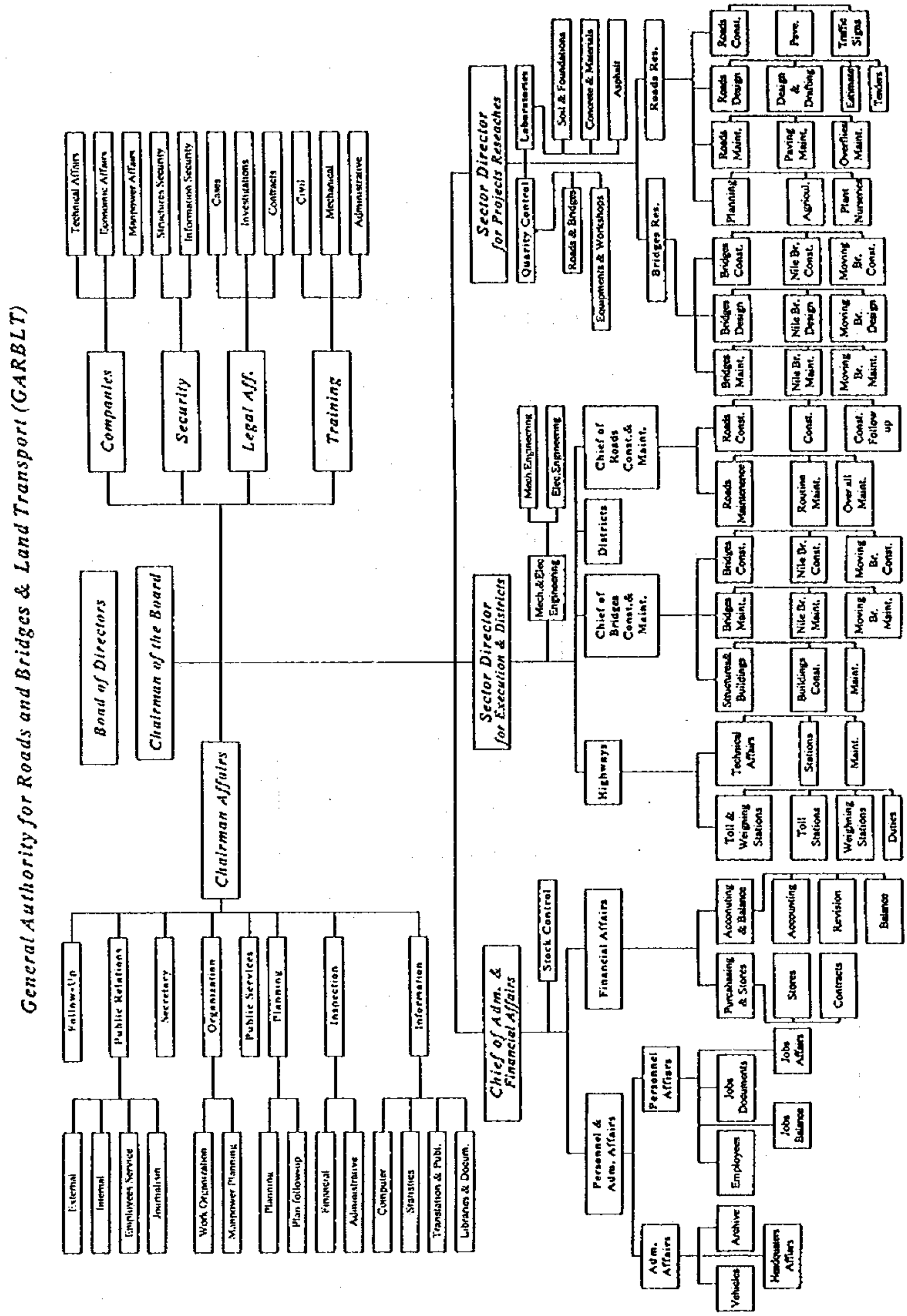


Fig. 13.2.1 General Authority for Roads and Bridges & Land Transport (GARBLT)

