c. Most Suitable Formula of Rainfall Intensity

5.33 The most suitable formula shall be selected from the above mentioned three formulas. In regard to the selecting method, at first, each rainfall intensity of 30 minutes shall be calculated, next the formula that shows most equally value to 95 mm/hr at 30 minutes shall be selected as the most suitable formula.

Rainfall intensity of 30 minutes

Talbot's formula

$$I = \frac{15120}{t + 29} = 95.1 \text{ mm/hr}$$

Sharman's formula

$$I = \frac{179}{t^{0.2}} = 90.7 \text{ mm/hr}$$

Kuno & Ishiguro's formula

$$I = \frac{1300}{\sqrt{t} + 8.5} = 93.0 \text{ mm/hr}$$

5.34 From the above results, it is found that Tarbot's formula is the most suitable formula of rainfall intensity. Therefore, the formula of rainfall intensity is defined as following formula.

$$I = \frac{15120}{t + 129}$$

2. Calculation of Drainage

The Project road would cut the sugarcane field and the rainfall in the upstream area of the project road should be flown through the drainage structures undercrossing the road.
Runoff area is shown in Fig. V-12 and the procedure of the runoff calculation is as follows, and the results of the calculation is shown in Table V-13.

a. Runoff

Runoff is calculated by the Rational formula.

$$Q = \frac{1}{3.6 \times 10^6} \cdot C \cdot I \cdot A$$

Q : Runoff (m^3/sec)

C : Coefficient of runoff

I : Rainfall intensity (mm/hr)

A : Area of water shed (m^2)

b. Rainfall intensity

5.35 Rainfall intensity for the short term is given by the following formula, and this is adopted for small scale drainage area as drainage of pavement and slope. However, if the duration of storm is less 30 minutes, rainfall intensity shall be 95 mm/hr.

$$I = \frac{15120}{t + 129}$$

I : Rainfall intensity

t : Inlet time

c. Drainage facilities of the road

5.36 Drainage facilities are designed using 10 years probable rainfall intensity.

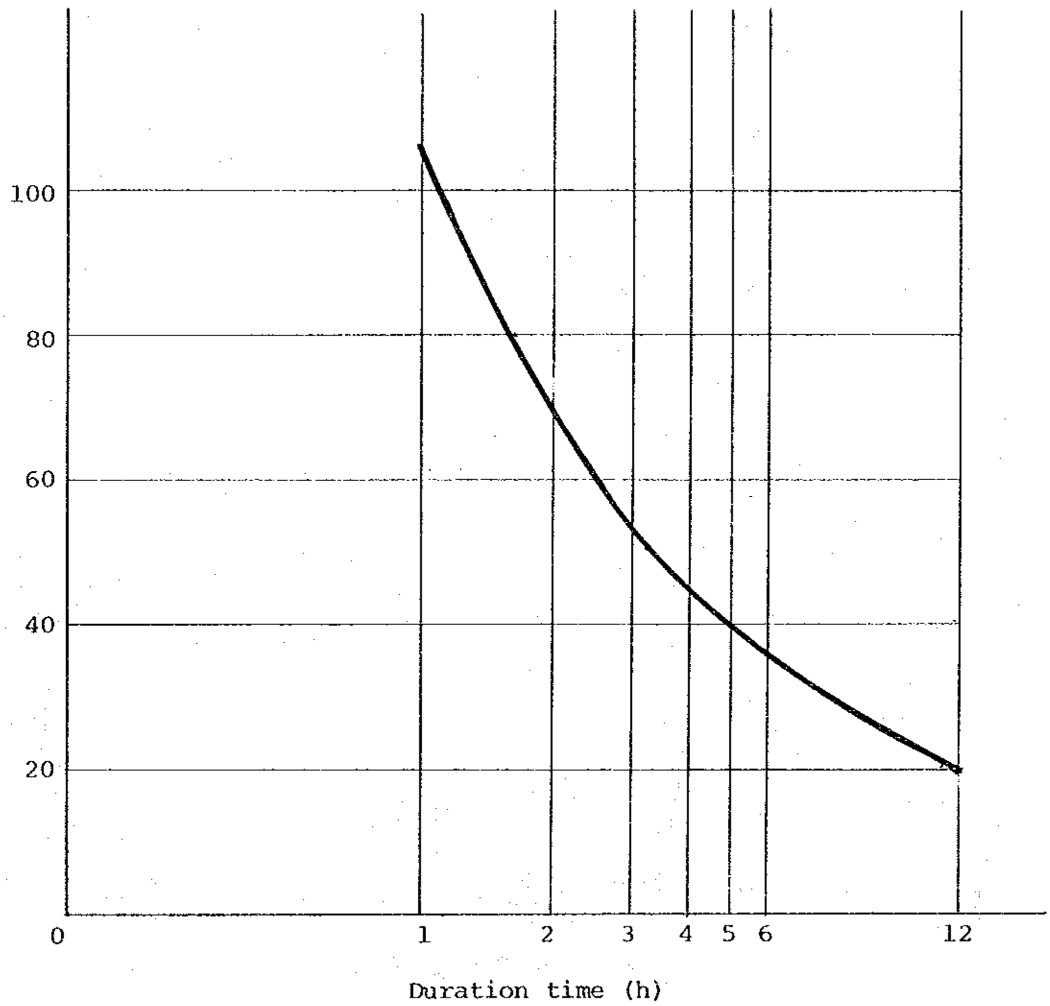


Fig. V-11 10 Years Probable Rainfall Intensity

d. Runoff coefficient : C

Table V-10

Surfaces	Value
Pavement	0.9
Slope	0.6
Sugarcane field, etc.	0.3
Residence area	0.4

e. Time of concentration

5.37 Time of concentration is composed with inlet time (t_1) and time of flow (t_2) in channel.

In case of pavement surface

$t = t_1$

In case of pipe and box culvert

(i) Inlet time (t_1)

$$t_1 = [\frac{2}{3} \times 3.28 \times L \times \frac{nd}{\sqrt{S}}]^{0.467}$$

t_1 : Inlet time (min)

L : Distance remote point to inlet (m)

S : Average slope of watershed

nd : Coefficient of retardation

Table V-11

Surface	nd
Comment Concrete	0.015
Slope	0.02
Sugarcane field and grass	0.4

(ii) Flow time in channel (t_2)

$$t_2 = \frac{L}{V}$$

L : Length of channel (m)

V : Velocity (m/sec)

f. Calculation of discharge (Q_2)

5.38 Discharge is calculated by the Manning's formula as follows.

$$Q = \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot I^{\frac{1}{2}} \cdot A$$

Q : Discharge (m^3/sec)

n : Coefficient of roughness of channel

R : Hydraulic radius (m)

I : Slope of channel invert

A : Cross-sectional area of flow (m^2)

Coefficient of roughness of channel (n)

Table V-12

Type of channel	Value
Naked ditch - soil	0.02
rock	0.03
Cement Concrete	0.015
Precast Concrete	0.013

Fig. V-12 Runoff Area

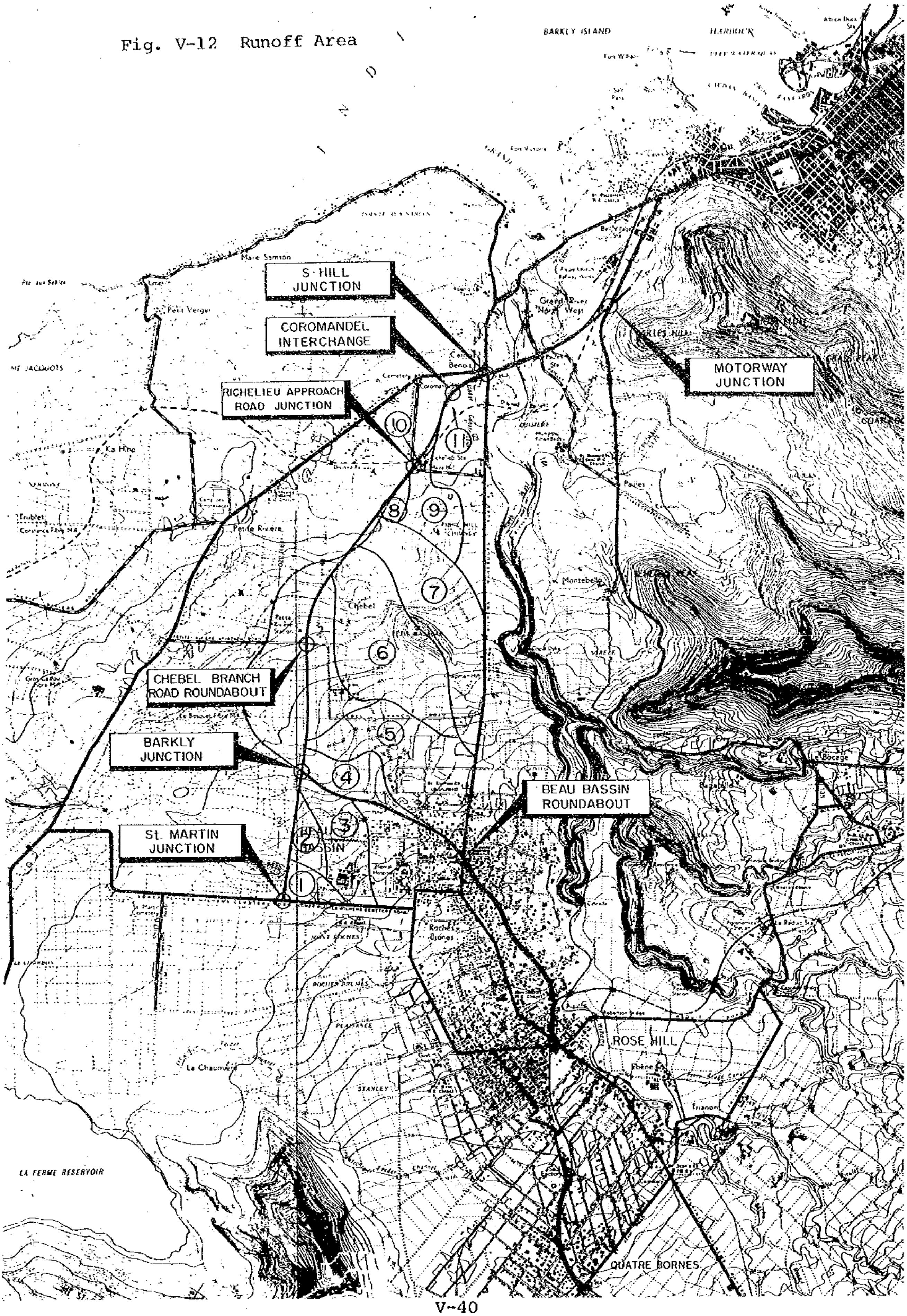


Table V-13 Results of Runoff Calculations

Location	(1) STA3+95	(2) STA8+48	(3) STA13+18	(4) STA15+13.4	(5) STA15+66	(6) STA36+25
Type of Drainage Structure	Pipe ø1.066	Pipe ø0.762	Pipe ø1.066	Box culvert 2,500x1,500	Box culvert 2,500x1,500	Pipe ø1.066 x 2
Slope of Drainage Structure (%)	1.4	5.0	4.0	1.5	1.8	4.5
Capacity of Drainage Structure (m^3/sec)	2.689	2.077	4.545	14.77	16.18	12.052
Catchment Area (m^2)	160,000	145,000	512,500	1,050,000	1,200,000	1,292,000
Runoff Coefficient "C"	0.4	0.3	0.3	0.3	0.3	0.3
Time for Overland Flow (min)	50	50	61	73	81	69
Distance Remote Point to Inlet (m)	900	900	1,500	2,100	2,300	2,250
Coefficient of Retardation	0.4	0.4	0.4	0.4	0.4	0.4
Rainfall Intensity "I" (mm/hr)	105	105	105	100	93	96
Runoff "Q" (m^3/sec)	1.867	1.269	4.484	8.750	9.300	10.366

Location	(7) STA39+35	(8) STA44+80	(9) STA46+44	(10)	(11)
Drainage Structure Type (mm)	Pipe ø1.066 x 2	Pipe ø1.066	Pipe ø1.066		
Structure Grade (%)	2.0	0.5	1.0		
Capacity of Drainage Structure (m^3/sec)	8.035	1.607	2.273		
Catchment Area (m^2)	1,031,000	59,000	259,000	52,800	66,000
Runoff Coefficient	0.3	0.3	0.3		
Inlet time (minutes)	77	60	51	20	60
Maximum Length of Flow (m)	2,750	400	1,050		
Delay Coefficient	0.4	0.4	0.4		
Rainfall Intensity of Ten Years (mm/hr)	91	105	105	95	105
Runoff (m^3/sec)	7.818	0.516	2.266	0.557	0.770

G. Pavement

5.39 As regards the method of pavement design, there are various methods, for instance Rode Note No. 29 in England, AASHTO INTERIM GUIDE FOR DESIGN OF PAVEMENT STRUCTURES in U.S.A., Asphalt Pavement Design Manual in Japan and so on. Each method has been made for meeting the conditions of each country.

5.40 Therefore, in Mauritius, it is desirable that the most suitable pavement method for the natural features, weather and traffic conditions of Mauritius should be adopted to design the pavement structure.

5.41 However, there is no pavement method suitable to the conditions of Mauritius. Accordingly, the pavement structures of this project road were designed by way of trial using the above-mentioned three methods.

5.42 After that the consultant made a comparative study and adopted AASHTO's method after discussion with the engineers of Ministry of Works.

5.43 The pavement structures are as follows.

Main road

The total number of heavy vehicles in one direction for the 20 years		15,856,000
Design C.B.R.		7.5 %
Structural number		4.4
Surface course		
	Fine graded course	5 cm
	Coarse graded	5 cm

Base course	
Asphalt treatment	10 cm
Subbase course	
Crushed stone	30 cm

Beau Bassin Access Road

The total number of heavy vehicles is in one direction for the 20-year	1,580,000
Design C.B.R.	7.5 %
Structural number	3.2
Surface course	5 cm
Base course	
Asphalt treatment	10 cm
Subbase course	
Crushed stone	20 cm

H. <u>Culverts</u>

1. Design Criteria of Pipe Culvert

a. Type of Pipe:

5.44 Pipe culverts consist of reinforced concrete pipe made by British Standards.

b. Joint:

5.45 The joint of the pipes is the socket type.

c. Diameter of Pipe:

5.46 Diameter of pipe for irrigation and drainage under-crossing the Motorways and Ramps shall be 1,066 mm or more.

5.47 Diameter of pipe for road surface drainage underpassing the roads shall be 457 mm or more.

5.48 Diameter of pipe undercrossing the frontage road and service road shall be 304 mm or more.

d. Installation of Pipe:

5.49 The pipes shall be installed in the bottom of trenchs.

5.50 Earth covering shall be as follows.

undercrossing roads : 1.2 m or more
other places : 0.9 m or more

5.51 If the earth covering is less than above, the pipe shall be reinforced by surrounding it with concrete of 15 cm thickness or more.

5.52 All pipes shall be installed on the concrete bed shown in the following figure.

Typical Cross Section of Pipe Culvert

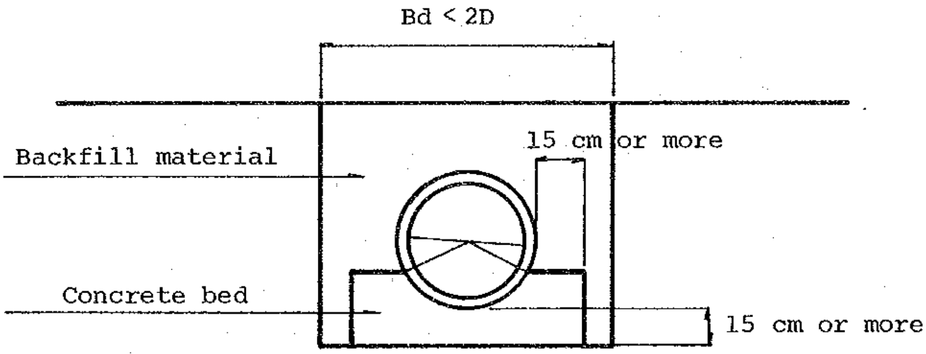


Fig. V-13

e. Load

(i) Live load (WTL)

5.53 Live load on the pipe culvert is expressed by the following equation.

$$WTL = CL \times Bo$$

$$CL = \frac{10.62}{H + 0.0375}$$

where,

WTL : Live load (t/m)

CL : The load coefficient

Bo : Outside diameter

H : Earth covering (m)

(ii) Dead load (WDL)

5.54 Dead load is expressed by the following equation.

$$WDL = \gamma t \cdot H \cdot \frac{(Bo + Bd)}{2}$$

where,

γr : Unit weight of the fill material (t/m^3)

H : Earth covering (m)

Bd : Width of the trench (m)

Bo : Outside diameter of the pipe (m)

(iii) Ultimate-strength design of pipe

$$Lc \geqq FC \left(\frac{WTL}{1.5} + \frac{WDL}{L5}\right)$$

where,

Lc : Ultimate strength capacity of section

Fs : Safety factor

Lf : Load factor by condition of pipe installation

Table V-14

$\frac{H}{Bc}$	Lf
0.5	8.52
1.0	5.96
1.5	5.41
2.0	5.30
3.0	5.18
5.0	4.96
10.0	4.80
15.0	4.69

Lf: Load Factor by Condition of Pipe Installation

Table V-15 Ultimate-Strength of Pipe
(BSS 556, Part 2, 1972)

(kg/m)

Normal Bore of Pipe	Standard Pipes		Extra Strength Pipe					
			Class L		Class M		Class H	
	Proof	Ultimate	Proof	Ultimate	Proof	Ultimate	Proof	Ultimate
300 mm	2010	2380					2380	2980
450 mm	2010	2380			3570	4460	4170	5210
600 mm	2010	2380			4610	5760	5510	6870
750 mm	2010	2380	3870	4840	5360	6700	6550	8190
900 mm	2010	2380	4610	5760	6850	8560	8630	10790
1050 mm	2010	2380	5210	6500	7740	9670	9820	12280

2. Design Criteria of Box Culvert

a. Allowable Working Stress

5.55 Type HB loading is considered in designing culverts, and it is permissible in considering the effect of this loading to allow 25 % over-stress.

(i) Allowable compressive stress in concrete:

$$\sigma c \leqq \frac{\sigma ck}{3} \times 1.25 = \frac{255}{3} \text{ Kg/cm}^2 \times 1.25$$

where,

σck = 255 Kg/cm^2, compressive strength of 28 days

(ii) Allowable shearing stress in concrete:

T = 8.2 x 1.25

= 10.25 Kg/cm^2

(iii) Allowable tensile stress in steel:

σs = 1,428 x 1.25

= 1,785 Kg/cm^2

b. Load

(i) Dead load and earth pressure

The load on the top of culvert:

5.56 Vertical load due to backfill is assumed to be uniformly distributed. The load is expressed by the following equation.

$$Pv = \alpha \cdot \gamma \cdot D$$

where,

Pv : Load on the top of culvert

γ : Unit weight of fill material, 1.9 t/m^3

D : Height of fill above the top of the culvert

Bo : Width of the box culvert

α : Coefficient of the vertical earth pressure

5.57 Value of α is changed accompanied with value of D/Bo.

5.58 The relation between α and D/Bo is shown in the following Table.

Table V-16

D/Bo	D/Bo<1	$1 \leqq \frac{D}{Bo} < 2$	$2 \leqq \frac{D}{Bo} < 3$	$3 \leqq \frac{D}{Bo} < 4$	$4 \leqq \frac{D}{Bo}$
α	1.0	1.2	1.35	1.5	1.6

Weight of the top slab of culvert:

$Wd = \gamma c \cdot T_1$ t/m^3

where,

γc : Unit weight of reinforced concrete (2.4 t/m^3)

t : Thickness of top slab (m)

Bottom Reaction (qd)

5.59 Bottom reaction is assumed to be uniformly distributed and it is expressed by the following equation.

$$qd = Pv + Wd + \frac{2T_3 \ H \ \gamma c}{Bo}$$

where,

T_3 : Thickness of the side wall (m)

H : Inner height of the box culvert

Bo : Outside width of the box culvert

Lateral Earth Pressure to the side wall (Ph):

$$Ph = K \cdot \gamma \cdot Z$$
$$= 0.6 \cdot \gamma \cdot Z$$

where,

K : Coefficient of earth pressure

Z : Depth from the surface of pavement to an arbitary point.

Fig. V-14

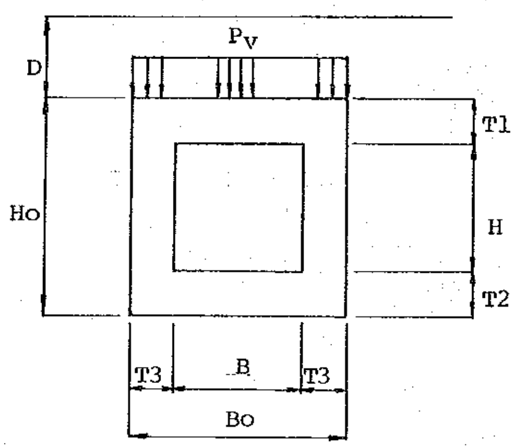
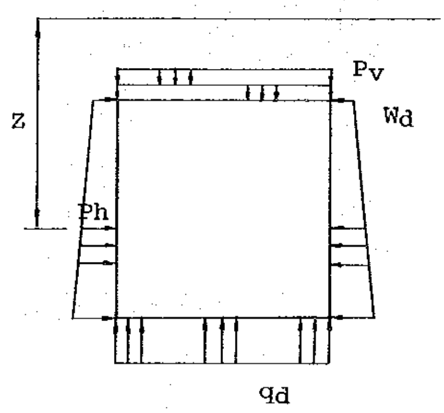


Fig. V-15



5.60 According to Dr. Terzaghi's experiment, each coefficient of earth pressure of sand and clay had been decided 0.42 and 0.70 - 0.75

5.61 After that, it has been found that the coefficient of earth pressure of sand is too small and one of clay is too much by many experimental results and studies.

5.62 It is assumed to be sufficient that the coefficient of earth pressure of backfill material for the culvert is 0.6, because the backfill material is generally crushed stone or good sandy soil.

(ii) Live load

Type HB Loading

5.63 Type HB loading (37.5 units) is adopted as live load and it is distributed as follows.

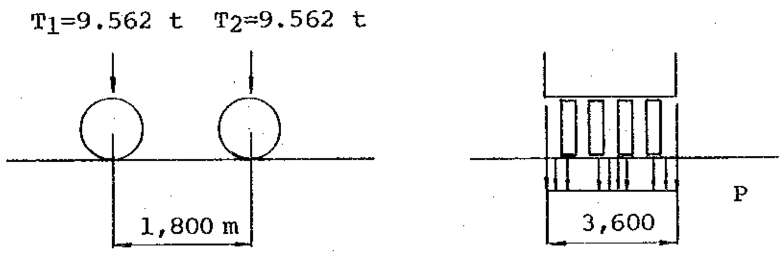


Fig. V-16

5.64 The live load per meter of the longitudinal direction of the bex culvert is calculated by the following equation.

$$P = \frac{4 \times T_1}{3.60}$$

$$= \frac{4 \times 9.562}{3.6}$$

5.65 Contract length of tire is 0.075 m and applied wheel load is distributed downward in the form of a 45 degree cone.

Vertical Load to the Top Slab and Lateral Pressure to the Side Wall

5.66 Vertical load to the top slab is expressed by the following equation.

$$Pvl = \frac{P(1 + i)}{W_1}$$

$$= \frac{P(1 + i)}{0.075 + 2 \cdot D}$$

where,

W_1 : Width of distributed live load

D : Earth covering (m)

i : Coefficient of impact when the HB loading is considered it is neglected.

