### A10.1.2 Location of Road Crossing

(1) General

The best crossing location has been examined in Chapter 10 and SCA 48 + 505 has been decided as the best crossing location of the road crossing the Suez Canal.

However, this crossing location is considered to cause the demolishing of three public institution. The road crossing the Canal passes over some important institutions including the military area at this location. Therefore, other locations are studied to prepare countermeasures for problems caused by passing over these facilities by the road crossing.

(2) Alternatives

The following 3 additional alternative crossing locations are studied to avoid passing over the military area, important institutions and private houses.

- Reference 1 : SCA Km 48 + 450 ( Straight )
  The horizontal alignment of the road crossing the Canal is straight in the bridge and approach viaduct sections.
- Reference 2 : SCA Km 48 + 400 ( Straight )
  The horizontal alignment of the road crossing the Canal is straight in the bridge and approach viaduct sections
- Reference 3 : SCA Km 48 + 460 ( Curve )
  A large curve with a radius of 3,000m is provided at the end section of the approach viaduct.

(3) Discussion

The results of the comparison are shown in Table A10.1.2.

SCA Km 48 + 505 has been selected as the best alternative crossing location which passes over the north end of the military area, the irrigation canal office and two schools. Land acquisition and removal of public institute are anticipated to be difficult. If land acquisition and removal of theses facilities are impossible, these reference alternatives should be studied again.

In order to avoid passing over these public institutions, the above alternatives were studied as references. Reference 1 is considered to be the best countermeasure to avoid passing over the important public institutions.

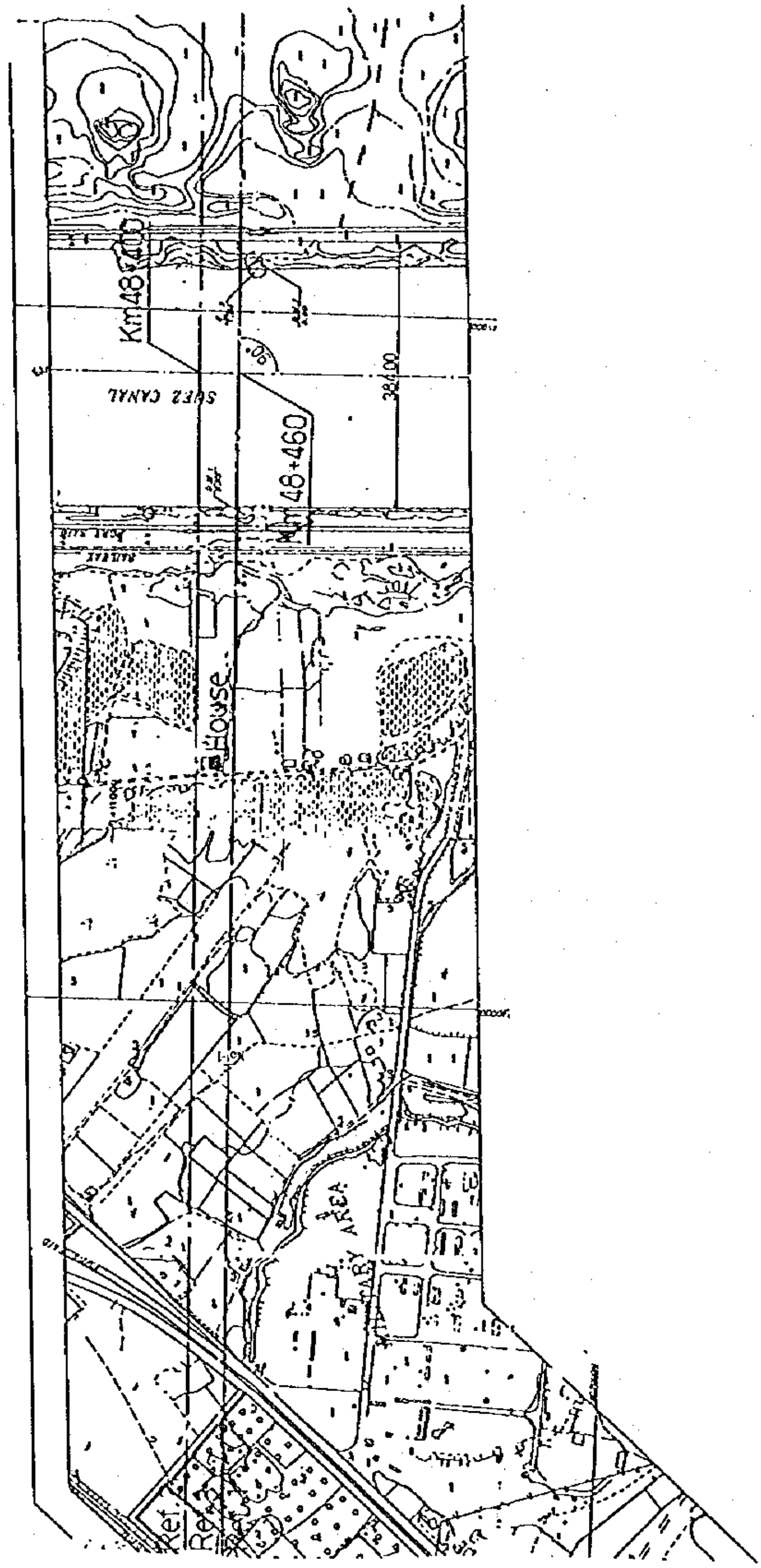



Fig. A10.1.5 Alternative Crossing Location (1)

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

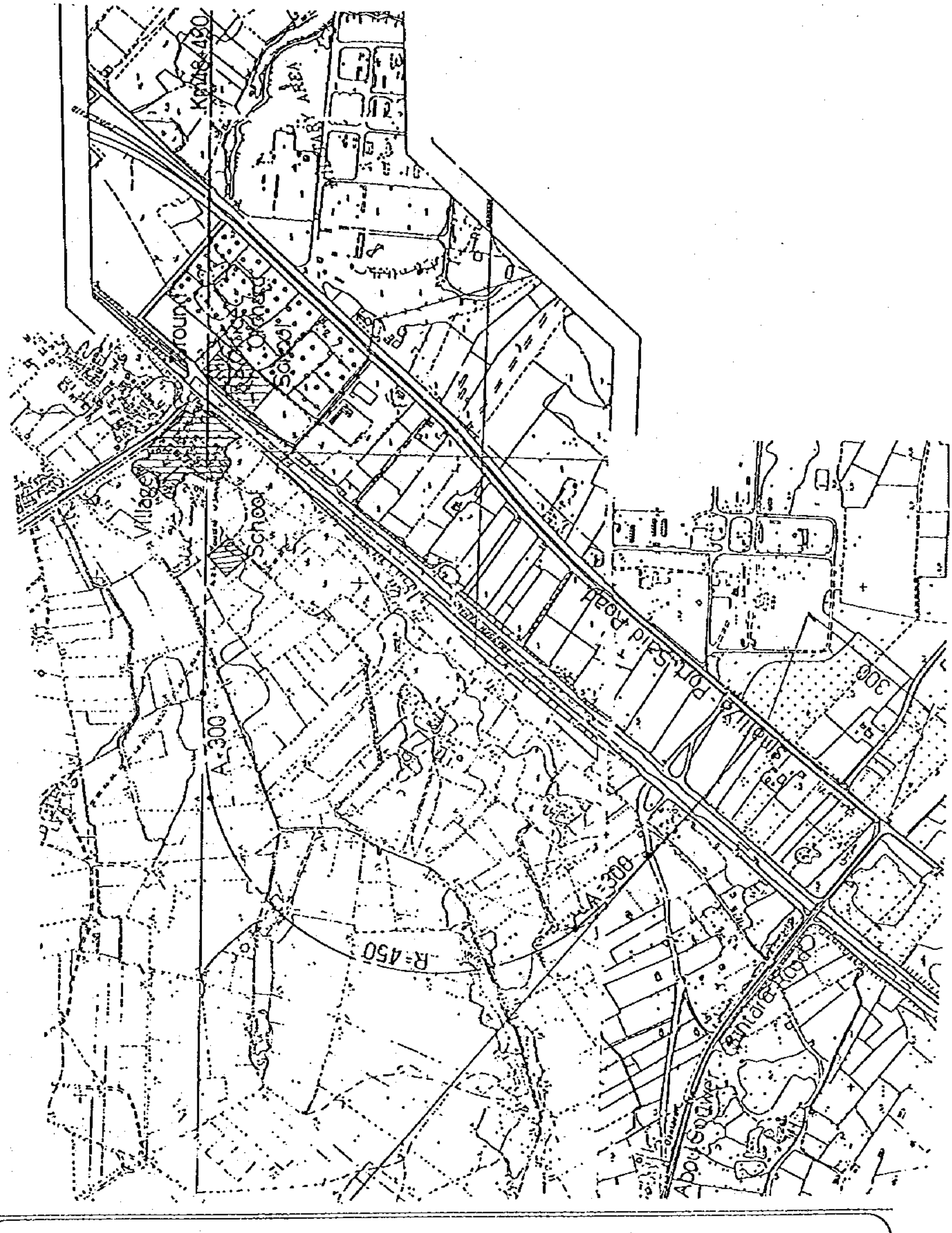



Fig. A10.1.6 Alternative Crossing Location (2)

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

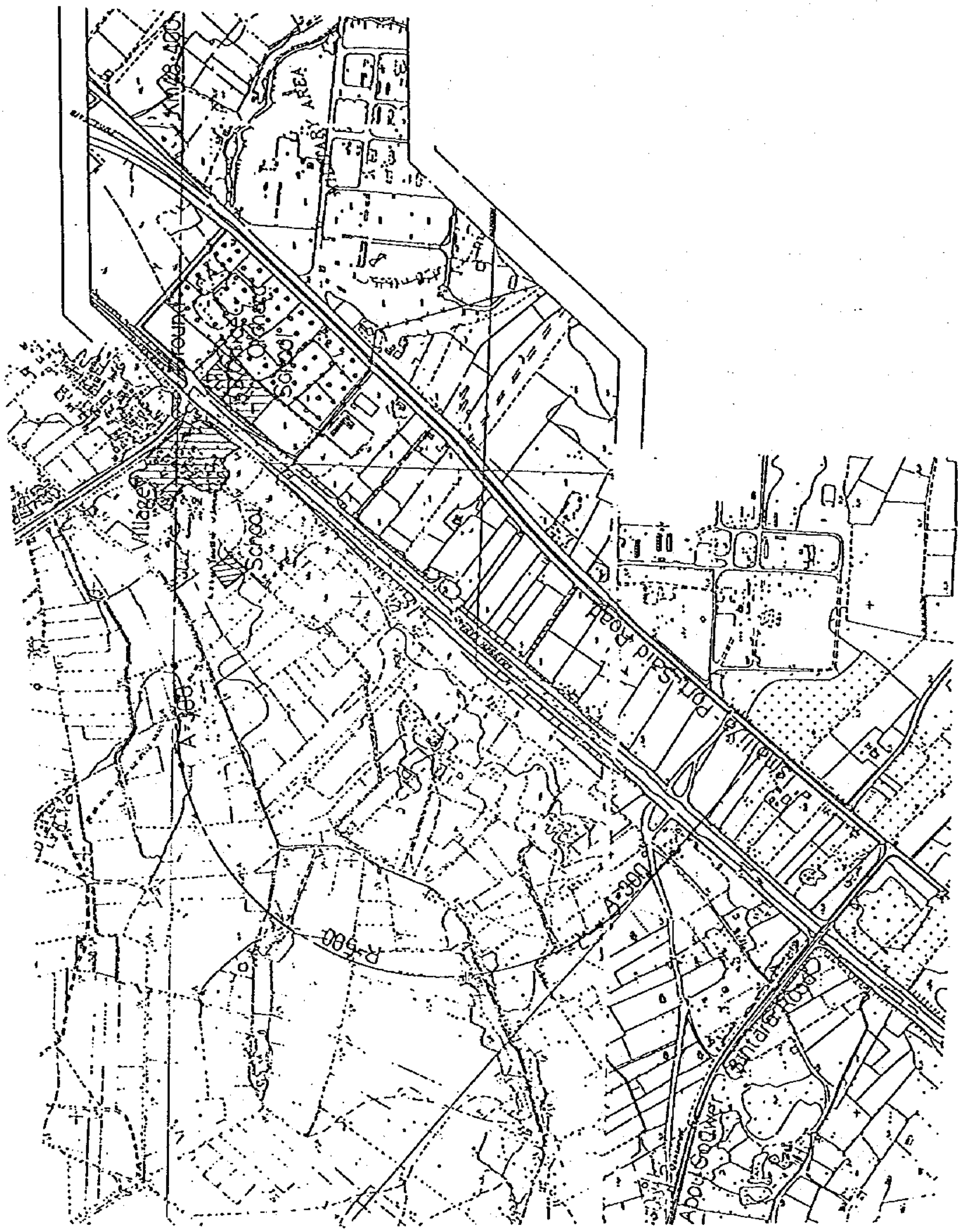



Fig. A10.1.7 Alternative Crossing Location (3)

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

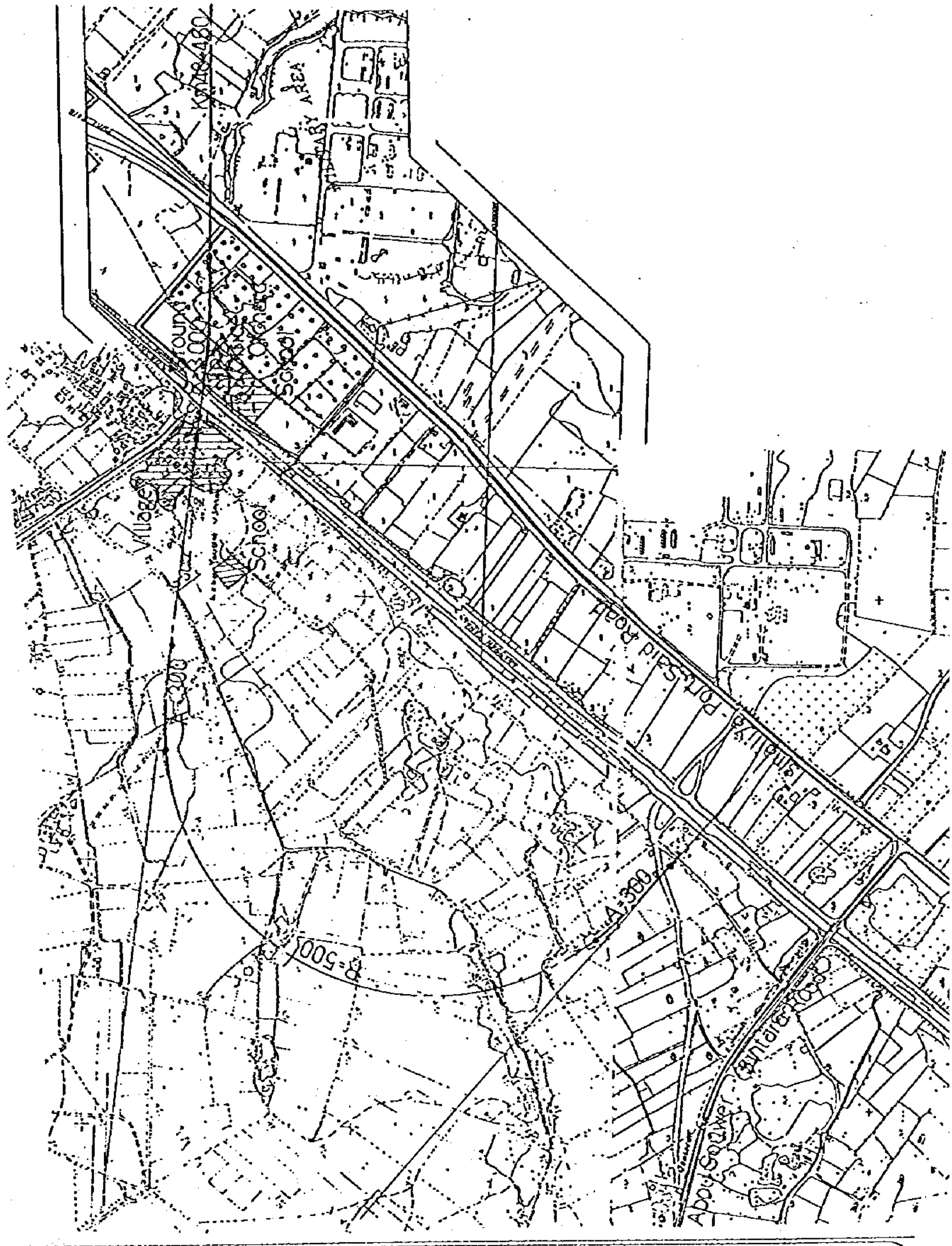



Fig. A10.1.8 Alternative Crossing Location (4)