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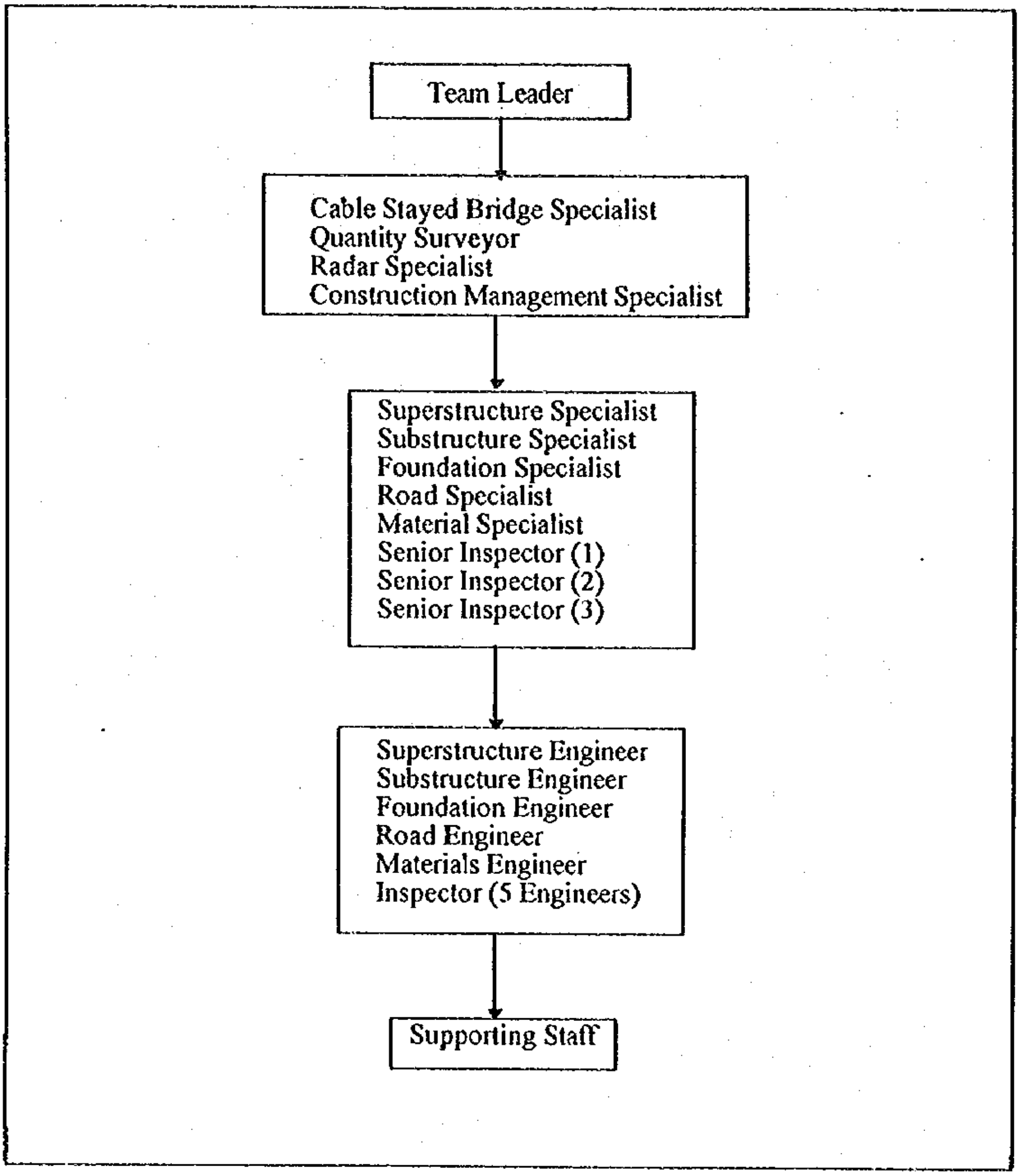