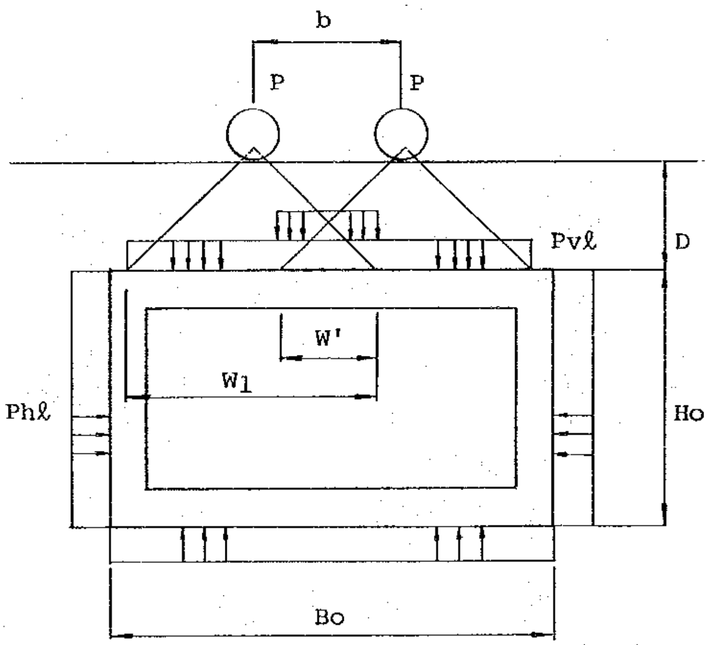


Fig. V-17

5.67 The bottom reaction by live load is expressed by the following equation.

$$ql = \frac{\Sigma Pv}{Bo}$$

5.68 The lateral pressure to the side wall is constant as follows.

$$Phl = 0.6 \times q$$
$$= 0.6 \times 1.66\ t/m^2$$
$$\fallingdotseq 1.00\ t/m^2$$

where,

q : Surcharge ($16.25\ KN/m^2$) .... B.S.

Earth Covering: D > 4.0 m

5.69 Vertical load and lateral pressure to the box culvert is constant as shown in the following figure.

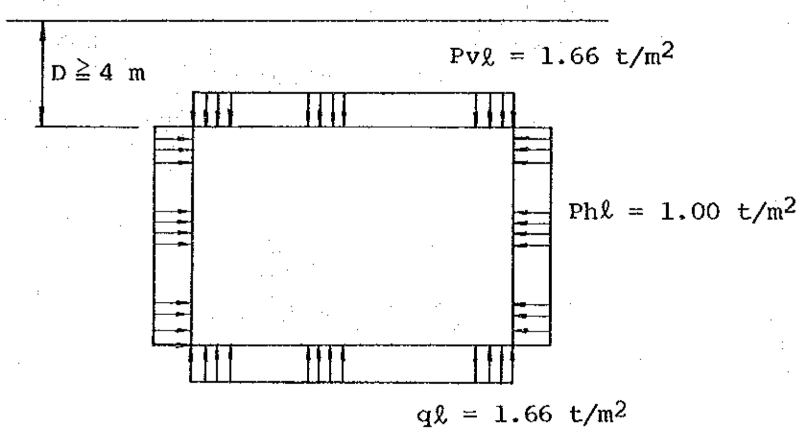


Fig. V-18

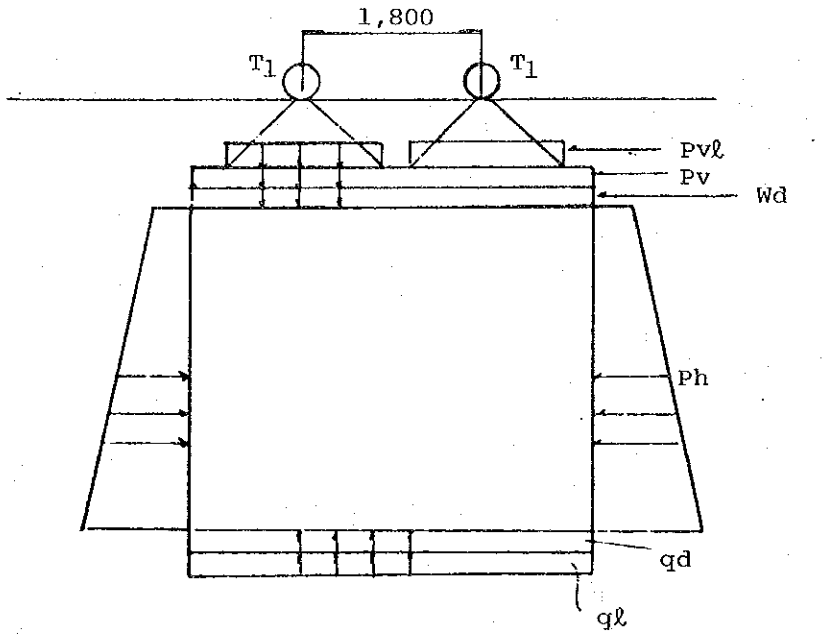


Fig. V-19 Maximum Bending Moment on the Slabs

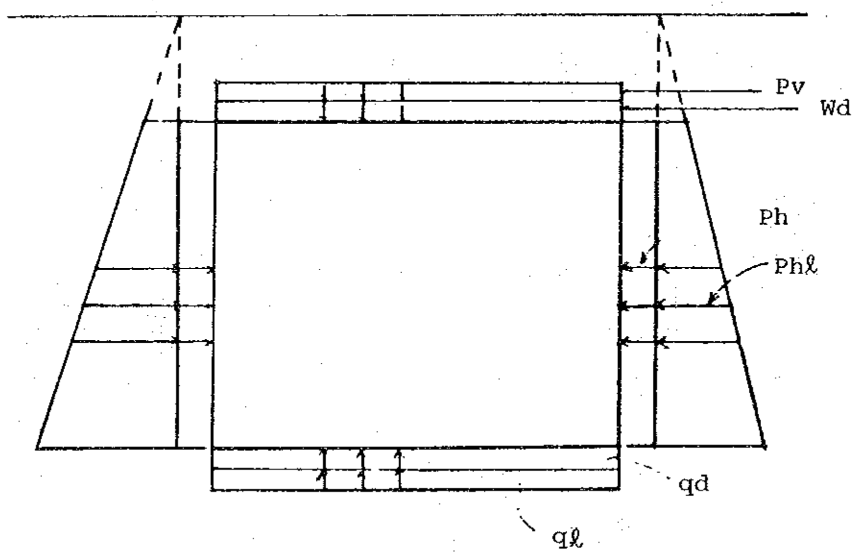


Fig. V-20 Maximum Bending Moment on the Side Wall

(iii) Influence by temperature change and drying shrinkage

5.70 The influence is not considered, because culverts shall be constructed underground.

(iv) Combination of the loads

5.71 The combination of the loads is as follows.

Case I: Earth Covering < 4.0 m

5.72 Stress in box culvert of the following two loading cases is calculated and the designing of the box culvert is carried out with the larger of the stresses.

Case II: Earth Covering; D > 4.0 m

5.73 In this case, designing of the culvert is carried out with following load distribution.

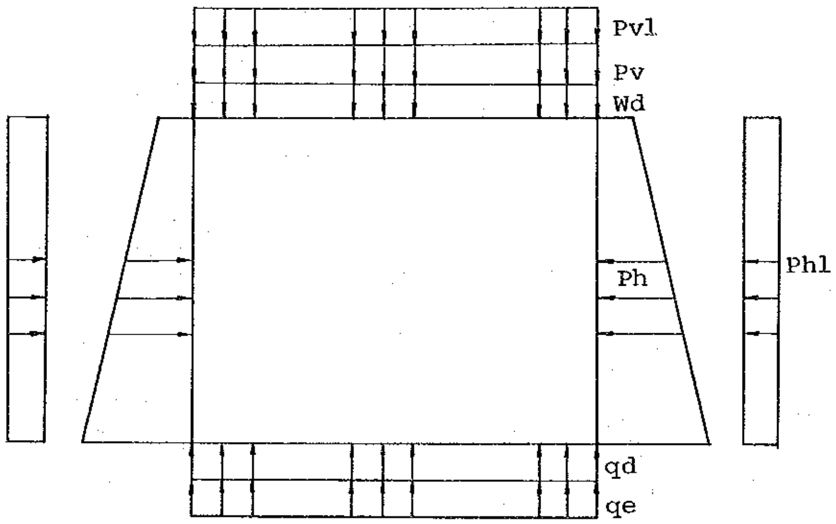


Fig. V-21

c. Others

1. Angle of skew culvert is 60 degree or more.

2. Joint spacing is 10 or 15 m.

3. Earth covering is 50 cm or more.

I. Lighting

5.74 As regards the lighting facilities, the consultants discussed with the engineer of the Ministry of Works, and it is decided that the lighting facilities should be installed only at Motorway Junction and Coromandel Interchange.

5.75 Design of lighting is conducted based on "Design Manual on Lighting of Highway" by EXPRESS HIGHWAY RESEARCH FOUNDATION in Japan. It is almost the same as the British Standard.

1. Estimated Traffic Volume in 5 Years after Opening of the Project Road

a. Through Traffic

Motorway Junction	25,000	vehicle/day
Coromandel Interchange	18,000	"

b. Entrance and Exit Traffic

Motorway Junction	18,000	"
Coromandel Interchange	15,500	"

2. Kind of Pavement

Asphalt

3. Grade of the Project Road

Motorway

4. Average Brightness on the Pavement

5.76 Average brightness on the pavement of Interchanges is as follows.

Design speed	80 Km/h
Average brightness	1.0 nit (15 luxes)

5. Grade of Lighting

5.77 Design of the lighting shall be of grade D (Lowest Category) in order to save electricity.

Grade D: Lights are provided only near noses of ramps.

6. Lighting System

5.78 In general, dispersion lighting system by street light is taken into account.

7. Light Source

5.79 Mercury-vapor lamp is adopted for installing as a source of highway lighting

a) Efficiency is approximately 47 lm/W at 400 W.

b) Colour is white

c) Colour vendering property is ordinary and its average evaluated number of colour vendering property (Ra) is approximately 50.

d) Starting time is approximately 8 minutes.

e) It needs time for restarting.

8. Lighting Equipment

5.80 Lighting equipment is semi-cut-off type as in urban areas.

9. Wiring

5.81 Wiring shall be conducted using SC-VV cable and it shall be set at 0.6 m under the ground surface.

10. Power Source

Distribution voltage:

230 V (± 6%) single-phase

400 V (± 6%) 3 -phase

Frequency:

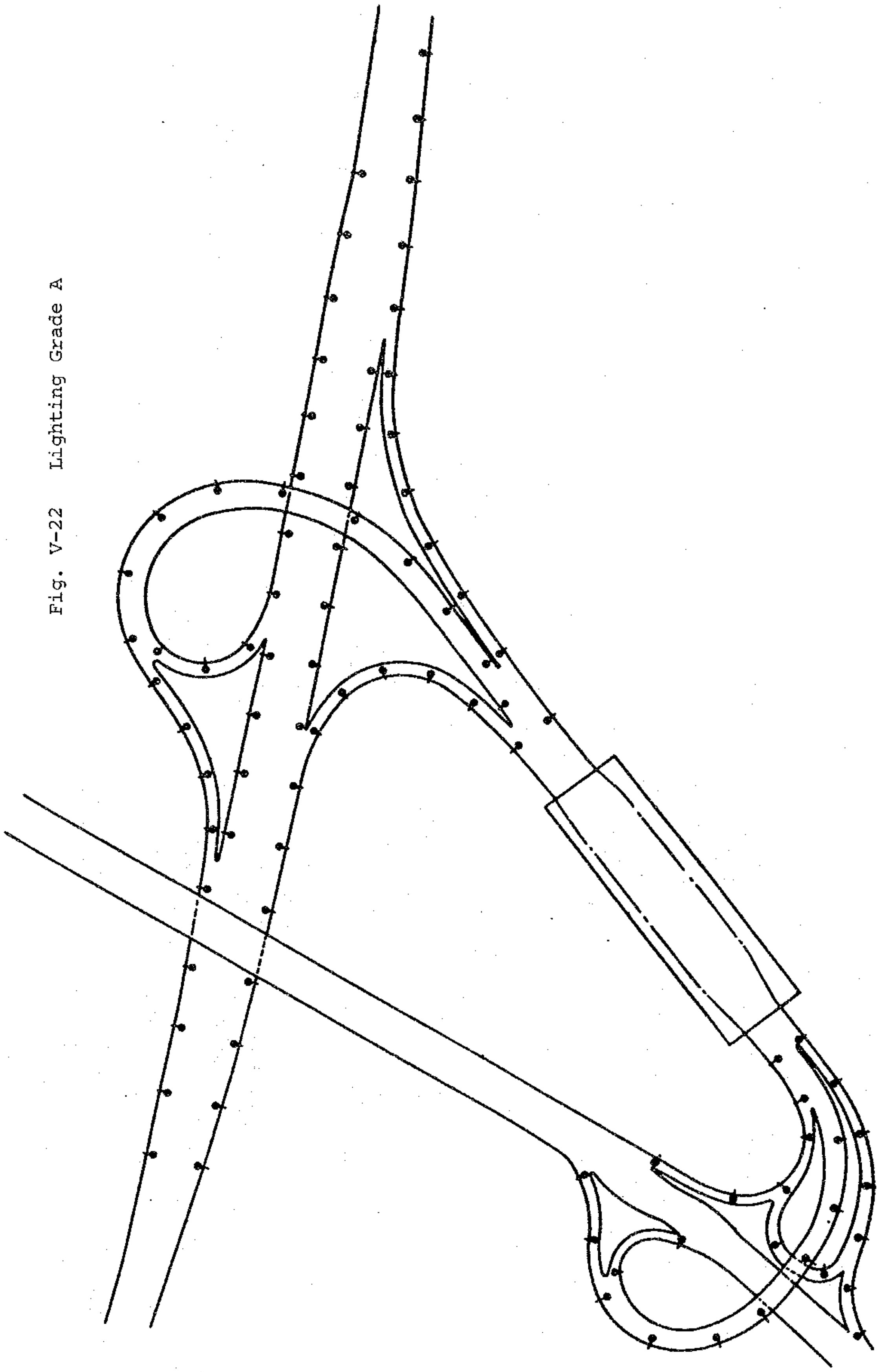
50 Hz

11. Power Source Service

5.82 Point of power source service is preferably set near center of new interchange.

5.83 Power distribution to the service point shall be done by the Mauritius Government.

Fig. V-22 Lighting Grade A



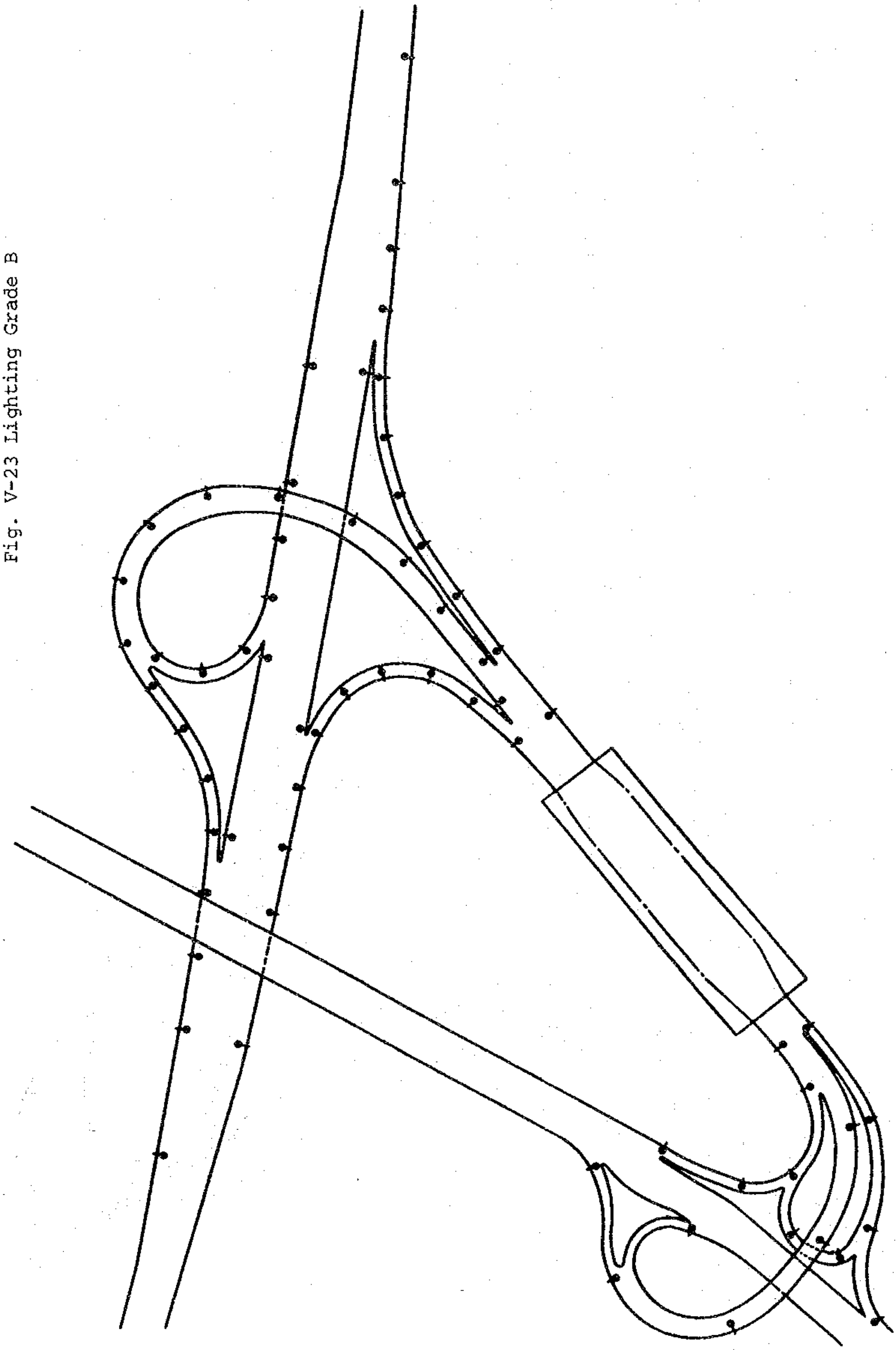


Fig. V-23 Lighting Grade B

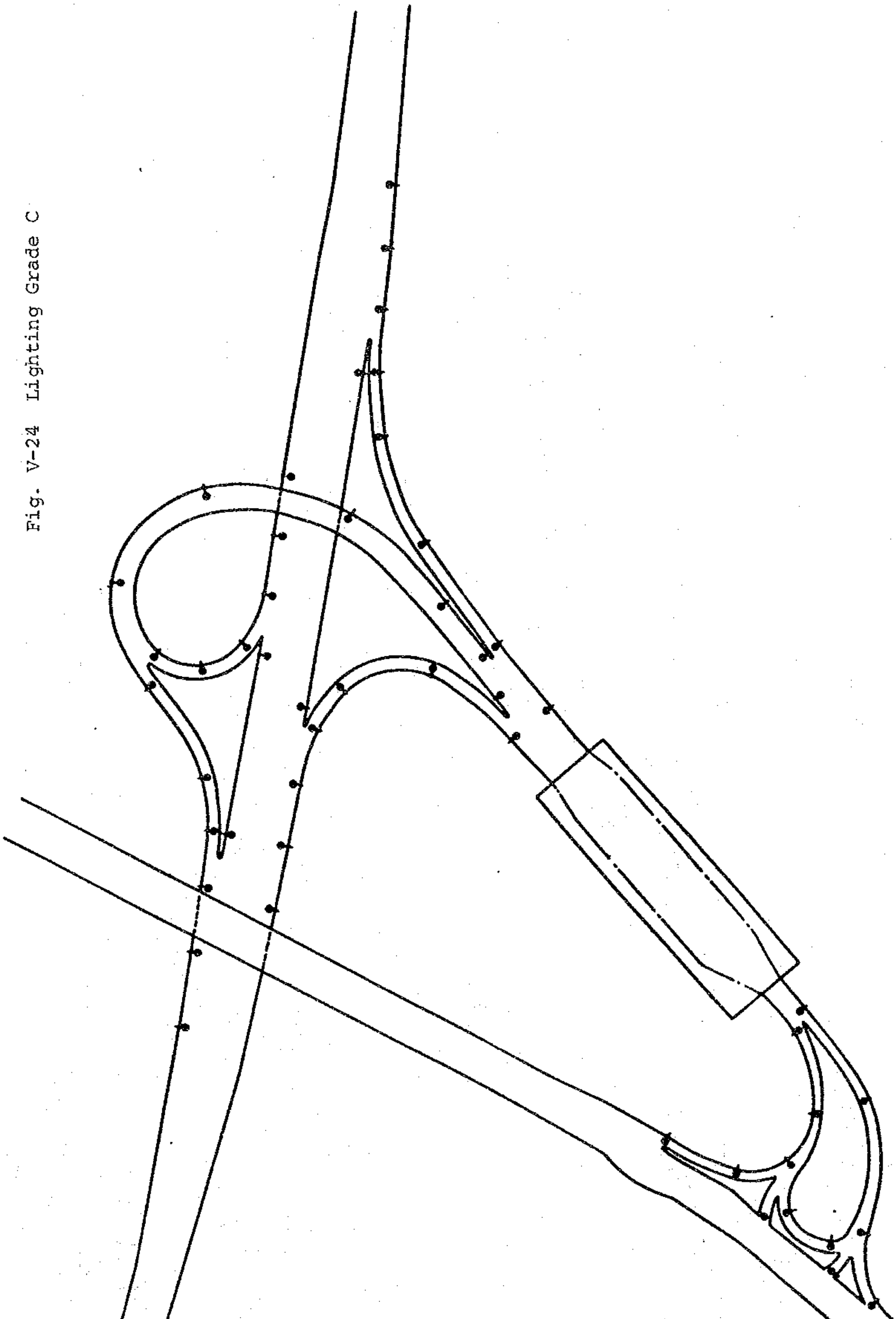
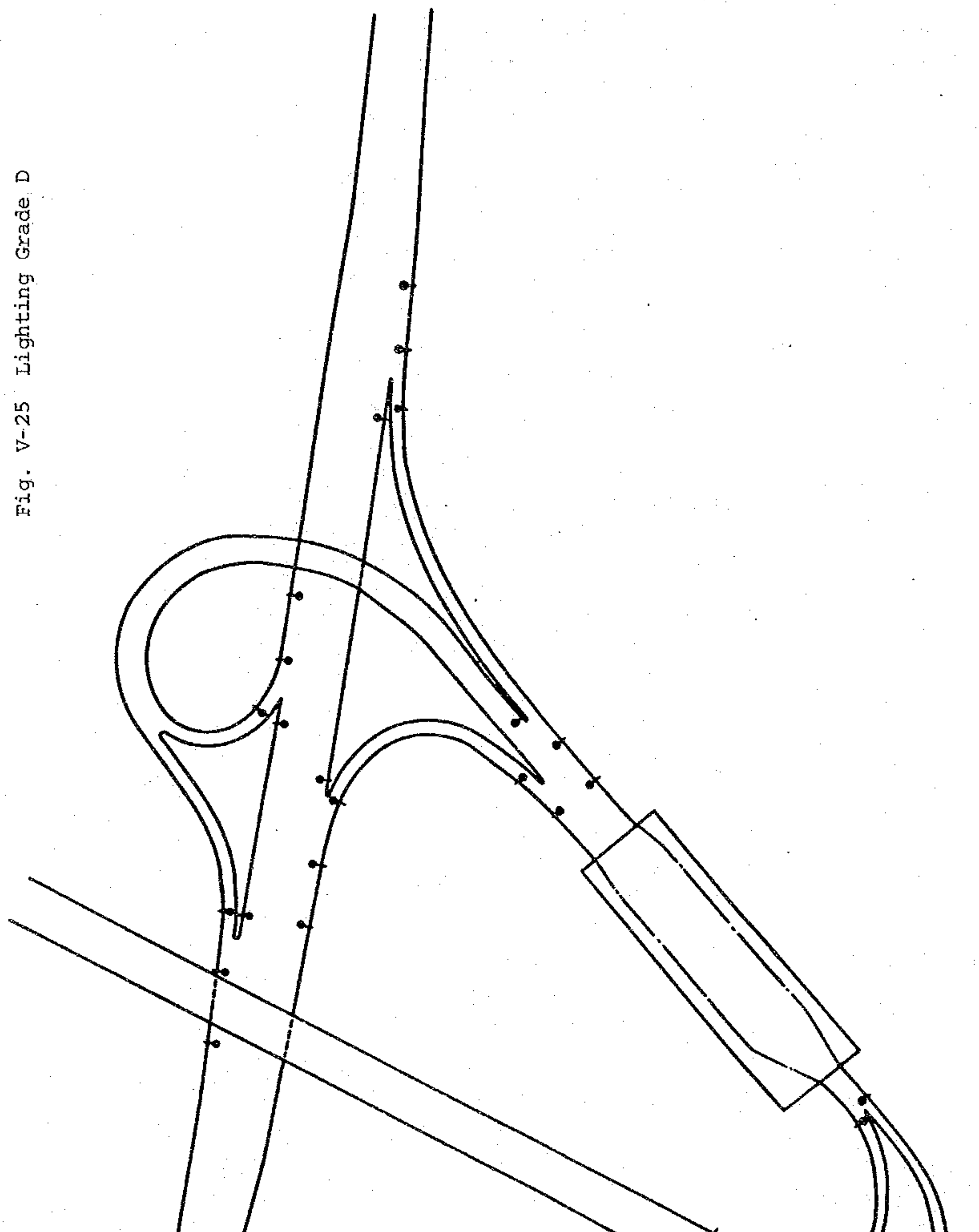


Fig. V-24 Lighting Grade C

Fig. V-25 Lighting Grade D



VI. BRIDGES

CONTENTS

VI. BRIDGES

A. Outline of Bridge Planning

6.01 Bridge planning is based on the results of the Road Planning previously conducted. Planned bridges cover a total of 24 bridges, 4 link road bridges, 4 rampway bridges, 7 motorway junction bridges, 5 over-bridges, 2 pedestrian bridges and 2 aquaducts.