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

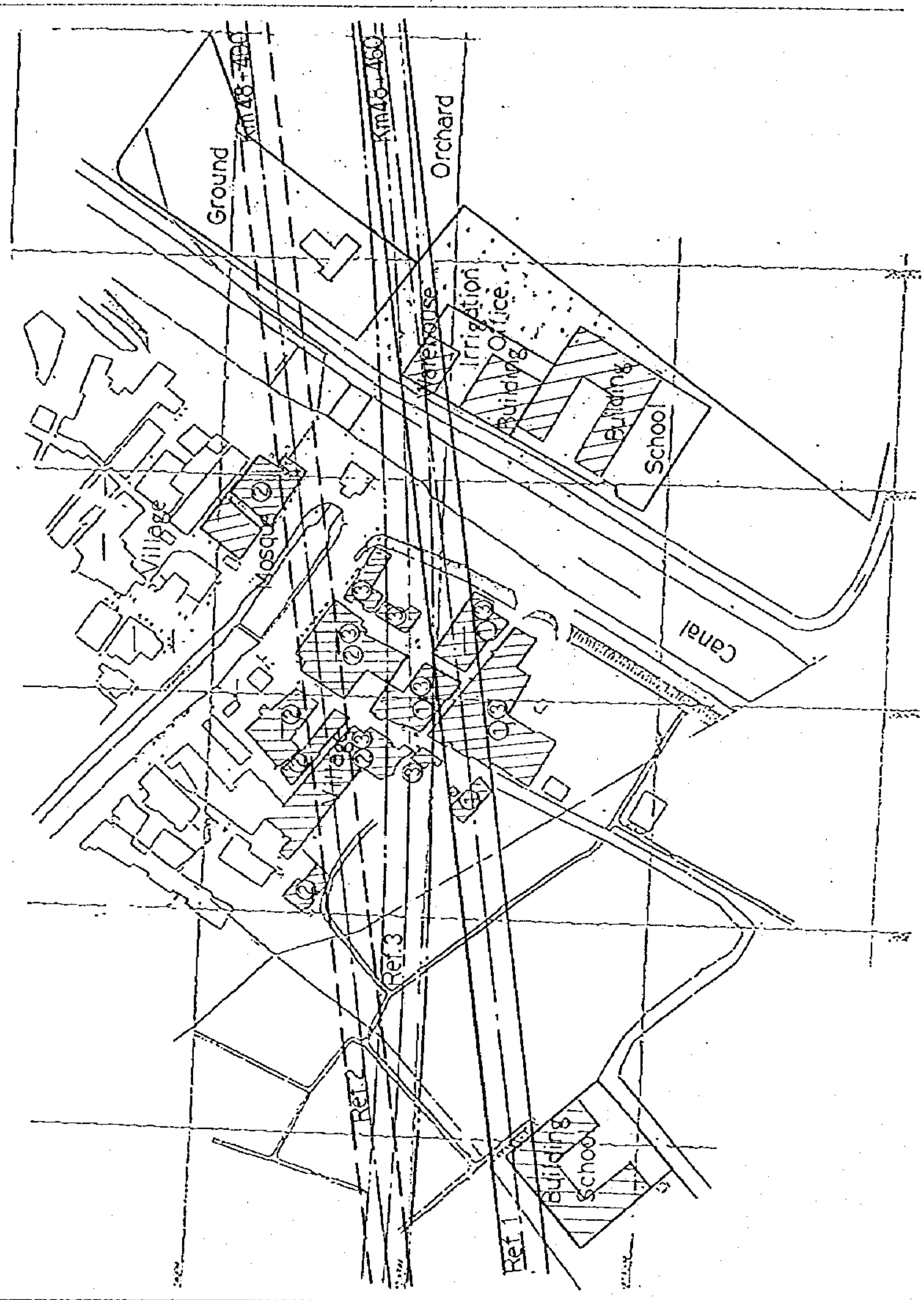
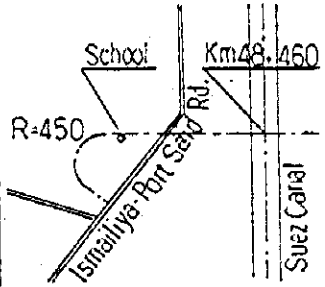
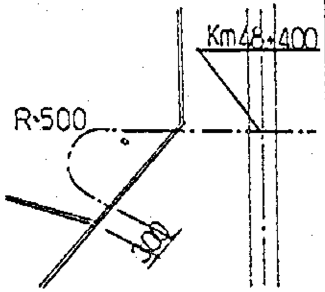
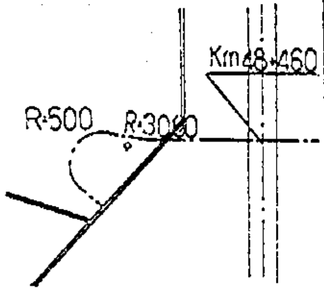



Fig. A10.1.9 **Relationship between Road and Control Points**

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

Table A10.1.2 Comparison of Locations of Road Crossing ( Reference )

| Alternatives | Horizontal Alignment | Length of Road (m) | Comments | Evaluating | | | | | | | | | Priority |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Horizontal | Control Points | | | | | | | Approach | |
| | | | | Align-ment | School West | School beside Canal | Irriga-tion Office | Orchard | Village | Ground | Irriga-tion Canal | Viaduct | |
| Reference 1 Km. 48 + 460 ( Straight ) |  | 3,750 | The road crossing the Canal will cross the Suez Canal at SCA Km. 46 + 460. The road crossing is straight in the approach viaduct section. The school in the west of the irrigation canal will be demolished. | Good 450m | × | ○ | △ | △ | △ (Demo-lish 4 houses) | △ | ○ | ○ ( In a straight section ) | Medium |
| Reference 2 Km. 48 + 400 ( Straight ) |  | 3,800 | The road crossing the Canal will cross the Suez Canal at SCA Km. 46 + 400 to avoid the school in the west of the irrigation canal. The road crossing is straight in the approach viaduct section. | Good 500m | ○ | ○ | ○ | ○ | × (Demo-lish 6 houses) | × | △ ( Close to a bridge and cross another small canal ) | ○ ( In a straight section ) | Medium |
| Reference 3 Km. 48 + 460 ( Curve ) |  | 3,850 | The road crossing the Canal will cross the Suez Canal at SCA Km. 46 + 460. A curve with a large radius will be provided to avoid he school in the west the irrigation canal. | Good 3,000m + 500m | ○ | ○ | △ | △ | × (Demo-lish 8 houses) | △ | △ ( Close to a bridge and a gate ) | △ ( In a curved section ) | Low |

Source : JICA Study Team

### A10.1.3 Horizontal Alignment on the West Bank

(1) General

The Study Team consider that to avoid passing over the military area and demolition of private houses is critical to decide the horizontal alignment of the road crossing the Canal on the West Bank.

In order to avoid passing over important public institutions and private houses to the west of the irrigation canal after passing through the north of the military area, the horizontal alignment of the road crossing the Canal to the west of the military area are studied.

(2) Alternatives

The following 4 alternatives of the horizontal alignments after passing through the north of the military area are compared.

- Alternative 1 : A radius of 900m
  Connecting onto Abou Souwer - Qantara Road at the point 700 west from Cairo - Iamailiya - Port Said Road.
- Alternative 2 : A radius of 850m
  Connecting onto Abou Souwer - Qantara Road at the point 700 west from Cairo - Iamailiya - Port Said Road.
- Alternative 3 : A radius of 1,500m
  Connecting onto Abou Souwer - Qantara Road at the point 700 west from Cairo - Iamailiya - Port Said Road.
- Alternative 4 : A radius of 2,000m
  Connecting onto Abou Souwer - Qantara Road at the point 700 west from Cairo - Iamailiya - Port Said Road.

(3) Discussion

The results of the comparison are shown in Table A10.1.3.

Alternative 1 is considered to be the best alternative because of its better horizontal alignment and ease of future improvements of the intersection between the road crossing the Canal and Cairo -Ismailiya - Port Said. Besides, if Alternative 1 is selected, the road crossing can avoid passing over public institutions including the irrigation office building and two schools.

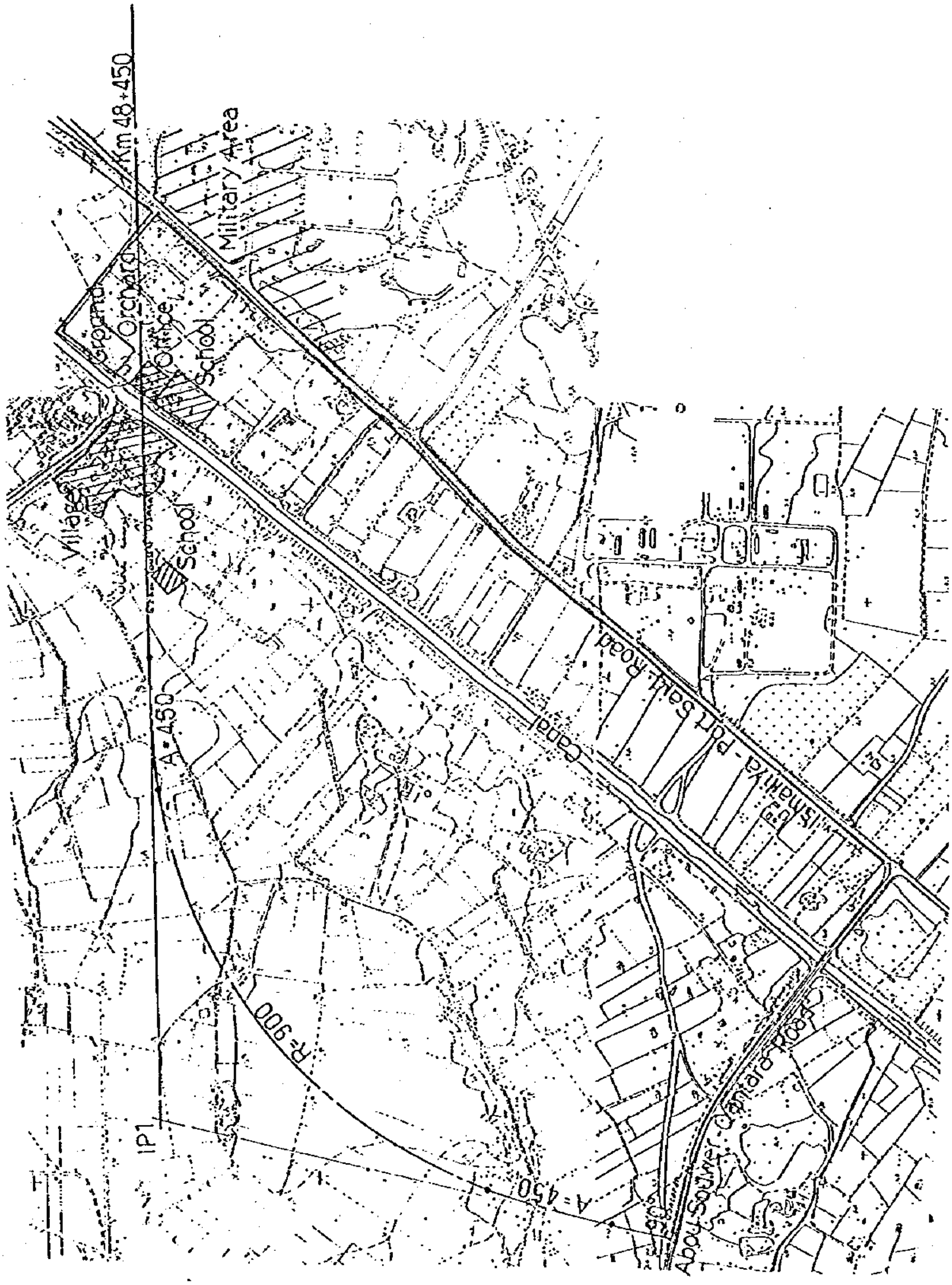



Fig. A10.1.10 Alternative Horizontal Alignment (1)

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

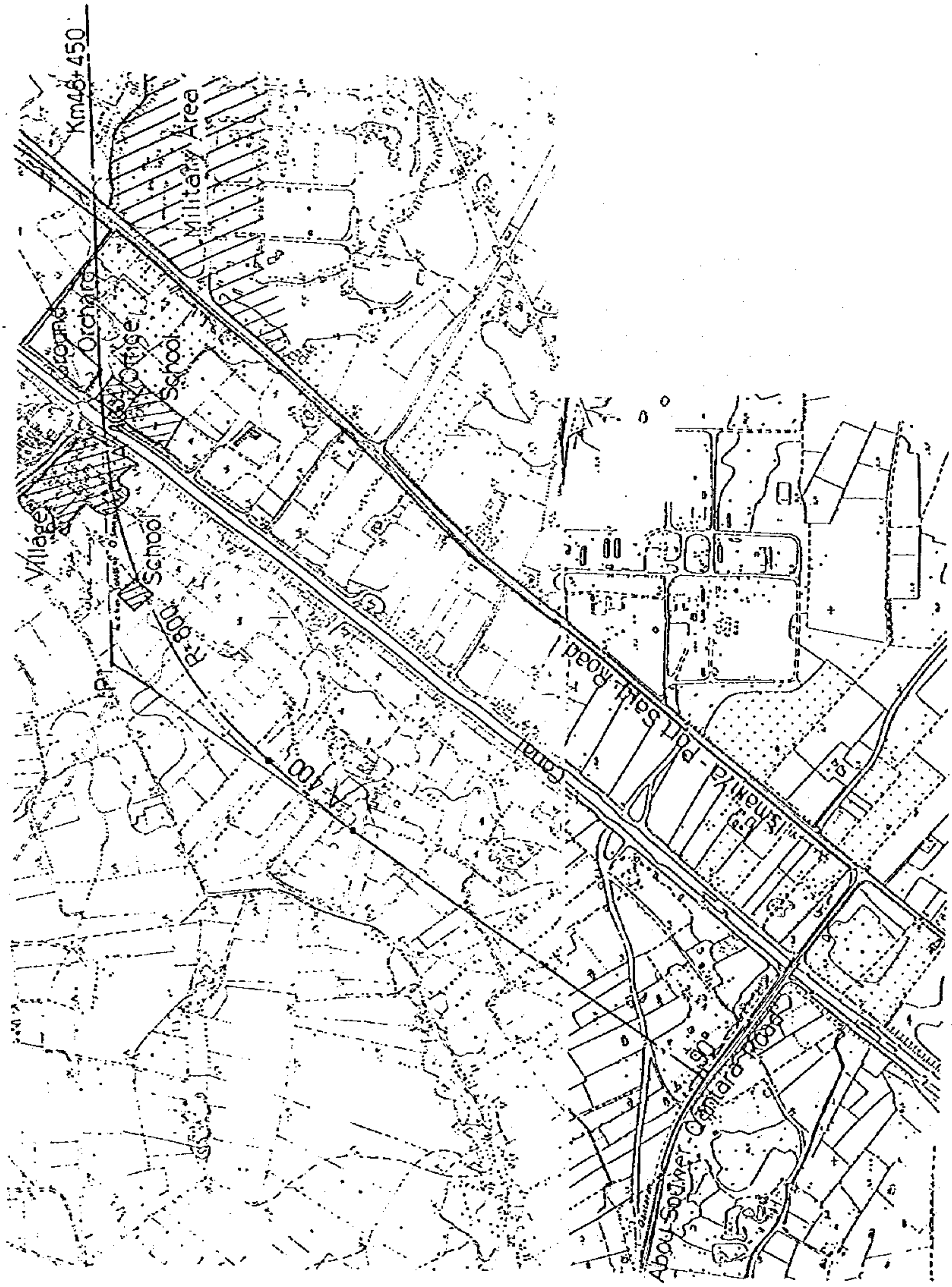



Fig. A10.1.11 Alternative Horizontal Alignment (2)