Fig. 13.2.2 Consultants Organization Chart for Supervision

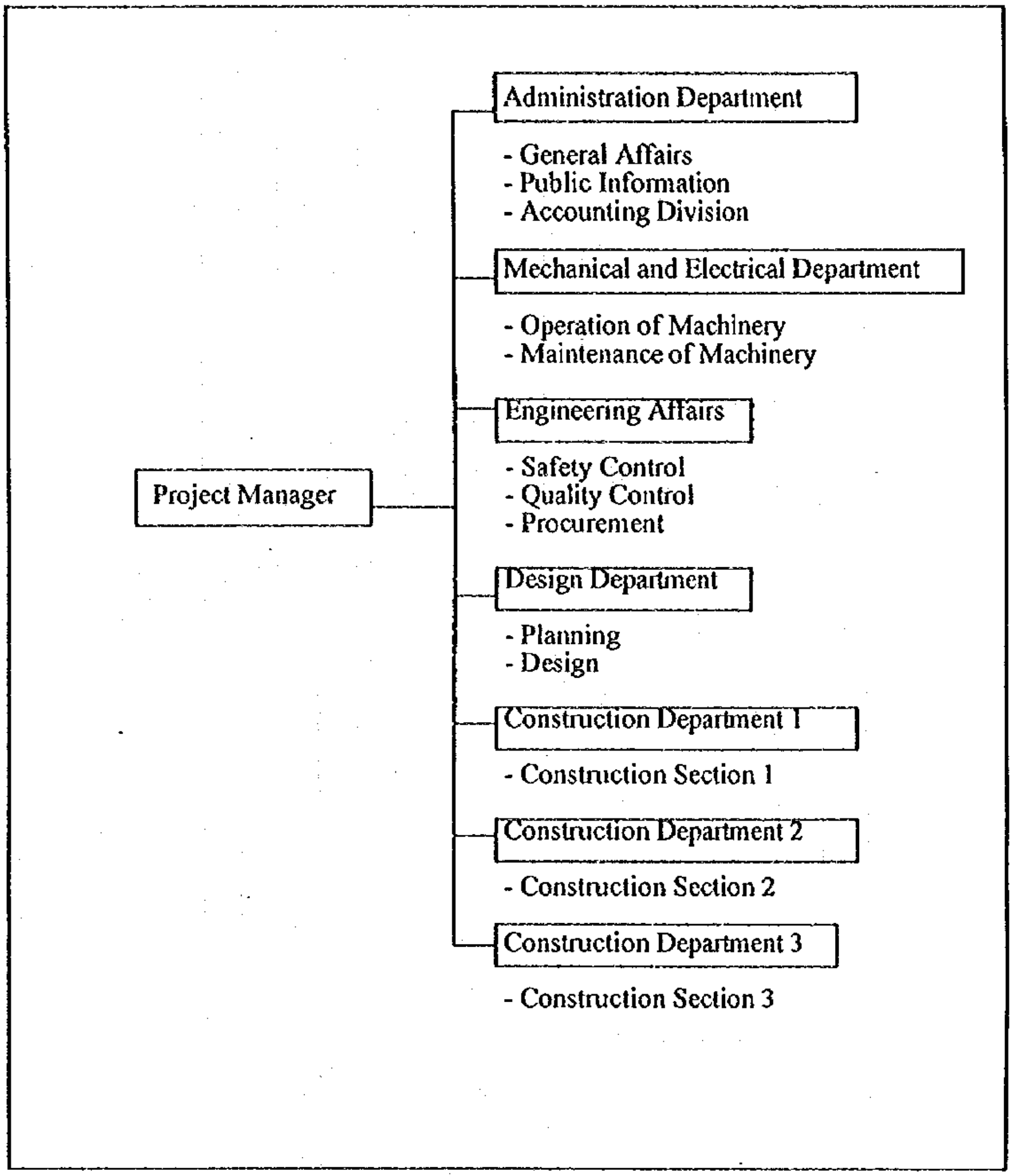

Fig. 13.2.3 Contractor