6.02 The basic form of the bridge structure is determined by studying the length and type of the bridges and "other factors", after designed loads, river and crossing road conditions. Calculation for detailed designs is made by determining the detailed design conditions and design technique.

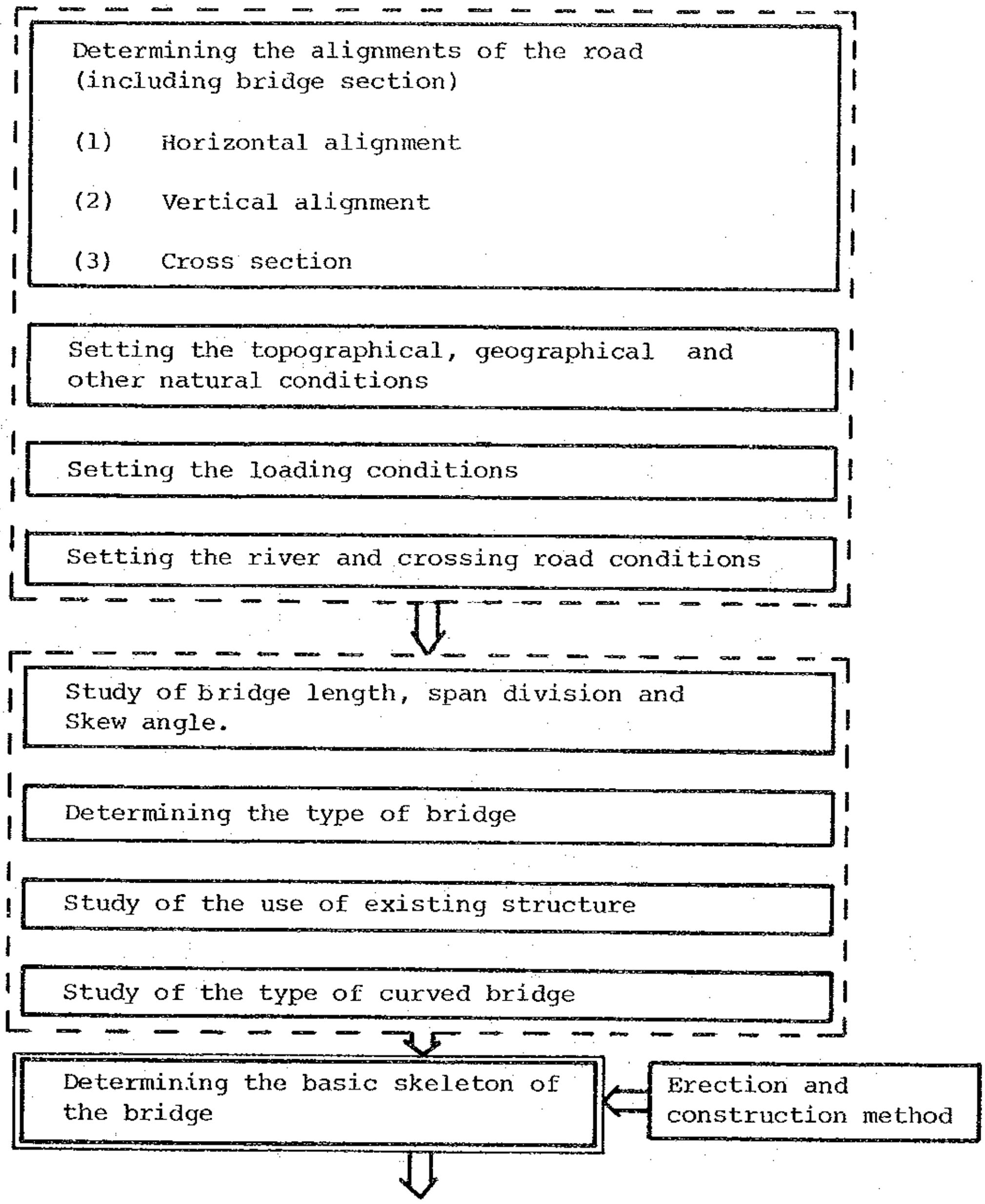
6.03 The study of "other factors" for this Project includes the study of the use of the railway bridge substructures and analysis of the curved RC slab bridges. The survey and study of the substructure of existing railway bridge have revealed that the substructure can be used.

6.04 These bridges are planned according to British Standards.

BS 153	Part 3A	1972	(Loads)
BS 5400	Part 7	1978	(Material)
CP 114	Part 2	1969	(Reinforced concrete)
CP 115	Part 2	1969	(Prestressed concrete)
CP 116	Part 2	1969	(Precast concrete)

CP 110	Part 1	1972	(Concrete)
CP 2004		1972	(Foundation)

6.05 The following diagram shows the flow of the structure planning and detailed design:



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Detailed bridge design

Determining the design conditions

(1) Loads

(2) Material and permissible stresses

Determining the design technique

Determining the furnishings

Fig. VI-1

B. Basic Condition for Planning

1. Road Alignment

a. Link Road Bridges

Horizontal alignment		Radius = 00
Vertical grade		i (Gradient) = 0.3%
Width of Lane	Main Road	3.6m x 2 = 7.2m
	Shoulder	0.5m x 2 = 1.0m
	Foot path	1.5m

For detailed alignment, refer to Roadway Drawings.

b. Rampway Bridges and Motorway Junction Bridges

6.06 Of the bridges planned to be constructed at Motorway Junction and Coromandel Interchange, the bridges on the curved positions are called "Rampway Bridges" and other bridges on the straight positions are called "Motorway Junction Bridges".

(1) Main Road

Horizontal alignment	R = 00		
Vertical grade	i = 5%, 4%		
Width of Lane	Main Road	3.6m x 2 = 7.2m	
	Shoulder	Left side	1.2m
		Right side	0.5m

(2) Straight Ramp

Design speed	40 Km/H		
Horizontal alignment	R = 00		
Vertical grade	Maximum gradient	8%	
Width of Lane	Ramp	3.6m	
	Shoulder	Left side	2.0m
		Right side	0.5m

(3) Curved Ramp (Roundabout)

Horizontal alignment R = 30, 60, 100m

for width of lane, refer to roadway planning.

For detailed alignment, refer to Roadway Drawings.

c. Over Bridges

Horizontal alignment	R = 0	
Vertical grade	Maximum gradient	10%
Width of Lane	Refer to Bridge DWGS	

d. Pedestrian Bridges

Horizontal alignment	R = 00
Vertical grade	i = 2.5% or 0.3% Parabola
Width of Lane	2.4m
Superelevation	1.5%

6.07 The topographical map used for bridge planning is an extension of the topographical plan scale from 1/1000 to 1/200. The contractor is required to conduct a detailed survey and to recheck the vertical alignment and bridge length plan.

2. Basic Conditions for Bridge Planning

a. River Conditions

6.08 The high water discharge (on the basis of estimated rainfall intensity for probability of 100 years)

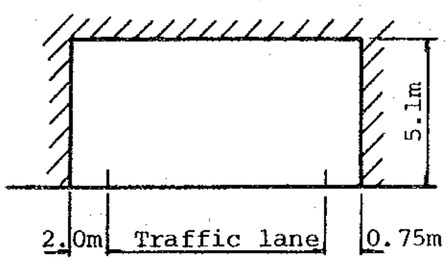
G.R.N.W.	Q'ty = 740 m^3/sec
St. Louis River	Q'ty = 130 m^3/sec

Estimated high water level

G.R.N.W.	HIGH WATER LEVEL 9,750m
	(Maximum water depth 2.04m)

b. Clearance of Crossing Road

Main Road



Other Roads

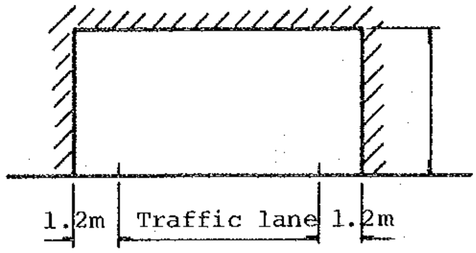


Fig. VI-2

c. Loading Condition

6.09 Loading conditions for bridge design and retaining wall shall be in accordance with "BS 153 Steel girder bridges Part 3A Loads".

C. Bridge Planning

6.10 Fig. 3 shows a reference for selecting the type of bridge for each span. According to the results of the feasibility study, both the superstructure and substructure are constructed in concrete structure.

1. Link Road Bridges

6.11 The following shows the results of the feasibility study:

Bridge name	Bridge Length	Span	Bridge type
G.R.N.W.A-Le.Br.	192.5m	7 x 27.5	PC T-Girder
G.R.N.W.B-Le.Br.	192.5m	7 x 27.5	Ditto
St.L.Ri.A-Le.Br.	27.5m	27.5	Ditto
St.L.Ri.B-Le.Br.	69.5m	21.0+27.5+21.0	Ditto

length and span of the G.R.N.W.A.-Le. and St.L.R.A-Le. bridges are determined by using the existing substructures. The G.R.N.W.B.-Le bridge is adjacent to the A-Le bridge, and has been planned to have the same length and span as those of the A-Le bridge. Fig. VI-4, 5 shows the results of a comparative study of the St.L.R.B-Le Bridge. That is, the span will be "3 x 27.5m". The type of the superstructures is selected according to the planned effective span length. Fig. VI-6, 7 shows a comparision of the two types. Thus, the post-tensioned T-girder noncomposite type will be adopted.

6.12 The abutment type is selected according to the height, as shown in Fig. VI-8.

6.13 The elliptical column type pier is selected for the G.R.N.W. B-Le bridge, while the circular column type pier is selected for the St.L.Ri.B-Le bridge. (Refer to Fig. VI-9.)

6.14 The spread footing type foundation is used since the bearing layer is located close to the surface or the river bed. In this case, the embedment will be determined, taking into consideration the scour shown in Fig. VI-10.

6.15 The bearing capacity of foundation ground will be 50 t/m^2, making reference to the "CP 2004" and "Substructure Design Guide" of the Japan Road Association.

a. Superstructure

Fig. VI-3 Comparison of Superstructure Type

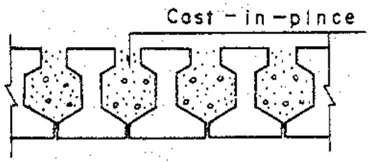
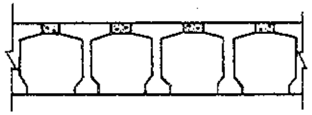
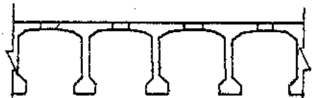
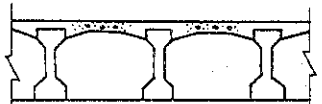
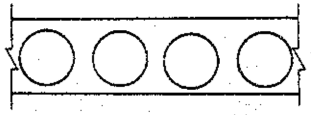
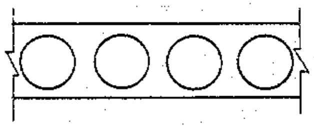
	Type	Cross Section	Available Span (m) 10 20 30 40 50	Comment
Prestressed Concrete Pre-tension Type	Slab			Both Fabrication and Erection are easy. Short span (up to 17 m) is available.
	T-Girder			Both Fabrication and Erection are easy. 15.0 m - 20.0 m is available.
Prestressed Concrete Post-tension Type	T-Girder non-composite			Both Fabrication and Erection are easy. Over 20.0 m is available
	T-Girder composite			- ditto -
	Hollow Slab		Simple beam Continuous beam	All staging method
Reinforced Concrete	Hollow Slab		Simple beam Continuous beam	All staging Method

Fig. VI-4 St. Louis Bridge

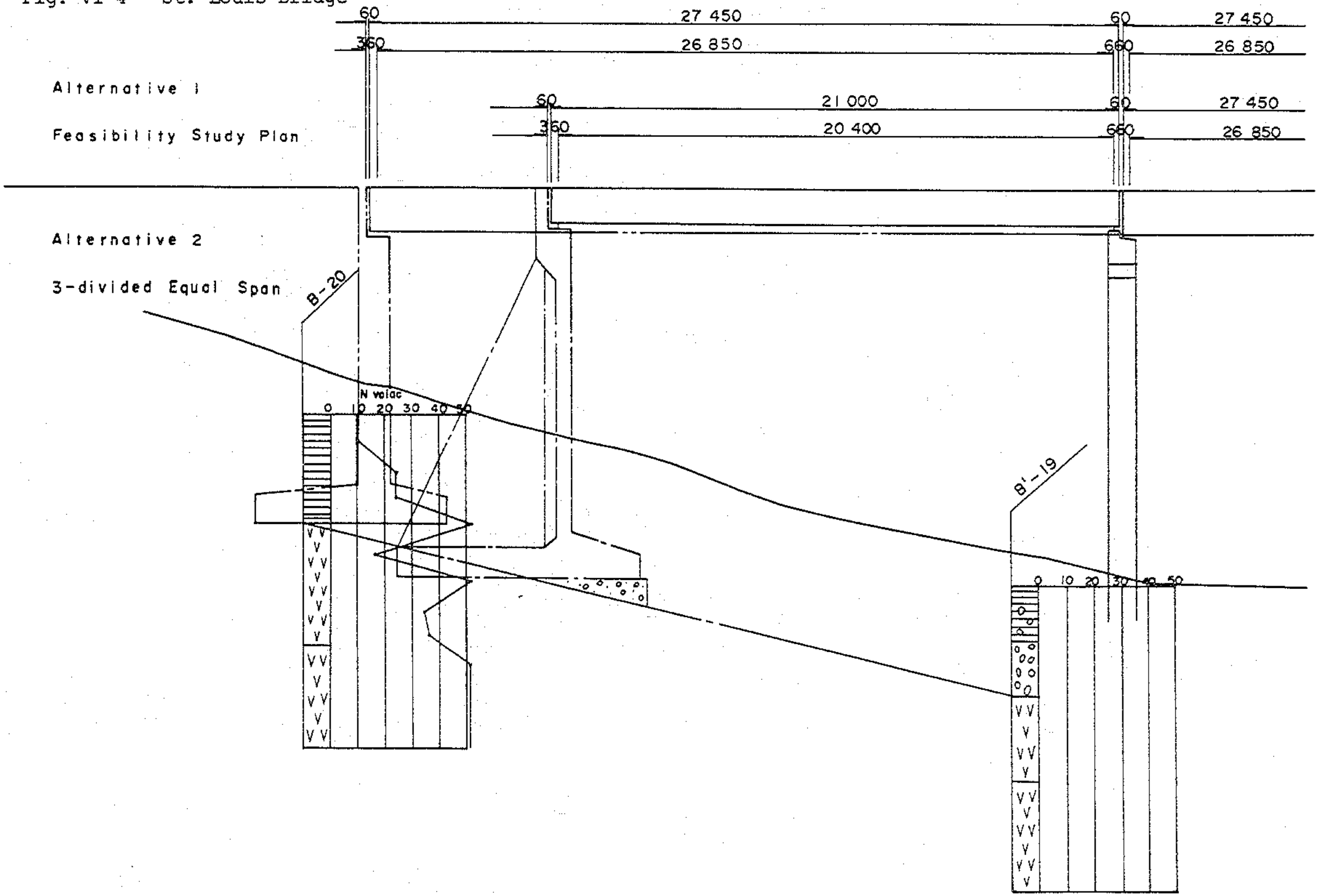
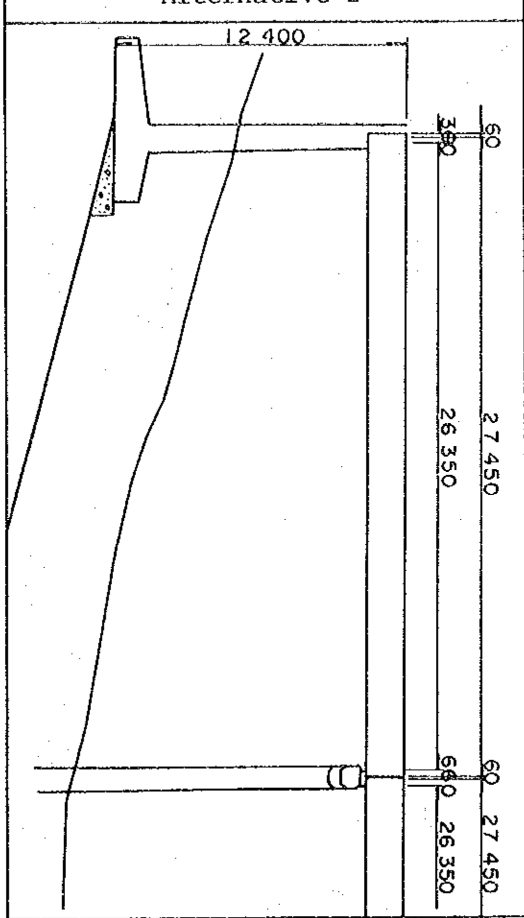
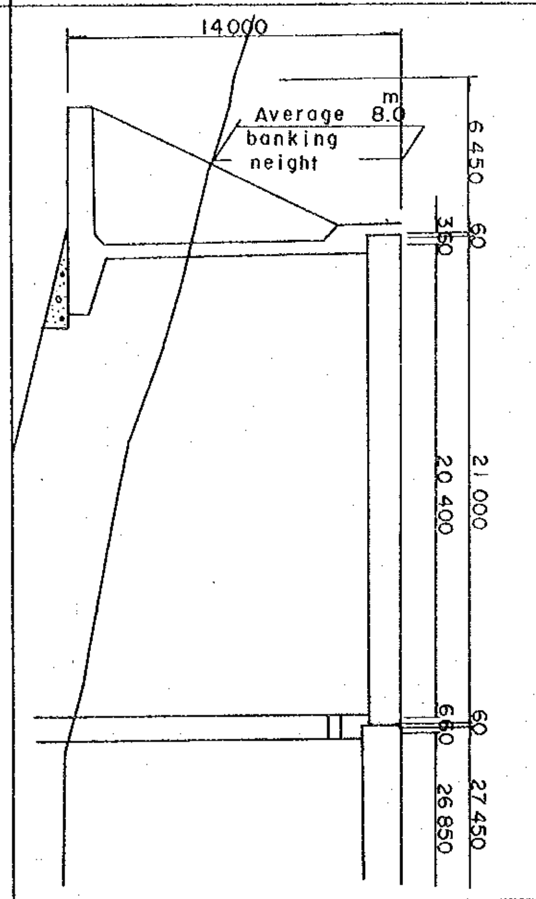


Fig. VI-5 Comparison Table

<table>
<tr><th></th><th>Alternative-2</th><th>Alternative-1</th></tr>
<tr><td></td><td>
</td><td>
</td></tr>
<tr><td>Bridge Length</td><td>82.590 m
60+27450+60+27450+60+27450+60</td><td>69.690 m
60+21000+60+27450+60+21000+60</td></tr>
<tr><td>Characteristic</td><td>Girder height is equal, so side view is a good feature.

Abutment Type is L-shaped, so it is economical and banking volume is little.</td><td>Abutment Type is buttess.</td></tr>
<tr><td>Cost Estimate</td><td>thousand yen
Superstructure 5,600
Substructure 15,800
Banking 0
21,400</td><td>thousand yen
Superstructure 0
Substructure 22,700
Banking 1,000
23,700</td></tr>
<tr><td>Judge-ment</td><td>○</td><td>×</td></tr>
</table>

Fig. VI-6 Comparison Table between Non-Composite Girder and Composite Girder

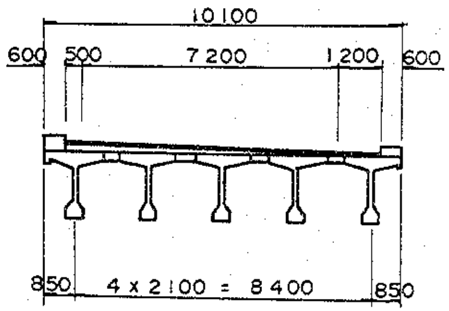
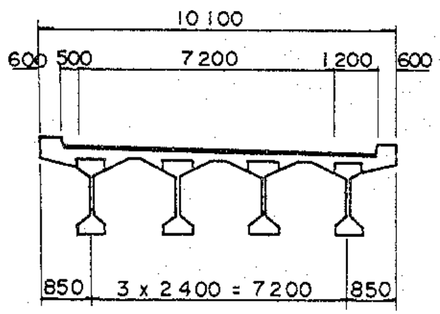
Type	Cross Section	Construction	Erection	Cost Estimate	Remarks
Prestressed T Girder Non-composite		Fabrication No problem Cross Frame It is necessary for Deck slab and Girder prestressing (Transverse)	Girder Erection	96,000 yen/m^2	Girder span 20 - 50 m is available. Structure height is more favorable than prestressed composite Girder. Construction period is short.
Prestressed I Girder Composite		Fabrication No problem Construction Reinforcement arrangement and concrete work is necessary at site	Girder Erection	92,500 yen/m^2	It is available for any dimension. (Plan geometry) It is necessary to care at Girder transfer and erection. Construction period is long.