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

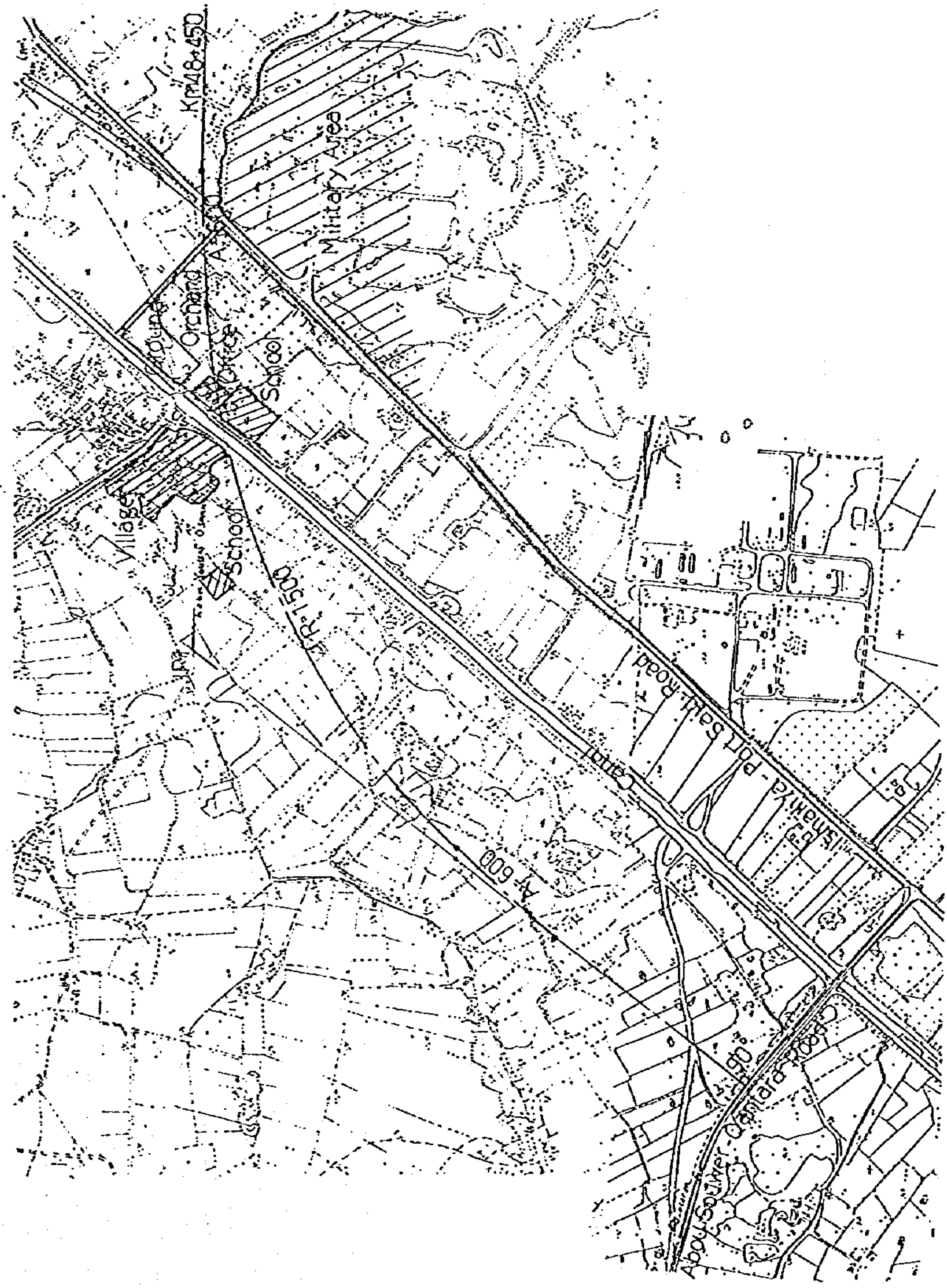



Fig. A10.1.12 Alternative Horizontal Alignment (3)

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

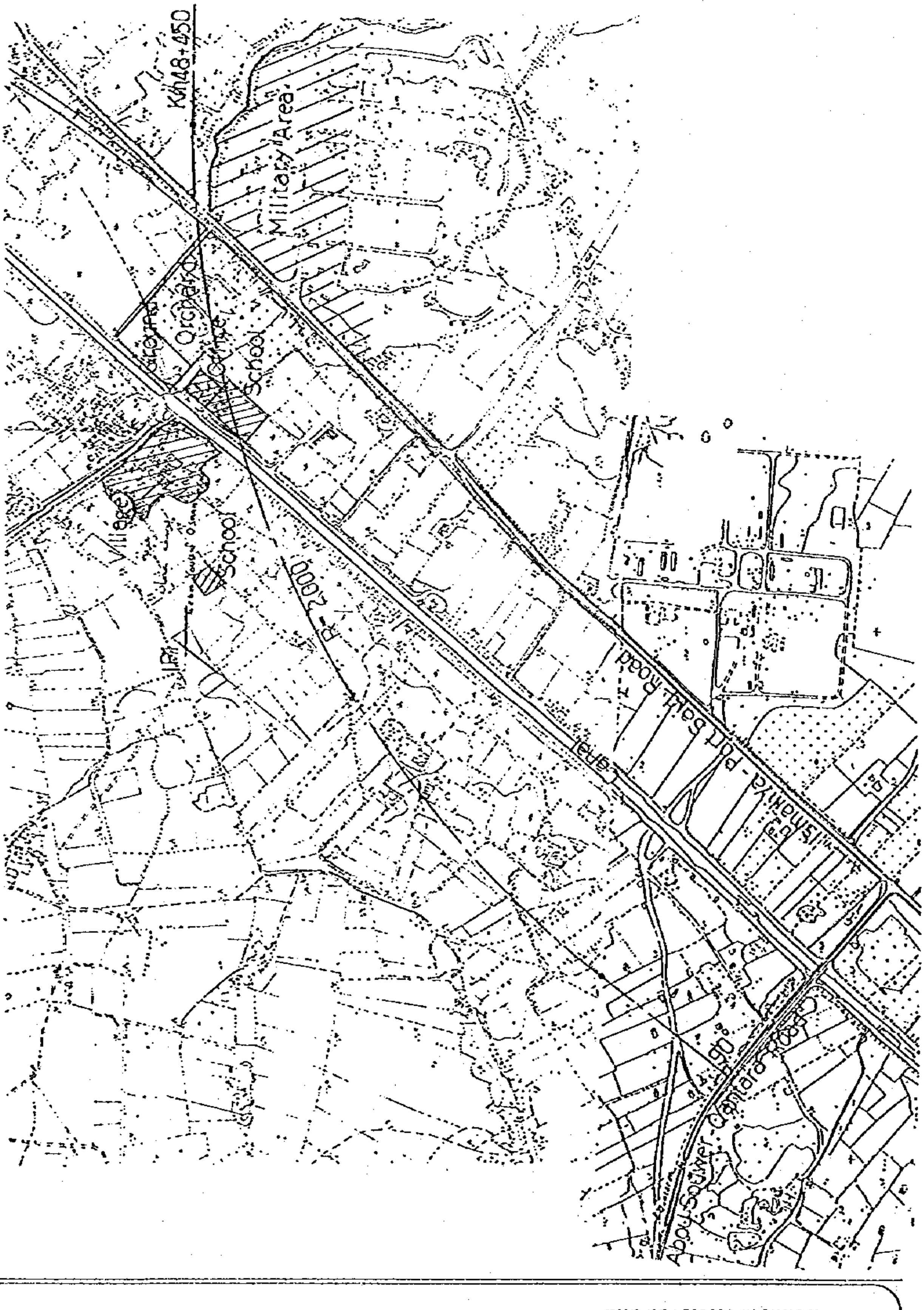



Fig. A10.1.13 Alternative Horizontal Alignment (4)

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

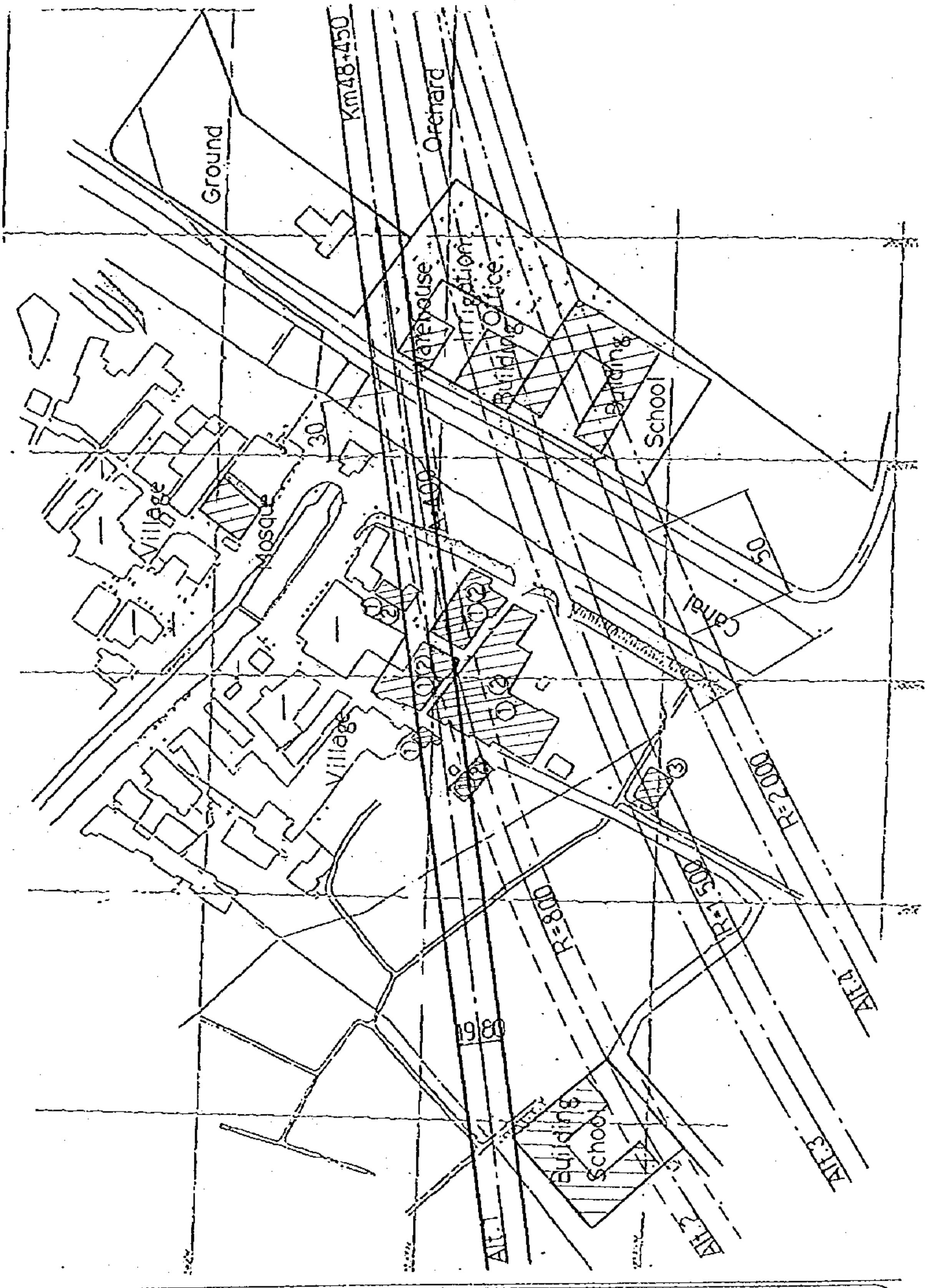
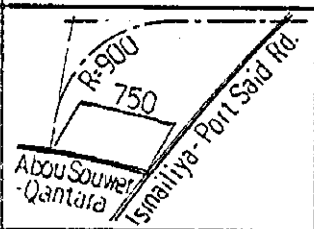
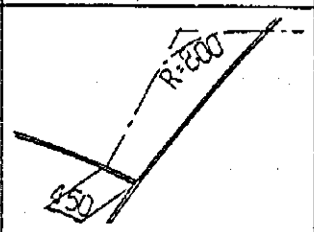
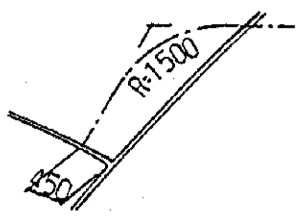
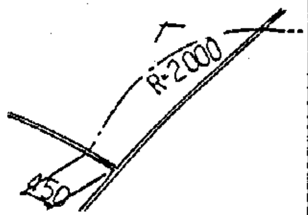



Fig. A10.1.14 Relationship between Road and Control Points

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

## Table A10.1.3 Comparison of Horizontal Alignment

| Alternatives | Horizontal Alignment | Length of Road (m) | Comments | Evaluating | | | | | | | | | | Priority |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Horizontal | Control Points | | | | | | | Approach | Const- | |
| | | | | Align-ment | Irri-gation Office | School beside Canal | School West | Orchard | Village | Irrigation Canal | | Viaduct | ruction Cost | |
| Alternative 1 R = 900 m |  | Newly-build 3,750 Improvement 750 Total 4,500 | The road crossing the Canal will be connected onto Abou Souwer - Qantara Road with a radius of 900m at the point of 750m from Ismailiya - Port Said Road. | Excellent 900m | △ | ○ | ○ | △ | × | ○ (Canal crossing length L=30m) | | ○ (In a straight section) | ○ | High |
| Alternative 2 R = 800 m |  | Newly-build 3,350 Improvement 450 Total 3,850 | The road crossing the Canal will be connected onto Abou Souwer - Qantara Road with a radius of 800m at the point of 450m from Ismailiya - Port Said Road. | Good 800m | △ | ○ | × | △ | × | ○ (Canal crossing length L=30m) | | △ (In a curve section) | ◎ | Medium |
| Alternative 3 R = 1,500 m |  | Newly-build 3,350 Improvement 450 Total 3,800 | The road crossing the Canal will be connected onto Abou Souwer - Qantara Road with a radius of 1,500m at the point of 450m from Ismailiya - Port Said Road. | Excellent 1,500m | × | × | ○ | × | ○ | △ (Canal crossing length L=40m) | | △ (In a curve section) | ◎ | Low |
| Alternative 4 R = 2,000 m |  | Newly-build 3,300 Improvement 450 Total 3,750 | The road crossing the Canal will be connected onto Abou Souwer - Qantara Road with a radius of 2,000m at the point of 450m from Ismailiya - Port Said Road. | Excellent 2,000m | ○ | × | ○ | × | ○ | △ (Canal crossing length L=50m) | | △ (In a curve section) | ◎ | Medium |

Source : JICA Study Team

### A10.1.4 Comparison of Vertical Grade

(1) General

Vertical grades of 4.0% and 3.3% are considered as alternatives for this study.
In order to decide the vertical grade of the road crossing the Suez Canal, vertical grades of 4.0% and 3.3% are compared in this section.

(2) Maximum Vertical Grade

The maximum vertical grades of each highway design standard is shown in table A10.1.4. From this table, maximum vertical grades are 4.0% or more for a design speed of 80 km/hr.

**Table A10.1.4 Maximum Vertical Grade**

| Design Standards | Design Speed ( km/he ) | Vertical Grade ( % ) | Remarks |
|---|---|---|---|
| Egyptian | 80 | 5.0 | Primary Rolling Desert Road |
| American | 80 | 6.5 | |
| | 112 | 5.0 | |
| Japanese | 80 | 4.0 | |
| British | 96* | 6.0 | AP Single Carriageways |
| | 112* | 4.0 | AP Dual Carriageways |

Source : JICA Study Team

Note : 96* or 112* is mandatory speed limits

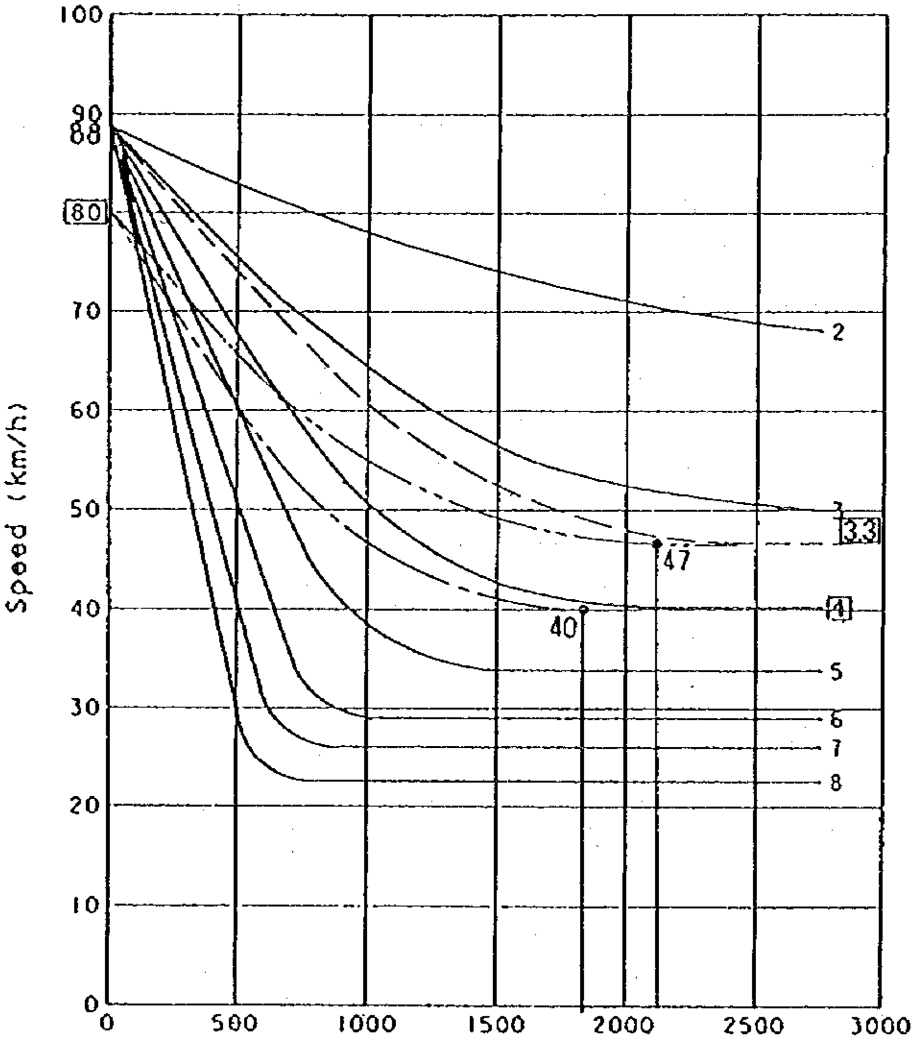
(3) Speed Reduction

Reduction of running speed of trucks has been calculated by AASHTO and Japan Highway Cooperation methods. The results of the calculation of speed reduction are shown in Fig. A10.1.15 and Fig. A10.1.16.