Organization Chart

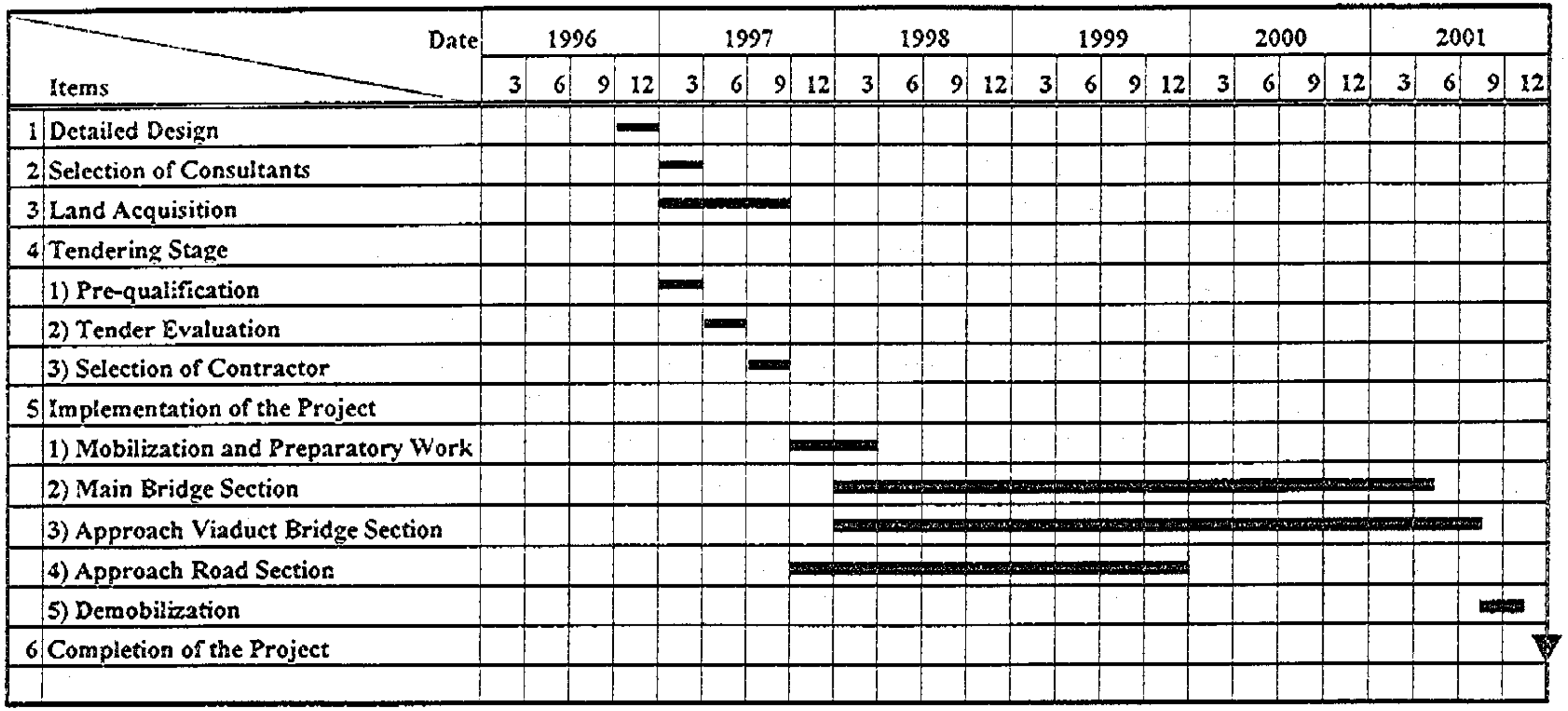

Fig. 13.3.1 **Implementation Schedule**