Fig. VI-7

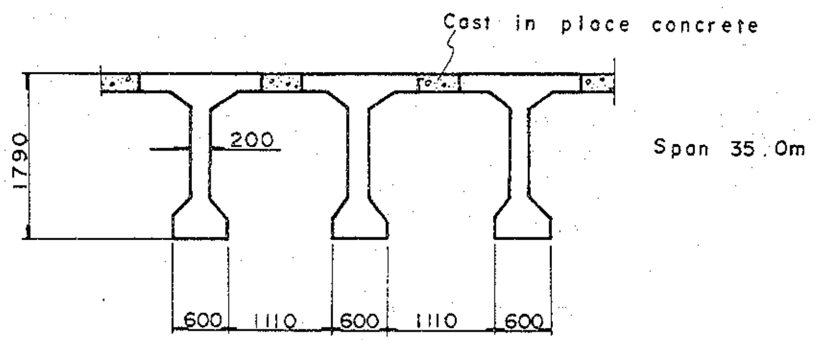
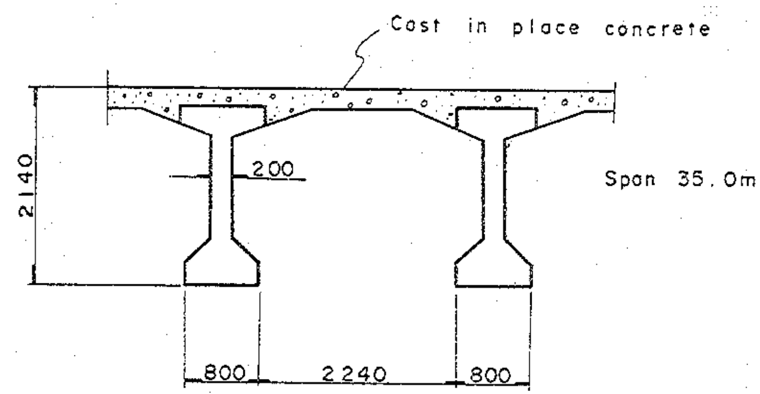
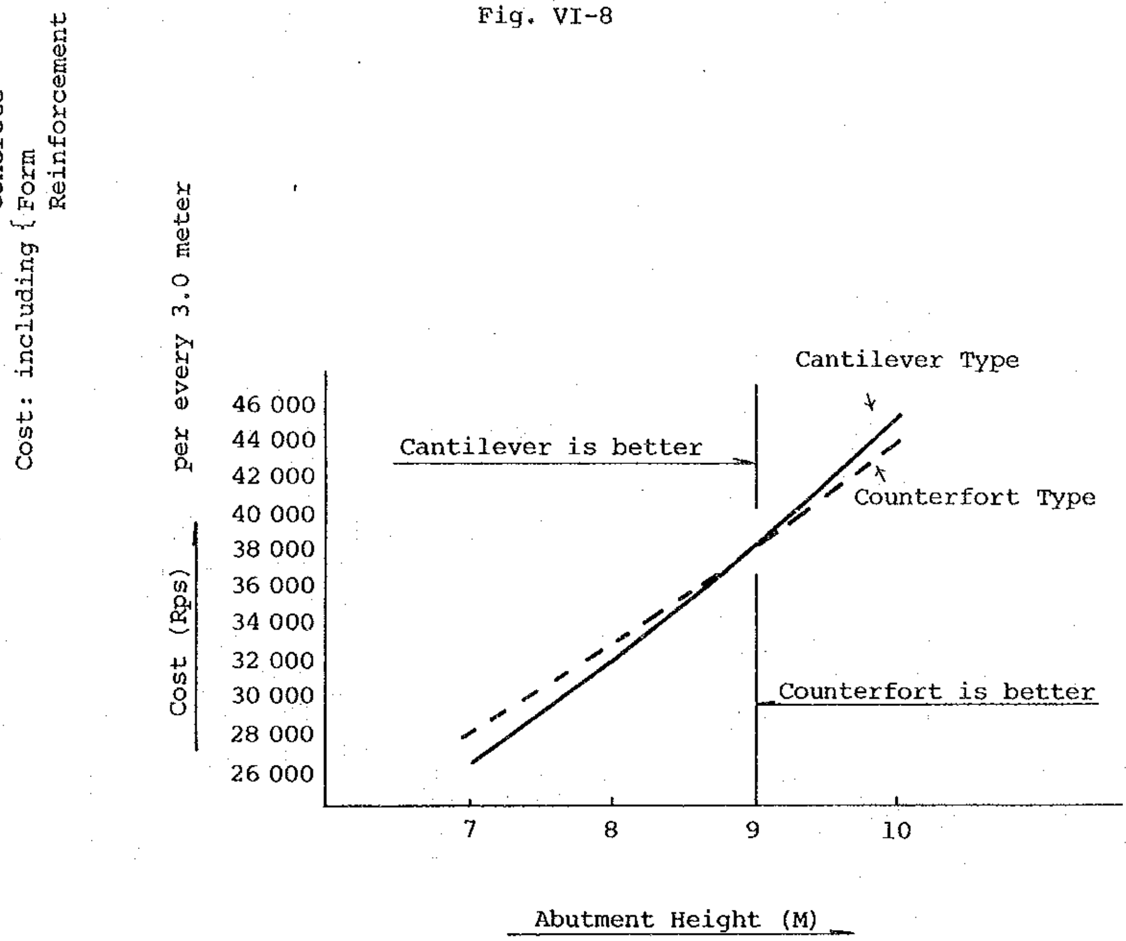
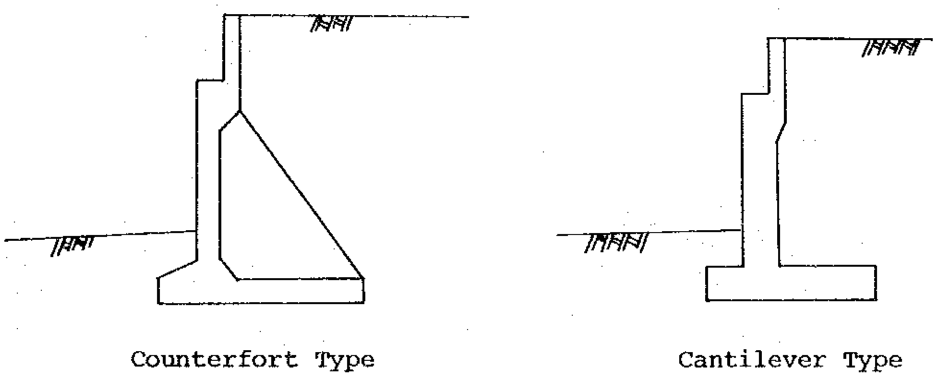
Construction of PC T-Girder	Construction of PC Composite Girder
1. Fabricate Precast Girder at yard and set on Piers.	1. Fabricate Precast Gilder at yard and set on Piers.
2. After setting of cross-frame formwork, carry out cross-frame concrete work. And after having the required strength of concrete, carry out prestressing work of cross-frame and carry out prestressing work of deck slab.	2. After setting of cross-frame formwork, carry out cross-frame concrete work. And after having the required strength of concrete carry out prestressing work of cross frame.
3. Concrete work between T-section Girders.	3. Arrangement of formwork of Deck Slab.
4. Curing of concrete.	4. Arrangement of reinforcement and concrete work.
5. Road surfacing.	5. Curing of concrete.
6. Opening.	6. Read srufacing.
	7. Opening.
Period of Works 120 days	Period of Works 150 days
(Total width 18.0 m, span 35 m)	(Total width 18 m, span 35 m)
	

Fig. VI-8



Cost: including { Concrete Form Reinforcement
per every 3.0 meter
Cost (Rps)
46 000
44 000
42 000
40 000
38 000
36 000
34 000
32 000
30 000
28 000
26 000
Cantilever Type
Cantilever is better
Counterfort Type
Counterfort is better
7
8
9
10
Abutment Height (M)



Counterfort Type
Cantilever Type

Fig. VI-9 Pier Type 2 : St. Louis and G.R.N.W. Br.
Gomparison Table

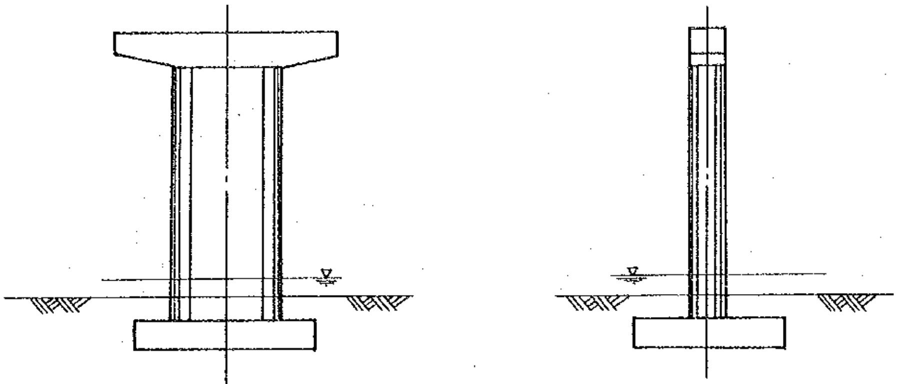
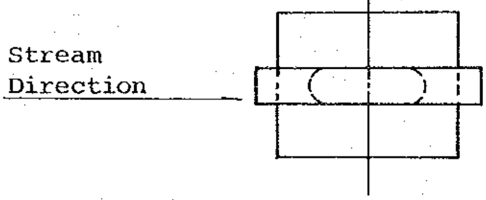
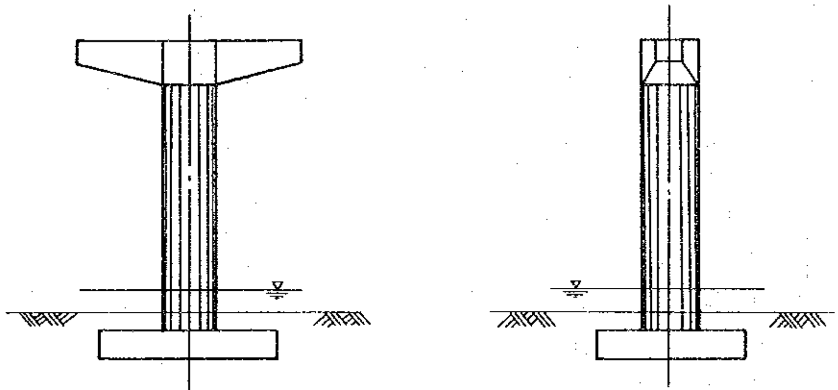
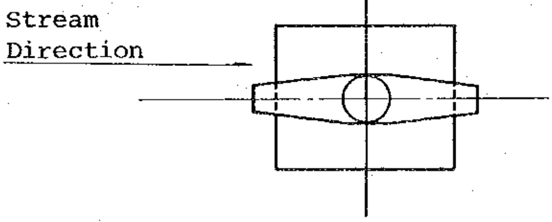
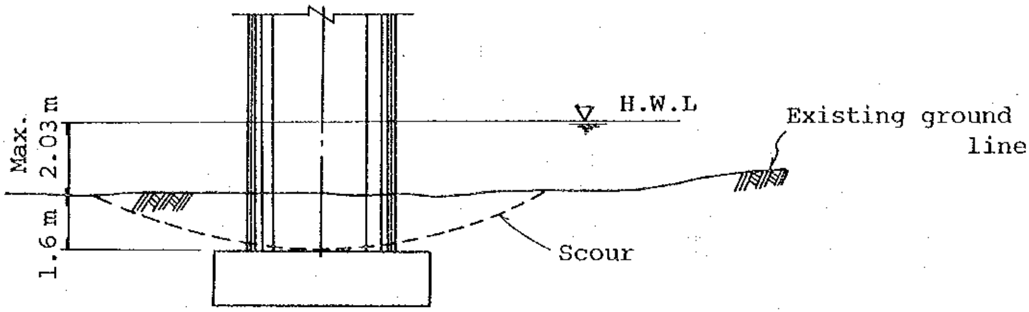
Elliptical Column	  Favorable to cross sectional area of river. Wall direction is to be parallel to river stream
Circular Column	  Direction of Top beam member is free.

Fig. VI-10



2. Rampway Bridges and Motorway Junction Bridges

a. Motorway Junction Bridges

6.16 Sections before and after the bridge are embankment sections. The bridge length is determined by comparing the construction cost of bridge with those of the embankmant. It is economical to design the bridge length as short as possible, within the permissible clearance of the crossing road.

6.17 The A-Le 1 bridge and B-Le 1 bridge are one-span bridges extending over the B-ramp and E-ramp.

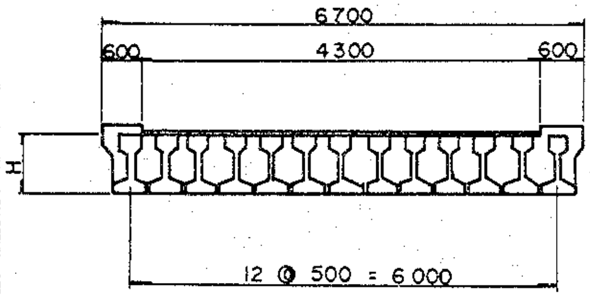
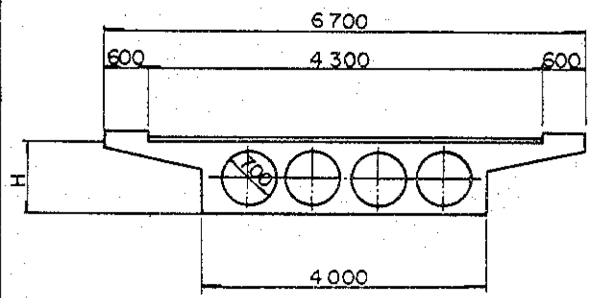
6.18 The bridge length should be determined according to the sight distance and uniformity of girder length. As a result, the length of the A-Le 1 bridge is planned to be 30.1 meters and that of B-Le 1 bridge is to be 21.2 meters.

6.19 Both the A-Le 3 bridge and B-Le 3 bridge are one-span bridges extending over the H-ramp. Their length is 17.0 meters.

6.20 The A-Le 2 bridge, B-Le 3 bridge and E-Rp bridge extend over the M1-M2 road and B-ramp (crossing road). So the planned length is about 85 to 90 meters. The length of each bridge is determined according to the number of spans and uniformity of the girder length. Piers are installed at the median of the M1-M2 road, and between the M1-M2 road and B-ramp to form three-span bridges. This is as shown in the drawing.

6.21 The superstructures of five bridges, A-Le 1 bridge, B-Le 1 bridge, A-Le 2 bridge, B-Le 2 bridge and E-Rp bridge, will be of post-tensioned T-girder non-composite type. Two bridges, A-Le 3 bridge and B-Le 3 bridge will be RC voided slab bridges according to the study of the Comparison Table in Fig. VI-11.

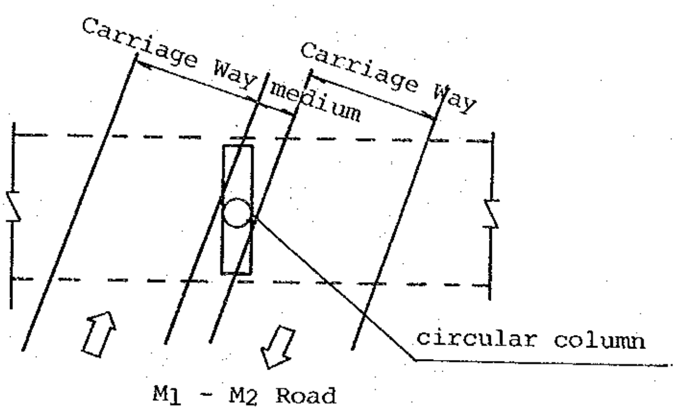
Fig. VI-11 Comparison between Pre-tension Slab Br. and Reinforced Concrete Voided Slab Br.

	Cross Section	Ratio L/H	Cost Estimate	Characteristic
PC Pre-tension Slab		H = (1/20)xL L; span length (m) H; structure height (m)	85,000 yen/m^2	. Working period is short . Pre-cast concrete . Truck crane erection . Construction is easy
Reinforced Concrete Voided Slab		H = (1/16)xL (for continuous) H = (1/12)xL (for simple)	75,000 yen/m^2	. Working period is long . Available for curved bridge . All staging method . Structure height is higher than PC pre-tension slab . Formwork is complicated, however work is not difficult

For the T-girder bridge, the uniformity of girder depth should be taken into consideration.

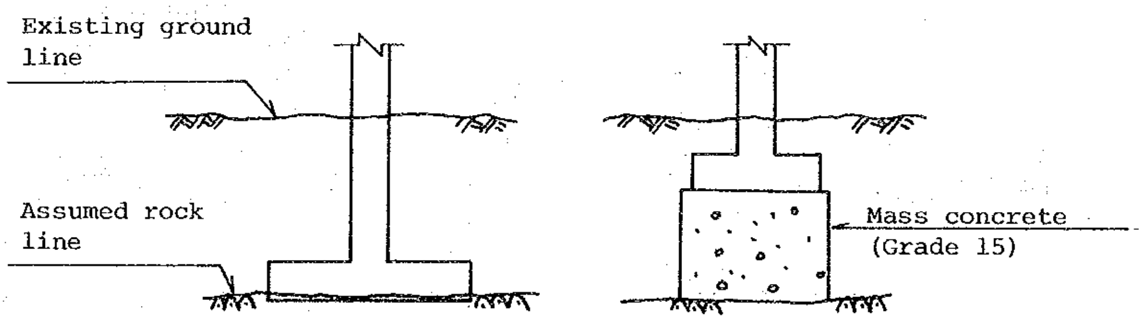
6.22 The type of the abutment is determined according to Fig. VI-8. A circular column type pier will be adopted. (Refer to Fig. VI-12)

Fig. VI-12



6.23 The spread footing type foundation is used since the bearing layer is located close to the surface. However, when the enbedment is to be placed far from the surface, mass concrete will be used for the foundation. (Refer to Fig. VI-13.)

Fig. VI-13



6.24 The permissible bearing capacity of the new lava layer considered to be a bearing layer is asummed to be 60 t/m^2.

b. Rampway Bridges

6.25 Fig. VI-14 shows the three possible bridge lengths. After a comparative study, we have selected the open end span.

Fig. VI-14

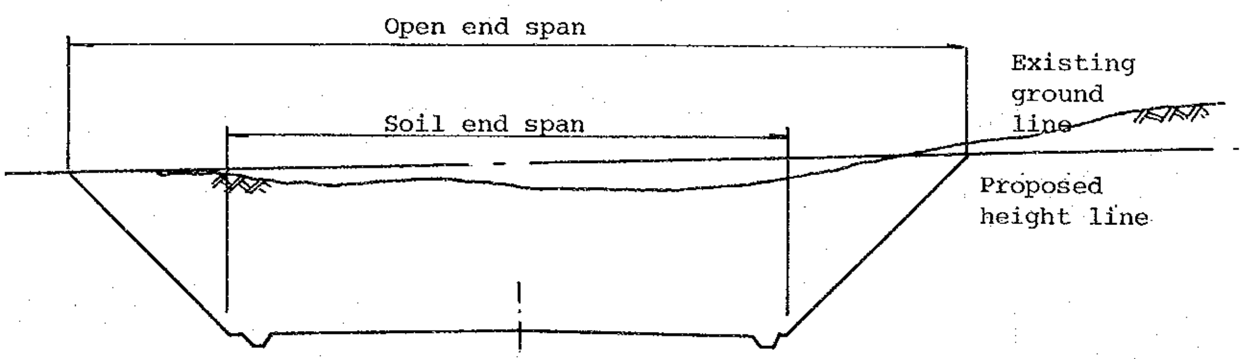


Fig. VI-15 Rampway Bridge
Comparison of Bridge Length

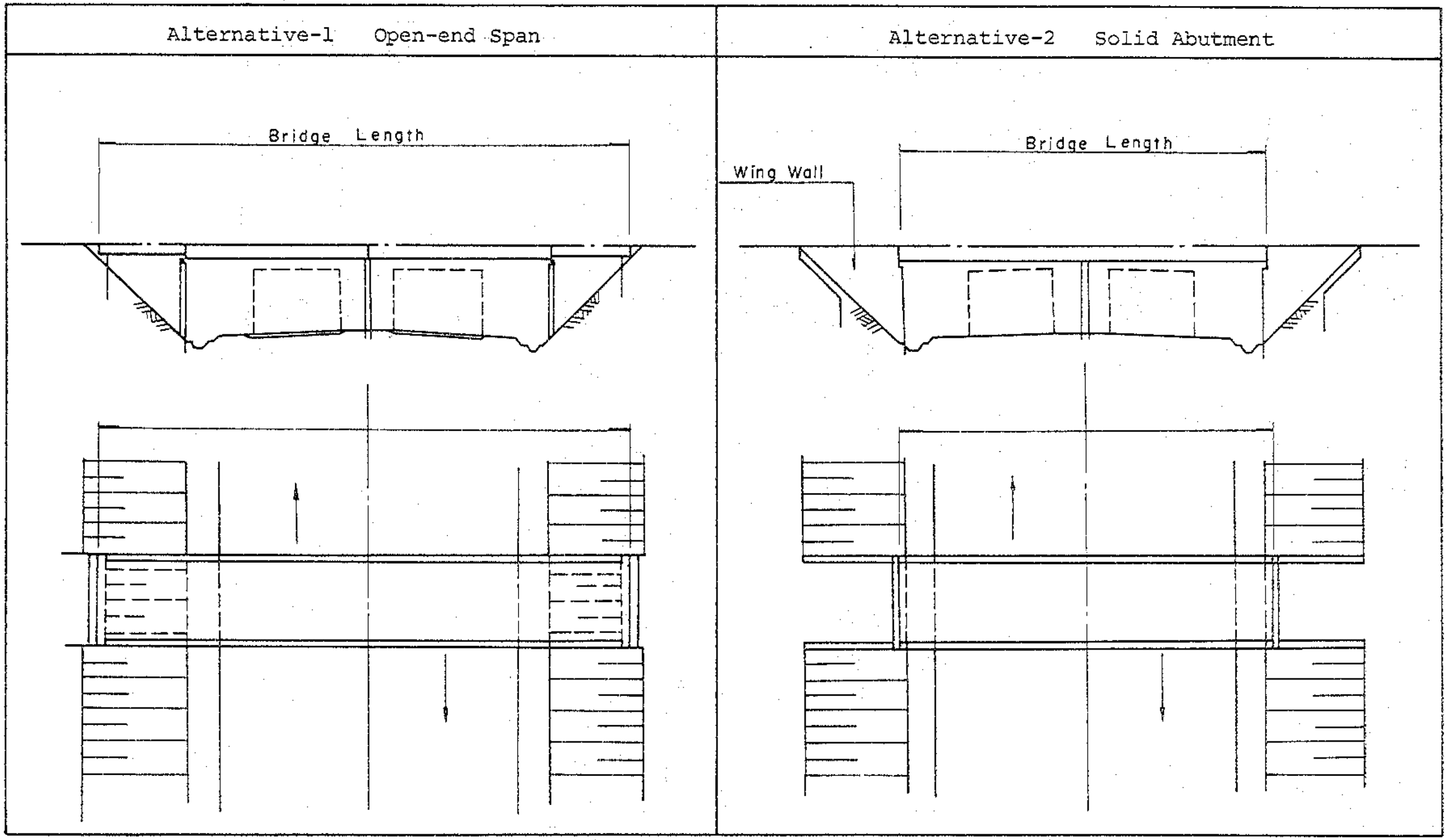


Fig. VI-16 Comparison Table

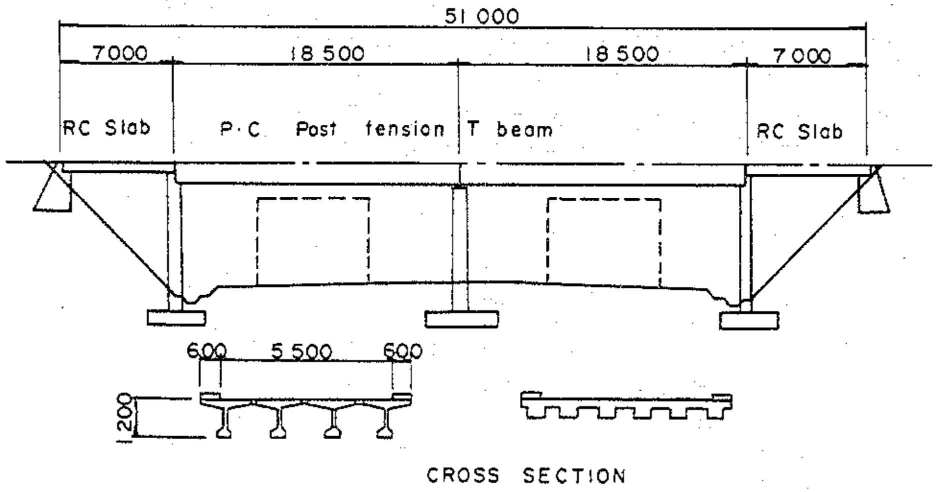
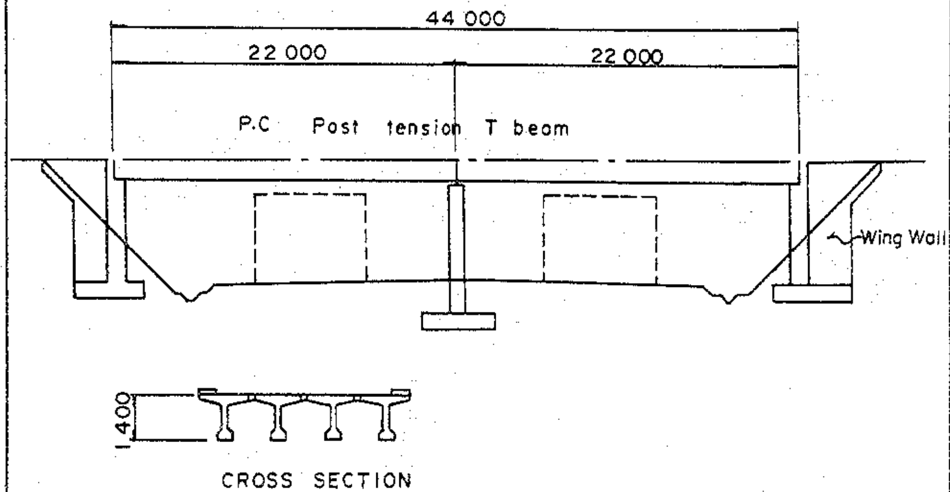
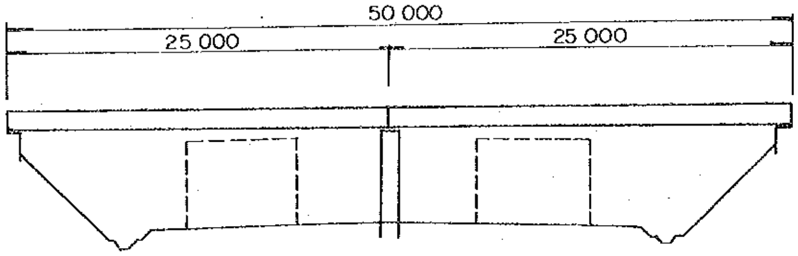
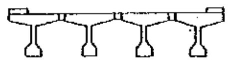
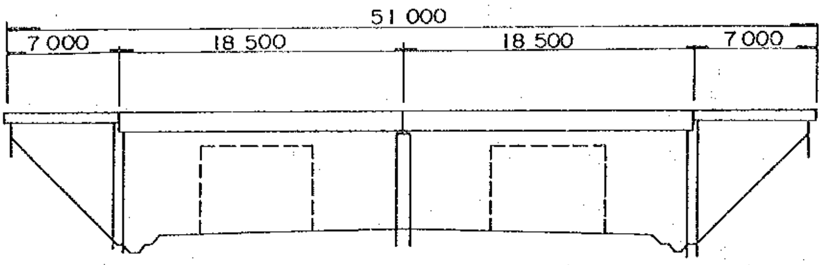
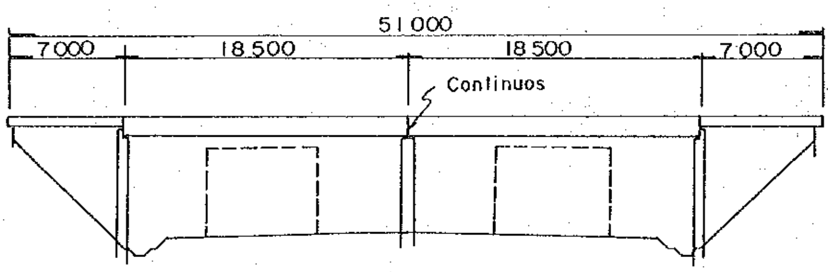
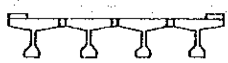
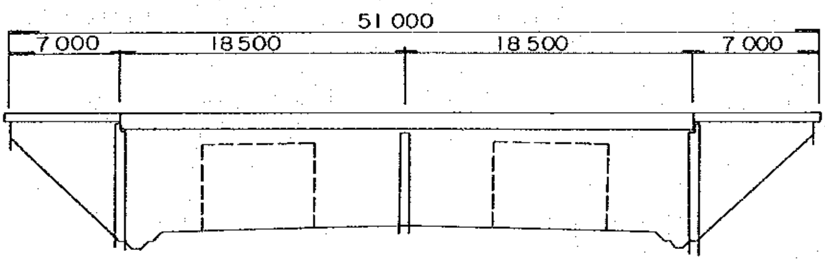
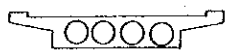
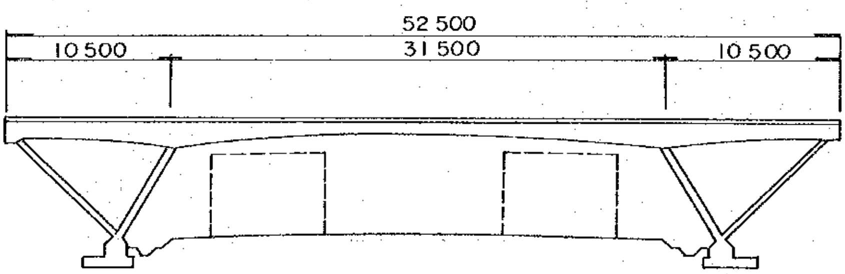
<table>
<tr><th></th><th></th><th>Featuring Point</th><th>Construction Cost</th><th></th></tr>
<tr><td>4-spans</td><td></td><td>Abutment is small</td><td>(thousand yen)
Super 25,300
Sub 12,500
Bank
37,800</td><td>o</td></tr>
<tr><td>2-spans</td><td></td><td>Abutment is rather large</td><td>(thousand yen)
Super 23,700
Sub 15,300
Bank 300
39,300</td><td>x</td></tr>
</table>

Fig. IV-17　Comparison Table of Super Structure Type

	Side View	Cross Section
PC Post Tension T-beam		
PC Post Tension T-beam, RC Slab		
PC Post Tension T-beam, RC Rahmen Abutment		
RC Continuous Voided Slab, RC Slab		
T Type PC Voided Slab		

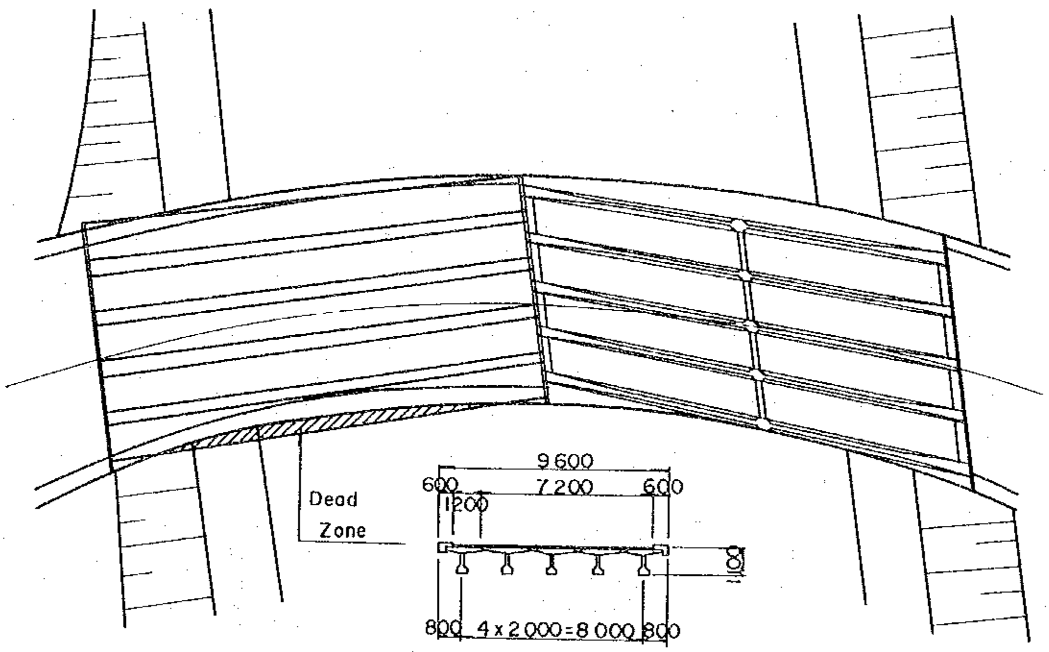
6.26 Fig. VI-17 shows the proposed number of spans and types of the superstructure given in comparison.

6.27 Comparison is made of two types: post-tensioned T-girder + RC solid slab and RC continuous voided slab + RC solid slab, which are superior in economy and construction. Since the rampway bridge is a curved bridge, the RC continuous voided slab + RC solid slab type is adopted. (Refer to Fig. VI-18).

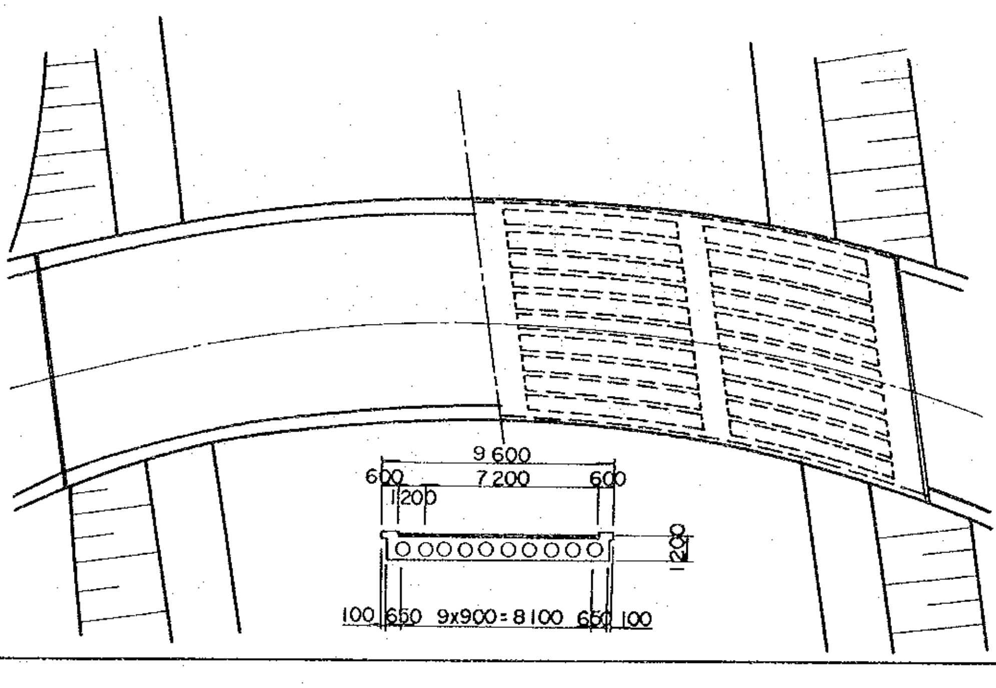
Fig. VI-18   Curved Bridge
Comparison Table of Curved Bride

Girder Arrangement   No Scale

Non Composite T Beam Girder



Continuous RC Voided Slab

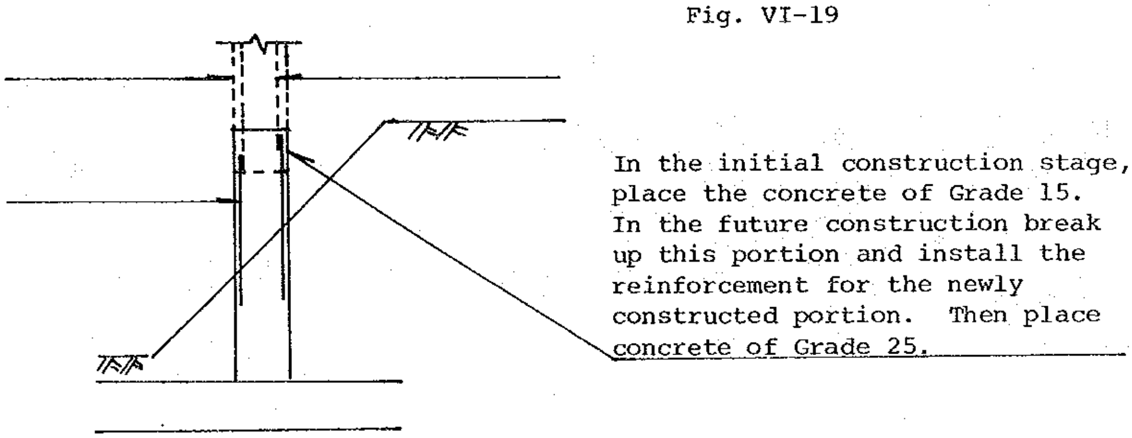


6.28 The bridge pier is available in two types: wall type having overhanging, and the rigid frame type. Because the ratio of the bridge width to pier height is large, the Rigid frame type is adopted.

6.29 Since the bearing layer is located closed to the surface, the abutment height is from 3.0 to 4.0 meters. To conform to this height, the gravity type abutment is adopted. The bearing layer is assumed to be cohesive soil mixed with gravel, and the permissible bearing capacity is assumed to be 30 t/m^2.

6.30 Since the G-Rp bridge A2 is located close to the E-Rp bridge P2, their abutment and pier footings are made integral. Since there is a slight difference for construction time between the G-Rp bridge and E-Rp bridge, the E-Rp bridge (P2) will be processed, as shown in Fig. VI-19.

Fig. VI-19



3. Over-Bridges

6.31 Based on the same method as the rampway bridge, the open end span will be used. Where the one-span length is 20 meters or more, the post-tensioned T-girder bridge will be used. Where the span length is less than 20 meters, the RC voided slab bridge will be adopted.

4. Pedestrian Bridges

6.32 The Hindu Temple pedestrian bridge will be a two-span continuous RC box girder bridge, and the Beau Bassin pedestrian bridge will be a simple RC box girder bridge. Assuming the ground to be a silt layer, permissible bearing capacity of the foundation ground is designed to be 30 t/m^2.

5. Aquaduct

6.33 The Link road crossed the existing waterway at positions near STA. 22 and STA. 57. The bridge length is about 47.0 meters for STA. 22 and 62.0 meters for STA. 57. We propose a two-span bridge with piers installed at median.

The post-tensioned continuous U-girder type will be used for the superstructure.

6. Study on the Use of Existing Pier of Grand River North West Bridge

a. Investigated Items and the Results

(1) Observation of Pier's Apperance

6.34 There is no defect like cracks in the stone blocks forming the outside walls, nor evidence of having been deformed by excessive stress. Therefore, it seems still in sound condition.

(2) Observation of Internal Concrete and Tests by Shumit Hammer

6.35 The internal concrete found to be not carbonized through visible investigation. As a result of Shumit Hammer Test, the concrete strength is estimated approx. 120 kg/cm^2.

(3) Boring Investigation

6.36 From the view point of strength, it may be classified as low strength concrete and the core recovery is 50% in the worst spot.

(4) Laboratory Test by Boring Cores

6.37 Single Axial Compression Test: 94 - 143 kg/cm^2 (Fig. VI-21)
Carbonation Test: Not carbonized

b. Interpretation of the Result and the Conclusion

6.38 The existing pier is being kept in sound condition from the construction up to the present.

6.39 The concrete strength is estimated approx. 100 kg/cm^2.

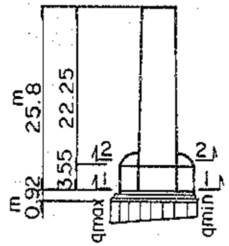
6.40 It is natural that the core recovery of boring is rather low, because larger coarse aggregates (dia. 20 - 30 cm) are being used and there is a big difference in the strength between the coarse aggregates and the mortar. However, the concrete strength is not always low in the case of lower core recovery.

6.41 The comparison between the stress acted in the concrete when the existing pier was being used as the pier of railway bridge and the stress as may act when the highway bridge, is as shown in the table of next page.

6.42 From the table, the compressive stress is found to be increased by 2.2 kg/cm^2 and the tensile stress is found to be decreased. Therefore, there is no problem with the stress.

6.43 From the above viewpoint, the existing pier is judged to be usable for the proposed highway bridge.

Fig. VI-20 List of Stresses



σ ; kg/cm^2

q ; t/m^2

		Sect - 1		Sect - 2		Soil reaction		Percentage of Unit Stress
		σmax	σmin	σmax	σmin	qmax	qmin	
Railway Bridge	Dead + Live + Trac.	7.0	2.0	9.2	2.6	49.4	19.8	100%
	Dead + Wind (1)					40.7	14.5	125%
	Dead + Wind (2)	7.3	-0.3	9.4	-0.6	54.6	0.6	125%
	Dead + Live + Trac. + Wind (1)					60.2	9.0	125%
	" + Wind (2)	98	-0.8	13.0	-1.2	69.5	-0.3	125%
Highway Bridge	Dead + Live(HA) + Trac.	7.3	3.7	10.0	5.0	53.2	30.8	100%
	Dead + Live(HB) + Trac.	9.1	2.7	11.1	3.7	58.3	25.1	125%
	Dead + Wind (1)					49.7	25.1	125%
	Dead + Wind (2)	8.6	1.0	11.2	1.8	63.5	11.7	125%
	Dead + Live(HA) + Trac + Wind (1)					64.1	19.9	115%
	Dead + Live(HA) + Trac. + Wind (2)	10.4	0.6	14.1	0.9	70.1	13.9	115%
	Dead + Live(HB) + Trac. + Wind (1)					69.2	14.2	130%
	Dead + Live(HB) + Trac. + Wind (2)	11.2	-0.4	15.2	-0.4	75.2	8.2	130%

Wind (1) Transverse direction

Wind (2) Longitudinal direction

σ_{cr}: Concrete strength about 100 kg/cm^2

qa: Permissible soil reaction 60 t/m^2

$q_{max} = 70.1 \fallingdotseq 60 \times 1.15 = 69$

Fig. VI-21 Test Resultant for Compressive Strength of Concrete

Sample name ; Mauritius Link Road Project

Date ; 26th April, 1979

Numbers of specimens ; 4 specimens (Diameter ø=7.5 cm)

Specimen name	specimen dimensin (c.m.)					$\frac{h}{d}$	modified factor	compressive strength	
	diameter d				height h			maximum load (ton)	compressive strength (kg/cm^2)
	Upper part	Middle part	Bottom part	mean diameter					
No.25 $1.8^m-2.0^m$	7.58	7.55	7.50	7.54	12.17	1.61	0.97	6.60	143
No.25 2.1-2.6	7.58	7.57	7.57	7.57	14.88	1.97	1.00	4.22	93.8
B - 6 9.6-9.85	7.25	7.26	7.27	7.26	15.63	2.15	-	5.93	143
B - 16 7.4-7.65	7.51	7.55	7.55	7.54	12.99	1.72	0.98	4.89	107

Note;

No.25 G.R.N.W.Br. Pier

B - 6 G.R.N.W.Br. Abutment

B - 16 St. Louis River Br. Abutment

$1.8^m-2.0^m$ shows boring depth

D. Design Criteria for Bridges

1. Loads

6.44 The design loads shall be in accordance with "BS 153 part 3A Loads". For the purpose of computing stress, the following items shall be taken into account.

a. Dead load

b. Live load

c. Impact effect

d. Longitudinal force

e. Wind pressure effects

f. Temperature effects

g. Collision with parapet or handrail

a. Dead Load

6.45 The unit weight of dead load shall be in accordance with "BS648" or "Reinforced Concrete Designer's Handbook".

Reinforced concrete (Nominal)	23.6 KN/m^3
Plain concrete (Nominal)	22.6 KN/m^3
Asphalt	22.6 KN/m^3
Structural steel	76.9 KN/m^3
Soil	18.6 KN/m^3

b. Live Load

6.48 Live load shall be in accordance with "BS 153 Part 3A".

Type HA loading applies to all structures.

Type HB loading applies to all structures excluding COROMANDEL Ov. Br., Cor. Int. H-Rp. Ov. Br. and STA. 22 Ov. Br.

37.5 units of HB loading shall be taken into account.

Footway loading ------- 5 KN/m^2

6.47 Notations for bridge loading are as follows.

Numbers of National lanes for the HA and/or HB loading shall be decided according to the carriageway width including hard shoulders and/or verges.

Where the HB vehicle straddles two lanes, the remainder of the loaded length of the straddled lanes shall not carry any other load. All other lanes, if nay, shall be loaded with one-third HA loading.

This requirement makes reference to BS 5400 6.4.2.2. articles.

The footway shall be designed to support a wheel load of 40 KN placed in any position.

c. Impact Effect

6.48 HA and HB loading given in Appendix A of BS153 Part 3A include impact.

d. Longitudinal Force

6.49 According to BS-153 Part 3A Loads 10. "Longitudinal force on highway bridges".

e. Wind Pressure Effects

6.50 The maximum mean hourly wind speed shall be taken as 38 meters per second. This speed has been obtained from the records of the Meteorogical Department of Mauritius. As BS 153 gives no detailed guidance on the application of wind loading, reference shall be made to BS 5400 Part 2.

Bridges of G.R.N.W. shall be carefully studied with the funnelling factor S1 (applied figures = 1.1) based upon BS 5400, article 5.3, especially for Vc and/or Vc'.

f. Temperature Effects

(1) Temperature Change

6.51 Temperature change is based on the "Climate of Mauritius". Considering the regional features within Mauritius for this Project, the normal temperature is set at 25°C. with the temperature rise of concrete 20°C and the temperature fall of concrete -12°C.

(2) Temperature Difference

6.52 When the temperature difference is taken into consideration in designing, it should be based on BS 5400.

g. Collision with Parapet or Handrail

6.53 The load conforms to Section 2 Design Loads in National Association of Australian State Road Authorities (NAASRA). However, the parapet is designed according to Technical Memorandum (Bridge) No. BE5. (Department of the Environment)

2. Material and Permissible Stresses

a. Material

(1) Concrete

6.54 Concrete shall be used in accordance with BS5400

		Grades of concrete	Characteristic strength
Prestressed concrete	Precast members (Main girder)	40	40.0 N/mm^2
	In situ members (cross beam and slab)	30	30.0 N/mm^2
Reinforced concrete	Superstructure	30	30.0 N/mm^2
	Substructure	25	25.0 N/mm^2
Plain concrete	Gravity type abutment and Gravity type retaining wall	25	25.0 N/mm^2
	Screeding concrete	30	30.0 N/mm^2
	Blinding concrete and Mass concrete	15	15.0 N/mm^2

(2) Prestressing Steel

	Nominal size	Specified characteristic strength Asp·fpu	Nominal cross-sectional area Asp
Prestressing strand	12.5 mm	165.0 KN	94.2 mm^2
Prestressing wire	7.0 mm	60.4 KN	38.5 mm^2
Prestressing wire	5.0 mm	30.8 KN	19.6 mm^2

(3) Reinforcement

	Nominal size	Specified characteristic strength fy
Hot rolled high yield (BS4449)	from 10mm to 32mm	410 N/mm^2
Hot rolled mild steel (BS4449)	all sizes	250 N/mm^2

b. Permissible Stress

6.55 Refer to following memorandums (Department of Transport)

BE 1/73 Reinforced concrete for highway structures

BE 2/73 Prestressed concrete for highway structures

(1) Prestressed Concrete

(i) Grade 40 Concrete

	At working load	At transfer
Permissible compressive stress in bending	0.33 x 40.0 = 13.0 N/mm^2	0.5 x (0.85x40.0) = 17.0 N/mm^2
Permissible tensile stress in bending	0.0 N/mm^2	-1.0 N/mm^2
Limitting principal tensile stress	-1.0 N/mm^2	-2.4N/mm^2

(ii) Grade 30 concrete

	At working load	At transfer
Permissible conpressive stress in bending	0.33 x 30.3 = 9.9 N/mm^2	0.5 x (0.85x30.0) = 13.0 N/mm^2
Permissible tensile stress in bending	0.0 N/mm^2	-1.0 N/mm^2

(2) Reinforced Concrete

(i) Grade 30 concrete

		At working load
Permissible compressive stress in bending		10.0 N/mm^2
Permissible shear stress	beam	0.87 N/mm^2
	slab	Related to percentage of reinforcement

(ii) Grade 25 concrete

		At working load
Permissible compressive stress in bending		8.3 N/mm^2
Permissible shear stress	beam	0.80 N/mm^2
	slab	Related to percentage of reinforcement

(3) Reinforcement

			At working load
High-yield	Permissible tensile stress		230 N/mm^2
	Shear reinforcement		170 N/mm^2
Mild steel	Permissible tensile stress	40mm dia	140 N/mm^2
		40mm dia	125 N/mm^2

(4) Permissible Bearing Capacity

6.56 Refer to BS 2004 and "Substructure Design Guide" of Japan Road Association.

			Permissible bearing capacity
Motorway Junction Bridges: Abutments, piers and retaining walls except gravity type abutments			60 t/m^2
G.R.N.W. and St.L.Ri.Bridges: Abutment and piers			50 t/m^2
Rampway and over bridges	Rigid frame piers foundation		50 t/m^2
	Gravity-Type Abutments and retaining walls	Height 3.5m 3.0m	30 t/m^2
		Height 4.0	35 t/m^2
Pedestrian bridges			30 t/m^2

(5) Increase in Basic Permissible Stresses

Combination of forces	% (per cent)
dead load	0
dead load + HA loading	0
dead load + HA loading + wind load	15
dead load + wind load	15
dead load + HB loading	25
dead load + HB loading + wind load	30

3. Summary of Design Method

a. Superstructure

(1) PC Simple T-Girder Bridge

6.57 An analysis has been made according to the grillage analysis theory based on the displacement method, using an electronic computer.

(2) Curved 2-Span Continuous RC Voided Slab Bridge

6.58 An analysis of this bridge has been made as a grid girder structure, assuming the section between voids to be main girder line. When the curvature of the curved bridge is large, the grillage analysis does not accurately reflect the actual behavior. Therefore, this bridge is designed, applying slight compensation to the result of the grillage analysis by means of the sectional force ratio based on temperature study between the result by the grillage analysis and that of the finite element method for Radius=30m. For details, refer to "The study of curved voided slab bridge" in Appendix.

(3) Other RC Voided Slab Bridge

6.59 This has been analyzed as a grid girder structure, assuming the section between voids to be a main girder.

(4) Pedestrian Bridge (RC Box girder bridge)

6.60 This has been analyzed as simple or continuous beam.

(5) Side Span RC Solid Slab Bridge

6.61 This has been analyzed as a beam per unit width in the transverse direction.

b. Substructure and Retaining wall

6.62 Substructures are designed against the load transmitted from the superstructure dead weight of substructures, earth pressure, buoyancy and wind load affecting the substructure. The stability conditions of the substructure can be determined by checking the following three items:

(1) Bearing capacity of foundation ground.

(2) Eccentricity

(3) Safety against sliding

(1) Bearing Capacity of Foundation Ground

6.63 Based on the existing boring data and CP 2004 "Code of Practice for Foundations, we have determined the permissible bearing capacity described above. The design should be made so that the computed working stress will not exceed the permissible value.

(2) Eccentricity

6.64 The center of the working force at the bottom of footing should be located within the core, when HA loading is applied. The center of the working force should be within B/3 (B; foundation width) in any combination of loads.

(3) Safety against sliding

6.65 Safety is assessed by the safety factor given below:

$$F = \frac{Hu}{H}$$

Where Hu : The horizontal resistance of the foundation

H : The horizontal force acting on the foundation

F : Safety factor

6.66 The above safety factor should be 1.5 or more, when the HA loading is applied. It should not be below 1.2 in any combination of loads.

6.67 The horizontal resistance is assumed to be only the bottom friction resistance, ignoring the passive resistance earth pressure in front of foundation. The bottom friction coefficient should be 0.6 (0.45 only for the pedestrian bridge), taking the soil conditions into account.

c. Designing the PC T-Girder Section

(1) Check on Bending Moment

6.68 Strength of member shall be assessed by the Elastic Theory with the assumption that steel and concrete are elastic within the range of the permissible stress given in CP 115.

6.69 Check the ultimated strength in accordance with BE 2/73 TECHNICAL MEMORANDAM. Tensile stress of concrete shall not be permitted at working load [Dead load + HA Live load (HB)]. The ultimate moment of resistance shall be analysed in accordance with the assumption given in CP 110 article 4, 3, 4, 1.

(2) Check on Shear

6.70 The principal tensile stress shall be checked at working load and at ultimate load.

6.71 Shear reinforcement shall be provided in accordance with provisions of CP 115 where the principal tensile stress exceeds the permissible value.

The shear reinforcement provided shall be as follow:

$$Aw = \frac{S' \cdot a}{\delta s \cdot d}$$

Where $S' = S - Sp$

S : Shear force at ultimate load

$Sp = Pe \cdot \sin d$

a : The link spacing along the length of member

δsy : Characteristic strength of shear reinforcement

d : The effective depth

Aw : The required cross-sectional area of shear reinforcement

d. Designing the Reinforced Concrete Section

6.72 The section of reinforced concrete is calculated according to the elastic design method. Modular ration between reinforcement and concrete will be 15. The shear stress should be calculated as follows:

(1) Superstructure RC Voided Slab Bridge

6.73 In this case, the ultimate strength design method was used, according to CP 110.

$$v = \frac{V}{b \cdot d}$$

where v : The shear stress

V : The shear force under the ultimate load

b : The breadth of the section

d : The effective depth

The ultimate load was calculated, making reference to BE 2/73;

HA loading	1.5 x dead load + 2.5 x live load or 2 x (dead load + live load) whichever is the smaller
HB loading	1.5 x dead load + 2.0 x live load

Stirrups are calculated as follows:

$$\frac{Asv}{Sv} \geqq \frac{b \cdot (v - vc)}{0.87\, \gamma sy}$$

where Asv : The required cross-sectional area of the stirrups.

Sv : The spacing of stirrups along the member

b : The breadth of section

v : The shear stress under the ultimate load vc : Ultimate shear stress

γsy : The characteristic strength

(2) Superstructure RC Solid Slab Bridge

6.74 The following method of common practice was used for this calculation.

$$v = \frac{V}{b \cdot j \cdot d}$$

v : The shear stress under the working load

V : The shear force due to working load

b : Breadth of section

j·d : Lever arm

d : The effective depth

6.75 The permissible shear stress is in accordance with BE 1/73. Stirrups were calculated according to the following formula:

$$\frac{Asv}{Sv} \geqq \frac{b \times (v-va)}{fsa}$$

Asu : The required cross-sectional area of stirrups

Su : The spacing of stirrups along the member

b : Breadth of section

v : The shear stress under the working load

va : Permissible shear stress

fsa : Permissible shear reinforcement stress

(2) Substructure

6.76 The substructure is also calculated according to the method of common practice. The permissible shear stress for the wall and the footing is calculated as that of the slab, and that of the projected beam of column is calculated as that of the beam.

E. Plan of Furnishings

1. Parapets

6.77 Parapets are planned, using three types (P1, P2 and P4) according to Parapet Group Designation specified in the Technical Memorandum (bridge) No. BE 5. (Refer to following table.)

	Application	Containment for which Designed
P.1	Vehicle parapets for bridges carrying motorways, or roads to motorway standards. (Excluding culverts, cattle creeps and motorway bridges over railways)	1.5t vehicle at 113 Km/h and 20° angle of incidence
P.2	Vehicle pedestrian parapets for bridges carrying all purpose roads and for accomodation bridges (Excluding bridges over railways)	1.5t vehicle at 80 Km/h and 20° angle of incidence (See also clause 202 (a)(i))
P.4	Pedestrian parapets for use on footbridges	Horizontal loads of 700 N/m to 1400 N/m, acting at a height of 1.00m above the level of footway. The value taken to be at the discretion of the Engineer. (The maximum value will only occur in extreme cases of crowd loading) See also clause 202. b.ii.

2. Bearings

6.78 We studied the bearing structure in the planning stage, regarding three types; concrete hinges, rubber pads and ring shoes. The concrete hinge type was not taken into consideration, because of difficulty in structural analysis, construction accuracy and maintenance control. Ring shoe type bearings are used for the PC girders and the parts where the reaction exceeds 100 tons, while the rubber pad type bearings are used for other parts. The rubber bearings are movable on both ends against normal deformation such as temperature change, creep and shrinkage due to drying. The force in the longitudinal direction and/or the transverse direction is resisted by the friction force occurring to the contact surface between the bearings and concrete structure. The rubber bearings are designed according to the Manual for Highway Road Bearings of the Japan Road Association. The permissible compressive stress of rubber bearing should be 70 Kg/cm^2.

3. Expansion Joint

6.79 Of all the bridge structures, the expansion joint is most difficult device for maintenance control. Therefore, a careful study is required before selecting the expansion joint and installing it. For selecting this devise, we checked the following items.

a) Traveling features

b) Noise

c) Maintenance

d) Water-tightness

e) Installation and replacement

f) Shock absorption and vibration prevention

g) Economy

h) Durability

i) Past results of installation

6.80 After the above studies, we have adopted the transflex joint for the LINK ROAD BRIDGES and the MORTERWAY JUNCTION BRIDGES excluding the B-Rp. Br and G-Rp. Br. For other bridges, we have adopted the cut-off joints.

4. Drainage

6.81 When planning the drainage, we calculated the discharge for each bridge, and determined the spacing of catch basins along the longitudinal direction. The discharge was calculated according to the following formula.

$$q = \frac{1}{2.6 \times 10^3} \cdot C \cdot I \cdot W \quad (1/sec/m)$$

where q : Discharge at out-let per unit length

C : Run-off coefficient (= 0.9)

I : Rainfall intensity (= 95mm/hour)

W : Catchment width of road (m)

$$Ls = \frac{\gamma \cdot Q}{q}$$

where Q : Allowable discharge (m^3/sec) = A · v

A : Catchment area of catch basin

v : Mean velocity of flow (m/sec)

$$v = \frac{1}{n} R^{2/3} \cdot i^{1/2}$$

R : Hydraulic mean depth $\left(= \frac{A'}{P}\right)$

A': Cross sectional area of stream

P : Wetted perimeter

n : Coefficient of roughness (= 0.013)

i : Surface slope

γ : Drop ratio (= 0.25 - 0.6)

Ls : Maximum spacing of catch basin (m)

5. Attached Gadgets or Facilities

6.82 The existing COROMANDEL Ov.Br. carries the sewerage pipe supported by both abutments under the girders. This pipe will be carried between girders and supported from the bottom of flanges with the adequate fittings detachable when necessary to exchange the above pipes.

Any other facilities known and/or unknown shall be adequately investigated by the Contractor in accordance with the contract specification.

Usual facilities will be under the footpath.

APPENDIX: THE STUDY OF CURVED VOIDED SLAB BRIDGES

1. Preface

Generally speaking, it is rather difficult to design curved bridges with large curvatures, since it shows action as a slab in dynamic calculation, and in cases of having special curvature and/or skew, another study as a slab is inevitably required.

Herein is a study of the 2-span continuous R.C. hollow slab bridge with curvature (R = 30m) in G - Ramp as a typical one. The result of this study may be applicable to the bridge with curvature (R = 60m) as well. The loading shall be studied as per BS - 153 Type - HA loading.

Meanwhile, in actual design calculation, the hollow slabs shall be replaced with grillage girders.

Fig. A-1 Flow Chart of the Study

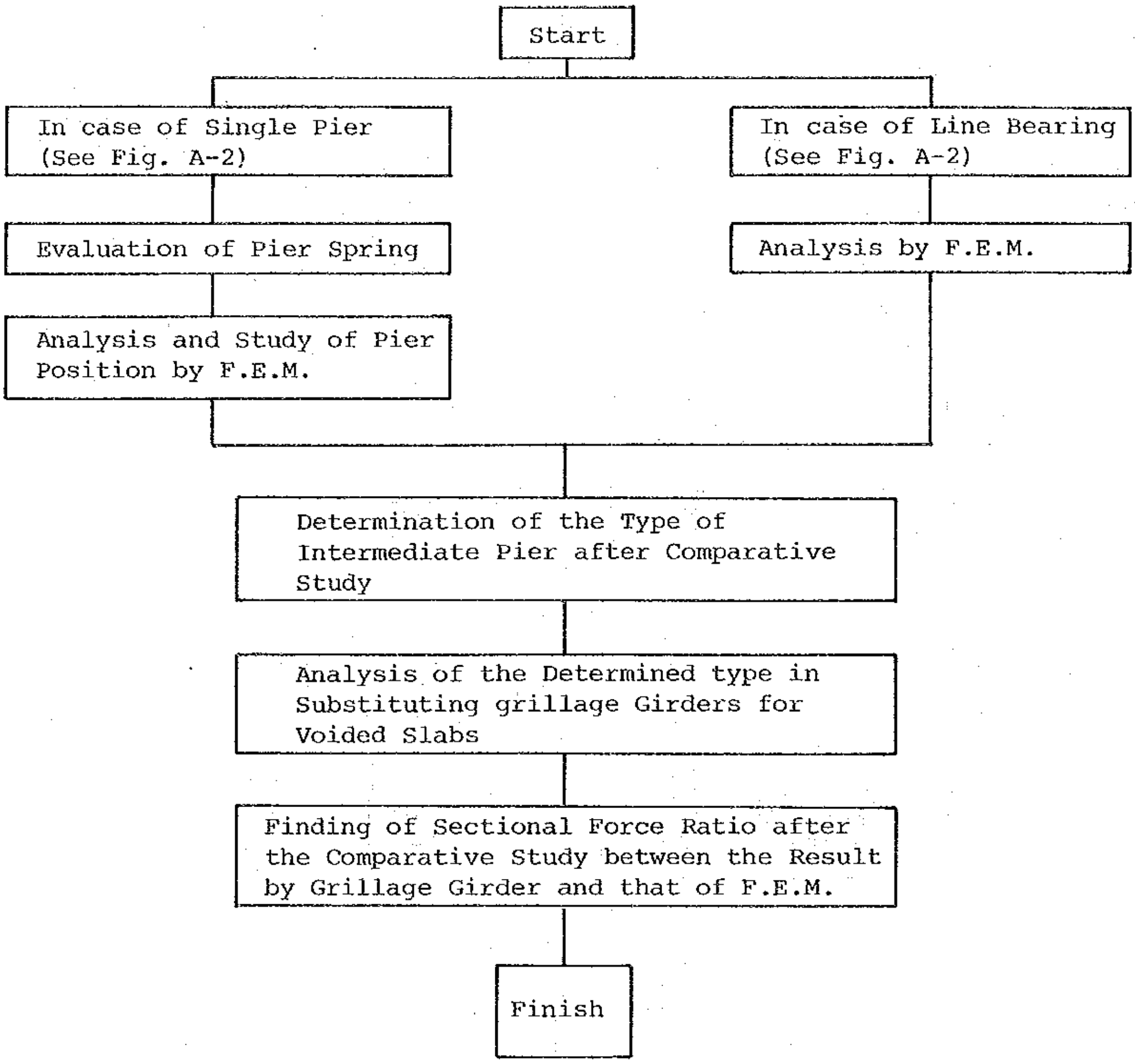
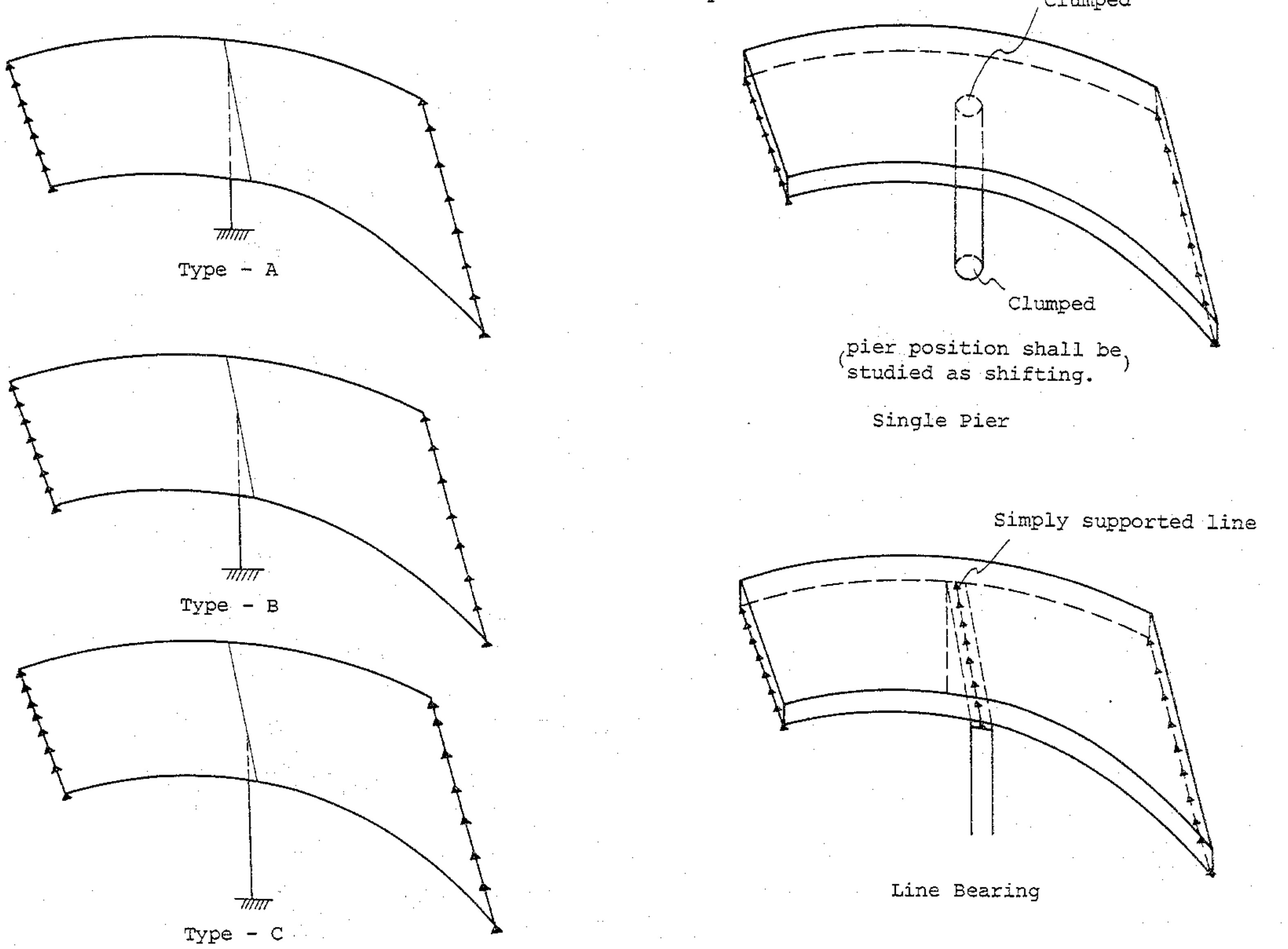


Fig. A-2 Case of Analysis



2. Comparative Result of Types of Intermediate Pier

The maximum values of principal bending moment and the maximum reaction force of intermediate pier and abutment are also shown in Table A-1.

Table A-1

For Type- A, B, C, refer to Fig A-2.

			Type-A	Type-B	Type-C
Maximum reaction force	Int. Pier		426.1 ton	407.8 ton	466.3 ton
	Abut.	positive	35.6 "	45.7 "	88.4 "
		negative	15.1 "	0.0	2.3 "
Maximum principal bending moment		Major	199.5 t.m/m	160.5 t.m/m	186.2 t.m/m
		Minor	262.0 "	187.6 "	204.4 "

For the comparison of each principal stress, Type - B of Single Pier and Line Bearing may be drawn up in a taole as shown below.

Table A-2

	Single Pier	Line Bearing
Streams of Stresses	.They are very complicated near Pier.	.They flow smoothly along longitudinal direction of the bridge as a whole.
Dimension of Bending Moment	Major Max. = 160.5 t.m./m Minor Max. = 187.6 t.m./m	Major Max. = 35.4 t.m./m Minor Max. = 65.7 t.m./m
Distribution of stresses	It is higher than others near pier.	It becomes higher near intermediate pier, but it is distributed uniformly.
Arrangement of reinforcing bars	The direction of stresses is complicated near the pier and the stresses are high. Consequently, the arrangement of bars may become very complicated. The arrangement may become more difficult and extremely complicated if considering punching shear force of slab due to pier.	Even providing reinforcement near the intermediate pier, the arrangement may bot become very complicated.

3. Conclusion

From the above results, Type "B" is found to be most advantageous for follow slabs in case of single pier. Ad the following conclusion may be also obtained.

Taking the appearance into consideration, single pier seems to be better. And Considering that piers locating before and behind the proposed bridge are designed as Single Pier, Single Piers would be most suitable for this bridge in the aspect of uniformity.

However, (as is found in table A-2.) Single Pier is disadvantageous in view of stresses, especially the arrangement of bars near the pier would become very difficult in actual construction.

Terefore, Line Bearing shall be taken for intermediate piers of the proposed bridge.

4. Comparative Study between the Result by Grillage Analysis and that of F. E. M.

These results are shown in Table A-3.

In the actual design, the design stress can be given as "r" time the stress calculated by Grillage girder.

Table A-3

	kind of stress	place		r
main girder	bending moment			1.0
	shear force	outside girder	near abut.	1.3
			near pier	1.0
		inside girder	near abut.	1.0
			near pier	1.3
	reaction	at pier		1.0
		at abut.		3.0
cross beam	bendingmoment	on pier		1.0
		on abut.		1.0
		between A-1 and P-1		3.5
		between P-1 and A-2		2.0

Nore ; design stress in main girder = r , Sm.

design stress in cross beam = r , Sc.

But, at cross beam on pier*

design stress in cross beam = r', Sm.

Where,

Sm ; stress in main girder calculated by Grillage girder

Sc ; stress in cross beam calculated by Grillage girder

APPENDICES

Notes of the meeting held on Tuesday, the 30th January 1979 at 3.30 p.m in the office of the Permanent Secretary, Ministry of Works.

Present:

Mr D. Ramyead, Permanent Secretary (Chairman)
Mr C.H. Mangua of the African Development Bank
Mr Hirokazu Ito, Leader of) the Japanese Survey Team
Mr Ko Kuwata, Member) " " " "
Mr Yutaka Iida, Supervisor) " " " "
Mr Hishashi Fujishita, Coordinator) " " " "
Mr E. Norton, Principal Assistant Secretary) Ministry of
Mr I. Limbada, Chief Engineer) Works
Mr D. Rajahgopal, Principal Engineer)

Mr G. Dulloo, Administrative Officer) Ministry of
Mr R. Duverge, Deputy Surveyor) Housing, Lands & Town & Country Planning

Mrs A. Bellepeau, Administrative Officer (Secretary)

1. The Chairman welcomed the persons present and informed them that Mr Mangua was on mission in Mauritius to review the progress made in connection with the various projects financed by the African Development Bank.

2. The Chairman said that as the detailed engineering studies of the Beau Bassin to Port Louis Link Road were being financed by the Japanese Government through the African Development Bank; opportunity was being taken to apprise Mr Mangua of the latest developments in connection with that project.

3. Mr Limbada said that the detailed survey had started and that a Japanese Survey Team was in Mauritius for that purpose. The Japanese proposed to undertake cross sections, every 100 metres, * along the proposed alignment of the link road and it was expected that they would have to enter on private land to carry out that exercise.

4. Mr Limbada added that crops could be damaged in that process and claims for compensation received. He therefore, asked the advice of the officers of the Ministry of Housing on the best way to tackle the problem.

5. Mr Duverge said that he could foresee no problem as far as lands belonging to Medine S.E and to the other big land owners were concerned. He suggested that the Chief Engineer contact the managers of those estates and ask for their permission to enter the lands, it being made clear that any reasonable claim for damages caused to the crops would be settled by the Government.

6. Mr Duverge agreed to Mr Limbada's suggestion that Mr Bahadoor, the surveyor attached to the Ministry of Works, be requested to likewise contact the small land owners. Should any difficulty be experienced in that connexion, the Ministry of Housing would under the Lands Ordinance - issue a press notice informing those owners that it was proposed to carry out a survey. It will be possible for the surveyors to enter the private lands fifteen days after the issue of such notice without having to obtain the permission of the owners.

/7...

* extending 50 metres on each side of centre line

7. Mr Limbada then invited the attention of the officers of the Ministry of Housing to the need to start with the procedure for the acquisition of land for the construction of the link road as early as possible.

8. According to Mr Limbada almost 40% of the land required in that connection was privately owned land. Mr Duverge said that it was too early to say whether the survey work would be undertaken by the officers of his Ministry or by private surveyors.

9. The Chairman said that, in about three months time, the actual extent of land which would be required for the construction of the road would be known. On the assumption that the project was approved, land acquisition procedure should start simultaneously with the detailed engineering studies.

10. The Chairman thanked the officers of the Ministry of Housing for their assistance and they left the meeting.

11. Mr Limbada said that the first part of the survey exercise (that is the aerial survey) had already been done and that the Japanese team was presently engaged in the ground survey. The land survey was expected to be completed in two or three months.

12. The detailed engineering design study was expected to be completed by the end of December 1979.

13. If the project is approved, the prospective contractors would be invited in November 1979 - to apply for prequalification. When the tender documents would be ready - by March or April 1980 - the formal tenders would be invited. It was expected that construction works would start by October 1980 and that the construction works would take about 24 months.

14. It was suggested that there should be two separate contracts for the project:

one contract for the structures such as the bridges and interchanges; and
the other one would be for the construction of the road itself.

15. That suggestion was retained and it was noted that nothing would prevent one contractor from applying for (and obtaining) the two different contracts, if he proved that he had sufficient executive capacity.

16. Mr Limbada then referred to the evaluation of the bids which would be received for the construction of the link road.

17. The Chief Engineer said that he had understood from the Japanese that they would not be involved in that exercise. He suggested that a request should be made to the Japan International Cooperation for the services of its experts to be made available to assist in the evaluation of the bids.

18. Mr Mangua suggested that the Japanese Government be approached in that connection. He said that the African Development Bank would support such a request.

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19. The question of the supervision of the construction works was also discussed. Mr Limbada was of the opinion that the supervision should best be done by the organisation to whom the design of the road had been entrusted - that is the Japan International Cooperation Agency.

20. Mr Mangua shared that opinion and said that, if the Japanese Government was unable to supervise the construction works under their technical assistance scheme, it would perhaps be possible for the J.I.C.A. to act as an independent body for the supervision contract even against payment of a fee.

21. It was therefore agreed that a formal approach would be made to the Japanese Government for the s ervices of the Japanese experts either in the form of a grant or against payment.

22. Mr Mangua said that the African Development Bank would be prepared to pay for the services of the Japanese Agency.

23. Mr Mangua noted that the estimated cost of constructing the link road was Rs 94.5 million and prefinancing would be required by mid- 1980.

Ministry of Works
2nd February, 1979

SS

CONFIRMATIONS

1. At the meeting with Mr. I.A.Limbada, Chief Engineer and Mr. D. Rajah Gopal, the coordinating engineer on the Inception Report and others at Ministry of Works Office on January 22 to February,1 1979, the following were discussed and defined.

1.1. Regarding the paragraph III-2, the development plan for Pointe aux Sables area is under preparation by Australian Consultants and the feasibility study on Port Louis Ring Road by French Consultant ~~respectively~~. The draft reports for both projects will not be available before September 1979, and therefore both junctions shall be planned on the basis of the feasibility study provided by the Japanese missions.

1.2. The complaint of the inhabitants adjoining the Hindu Temple between Barkly Junction and St. Martin Junction as to the proximity of the proposed link road shall be dealt with by the Mauritian Authorities.

1.3. All requisite actions for acquiring the right of way and indemnifications for evacuation and expropriation shall be carried out according to the land utilization plans of the Government of Mauritius.

1.4. Regarding the paragraph III-3-10, designs for bridges and road crossing structures B.S. 153, Type HA loading shall be used for live load and checked for 30 units (120 tons) of HB loading.

1.5. Regarding para III-3-14, tender documents shall be prepared and presented in the same form as for previous highway projects undertaken by the Government of Mauritius.

1.6. Regarding Para 3 on the requisition and questionnaire, working drawings shall be made on A1 size paper. For tendering purposes A3 size reproductions shall be used.

1.7. Unit prices for each type of land for land rights will be estimated by officials of Ministry of Housing, Lands, Town & Country Planning according to the land utilisation plans.

1.8. Data for construction materials available in the area, salaries and wages of local employees, Taxes, labour Laws, Laws and Regulations for the use of explosives will be prepared by officials of the Ministry of Works.

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1.9. The following scales shall be used in the preparation of drawings:-

Longitudinal profile:	Horizontal scale 1: 1000	
	Vertical scale	1: 200(instead of 1:100)
Cross-Sections	: 1:200 (instead of 1:100)	

1.10 All dimensions shall be in metric units.

1.11 The right-of-way shall include a width of 4 metres from the outer edge of structures.

No building construction shall be allowed within a distance of 15 metres from the edge of the carriageway.

1.12 The length of the climbing lane shall be decided on the basis of the capacity of heavy vehicles, during the detailed design stage.

1.13 Splays as wide as possible shall be provided at Beau Bassin Roundabout. The planning of the roundabout shall avoid the Bank building otherwise heavy compensation may have to be paid.

1.14 The cost for relocating existing water pipes, specially for the site between Beau Bassin and Barkly junction shall be negotiated with the authority concerned by officials of Ministry of Works.

1.15 The cost for relocating existing unnoticeable underground utilities shall be excluded from the cost estimates for the road construction project.

1.16 The location of service roads as discussed when examining the alignment plan is accepted, the width of the service road shall be 2.5 metres with proper passing bays.

1.17 The width of over bridge for pedestrians at Hindu Temple shall be 2.4 metres.

1.18 1.2 metre for pedestrians in the width of crossing box culverts shall be secured.

1.19 Guardrails, but not guardcables, shall be provided on embankments higher than 3 metres. The type of guardrail shall be optional.

1.20 The different classes of concrete used in the works shall be defined in the Technical Specifications.

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1.21 The proposed alignment of the road, the general layout of the interchange at the Motorway Junction and the grade seperated Rotary Intersection at Coromandel are accepted.

Near St. Louis Power Station, a vehicular overbridge shall be provided if possible as the nearby village is cut into 2 parts by the proposed link road.

1.22 For the purpose of connecting the road with the proposed Port Louis Ring Road, the end of the road shall be extended about 50 metres in length beyond the crossing with Moka road.

1.23 For getting into private land by the crews of survey and boring teams, official notices shall be served in advance.

1.24 The size of iron peg for surveying of alignment shall be 16 mm in diameter and 30 cm to 60 cm in length, the size of concrete posts shall be 12 cm square with a length of 1 metre.

1.25 A Liaison Officer of the government for the construction project shall be appointed in due course.

1.26 It will take about two months for the evaluation of tenders and two months for the mobilization of the Contractor.

I. A. LIMBADA Chief Engineer Ministry of Works Mauritius.	H. ITO Team Leader The Beau Bassin-Port Louis Link Road Project

THE BEAU BASSIN-PORT LOUIS LINK ROAD

MINUTES OF PROCEEDINGS

~~(Bridge Team)~~

From 17th Sept., to 4th Oct., 1979

8th OCTOBER, 1979

8th October, 1979.

C O N F I R M A T I O N S

At the meeting with Mr. I. A. Limbada, Chief Engineer, and Mr. Ramjan, the Coordinating Engineer, from 17th Sept., to 4th October, 1979, at the Ministry of Works Office in Phoenix, about technical proposals and other matters, the following points were discussed and defined.

I. Roads and Interchanges

1. Vertical Alignment is approved.
2. Plan is approved.
3. Cross Section is approved.
   Side slope in the cut section is made with 1 in 1 in spite of soil condition because of the balance of cut and fill.
4. It is requested that the vertical clearance be changed from 5.50m to 5.10m unless it causes much revision works.
5. It is requested that the ramp from the trunk road climbing up to A_1 road at 'S' Hill shall have two lanes if possible.
6. The temporary road as a detour during the A_1 bridge construction at 'S' Hill may have three lanes if possible.
7. It is not necessary to connect the ramps of the interchange with private roads.
8. Drainage and Irrigation channel
   a) Design criteria is approved.
   b) Diversion of irrigation channels and drainage system are approved.
   c) Catch pits shall be provided at the junctions of ditches and irrigation channels.
9. Culvert
   a) Design criteria of Box Culverts and Pipe Culverts are approved.
      Surcharge for Box Culvert shall be 37.5 units of HB Loading.
      HB Loading

45 units	20 KN/M^2	surcharge
25 units	10 KN/M^2	
therefore,		
37.5 units	16.25 KN/M^2	

10. Lighting at the interchange

Design of the lighting shall be of grade D (Lowest Category

/2......

Grade D: Lights are provided only near noses.

Mercury-vapour lamps shall be installed as source of lighting.

Light dimmer: Lighting shall be decreased by half to save electricity as less traffic is expected at night.

Lighting system:

In general, dispersion lighting system by taper pole street light is taken into account.

Power source:

Distribution voltage,

230 V(± 6%) single-phase

400 V(± 6%) 3 -phase

Incoming high voltage,

6600 V or 22000 V or 66000 V

Frequency,

50 HZ

Power source service:

Point of power source service is preferably set new interchange.

Power distribution to the service point shall be done by the Government.

11. Miscellaneous

a) Existing 'S' Hill junction

The improvement of the junction so as to simplify the design and construction of the A_1 bridge is approved.

b) An overcrossing bridge near St. Louis power station is changed to an undercrossing box culvert.

c) Stage construction of motorway junction is basically approved. Namely, the through road connecting with the Port Louis Ring Road shall be constructed at the second stage. Accordingly, the construction cost shall be separated into the first stage and the second stage.

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II. Bridges

The following items were discussed by the Bridge Team and the Chief Engineer during meetings.

1. Bridge Team submitted and explained:
   1) General Note (for confirmation).
   2) General view of all bridges of Project and some alternative ideas.
   3) Samples of Detailed Design Calculations for Post Tensioned Girder, Abutment, Pier and Drawings related to these calculations.
   4) Technical supporting Report of the Study upon the Existing Substructures of C.R.N.W. (Summary)
   5) Technical Supporting Report upon the Analysis of Reinforced Concrete Voided Slab Bridge especially located on horizontal curves.
   6) Bridge furnishings.

2. Items 1,2,3 and 6 will be examined in greater detail in the following paragraphs.. Agreement has been reached after thorough discussions of all aspects of the bridge structure with the Chief Engineer to whom the Bridge Team is grateful for precious guidance and suggestions. Every comment and suggestion made by the Chief Engineer will be taken into consideration by the Bridge Team as far as possible.

3. Items 4 and 5 were fully approved by the Chief Engineer and detailed design and shall proceed on the lines of the discussions and comments made by him.

4. The General Note will be attached to this minutes as confirmation of the fundamental concept of Design Specification and will be included as basic information to the set of detailed drawings.

5. The Memorandum which includes the result of discussions and agreement reached on the design concepts of the bridge structures will also be attached to these minutes. These design concepts will be used in the detailed calculations and the preparation of working drawings.

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GENERAL NOTE

1. DIMENSIONS

All dimensions are measured horizontally and vertically unless otherwise noted.
All dimensions and joint openings in the structure are measured at normal temperature of 25^{o} C.
The temperature range for movement is:
Concrete temperature rise = 20^{o} C
Concrete temperature fall = 12^{o} C

2. DESIGN SPECIFICATIONS

The structure, including all concrete superstructure, pier columns and footings are designed in accordance with British Standard Specifications, and/or Codes of Practice.

B.S. 153	Part 3A	1972	(Loads)
B.S 5400	Part 7	1978	(Materials)
C.P. 114	Part 2	1969	(Reinforced Concrete)
C.P. 115	Part 2	1969	(Prestressed Concrete)
C.P. 116	Part 2	1969	(Precast Concrete)
C.P. 110	Part 1	1972	(Concrete)

3. DESIGN LOADING

The design load shall be in accordance with B.S. 153

1) Dead Load

Reinforced concrete (Nominal)	23.6 KN/M^3
Plain concrete (Nominal)	22.6 KN/M^3
Asphalt	22.6 KN/M^3
Structural Steel	76.9 KN/M^3
Soil	18.6 KN/M^3
Wood	7.9 KN/M^3

2) Live Load

Bridge Loading

Type HA Loading
Applies to all structure

Type HB Loading 37.5 units.
Applies to Link Road and Pailles, 'S' Hill overbridges

Footway Loading
5 KN/M^2

/5.....

3) Impact effect

All live loads include impact

4) Longitudinal Force

According to B.S. 153

5) Wind Pressure Effect

Refer to B.S. 153, however mean hourly wind velocity shall be 85 miles/hour (38 metres/sec)

6) Temperature Difference

10^{0} C Refer to B.S. 5400

7) Vehicle collision with parapet (Guardrail)
According to NAARSA

4. PERMISSIBLE STRESS

Refer to B.E. 1/73 and/or BE. 2/73 (M.O.T. Memorandum)

5. PRESTRESSING STEEL

Prestressing steel shall conform to the requirement of B.S. 3617 Seven Wire Strand and B.S. 2691 Steel Wire.

6. REINFORCING BARS

Reinforcing bars shall conform to the requirement of B.S. 4449 high yield deformed bars for superstructures and for substructures.

Bar hooks shall be in accordance with B.S. 4466.
Laps in bars shall be in accordance with C.P. 110.
Spacing of bars shown on the drawing shall be a maximum.

7. REINFORCED CONCRETE

Reinforced concrete shall conform to the requirement of B.S. 5400.
Grade 30 concrete for superstructure.
Grade 25 concrete for substructure.

8. PRESTRESSED CONCRETE

Prestressed concrete shall conform to the requirement of B.S. 5400.
Grade 40 concrete (Minimum) for precast.
Grade 30 concrete (Minimum) for in situ concrete

9. MASS CONCRETE AND BLINDING CONCRETE

Mass concrete and blinding concrete shall conform to the requirement of B.S. 5400 grade 15 concrete, where necessary.

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10. COVER

Concrete cover to reinforcement shall conform to the requirement of C.P. 110 unless otherwise noted.

MEMORANDUM

A) Design Conditions for Loading

A-1) Live Load

- Numbers of Notional Lanes for the HA and/or HB Loading shall be decided according to the carriageway width including hard shoulders and/or verges.
- According to the Chief Engineer's requirement, where the HB vehicle straddles two lanes, the remainder of the loaded length of the straddled lanes shall not carry any other load; all other lanes, if any, shall be loaded with one-third HA Loading.

  This requirement makes reference to B.S. 5400, 6.4.2.2. articles.
- The footway shall be designed to support a wheel load of 40 KN placed in any position.

A-2) Wind Load

The maximum mean hourly wind speed shall be taken as 30 metres per second. This speed has been obtained from the records of the Meteorological Department of Mauritius. As B.S. 153 gives no detailed guidance on the application of wind loading reference shall be made to B.S. 5400 Part 2.

Bridges of G.R.N.W. shall be carefully studied with the funnelling factor S1 (applied figures = 1.1) based upon B.S. 5400, article 5.3, especially for Vc and/or Vc^1.

A-3) Collision with Parapet or Handrail

This item conforms to Australian Specifications of Bridge Design for the time being. When bridge team will get the B.E. 5 in hand before suitable time limit, the B.E. 5 will be referred to.

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B) Permissible Stresses

B.E. 1/73 or B.E. 2/73 is preferable, while the concerned articles of C.P. 110 are also available.

C) Material

The codes and/or specifications described in the General Note are suitable. The diameter of bars made locally is from 10 to 32 mm. (8mm and 40mm bars are usually imported).

D) Design Detail for cover, laps, stirrup, chamfer conforms to C.P. 110.

E) Structure Skeletons

E-1) The overbridge near the Power Station will be changed to the Box Culvert Type, as agreed from the discussion between the Chief Engineer and Japan Design Team. The culvert will be located near St. Louis Power Station.

E-2) According to the recommended alternative of Japan Design Team, 'S' Hill bridge will be changed to the Non Composite Post-Tensioned T-Girder type with a small skew to the A_1 road alignment, which will be suitably rearranged to a certain degree by the Contractor, who will be informed in the Special Specifications. Rough measurement of the existing pavement level was carried out on 22nd September, and its result will be used in the future design of cross fall for the said bridge.

E-3) Water pipe Bridge is to be designed as Prestressed Concrete Girder type which is selected among the alternatives proposed by bridge team.

E-4) The overbridge located near St. 12 the superstructure of water channel will be separated from the main bridge structure.

F) Special Items studied or analysed

F-1) Re-use of existing substructures at G.R.N.W.-St. Louis bridges.

- The investigations carried out were fully approved and the fundamental ideas of re-capping of those substructures are also approved.

- Protection for scouring at S.H.H.W. was discussed as to the method, and the areas of protection of each pier (P2-P5) are settled according to the water depth survey (6 metre range). The protection method is to place the boulders with the plain concrete of B.S. grade 15.

F-2) Curved R.C. Voided Slab Bridges

- The interim study report was submitted, and it is approved by the Chief Engineer that the analysis of sectional forces of the principal members is to be made by computer programme analysis for grillage girders.

F-3) R.C. Voided Slab Bridges

These bridges with side spans are to be designed as the continuous type to reduce their main girders' depth, if possible.

G) Detailed Design

G-1) Slab will be calculated by the method of Westorguard.

G-2) Passive pressure to the front of abutment will be neglected while horizontal effect by temperature and/or shrinkage shall be considered.

G-3) Surcharge of abutment backward conforms to B.S.5400.

G-4) Abutment type will be selected in accordance with the total height of abutment, either cantilever up to 9 metres or counterfort more than 9 metres, according to the Chief Engineer's suggestion and Mr. Kobudhi's cost-estimate study.

G-5) Top flange of T-girder may be a little inclined to match the degree of crossfall.

G-6) Mass concrete shall be of Grade 15, when necessary.

G-7) Location of cross beams (diaphragms) are accepted as they are designed in proposed drawings.

G-8) It was accepted for cover to be of 100 mm from the surface to the centre of main bars in the sample drawing of substructures.

G-9) Thickness of parapet wall may be enough to be from 300 mm, the Chief Engineer commented.

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G-10) Thickness of abutment wall itself may be enough up to 1.0 metre, also the Chief Engineer suggested.

G-11) The side span shall be provided with a fascia so as to match the total depth of the girders in the main spans. As to this item, the proposed idea of bridge team is in conformity with the Chief Engineer's suggestion.

G-12) Screeding concrete volume will be kept to a minimum as to lessen the dead load on the bridge deck(See G-5).

G-13) Slope protection of abutment-front will be suitably prepared with the means of, for example, precast concrete elements or stone-masonry, where necessary.

G-14) Approach slab will be set under the pavement at the back of the abutment parapet walls of main bridges of Link Road.

G-15) Width of coping will be 300 mm in pedestrian bridges.

G-16) For the Hindu-Temple pedestrian bridge, special provision will be made in the Special Conditions to contract the contractor to reset or demolish the existing gates according to the requirements of the relevant authority.

G-17) The bridge said in the last item includes foot steps approaching to the hillside.

G-18) Both double bars and bundled bars are acceptable, respectively.

G-19) The space under the footpaths shall be filled with sand. The bottom shall be waterproofed and provision made for disposal of water seeping inside. The top shall be covered with precast slab approximately 50 mm thick. This idea, recommended by the Chief Engineer, will be not only economical but also useful for accomodating services to be carried on the Bridges.

H) Bridge Furnishings

H-1) Handrails

Typical types of handrail are referred to in Concrete Bridge Designer's Manual, and made of galvanised steel.

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Horizontal type will be used for all highway bridges because it is more suitable to resist collision from vehicles.

Vertical type will be used only for pedestrian bridges.

The minimum number of different type will be used to facilitate repairs and to enable stock of spares to be kept as low as possible.

H-2) Bearings

The Chief Engineer suggested that such concrete bearings as Freyssynet bearing are the most economical and when properly designed and built require very little maintenance, although they are not as efficient as rubber bearings.

The Chief Engineer added that rubber bearings are also suitable. Therefore bridge team will study carefully the technical documents given by the Chief Engineer, and if possible concrete bearings will be installed after due consideration and research.

The Chief Engineer requested the end details of girder to be carefully designed to prevent edge cracking.

H-3) Drainage

Installation of drain boxes is a little difficult to be set in the slabs or the top flange of some bridges. Bridge Team will look into better ways of installation both in the longitudinal and transverse direction after returning to Japan, where this item shall be finally fixed during the visit of the Chief Engineer. Slope of bearings bed will be considered with respect to this item.

H-4) Expansion Joint

The use of "Transflex" type expansion joints are approved. The Bridge Team will study the possibility of using more economical type of joints for small bridges.

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I) Attached Gadgets or Facilities

I-1) Some of the Facilities or Gadgets on and/or under bridges are described here and attached to bridges by some means suitable.

G.R.N.W. (Existing) Telephone Cable
St. Louis(
Pailles (") Water pipe,
Coromandel(") Sewerage pipe, around Ø 380 mm (internal Ø 15")
(5° Hill (") Telephone Cable, Ø 80 mm

I-2) The existing Coromandel Bridge carries the sewerage pipe supported by both abutments under the girders. This pipe will be carried between girders and supported by the galvanised fixings, which are suspended from the bottom of flanges with the adequate fittings detachable when necessary to exchange the above pipes. The future vertical alignment of those pipes is already planned by Japan team.

I-3) Any other facilities known and/or unknown shall be adequately investigated by the Contractor in accordance with the contract specifications that will be prepared by design team.

I-4) Usual facilities will be under the footpath as described before in the article of this memorandum.

J) Others

J-1) The Chief Engineer suggested that if possible the end cross beams of T-Girder will be designed to have a little lower depth so that jacks will be put in between the bottom of those beams and pier top for the exchange of bearings when necessary in future.

J-2) Another suggestion of the Chief Engineer was that if possible cross beams will be jointed by reinforcement instead of P.C. tendons because of easier construction.

/12......

Bridge Team replied it seemed to be difficult, however would try to check the possibilities.

3-3) The Chief Engineer commented the difficulty of casting the prestressed beam because sufficient space to insert vibrator is not available. Bridge Team will look into this matter and suggest ways of compacting the concrete.

In Japan it seems to us, bridge team, that the use of external vibrator will be effective with severe quality control.

Bridge Team will take due consideration into the preparation of specifications for the Contractor.

III. Tender Documents, Construction Planning and Cost Estimate

The following are findings and recommendations obtained through tasks as assigned for Preparation of Tender Documents, Construction Planning and Cost Estimates.

1. The constitution of Tender Documents will be on the basis of "Notes on Documents for Civil Engineering Contracts" by International Federation of Consulting Engineers (FIDIC) issued on March, 1977, i.e.;

a) Instructions to Tenderers
b) Conditions of Contract
c) Drawings
d) Specifications
e) Bill of Quantities and/or Schedule of Rates
f) Information Data

Part I and Part II of FIDIC Conditions of Contract will control the stipulation of General Condition of the Project.

2. The Tender documents shall generally be similar to those of the two previous projects, i.e.

a) Port Louis Northern Entrance Road
- Sir Alexander Gibb & Partners (Mauritius), November 1976

b) The Relief Road to the North
- BCEOM (France), July 1976

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The latter project is partly financed by the EDF and is scheduled for tendering in December of this year.

Its Special Conditions of Contract supplements the clauses of General Conditions of the EDF, and furthermore, presents to tenderers very clear-cut instructions for bidding conditions. So, most of the provisions will be applicable to the Beau Bassin-Port Louis Link Road Project.

3. As the copyright of the documents referred to above is owned by the Government of Mauritius, the contents will be used, if necessary with whatever modification or amendments considered necessary for the Beau Bassin-Port Louis Link Road Project.

4. The background information used in the preparation of estimates for the construction cost together with a priced Bill of Quantities will be summarised in a separate confidential volume.

5. From information obtained during an interview with a local contractor the composition of unit prices for item of the Bill of Quantities is generally shown as follows;

a) Element of Direct Cost (labour, equipment and material cost)
b) Element of overheads and Profit (around 20% of Direct Cost sum)
c) Element to be included in General Items (Supervision, Preliminaries and Expenditures for small tools and appliances).

So, in our case, an example of Cost Element Analysis Sheet for the items with Bill of Quantities might be composed as shown below, with due regards to the division of both external and internal currency components, and the influence of inflation. However, further consideration, if any, shall be taken into account to ensure accuracy and simplicity.

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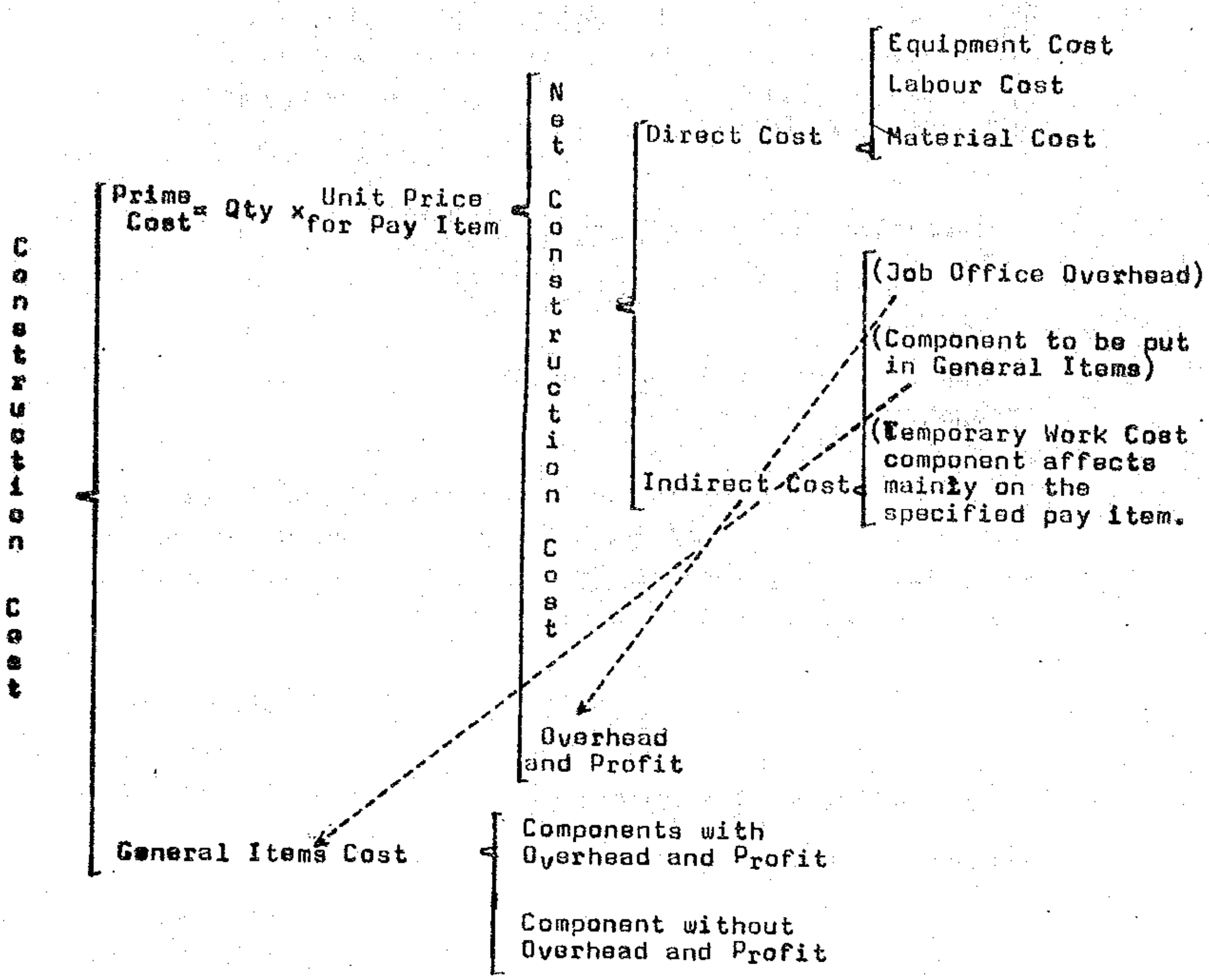


6. The Bill of Quantities will be prepared on the basis of "Standard Method of Measurement of Civil Engineering Quantities, 1976" published by the Institution of Civil Engineers (U.K.).

7. There is no official guide or code to contractors as to the depreciation cost system of equipment, so local practice in this respect will be assumed.

8. The current unit prices of main construction materials/pay items and hourly cost of labour/equipment have been obtained through interviews with local suppliers/contractors and discussions with Quantity Surveyors. We are confident that we have obtained realistic current prices. As for

/15.....

Construction costs of the Relief Road to the North, a comparison between the adjusted estimated cost made in September, 1979, by the Quantity Surveyor shows an abrupt inflation tendency;

$$\text{Inflation factor} = \sqrt[3]{\frac{74.9 \text{ million Rs.}}{51.7 \text{ million Rs.}}} \text{ for 3 years}$$

$$= 1.125/\text{year}$$

9. The cost estimate will be based on the price levels of September, 1979.

10. An appropriate assumption for the price/cost of subsidiary construction materials/equipment will be made by comparing the price/cost of the main items of 'construction' in Japan and other countries with those of Mauritius.

I. A. LIMBADA
Chief Engineer
Ministry of Works
MAURITIUS

K. KUWATA
Team Leader
The Beau Bassin-Port Louis
Link Road Project

NOTES OF MEETING

Date: 3, 4 December, 1979

Place: Conference Room, JICA, Tokyo

Topic: Beau Bassin - Port Louis Link Road Project

Attendance:

Mauritius Government

1.	Mr. I. A. Limbada	Chief Engineer, Ministry of Works

JICA Design Team

1.	Mr. K. Chiba	Chairman of Supervisory Committee
2.	Mr. H. Sanematsu	Member of Supervisory Committee
3.	Mr. Y. Iida	"
4.	Mr. Y. Yahiro	"
5.	Mr. K. Kuwata	Member of Design Team
6.	Mr. M. Tsukada	"
7.	Mr. I. Onishi	"
8.	Mr. I. Horiuch	"
9.	Mr. N. Kobuchi	"
10.	Mr. M. Yoshida	"
11.	Mr. Y. Higaki	"
12.	Mr. H. Fujishita	Coordinator, JICA

I. Roads and Interchanges

1. New vertical alignments as revised in accordance with the change of vertical clearance referred to the confirmation dated 8th October, 1979 are approved.

2. Standard Cross Section

In stead of the concrete curb as for a guide strip between the carriageway and the hard shoulder, white painted line will be adopted.

And concrete curb between the carriageway and the median strip will be constructed with precast concrete curb, 60 cm or 90 cm long.

Because of the easiness of resurfacing and economy, above changes were decided.

3. Stage construction of Motorway Junction is agreed on by each other as follows.

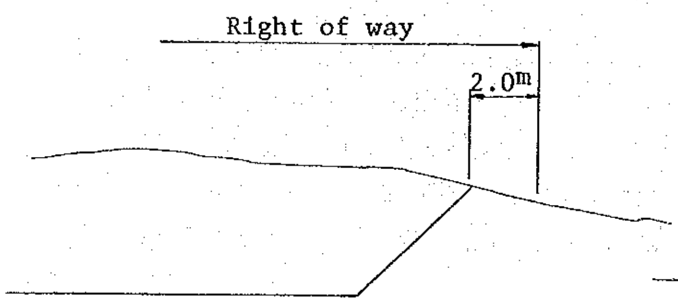
First Stage: (a) Construction of Roundabout

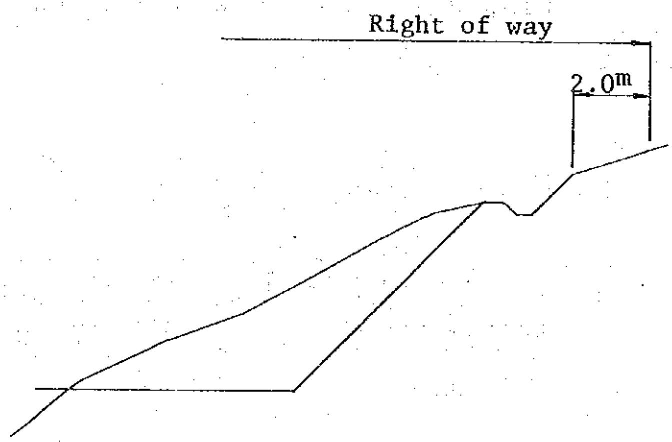
(b) Improvement of existing Motorway, which is undercrossing the roundabout.

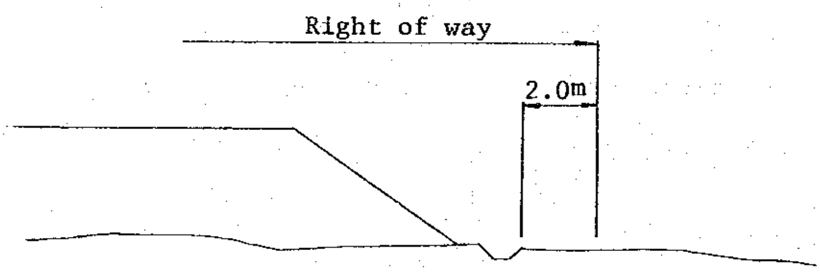
Second Stage: Construction of the through road connecting the Port Louis Ring Road during the construction of the Ring Road.

4. Right of Way

Right of way is defined as follows.







5. Cut and Fill

As a result of the draft calculation of Cut and Fill, there seems to be some available amount of surplus. This surplus is approved because it could be used for the land reclamation in Mauritius.

II. Tender Documents/Construction Planning/Cost Estimate Findings and Recommendation

1. Tender Documents

Composition of Tender Documents was defined in the "Minutes of Proceedings, from 17th Sept. to 4th Oct., 1979". Detailed description of Particular Condition will be prepared in next Site visit for review by the authorities concerned of the Mauritius Government. Particular Condition will be basically the same with that of the Relief Road to the North.

2. Construction Cost Estimate

The Unit Cost for Pay Item will be analized as in an attached sheet. It consists of five elements in the vertical column i.e.;

1) Labour Cost

2) Equipment Cost

3) Material Cost

4) Administrative Cost (Overhead)
   10 to 25 % of the sum of 1) to 3)

5) Profit (Taxable)
   5 % of the sum of 1) to 3)

And it contains three components horizontally i.e.;

1) Local Component (Including Taxes)

2) Foreign Component

3) Taxes (Separately presented)
   Import Duties, Corporate Tax and Income Tax)

These particulars will be adjusted, in due course, taking into account current market prices in Mauritius.

2-1 Labour Cost

As for Labour Cost, labourers are classified into seven local classes and one expatriate class by their wage levels as shown in the table. Mark up % of Fringe Benefit provision on labour cost derives from the analysis paper of Builders' Association of Mauritius.

2-2 Equipment Cost

The hourly owing and operating cost for Equipment is analized on the basis of newly delivered price at Site, so the results will be compared with existing market cost. The Equipment is categorized by the rate of import duties. Depreciation factors are assumed appropriately as in an attached table.

2-3 Material Cost

Construction Materials are classified into following groups:

1) Imported material

2) Local product, of which main prime material is imported; e.g., Reinforced bar

3) Local product, of which main material is locally produced; e.g., Aggregate

4) Local product, which comprise materials of 1), 2) and/or 3); e.g., Ready mixed concrete

Analysis of Cost Component

Item No.						Price	Local (Rs)		Foreign (Rs)	Per			
Particular	Description	Unit	Q'ty	Local Component		Foreign Component		Taxes	Tax Component				
				Unit cost(Rs)	(Rs)	Unit cost(Rs)	(Rs)	(Rs)	Unit cost(Rs)	Im. (Rs)	Co. (Rs)	In. (Rs)	
Labour Cost (including Operators' Wages of Equipment)													
Equipment Cost													
Material Cost													
Administrative Cost													
Profit													

3. Construction Planning

If Stage Construction is adopted from the view point of financing, it is recommended that bridges be executed in the 2nd phase. It is also recommended to award contracts by dividing the whole job into three sections, i.e.;

1) Earth Work including on-ground structures and pavement

2) Bridges

3) Lighting

A set of Tender Documents, together with Drawings will be prepared for each of the above three sections. But final numbers of award contract will be discussed in the next visit to Mauritius.

III. Lighting

The draft working drawings of lighting at the Interchanges are shown and approved.

IV. Bridge

1. Comparison between Grillage Analysis and Guyon-Massonet Method

   The reuslt of calculation is explained and shown in the tables on typical sectional forces at the center point of each main girdess.

   It is clearly shown that outside girders are usually overestimated when the Guyon-Massonet method is used.

2. Study on the Four Span Continous Type

   Four span continuous type is tentatively studied for the bridge located near the station No. 22. From the study, it is concluded that there is little possibility in applying the said type to those RC voided bridges because of rather big negative reaction.

3. Facia Block for the Side Appearance

   The idea of detail design for facia is approved as the design concept of the concerned pier top.

4. Drainage System

The located of drain boxes and the leading method of pipes are discussed and the general design concept is agreed as to the location, appearance and fittings. There will be no drain boxes for the bridges with rather steep slope and for small bridges after due checking of rain discharge.

The drain boxes shall be designed to avoid damages to the main parts of girders or cross beams as much as possible. If the drain pipes should be set outside of the outside girder, the length of the exposed pipes shall be as short as possible.

5. Pier Section

The ideas of pier section are decided based on the cost estimate. These ideas are of solid sections; where rectangular shape is taken for G.R.N.W. and circulay shape is for the others.

6. Cross Beam

The idea of end cross beam is fully approved.

7. Supporting Report of Analysis on Curved RC Voided Slab Bridge

The difference on the calculation results between the grillage analysis and F.E.M. is explained as to the sectional forces of the said.

It is approved that the curved RC voided slab bridges will be calculated by the grillage analysis method and checked by the converting ratio coefficient (r) on assumption of the results stated in the captioned report.

8. The Experiment Report of Ring Shoe (Rubber)

This report has been submitted just for information.

Mr. Ismael Ahmad Limbada Chief Engineer, Ministry of Works, MAURITIUS	Mr. Kimio Chiba Chairman of JICA Supervisory Comittee

Minutes of Discussion on Link Road Project Beau Bassin/Port Loui

The meetings on the above project were held between the Chief Engineer, Mr. Limbado, his staff and the Eighth Japan Survey team in the Phoenix Office of the Ministry of Works during the period 3rd to 10th March, 1980.

Discussions covered Road Design, Bridge Design, Bid and Contract Documents Production including the miscellaneous design details tobe finalised for the presentation of Draft Final Reports in the end of June, 1980.

The items discussed and agreed upon are as follows

1. Bridge Designs

The following Documents were submitted to the Chief Engineer and approved as a whole with some minor amendments.

1) Drawings of bridge structures with furnishings.

a. Link Road Bridges	4	bridges
b. Ramp way Bridges	4	"
c. Over Bridges	5	"
d. Pedestrian Bridges	2	"
e. Motorway Bridges	7	"

2) Typical sample of calculation sheets

a. PC T-Girder (G.R.N.W. Br.)
b. RC Voided Slab (STA 22 Br.)
c. Curved RC Voided Slab (Mwy.Jn. C-Rp Br.)
d. Substructure of G.R.N.W. Br. (Cantilever & Counterfort abutments; Wall-type, T-type piers)
e. Substructure of Mwy.Jn. B-Rp Br. (Rigid frame pier)

3) Typical s mple of Material lists (including reinforcement schedule)

4) The design concepts pertaining to the following items were discussed and accepted by the Chief Engineer on

a. Newel Post
b. Name Plate
c. Water Stop
d. Gravity type Retaining Wall
e. Stone Masonry

2. Road Designs and Cost Estimates/Tender Documents.

1) As for the construction Cost Estimate and Tender Documents Production, detailed discussion were held on the basis of the note prepared by Japanese Team and attached herewith.

..2/...

2) Bill classification for Bill of Quantities and principal methodology for cost analyses by Japanese Team were wholly agreed.

3) During the discussions it was agreed that the cost estimate sheet should have space for an adjustment of prices in case of Currency Devaluation or due to inflation.

4) All drafts of Bidding and Contract documents were presented, but they would be improved in some points in accordance with design developments of final stage.

5) In connection with bindings of Drawings/Technical Reports/Documents, they shall conform with the requirements of Scope of works. Some documents such as detailed work quantity computations would be presented to Ministry of Works in an appropriate form and number.

6) Concerning test equipment/apparatus for the Engineer's supervision, a short list was made.

7) Abbreviations and designations for the constructional areas or structures to be shown on drawings/reports were recommended by ~~Chief~~ Chief Engineer.

8) Descriptions of Special Provisions for General Conditions were discussed and agreed.

9) As for Land Acquisition Cost, the Ministry of Housing prepared the land Classifications and Cost Elements.

10) It was agreed that there should be one main contractor for the whole project with, if necessary, subcontractors for certain parts of the works.

11) Designs of Drainage, Traffic Signs, Road Markings, Lighting Installations and Miscellaneous item were fully reviewed and approved with some minor exceptions.

Chief Engineer,
Ministry of Works,
Mauritius.

Chairman of Supervising Committee
Japan International Corporation Agency

__10th March, 1980__

MW/AW-V/122/1

Notes of meeting held in the office of the Permanent Secretary, Ministry of Works on Friday the 20th June, 1980 at 10.30 a.m.

Present:

Mr D. Ramyead, Permanent Secretary, Ministry of Works, (Chairman);

Mr K. Chiba)
Mr H. Fujishita)
Mr Y. Higaki) Members of the Japanese team;
Mr K. Kuwata)
Mr I. Onishi)
Mr Y. Yahiro)

Mr I. Limbada, Chief Engineer, Ministry of Works;

Mr G. Moreea, Acting Principal Engineer (Roads), Ministry of Works;

Mr R. Ramjan, Engineer (Civil), Ministry of Works;

Mr G. Danjoux, Chief Town and Country Planning Officer, Ministry of Housing, Lands and Town and Country Planning;

Mr R. Ramlackhan, Principal Government Valuer, Ministry of Housing, Lands and Town and Country Planning;

Mr M. Derblay, Chief Surveyor, Ministry of Housing, Lands, and Town and Country Planning;

Mr P. Kistnasamy, Senior Economist, Ministry of Economic Planning and Development;

Mr S. Seeballuck, Administrative Officer, Ministry of Finance;

Mr S.K. Ah Kim, Administrative Officer, Ministry of Works, (Secretary).

The Chairman welcomed those present and said that the purpose of the meeting was to have general discussions with the Japanese team regarding the Beau Bassin - Port Louis Link Road Project.

2. Mr Chiba first made the history of the Japanese assistance regarding the project. In August 1977 a preliminary survey team from Japan came to Mauritius for discussions regarding the feasibility study of the project, which was financed by the Government of Japan. The feasibility study was carried during the years 1977 and 1978 and the final report was ready in December 1978. Afterwards the Japanese Government agreed to finance the detailed engineering design which was carried out since last year. The draft final report was now ready. The report would be finalised after the comments of the Ministry of Works and the African Development Bank would have been received. He, on behalf of the Japanese team, thanked the officers of various Ministries for their collaboration during those studies.

3. Mr Limbada pointed out that he had the opportunity to discuss the draft final report with the Japanese team during the week. The draft report was prepared with the joint effort of the Japanese and Mauritian sides. The recommendation in the report had been made after the various alternatives had thoroughly been discussed by both parties. Even the Ministry of Housing, Lands and Town and Country Planning was consulted where necessary. It was therefore expected that no major difficulties would be experienced during the implementation of the project, and that the project would progress satisfactorily. He also showed his appreciation of the high standard of the work performed by the Japanese Consultants.

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4. Mr Danjoux remarked that his Ministry was going ahead with the La Tour Koenig project and Phase I was expected to be completed in 1982. The impact of the development of La Tour Project on the Beau Bassin - Port Louis Link Road should be taken into account. Action has been initiated for the compulsory acquisition of the land required for the access road to the Petite Riviere Road.

5. Mr Limbada said that the development of La Tour had been taken into account and that it would also necessitate the construction of a new bridge over the Grand River North West. He was finalising the terms of reference and proposals would be invited soon from Consulting Engineers for the feasibility study and the detailed engineering design. After discussions with the World Bank, it was agreed that the term of reference should provide for the termination of the services of the Consulting Engineers after the feasibility study has been completed should it be necessary to do so.

6. Mr Kistnasamy said that proposals for the study and design could be invited on the basis of the terms of reference agreed with the World Bank whatever be the source of financing of the study and design, whether it be World Bank or U.N.D.P.

7. The Chairman asked the Japanese team what would be the implications if the project was implemented in staged construction instead of package construction now that the draft final report was ready.

8. Mr Chiba replied that certain amendments would have to be made to certain sections of the documents. As regards the cost of the additional work, he pointed out that this would have to be met by the Government of Mauritius. For the contribution of the Japan International Cooperation Agency (JICA) would end with the submission of the final report. It was roughly estimated that the additional work could be completed within a period of two months and would cost about Rs 100,000 on the understanding that no engineer would come from Japan to explain the revised documents. However further discussions on the subject would be held between Mr Limbada and the Japanese team.

9. The Chairman made it clear that no final decision regarding staged construction had been taken, but this possibility would have to be considered should there be any financial constraint regarding the package construction.

10. Mr Ramjan said that Mr Higeki who was responsible for preparing the cost estimates of the project had experienced some difficulties in obtaining an estimate of cost for land acquisition from the Ministry of Housing, and requested the concerned officer to provide the necessary data, as soon as possible, for the finalisation of documents.

11. Mr Ramlakhan explained that, from the general layout which he had, it would be difficult for him to give an estimate of cost. Now that the detailed plans were available he would be in a better position to give an accurate estimate of costs. As various factors had to be considered, this could only be done with the detailed plans. He was informed that the Ministry of Works had to submit comments on the draft report to J I C A by the end of July 1980. He undertook to submit an estimate of cost within one month, so that it could be submitted to J I C A at the same time.

/3...

12. Mr Limbada said that, from discussions which he had with the Japanese team, the Government of Japan could consider the possibility of making available to the Ministry of Works the services of two highway engineers under the Japanese Technical Assistance Programme to assist in the preparation of designs and tender documents mainly for the construction of drains along main roads. The services of those two engineers would be provided independently of the Beau Bassin - Port Louis Link Road project. If the Government of Mauritius would wish to avail itself of the services of those engineers, it should make a formal application to the Government of Japan. Mr Chiba confirmed what Mr Limbada said but pointed out that the final decision on the application rested with the Government of Japan.

13. The meeting ended at 11.30 a.m.

Ministry of Works,
Port Louis.
24th June, 19[illegible]0.

THE ANSWERS FOR THE COMMENTS

Volume A

(i) Form of Agreement: The conditions of Particular Application should be referred to specifically.

The attension of the Tenderers will be drawn to Conditions of Particular Applications as revised as follows:

In Clause 2

(d) The Conditions of Contract

. General Conditions

. Conditions of Particular Applications

(ii) Page PA 4 Clause 20: Reference is to FIDIC 1973 and not FIDIC 1977, the FIDIC used.

Subject to your comment, the relevant sentence will be revised as:

Delete the words "or and such operation of the forces of nature as an experienced contractor could not forsees, or reasonably make provision for or insure against all of which are herein collectively referred to as 'the excepted risks' " in 9th to 11th lines of sub-clause (2)

(iii) 3rd and 4th paragraphs of page PA 9 and 1st paragraph of page PA 10 should be referenced Clause 36.

The subtitle "Clause 36 MATERIALS AND WORKMANSHIP" will be inserted which covers the first paragraph of PA 10.

(iv) Page PA 11: Remaining clauses in 53 need re-numbering.

In Clause 53, the 1st sentence is revised as:

Delete sub-clauses (1) and (2), and substitute the following 11 sub-clauses. The numbering of remaining sub-clauses of the Clause (3), (4), (5) and (6) changes to (12), (13), (14) and (15) respectively.

(v) Page PA 20 and paragraph (7) in Appendix A: The retention is given as 10% with a maximum of 5%.

Percentage of retension money is revised from 5 % to 10 %.

Volume B

(i) 302: In addition to compaction trial, level of compaction should be indicated.

The 1st paragraph is revised as follows;

Before commencing and embankment construction of each section, the Contractor shall, at his own expense, carry out trial compactions within the right of way or in sections of roadway where the Engineer may direct. The purposes of these trials are to determine, for each main type of materials to be used in an embankment, the proper compaction equipment to be employed and the number of passes necessary in order to achieve the required degree of compaction. The number of trial compaction shall correspond to the cases the material sources may vary and the Engineer considers the trial compaction be necessary. The approximate dimension of trial compaction embankment is as follows:

Length: not more than 30 meters
Width: not more than 6 meters
Height: not more than 5 meters

(ii) 503: Method of specifying density for crushed stone subbase needs reviewing. The specification is too low.

A review on the method of specifying density for cruwhed stone subbase was made. The figure of compaction degree (at least 95 % of the density at optimum moisture) is considered enough to control the material, so no special ammendment for the stipulation is needed.

(iii) 505: Is a prime coat really necessary with 10 cm layer of base?

From the viewpoint of constructional procedure, regardless of base course the surface protection of subbase by prime coating is needed in preventing the material from damages due to the constructional equipment/ vehicles or rains.

(iv) 906: Aggregates: Because of incipient weathering in many rocks in Mauritius the soundness of aggregates must be tested.

The soundness of aggregates can fully be tested subject to 906.01 to 906.04. The testing method is stipulated in Clause 1009.

Volume C: Drawings

(i) 51/80: Drainage of crushed stone base not clear. Necessity for pre-cast concrete ditch on embankments not clear.

Drainage of the cut section is important from the point of view of pavement structure. According to the results of the geological survey conducted along the route, it was found that the groundwater level is very low and the subgrade woil is rather porous and dry, betraying no sign of softening of soil nor water seepage. Accordingly, the side ditches have been designed under the surface of subgrade; there is no problem as regards to drainage of subgrade and it is economical, too.

Precast concrete ditch on embankments is necessary from such reasons as described below:

(1) In Mauritius, it rains in torrential downpours with very high precipitation;

(2) Average gradient of vertical alignment is around 3 %;

(3) Therefore, rainwater falling on the road surface flows rapidly on the skew direction to the road edge;

(4) If there was no ditch on the edge of the shoulder, grown-up turf would prevent the surface water from draining smoothly and much surface water would flow along the lane at a dangerous speed;

(5) Rain water on the surface of the road needs to be drained as quickly as possible, and

(6) Setting of the ditch on embankments prevents corrosion of the shoulder-edge and slope by surface water flowing.

(ii) 53/80: Rooled gutter not likely to be effective. Better to dish central reserve.

In the superelevated section, turf roots in the median strip grow yearly and interrupt the surface water from flowing into the central ditch in the median strip, thus the surface water has to flow along the lane making conditions unsafe for vehicles driving.

Upon comparison of several alternative ditches from such points of view as cost, flowing capacity and safety, we obtained the result showing that the rolled gutter is the most effective. Recently, this type of ditch has been adopted in Japan on the expressway with satisfactory results.

(iii) 56/80 and following: A 1 in 1 slope appears to be used on all cut slopes. Is this the best?

According to the results of geological survey, it has been found practicable to cut by 1 in 0.5 at some cut sections. However, in view of the existence of surface soil and very much weathered rock on the hard rock, on the one hand, and the inconveniences caused in construction and extra costs resulting therefrom by adopting different cut slopes, on the other hand, we have decided to stick to a single cut slope.

(iv) Bridge drawings: It is noted that the consultant is using slabs for bridges. Is that cheaper than ensuring compaction of material in wedge?

Although material of backfill were compacted firmly, the settlement of backfill seems to be inevitable. Therefore, approach slabs were decided to be installed. Providing approach slabs the expansion joints and pavement shall not be damaged by traffics.

The approach slab will be a little expensiv at the time of construction, but the subsequent cost of maintenance for the pavement, etc. will not be required.

There fore, from the longrun point of view, the approach slab will be economical.

(v) Drainage material behind abutments and retaining walls appears to be omitted.

It seems to be necessary to keep the stability of backfill avoiding soil failure by porewater.

<u>Design Report</u>

Mauritius being an island does not have the very heavy vehicles that are found on the mainland. This is likely to reduce equivalence factors for axle loads. Further a design CRB of 7.5 is considered low and 10 is probably acceptable. Because of these two factors, design is considered conservative and should be re-checked. It would appear that the cost of 10 CM of bitumen bound base has been underestimated relative to the binder course.

(1) "Number of heavy vehicles" adopted for pavement design stands for a total equivalent 18-kip (80 KN) single axle load applications through the 20 year-project life by using AASHTO method; it has been converted by taking into consideration a future mixed traffic volume.

(2) Design CBR of 7.5 has been decided from the results of a soil test which was carried out along the route and it can not be conservative.

(3) The rate for Item E03 Bituminous Treated Base Course is modified from 73 Rs/m^2 to 140 Rs/m^2.

Historic information should be given on inflation. The factor given is considered low.

Historic information will be added in Confidential Report, and the inflation factor will be discussed.

JICA