The reduction of running speed for a vertical grade of 4.0% based on American and Japanese standards are shown in Table A10.1.5.

In general, 50% of speed reduction of large trucks is acceptable to determine a vertical grade. On the other hand, the capability and situation of Egyptian vehicles should be considered to decide the vertical grade of the road crossing the Canal.

Deceleration (on Percent Upgrades Indicated)

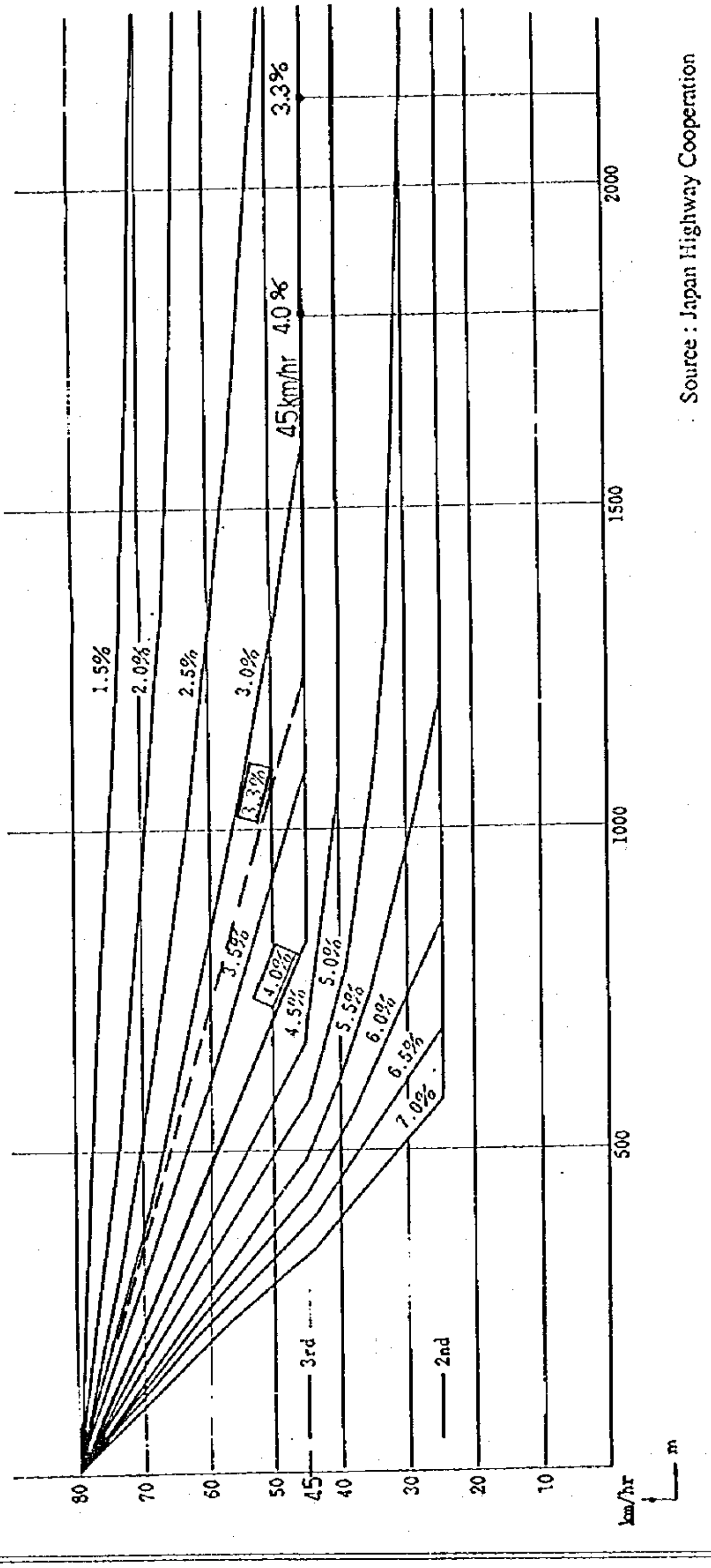



NOTE: Wt = Vehicle gross weight
$P_3$ = Power available for acceleration

Speed loss for vehicles which equal or exceed 87.5 percent of all tractor-trailers and single-unit trucks on all roads

Fig. A10.1.15 Reduction of Running Speed by AASHTO

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




| | | |
|---|---|---|
| Fig. A10.1.16 | **Reduction of Running Speed by Japan Highway Cooperation** | *THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL* |

**Table A10.1.5 Running Speed Reduction**

| Design Standards | Running Speed (km/hc) | | | Remarks |
|---|---|---|---|---|
| | Initial (A) | Final (B) | B/A*100 (%) | |
| American | 80 | 40 | 50 | |
| Japanese | 80 | 45 | 56 | |

Source : JICA Study Team

(4) Critical Length

The term of "critical length of grade" is used to indicate the maximum length of a designated upgrade on which a loaded truck can operate without an unreasonable reduction in speed.

There is no a critical length in the Japanese standard for a vertical grade of 4.0%. The critical length for a vertical grade of 4.0% by the American standard is shown in Table A10.1.6.

**Table A10.1.6 Critical Length**

| Case | Running Speed (km/hr) | | | Critical Length (m) | Remarks |
|---|---|---|---|---|---|
| | Initial | Final | Reduction | | |
| 50% Reduction (A) | 88 | 44 | 44 | 870 | |
| 40 km/hr Reduction (B) | 88 | 48 | 40 | 750 | |
| Final Speed 40 km/hr (C) | 88 | 40 | 48 | 1,050 | |

Source : JICA Study Team

(5) Discussion

The Study Team considers that a vertical grade of 4.0% is acceptable to provide to the road crossing the Canal due to the following reasons;

1) According to the Japanese standard, there is no length limitation ( critical length ) for a vertical grade of 4.0%,

2) Based on a study of Japan Highway Cooperation, the final running speed at the top of the inclination of trucks for a vertical grade of 4.0% is 45km/hr ( 56% of the initial speed of 80km/hr ) and this speed is acceptable,

3) The final running speed at the top of inclination of trucks for a vertical grade of 4.0% based on a study of AASHTO in 1994 is 40km/hr and this speed is considered to be also acceptable due to the following reasons,

- According to the AASHTO standard (1994), lower maximum truck speeds probably can be tolerated on multilane highways rather than on two-lane roads because there is more opportunity and less difficulty for passing delayed trucks.
- According to a study by AASHTO in 1994, the weight per horse power of trucks has been decreasing. This means that performance of new trucks will be improving in the future,
- The completion of the bridge across the Canal is scheduled be five years later from now. Performance of Egyptian vehicles will also improve within this time span.

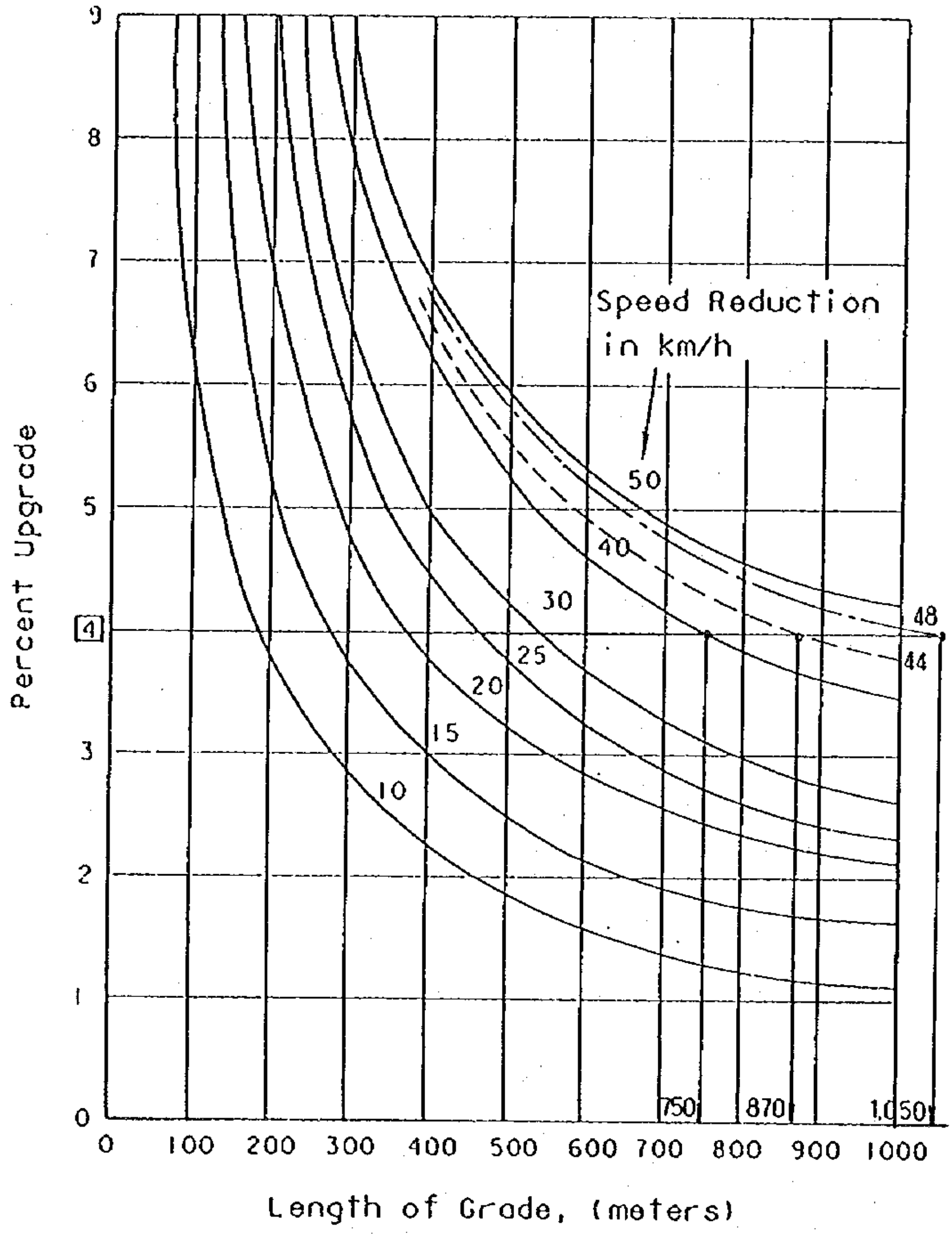
Therefore, the Study Team is considering that a length limit ( a critical length ) is not necessary for a vertical grade of 4.0% because little differences between these two vertical grades can be observed from an engineering view based on the American and Japanese design standards and the vertical grade of 4.0% has no problem from a view point of international standards.

(5) Proposed Vertical Grade

When compared the construction costs in cases of 3.3% and 4.0% vertical grades on condition of four lane crossing structure, the vertical grade of 4.0% is preferable if improvement of Egyptian vehicle conditions is expected during the construction of the bridge across the Canal.

On the other hand, a gentler vertical grade is more preferable for smooth traffic operation and a vertical grade of 4.0% is not evaluated to be suitable for present Egyptian vehicles if the current situation of the expressway in Cairo is observed.

Thus, providing a vertical grade of 3.3% for the road across the Canal is considered to be favorable, even if the construction cost for the vertical grade of 3.3% is higher than that of the vertical grade of 4.0%. Because the engine power of Egyptian vehicles are not strong enough to climb a long slope of 4.0% at present and remarkable improvement of Egyptian vehicle performances is not expected.




V0 = 88 km/hr

Fig. A10.1.17 Critical Length of Grade by AASHTO

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

## A10.2 Approach Embankments

### A10.2.1 Maximum Height of Embankments

(1) General

In order to decide the location of abutments, the Study Team studied the maximum height of approach embankment for the road crossing the Suez Canal.

The stability of embankment and site conditions such as crossing roads and canals, and land use, will be considered to determine the maximum height of the embankment.

(2) Stability of Embankment

Slide of embankment and bearing capacity of sub-surface of ground will be studied to evaluate the stability of approach embankment of the road crossing.

1) Slope Failure of Embankment

The following cases have been studied to decide the maximum height of approach embankment and results of the study is shown in Table A10.2.1 and Fig. A10.2.3.

- Embankment height of 10m with slope of 3 : 2 on the West Bank
- Embankment height of 10m with slope of 2 : 1 on the West Bank
- Embankment height of 20m with Slope of 2 : 1 on the East Bank

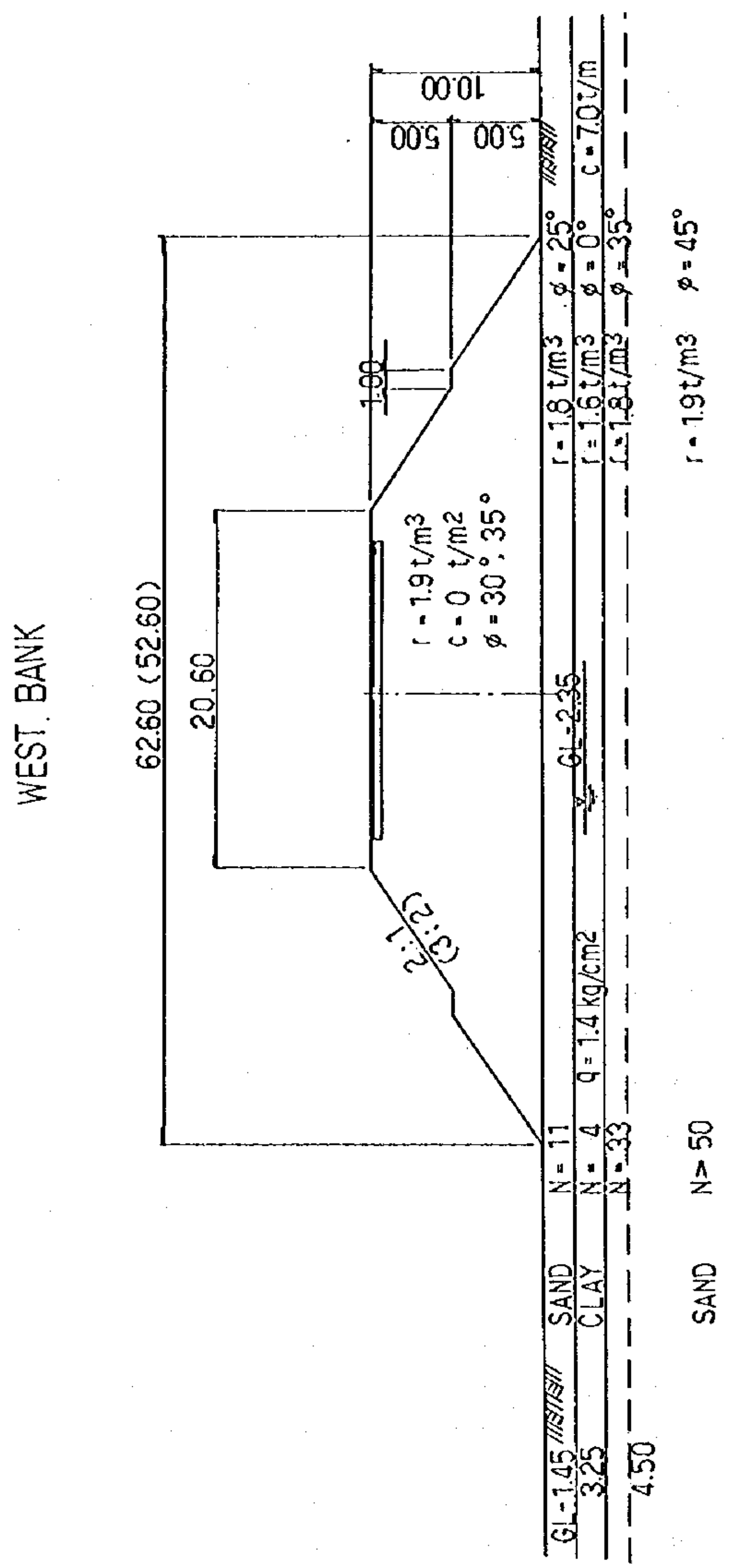
Internal friction angles of embankment of 30 and 35 for the above three cases have been calculated. ( Refer to Fig. A10.2.1 to Fig. A10.2.2 )

2) Bearing Capacity

The maximum height of embankment is also decided by bearing capacity of the foundation ground of the embankment. The bearing capacity is estimated by past experience based on N-value and other data from the geotechnical investigation.

- The West Bank : H = 10m $q = 19$ t/m² $<$ $q_a = 20$ t/m²
- The East Bank : H = 20m $q = 38$ t/m² $<$ $q_a = 40$ t/m²

Thus, the maximum heights of 10m on the West Bank and 20m on the East Bank will be possible.




| | | |
|---|---|---|
| Fig. A10.2.1 | **Stability Calculation of Slope Failure ( H=10m )** | *THE FEASIBILITY STUDY ON A BRIDGE OVER NORTHERN PART OF THE SUEZ CANAL* |

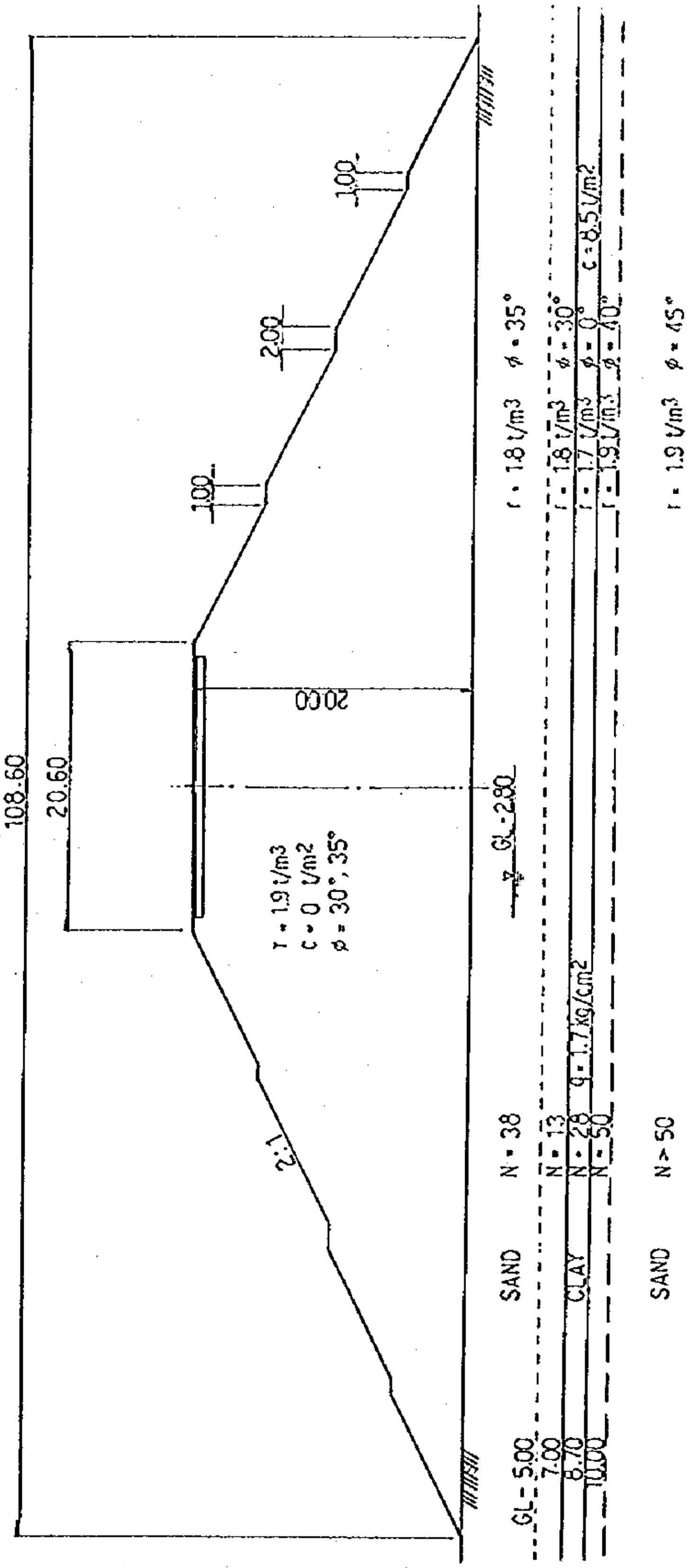



Fig. A10.2.2 Stability Calculation of Slope Failure ( H=20m )

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

**Table A10.2.1 Result of Study for Embankment Stability**

| Location | Height H (m) | Slope Inclination | Internal Friction Angle $\phi$(°) | Safety Factor Fs | |
|---|---|---|---|---|---|
| | | | | Embankment Fs1 | Foundation Ground Fs2 |
| West Bank (Main Land) | 10.0 | 3 : 2 | 30 | 0.78 | 1.66 |
| | | | 35 | 0.94 | |
| | | 2 : 1 | 30 | 1.00 | 2.07 |
| | | | 35 | 1.21 | |
| East Bank (Sinai Side) | 20.0 | 2 : 1 | 30 | 1.06 | 1.52 |
| | | | 35 | 1.28 | |

Source : JICA Study Team

Allowable Safety Factor : Fsa = 1.2

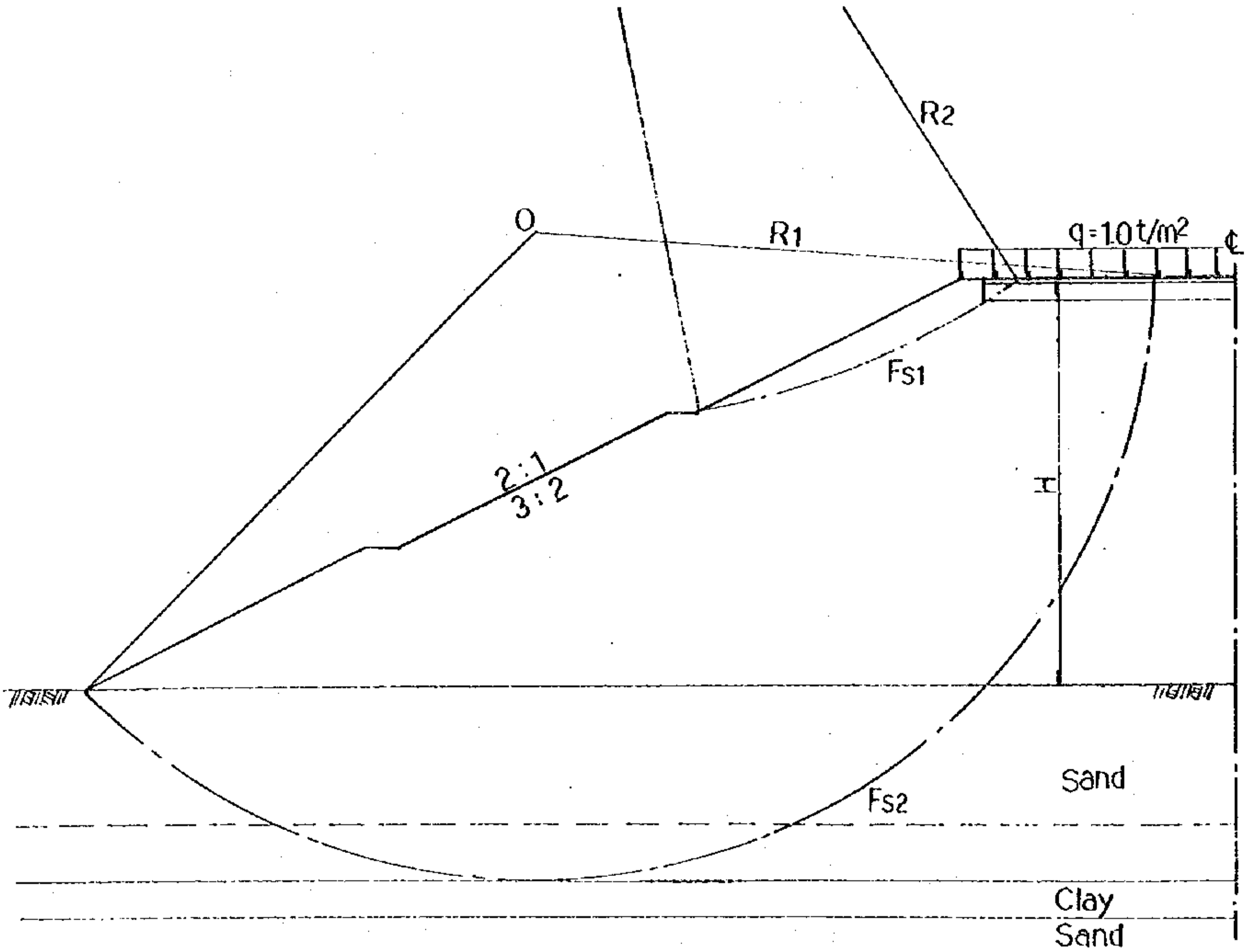



**Fig. A10.2.3 Results of Stability Calculations of Slope Failures**

(3) Site Conditions

1) West Bank ( Main Land Side )

The following controls on the West Bank should be considered to determine the location of abutment of the bridge over the Canal.

- Abassah Irrigation Canal
- The village on the west of the irrigation canal
- The irrigation canal office and school beside the irrigation canal
- The school on the west of the irrigation canal

The abutment should be located on the west of the village beside the irrigation canal or the school on the west of this canal to avoid or to minimize demolition of the houses in this village or the building of this school.

Therefore, the height of the approach embankment will be about 10m on the West Bank when the abutment is located on the west side of this village.

Refer to Fig. A10.2.4 to Fig. A10.2.9 for the details.

2) East Bank ( Sinai Side )

The East Bank consists of a desert and there are no controls to decide the location of abutment. Therefore, the maximum height of embankment is determined by stability of embankment.

(4) Maximum Height of Embankment

1) West Bank ( Main Land Side )

The maximum height of embankment on the West Bank is considered to be 10m or less by consideration of the site condition.

2) East Bank ( Sinai Side )

The approach embankment with the height of 20m is possible on the East Bank. However, 10m to 15m is expected as the maximum height of the Approach embankment because more than 30,000 $m^3$ of soil is necessary to fill the embankment if the maximum height of the embankment is 20m and it anticipated to be difficult to supply such a large amount of soil with good quality for high embankment. Besides, high embankment will detract from aesthetics of the bridge crossing the Canal.

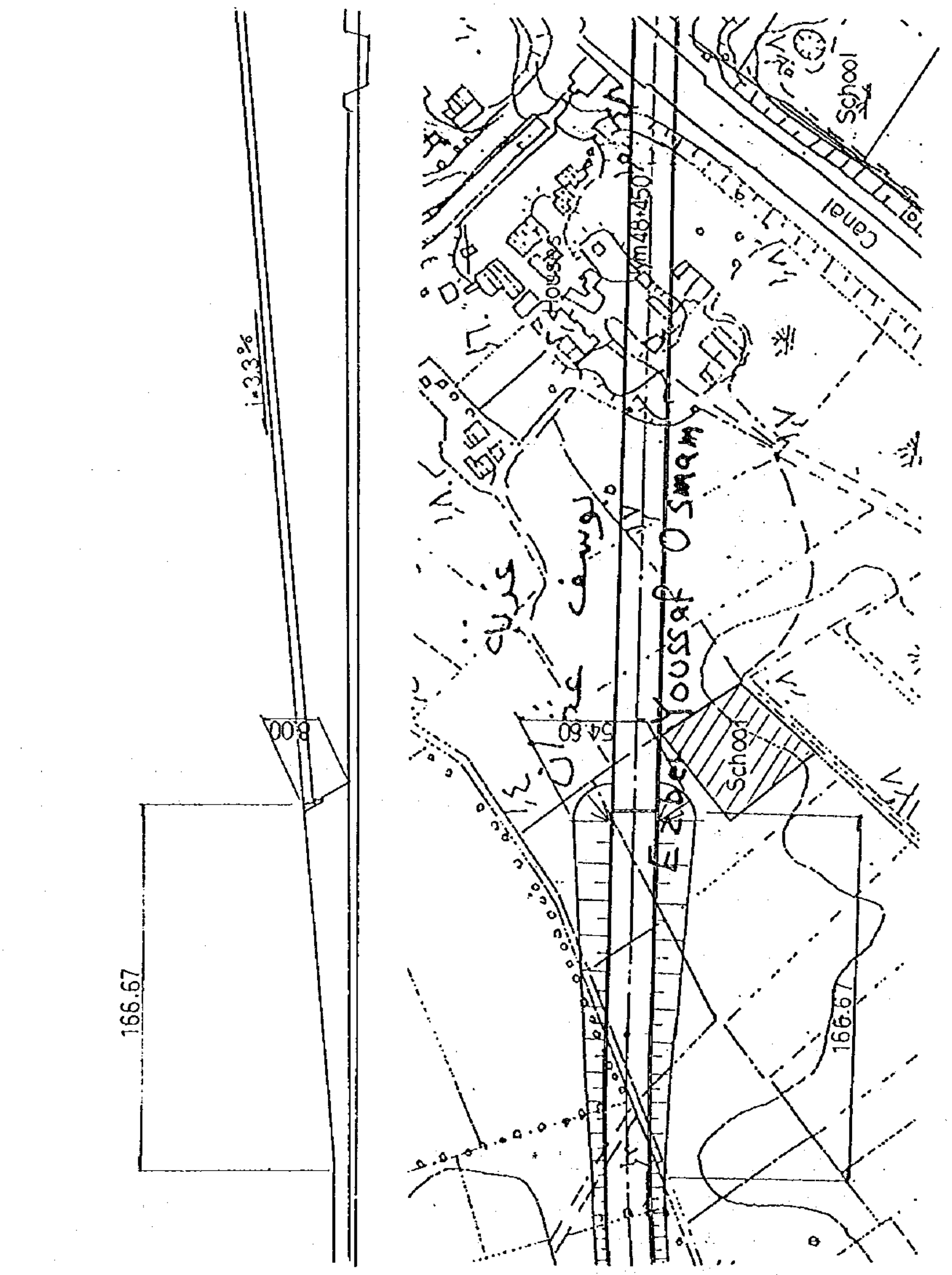



Fig. A10.2.4

**Location of Abutment**

( i = 3.3%, H = 8m )

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

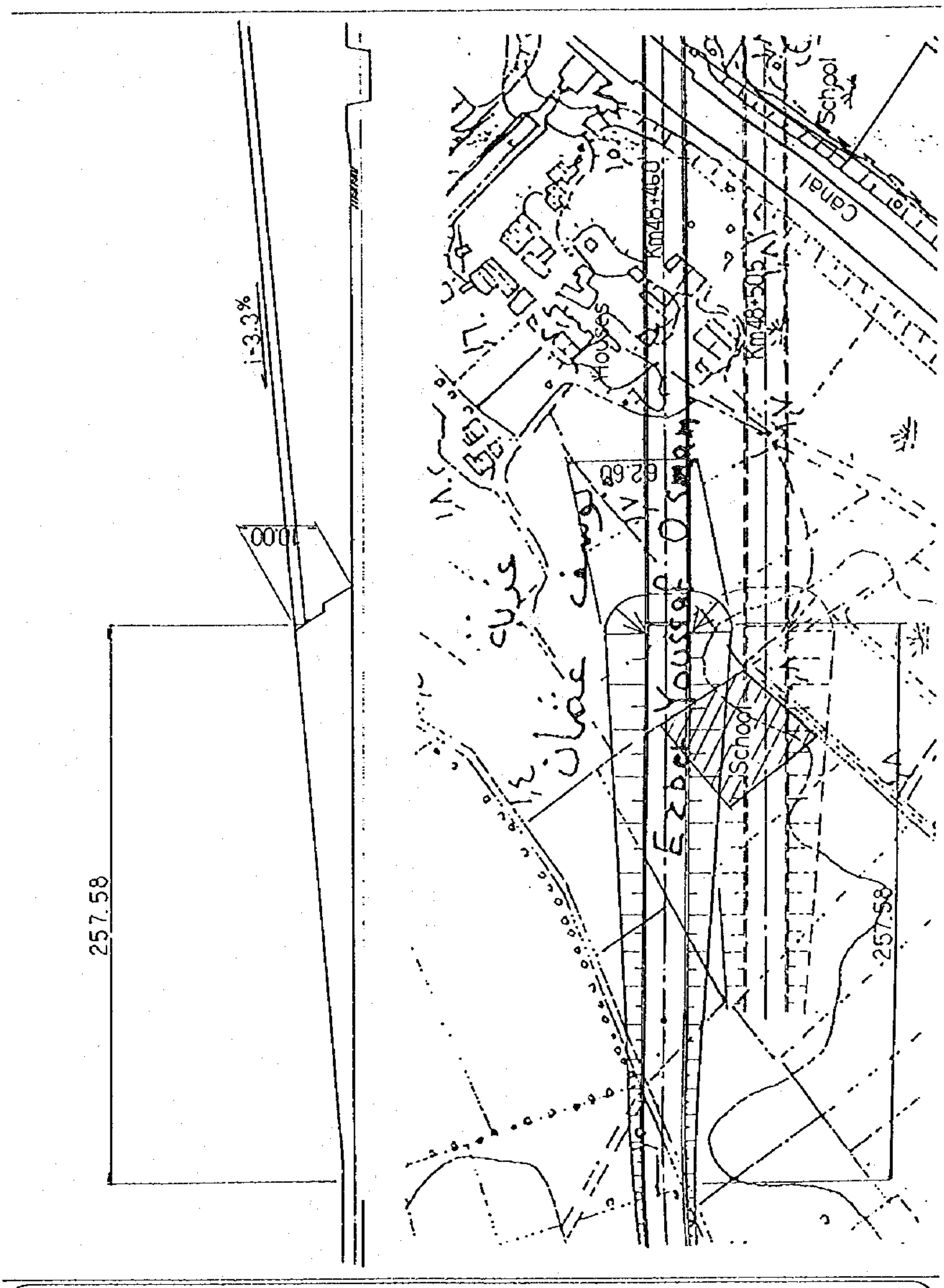



Fig. A10.2.5 **Location of Abutment**

( i = 3.3%, H = 10m )

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

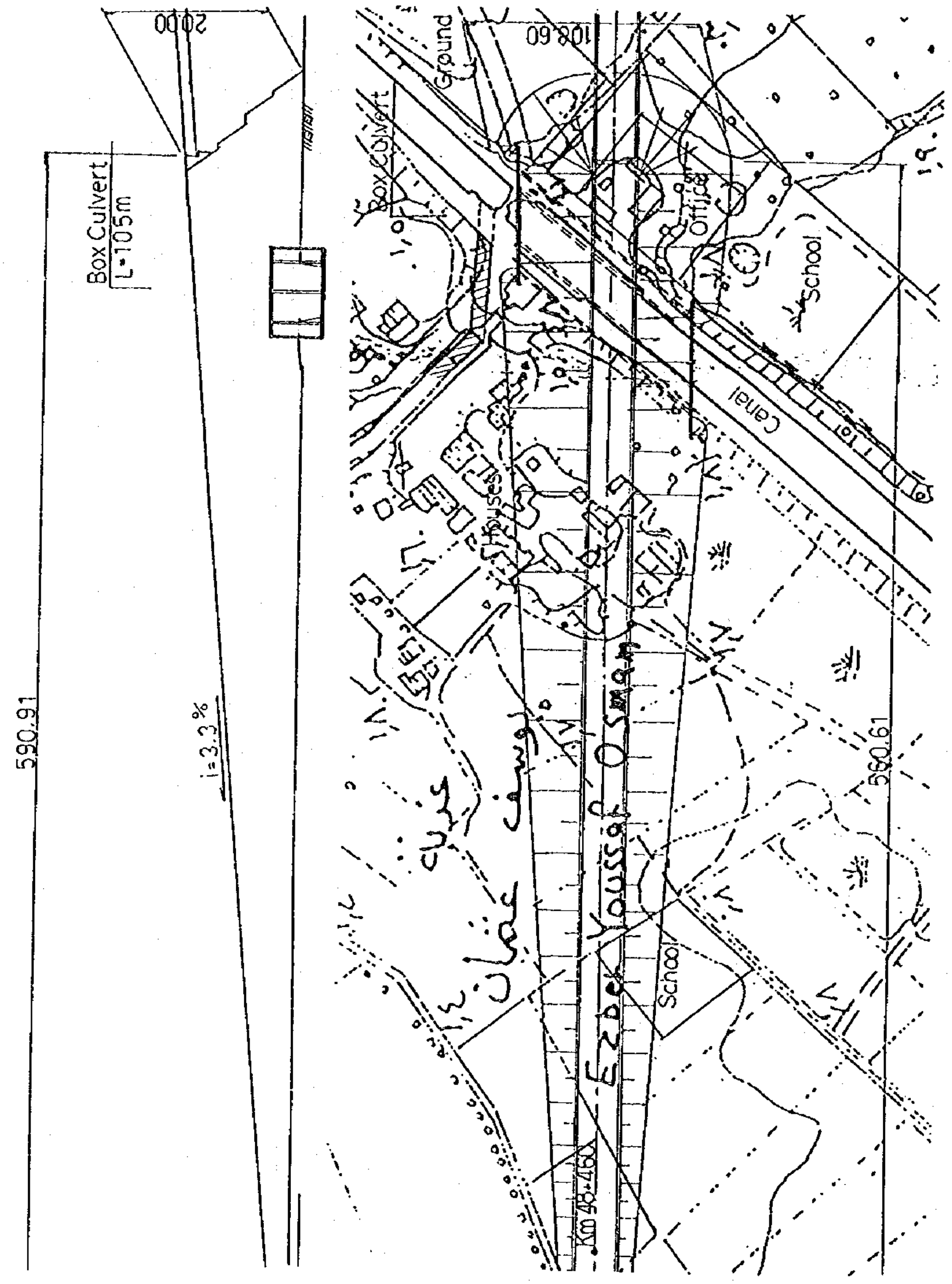



Fig. A10.2.6 **Location of Abutment**

**( i = 3.3%, H = 20m )**

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

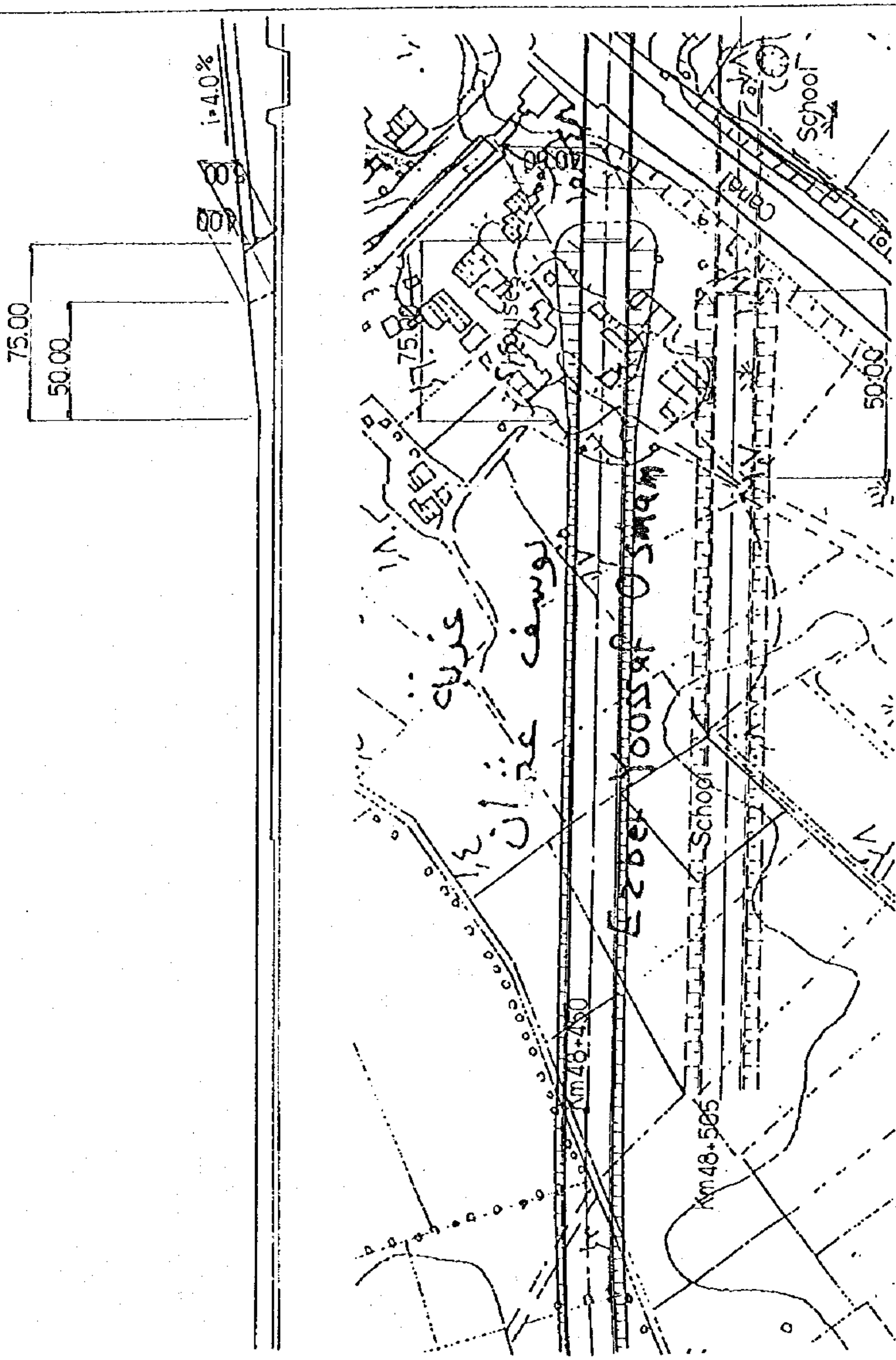



Fig. A10.2.7 Location of Abutment ( i = 4.0%, H = 5m )

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

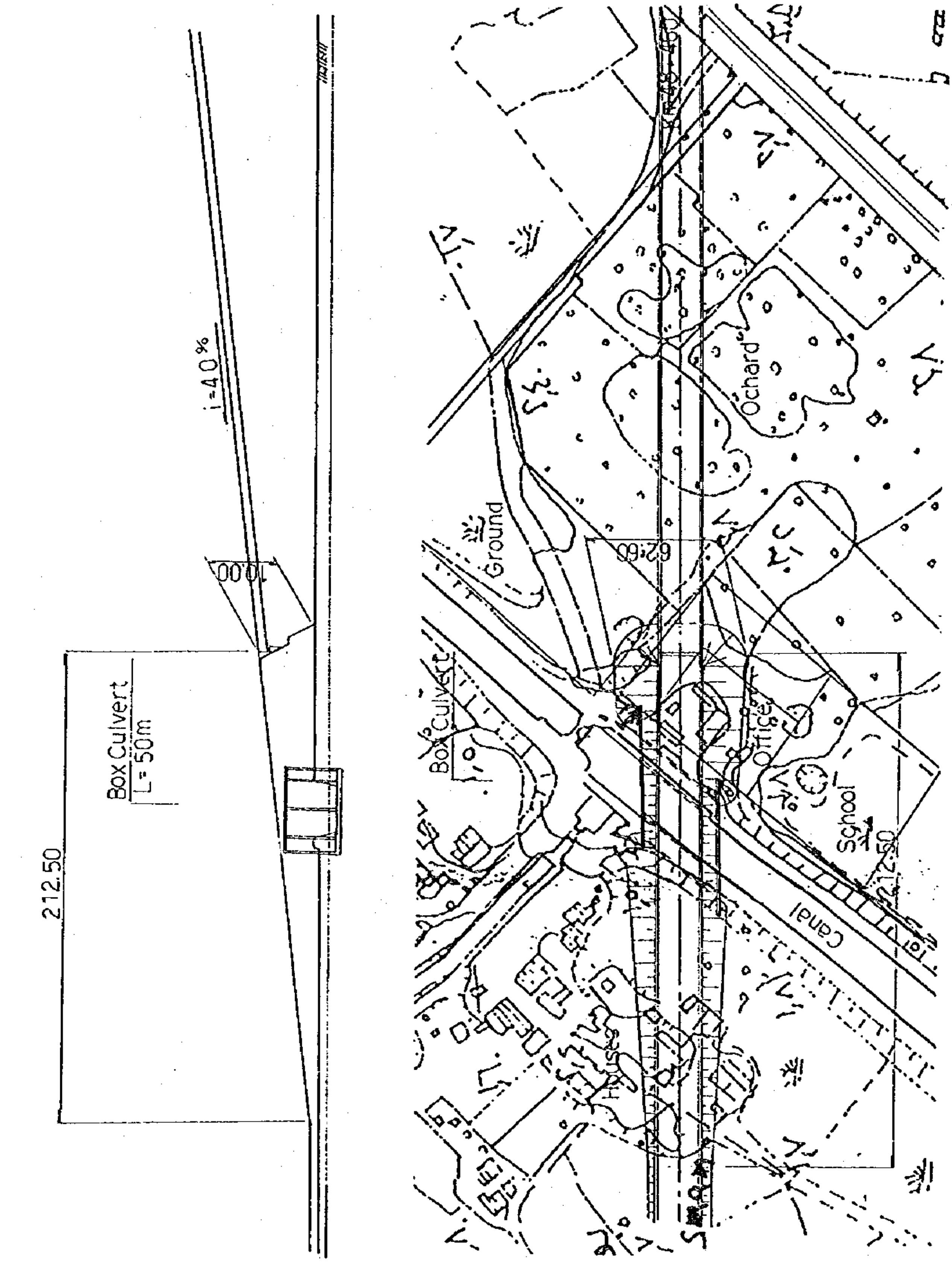



Fig. A10.2.8 **Location of Abutment**

**( i = 4.0%, H = 10m )**

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

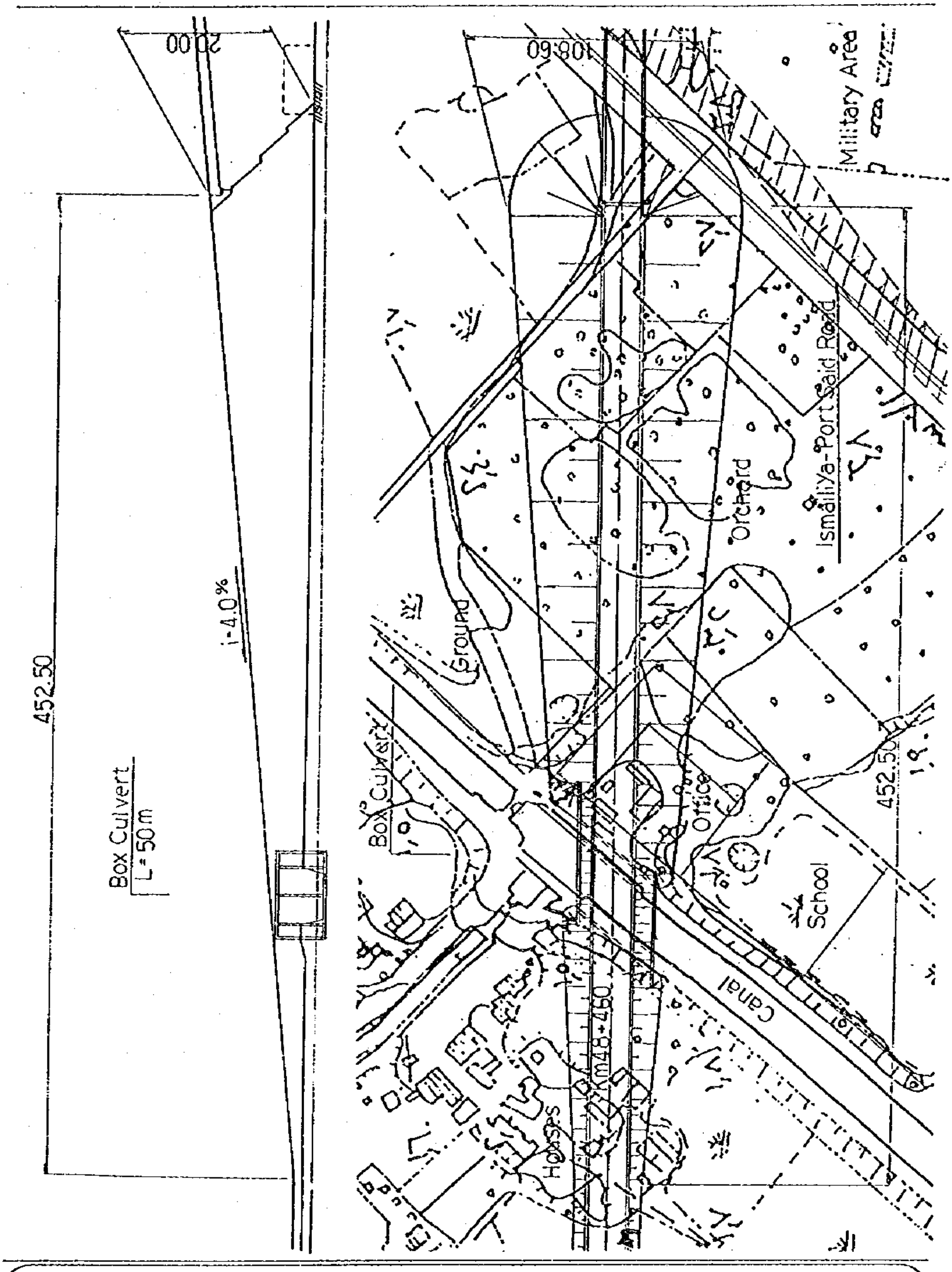



Fig. A10.2.9 Location of Abutment ( i = 4.0%, H = 20m )

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

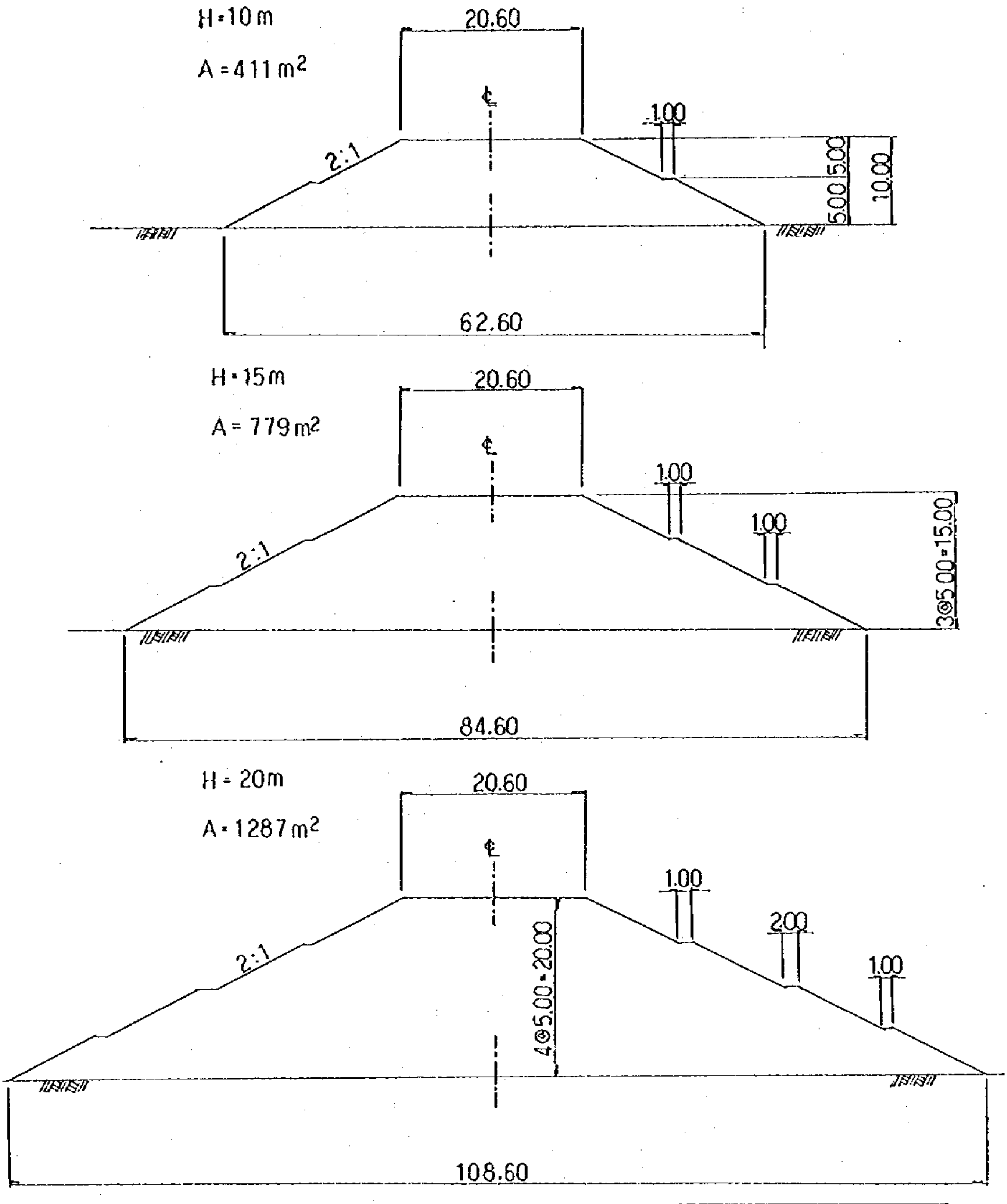



Fig. A10.2.10 Comparison of Embankment Section

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

## A10.2.2 Pavement Structure

(1) General

The provisional thickness and structure of the pavement for the road crossing the Suez Canal which are used for this feasibility study have been determined based on the Egyptian geometric design standards.

The thickness and structure of the pavement for the construction will be studied in detail and determined based on the results of the second geotechnical investigation in the detailed design.

The pavement thickness of the road crossing the Canal is examined based on the Japanese standard in this section for the reference to determine the thickness and structure of the pavement in the detailed design.

(2) Minimum Thickness

.1) Assumed Design Criteria

The Pavement thickness is studied based on the following design criteria.

- Classification of Traffic Volume    C Traffic
  ( Heavy traffic volume is 1,000 vehicles or more and less than 3,000 vehicles per day in one direction : $N = 28,800 / 2 \times 0.20 = 2,880$ vehicles )
- Design CBR    CBR = 8,12 or 20

1) Total Thickness

The total thickness of pavement is 39cm for CBR=8, 31cm for CBR=12 or 23cm for CBR=20. The total pavement thickness of 70cm based on the Egyptian standards exceeds that of the Japanese standard.

2) Equivalent Conversion Thickness

The equal conversion thickness of pavement is 26cm for CBR=8, 23cm for CBR=12 or 20cm for CBR=20. The equivalent conversion pavement thickness of 27.5cm based on the Egyptian standards exceeds that of the Japanese standard.

$TA = 5 + 5 + 25 \times 0.35 + 35 \times 0.25 = 27.5$ cm

3) Total thickness of Surface and Binder Courses

According to the Japanese standard, total thickness of a surface and binder courses is 10cm for the case when bituminous materials for mechanical stabilization is used for a base course and 15cm for the other cases. In this case, the total thickness of a surface and binder courses should be 15cm based on the Japanese standard.

(3) Structure of Pavement

There are some options of pavement structures which consist of different materials. The pavement structure for the road crossing the Canal will be decided taking into consideration of the construction cost and selection of obtainable materials in the detailed design.

The Study Team selected crushed stone for mechanical stabilization for the base course and crusher-run for subbase as the pavement materials for the feasibility study at present.

(4) Thickness and Structure of Pavement

If the thickness and structure of the pavement for the road crossing the Canal is determined based on the Japanese standard, the thickness and structure for a subgrade of CBR=8 or more will be those shown in Fig. A10.2.10.

- Total thickness of pavement $H = 55$ cm $>$ $Ha = 39$ cm
- Equivalent Conversion Thickness of Pavement
  $TA = 5 + 5 + 5 + 20 \times 0.35 + 20 \times 0.25 = 27$ cm $>$ $TAa = 26$ cm

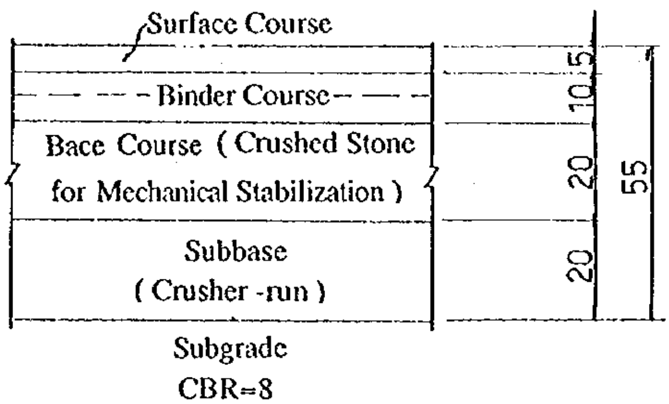



**Fig. A10.2.11 Pavement Structure based on the Japanese Standard (Reference)**

# Chapter 11 Bridge Design

# CHAPTER 11 BRIDGE DESIGN

## A11.2 Comparison of Cable-Stayed Bridge Main Girder Structure

### A11.2.1 Comparison of Steel-Box Girder and PC-Box Girder Types

(1) Description of Structures Comparison

Span : Main Span 404 m, Side Span 163 m

Main girder structure type compared :

1. 1-box steel deck girder
2. Prestressed concrete box girder (use locally mixed concrete)

(2) Economic Comparison

1) Construction Costs and Construction Periods

The direct construction cost and constuction periods are estimated as shown in Table A11.2.1.

**Table A11.2.1 Comparison of Construction Costs and Period**

Unit : US$ million

| Item | Cost | Time | Remarks |
|---|---|---|---|
| 1 Box Steel Deck | 38.6 | 3 Yrs 9 Mos | Factory mnfr./ Inc. delivery time |
| PC Box Girder | 36.8 | 4 Yrs 9 Mos | |
| Difference | 2.3 | 1 Yrs | |

Source : Study Team

2) Comparison of Financial Costs

By converting the difference of the construction costs using the average conversion factor given in Section 7.2, the cost will be as follows;

$2.3 \times 0.84 = 1.932$

In comparison the repainting cost in the Operation and Maintenance Works performed every 10 years, the cost of repainting is estimated to be as follows;

$2.161 - 0.229 = 1.932$

(See Paragraph 7.7.22)

Using a discount rate of 14% and converting the costs, the following costs will be :

| | | |
|---|---|---|
| 10th year | 1.932×0.44 | = US$ 0.278 mil. |
| 29th year | 1.932×0.039 | = US$ 0.075 mil. |
| Total | | US$ 0.353 mil. |

If this administrative cost is considered, the difference in the financial cost between steel girder and PC girder will be US$ 2.29 million.

On the other hand, there will be a difference of one year between the steel girder and the PC girder. By converting the loss of one year to the time by the waiting vehicles and pedestrians to present value, this is estimated to be US$ 3.45 million. This delay in planning into use of the bridge by selecting the PC-girder bridge the loss incurred is expected to be US$ 1.16 million.

(3) Selection of bridge Girder Type

The benefits of selecting the PC girder are as follows;

1) The maintenance and operations will be easier than for this steel-girder bridge, and maintenance cost will be less in future years.
2) Except for the prestressing tendonds, local materials can be used for the PC girder.

In spite of the benefits of the PC girder, the reasons for selecting the steel girder are as follows;

1) Delay in he completion of the bridge will not only increase the construction cost, but will delay the development of the Sinai Peninsula Development.
2) The initial investment costs for the steel bridge will be more costly than for the PC-girder type, but the difference is quite small, from the long term view point it will be beneficial for the steel girder.
3) The construction work over the Suez Canal will demand that the safety of the vessels plying the Canal be made the most important requirement and selection of the PC girder will require a longer construction period for work over the Canal and is not preferred.
4) The steel-girder bridge work can be finished by tightening the construction bolts after the segments are hoisted into place from the Canal surfaces.

5) The steel-girder bridge can be painted in a red colour will be easy to detect in times of heavy fogs.

In order to make-up for PC-girder bridge which has the deficiency of a longer construction period, it may be possible to use the present PC girder. However, it may be better to decide against its selection for the following reasons;

1) There is no experience in precast concrete work in Egypt for a cable-stayed bridge of this scale, and it will require a long study period to perform work of this class.
2) The construction period can be shortened to 4 years 3 months.
3) The works required to hoist the segments within 2 hours switching of the convoys from north to south and prestress the segments and assure stable operations to be performed. In a safe and accurate manner.
4) The weight of each segment will be heavy at 160 tonnes each, and the cost of the hoisting rig will be of large scale and costly.

### A11.2.2 On the Steel-Concrete Composite Girder

(1) Merits of Steel-Concrete Composite Girder (2 Main Girder) Cable-Stayed Bridge

The merits of the steel-concrete composite girder (2 main girder) bridge lies in only its low cost.

(2) Reasons not to select this type for use on the Suez Canal

1) The wind stability of the 2 main girder are not considered that favorable. For this reason bridges currently under construction are provided with many large sizwind stabilizer.

2) The wind stabilizer will be affected by the width of the bridge and the location of the bridge, while the bridge construction cost will increase to improve its characteristics, and all this should be investigated with wind tunnel testing.

3) Different from the short span composite girder assembled from girders and cross beam, the design guide 2-girder cable-stayed bridge will have to be established.

4) From the above consideration, in order to establish the 2-girder composite main girder cable-stayed bridge, it will require for a general guideline to be established by experiments and to find wind stabilizing criteria.

## A11.2.3 Section Forces

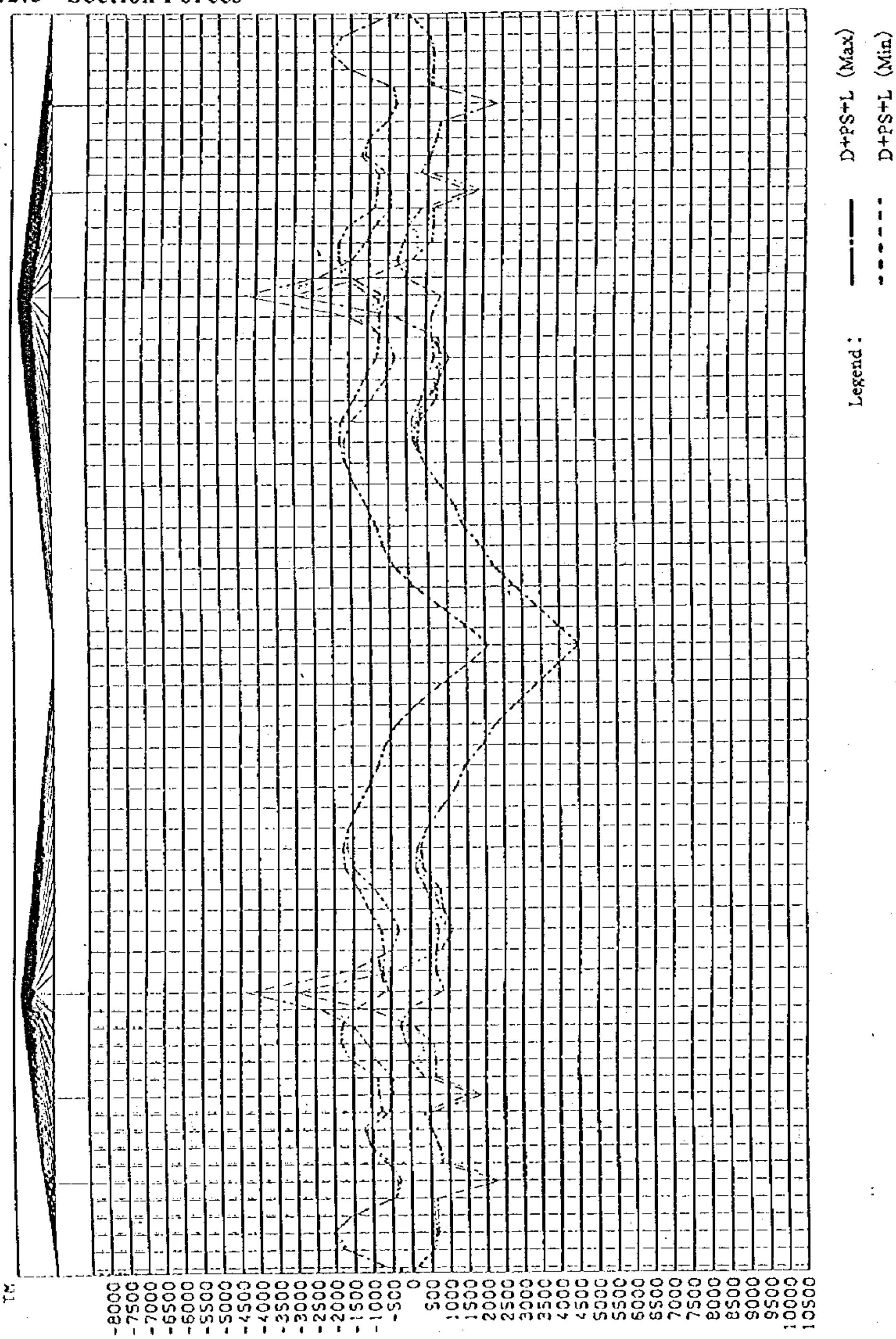



**Fig. A11.2.1(1) Moment of Main Girder**

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

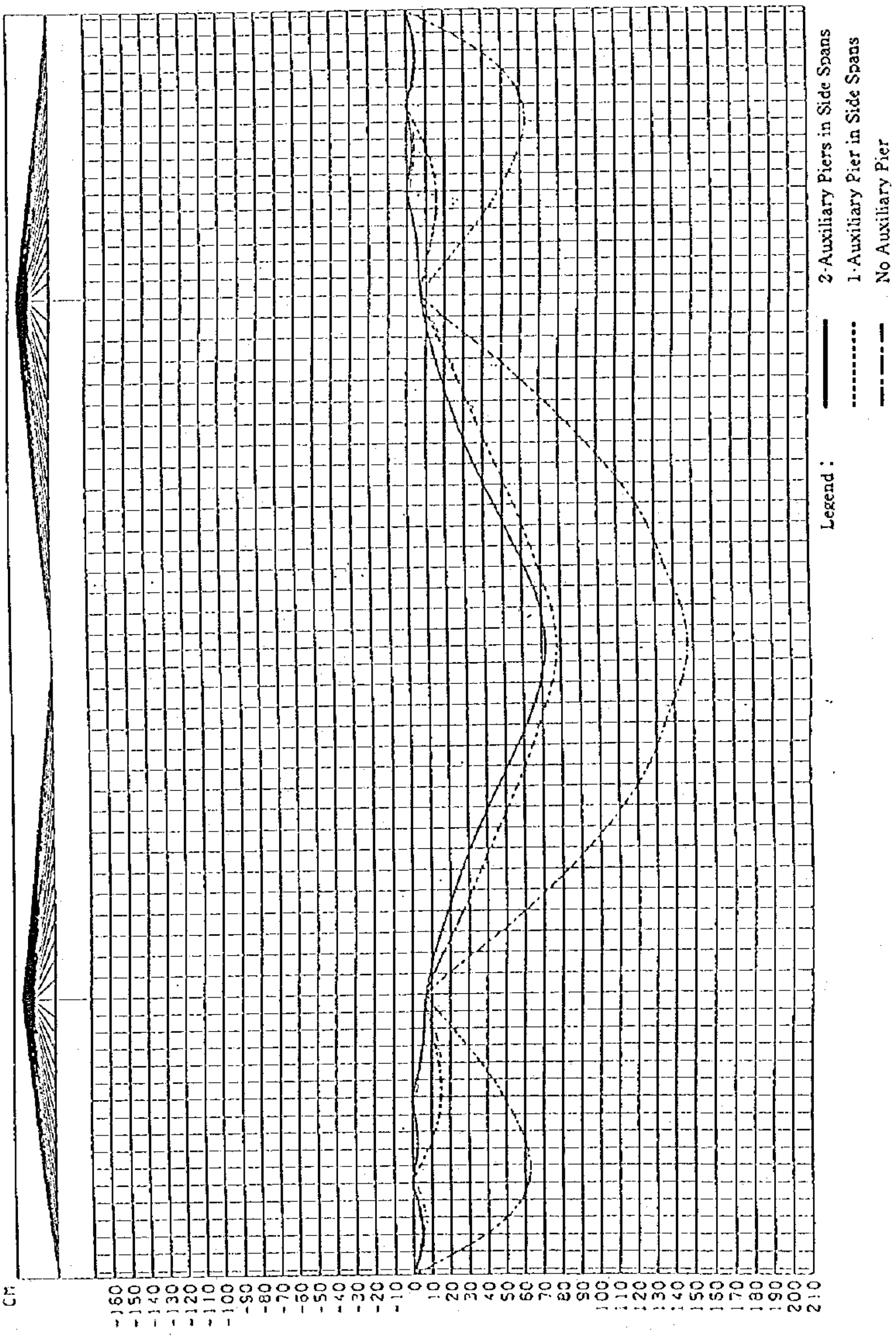



**Fig. A11.2.1(2) Deflection of Main Girder**

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

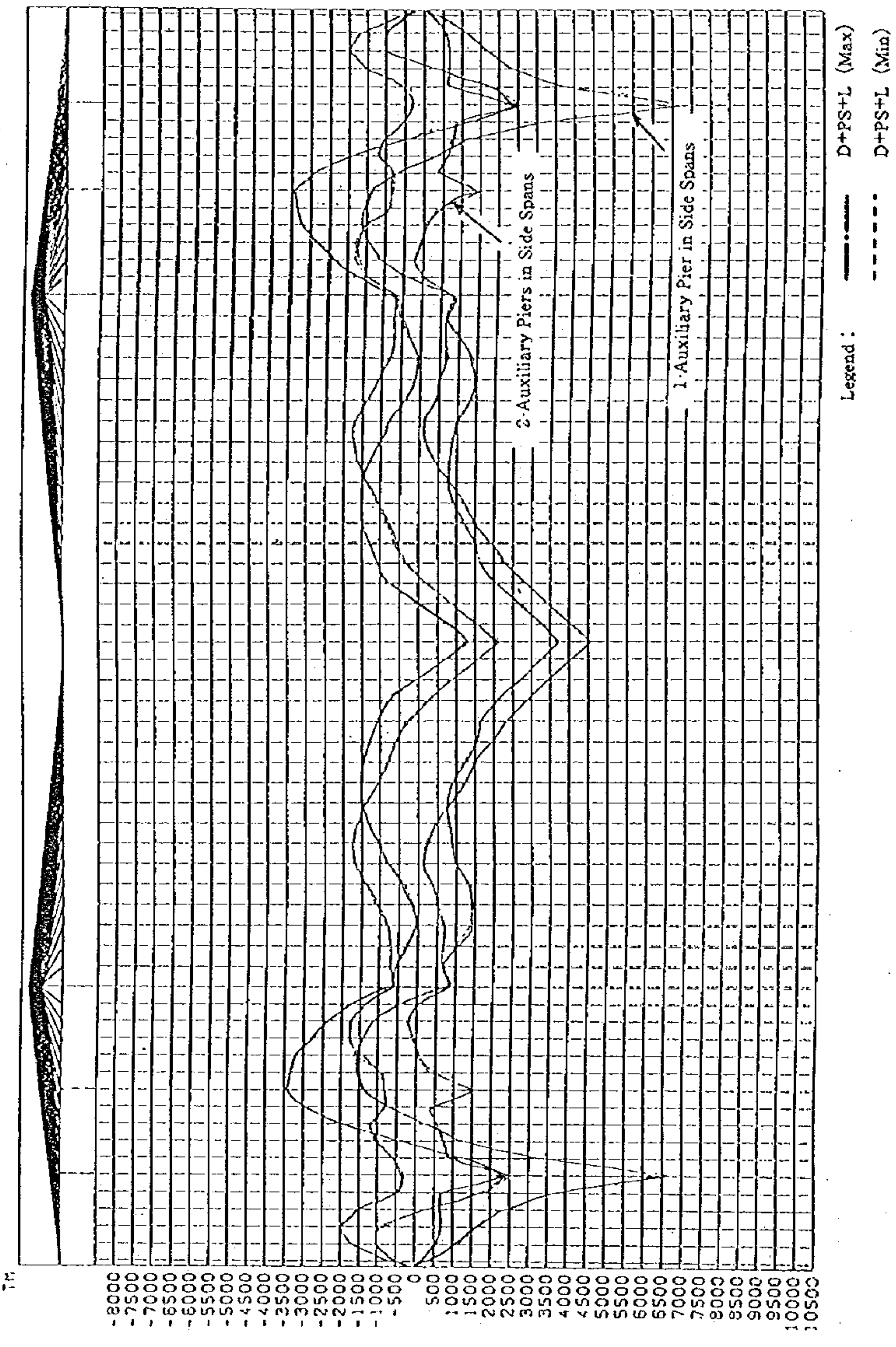



Fig. A11.2.1(3) **Moment of Main Girder (Comparison of the Number of Anchor Piers)**

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

## A11.6 Bill of Quantity

Table A11.6.1(1) Bill of Quantity (1)

| Section | Structure | Item | Specification | unit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| Main Br. | Foundation | Metal edge | • | ton | 31.6 | |
| | | Concrete | 210 kg/cm2 | m3 | 10,068 | |
| | | | 300 kg/cm2 | m3 | 2,576 | |
| | | Re-bar | | ton | 704 | |
| | | Formwork | | m2 | 10,132 | |
| | | Excavation | | m3 | 22,116 | |
| | | Scaffolding | | m2 | 8,848 | |
| | | Ground Anch. | | nos | 40 | |
| | | | | | | |
| | Main Pylon | Concrete | 300 kg/cm2 | m3 | 9630 | |
| | | Re-bar | | ton | 2,406 | |
| | | Formwork | | m2 | 22,186 | |
| | | PC-tendon | | ton | 5.2 | |
| | Aux. Piers | RC Pile | D1.5m x 15m | nos | 72 | |
| | | Pile cap | Concrete | m3 | 2,216 | |
| | | | Re-bar | ton | 156 | |
| | | | Formwork | m2 | 632 | |
| | | | Scaffolding | m2 | 808 | |
| | | Pier Shaft | Concrete | m3 | 4,124 | |
| | | | Re-bar | ton | 658 | |
| | | | Formwork | m2 | 14,020 | |
| | | | Scaffolding | m2 | 12,084 | |
| | Main Deck | steel deck | Fablication | ton | 7,156 | |
| | | | Site assembly | ton | 7,156 | |
| | | | Errection | ton | 7,156 | |
| | | Fender | | ton | 213 | |
| | Stay Cable | Cable | Strand cable | ton | 563 | |
| | | | PE pipe | m | 14,939 | |

## Table A11.6.1(2) Bill of Quantity (2)

| Section | Structure | Item | Material | unit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| Approach Viaduct (East Bank) | Foundation | RC Pile | D1.5m x 15m | nos | 547 | 244 |
| | | Pile Cap | Concrete | m3 | 18,303 | 8,417 |
| | | | Re-bar | ton | 1,281 | 589 |
| | | | Formwork | m2 | 5,419 | 2,386 |
| | | | Excavation | m3 | | |
| | | | Scaffolding | m2 | 6,845 | 3,041 |
| | Pier | | Concrete | m3 | 24,211 | 13,338 |
| | | | Re-bar | ton | 3,666 | 2,001 |
| | | | Formwork | m2 | 76,113 | 44,699 |
| | | | Scaffolding | m2 | 69,629 | 39,296 |
| | Abutment | | Concrete | m3 | 522 | |
| | | | Re-bar | ton | 36 | |
| | | | Formwork | m2 | 311 | |
| | | | Scaffolding | m2 | 180 | |
| | Concrete Girder | | Concrete | m3 | 19,559 | 7,798 |
| | | | Re-bar | ton | 2,847 | 1,36 |
| | | | PC-tendon | ton | 614 | 239 |
| | | | Mov. Scaffold | nos | 2 | |
| | | | Formwork | m2 | 62,783 | 24,378 |
| | | | Support | m3 | 21,456 | 8,344 |
| | | | Bearing shoe | nos | 54 | 16 |
| | Accessary | Handrail | Handrail | m | 2,880 | 1,120 |
| | | Drainage | Drainage | nos | 114 | 44 |
| | | Exp. Joint | Exp. Joint | nos | 6 | 2 |

note:The numbers shown in remarks column are the quantities by Japanese side construction.

## Table A11.6.1(3) Bill of Quantity (3)

| Section | Structure | Item | Material | unit | Quantity | Remarks |
|---|---|---|---|---|---|---|
| Approach Viaduct (West Bank) | Foundation | RC Pile | D1.5m x 15m | nos | 649 | 244 |
| | | Pile Cap | Concrete | m3 | 20,392 | 8,417 |
| | | | Re-bar | ton | 1,428 | 589 |
| | | | Formwork | m2 | 6,259 | 2,386 |
| | | | Excavation | m3 | | |
| | | | Scaffolding | m2 | 7,975 | 3,041 |
| | Pier | | Concrete | m3 | 25,954 | 12,812 |
| | | | Re-bar | ton | 3,932 | 1,922 |
| | | | Formwork | m2 | 78,954 | 41,136 |
| | | | Scaffolding | m2 | 73,824 | 38,340 |
| | Abutment | | Concrete | m3 | 797 | |
| | | | Re-bar | ton | 56 | |
| | | | Formwork | m2 | 560 | |
| | | | Scaffolding | m2 | 400 | |
| | Concrete Girder | | Concrete | m3 | 23,540 | 7,798 |
| | | | Re-bar | ton | 3,428 | 1,136 |
| | | | PC-tendon | ton | 754 | 239 |
| | | | Mov. Scaffold | nos | 2 | |
| | | | Formwork | m2 | 75,219 | 24,378 |
| | | | Support | m3 | 25,668 | 8,344 |
| | | | Bearing shoe | nos | 88 | 16 |
| | Accessary | Handrail | Handrail | m | 3,466 | 1,120 |
| | | Drainage | Drainage | nos | 138 | 44 |
| | | Exp. Joint | Exp. Joint | nos | 8 | 2 |

note: The numbers shown in remarks column are the quantities by Japanese side construction.

## Table A11.6.1(4) Bill of Quantity (4)

| Section | Item | Specification | Unit | Quantity | Remarks |
|---|---|---|---|---|---|
| Appr. Embment (West) | Embankment | Sand/gravel | m3 | 47,535 | |
| | Slope prot. | Stone pitching | m2 | 6,015 | |
| Appr. Embment (East) | Embankment | Sand/gravel | m3 | 394,974 | |
| | Slope prot. | Stone pitching | m2 | 29,902 | |
| Access Road (West) | Embankment | Sand/gravel | m3 | 126,558 | |
| | Slope prot. | Stone pitching | m2 | 16,616 | |
| | Bridge | PC slab bridge | m2 | 392 | |
| | Box culvert | RC 5m x 3m | nos | 5 | |
| | Pipe culvert | RC d1.0m | m | 600 | |
| Access Road (East) | Embankment | Sand/gravel | m3 | 202,065 | |
| | Slope prot. | Stone pitching | m2 | 25,837 | |

## Table A11.6.1(5) Bill of Quantity (5)

| Item | West Bank | East bank | Total | Remarks |
|---|---|---|---|---|
| Highway Length | | | | |
| Main Bridge | 365 | 365 | 730 | |
| Approach Viaduct | 1,723 | 1,440 | 3,163 | |
| Appr. Embankment | 178 | 486 | 664 | |
| Access Road | 1,321 | 3,466 | 4,787 | |
| Land Acquisition | | | | |
| Farming | 178,500 | - | 178,500 | |
| Orchard | 8,600 | - | 8,600 | |
| Millitary | 7,500 | - | 7,500 | |
| Desert | | 281,000 | 281,000 | |
| Demolition | | | | |
| Private House | 8 | - | 9 | |
| School Building | 1 | - | 1 | |
| Office Building | 1 | - | 1 | |

note: not finalized.

# Chapter 12　Construction Plans and Cost

# CHAPTER 12 CONSTRUCTION PLANS AND COST

## 12.8 Preliminary Cost Estimation

### Table A12.8.1 Construction Cost Estimate

| | | | |
|---|---|---|---|
| 1. Labor cost | Foreman | 70 | LE/day |
| | Skilled labor | 45 | LE/day |
| | Common labor | 40 | LE/day |
| 2. Material cost | Cement | 260 | LE/ton |
| | Re-bar | 1550 | LE/ton |
| | General | 40 | LE/ton |
| | Sand | 20 | LE/ton |
| | Prestressing tendon | 970 | US$/ton (CIF) |
| | Stay cable | 970 | US$/ton (CIF) |
| | Steel girder | 2325 | US$/ton (CIF) |
| 3. Contingency | Physical contingency | 7% | |
| | Price contingency | 3% per annum of price escalation | |
| 4. Indirect cost | 20% of direct construction cost | | |
| 5. Engineering cost | 10% of direct construction cost | | |

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