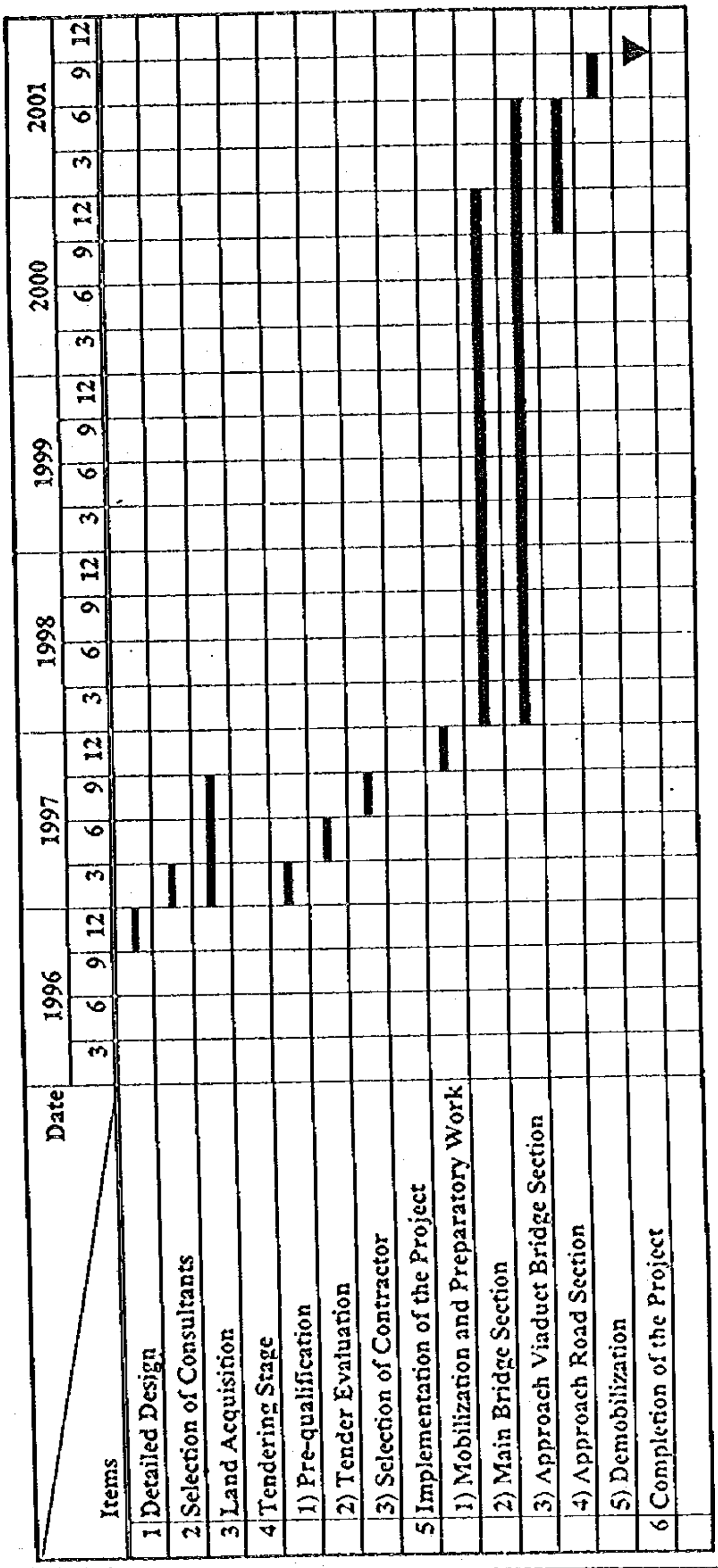

Fig. 13.3.1 Implementation Schedule

THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL