3.4.5 Concrete Plant

(1) Concrete Batcher Plant

The necessary concreting work for the spillway structures and water treatment facilities, which will require the concrete placing of about 53,200 m^3 during the period of about 14 months, will determined the capacity required for the concrete batcher plant.

Thus, the necessary capacity of the batcher plant is calculated at 250 m^3/day as follows:

$$\text{Capacity of Batcher Plant} = \frac{53,200}{14 \text{ months} \times 20 \text{ days}} \times 1.3 = 247 = 250 \text{ m}^3/\text{day}$$

The required hourly plant capacity is obtained to be 30 m3/hr, assuming the daily working hours of 10 hours/day, as follows:

- Daily concrete requirement = 250 m3/day
- Daily working hours = 10 hours/day
- Hourly concrete requirement = 250/10= 25= 30 m3/hr.

The design of the concrete batcher plant is made based on the above requirement. Two types, the full automatic one and semi-automatic one are examined. An approximate cost comparison between two types has indicated a slightly higher cost of Rs. 6.6 million for the full automatic one against Rs. 4.5 million for the semi-automatic one. However, the full automatic one is recommended to be installed in view that a higher concrete quality is secured in the full automatic one. The design of the concrete batcherplant is shown in Fig. 3.4.9.

(2) Cement Silo and Cement Warehouse

A cement silo of 100 tons is attached to the concrete batcher plant. Its capacity can withstand the concreting works for two to three days.
In usual cases, the cement silo is provided with the capacity to cope with concreting works for five to seven days. In the case of the Project, however, a less capacity as mentioned is given with consideration that the transportation and supply of cement will be very easy from the Port Louis harbour which is located near the project site and is equipped with a large stock of cement.

The cement warehouse having an area of 96 m^2 is planned to be built. This cement warehouse is possible to store the bag cement of about 50 to 60 tons.
The purpose of this cement warehouse is to supply the cement for grouting works. Assuming that the grouting works will use the cement of about 1.0 ton per day, the storage capacity of the cement warehouse will meet the grouting works for two months or more, which is considered sufficient.

3.4.6 Buildings

(1) General

The major design criteria applied for buildings are standard requirements conforming to "Architectural Institute of Japan Standard for Structural Calculation of Reinforced Concrete Structures and Commentary" and "Architectural Institute of Japan Standard for Structural Calculation of Steel Structures".

Design concepts are given below. The designs for major buildings are shown in Fig. 3.4.10 to 3.4.16. .

(2) Loading condition

In the structural calculations, the load and external forces that act on the structure are the following:

(A) Dead load
(B) Live load
(C) Seismic load

The dead and live loads of each part of building are applied in accordance with the Japanese Building Standard Law Enforcement Order.

The seismic load is applied as the force to act horizontally as follows:

- Seismic coefficient : $k = 0.05$
- Horizontal force to the building : $H = k \times W$
  W :Dead load of building plus adjusted live load

The stress is examined for the following combinations of loads, and the design is made to ensure the safety for all the combinations of loading.

Combination of Loads

Conditions of Stresses		Combination of Stresses
Permanent stresses	Normal time	G + P
Temporary stresses	Earthquake	G + P + K

where;

G : Stress due to dead load

P : Stress due to live load

K : Stress due to seismic load

(3) Design of members

The design of reinforced concrete structure is based on "AIJ Standard for Structural Calculation of Reinforced Concrete Structure".

The design is made on the following assumptions:

- Compressive strength of concrete at 28 days shall be 210 kg/cm^2 or more.
- Reinforcement bar materials shall comply with deformed bar, "SD30". (JIS G3112)
- Weight of reinforced concrete shall be calculated as 2.4 t/m^3 and the "Young Modulus" of reinforcement bar to concrete shall be "n=15".
- The design of steel beam depends on the "AIJ Standard for Structural Calculation of Steel Structure".
- The materials of steel shall comply with "SS 41". (JIS G3101)

(4) Allowable design stress

Allowable design stresses of the structural materials is as summarized below:

(i) Concrete and reinforcing bar

Allowable design stress of concrete and reinforcing

(kg/cm^2)

Materials	Type of Stress					
	For Permanent Load			For Temporary Load		
	Tension	Compression	Shear	Tension	Compression	Shear
Concrete ($Fc = 210\ kg/cm^2$)	-	Fc/3 = 70	4.25	-	2Fc/3 = 105	12.75
Reinforcing bar (JIS G3112)	1,800	1,800	1,000	2,700	2,700	1,500

Allowable bond stress per unit surfaces of reinforcing bar

(kg/cm^2)

Materials	Type of Stress			
	For Permanent Load		For Temporary Load	
	Top Bar	Other Bars	Top Bar	Other Bars
Deformed bar	Fc/15 14.0	Fc/10 21.0	1.5Fc/15 21.0	1.5Fc/10 31.5

(ii) Structural steel

(kg/cm^2)

Materials	Type of Stress					
	For Permanent Load			For Temporary Load		
	Tension	Compression	Shear	Tension	Compression	Shear
Structural steel (SS 41)	1,400	1,400	900	2,100	2,100	1,350

(iii) The allowable bearing capacity of soil is assumed to be 30 t/m^2.

3.4.7 Water Supply System

The construction work requires various water supplies for the offices, quarters, aggregate and concrete plants, grouting work, concreting works and so on.

Considering the estimated necessary staffs of the contractor and engineer, and respective work activities, etc., the water supply requirement during the construction work in terms of the peak capacity is approximately estimated as follows:

Estimated Water Requirement
(Required Peak Capacity)

	Descriptions	Water Requirement (m^3/min. at peak)
1.	Site office and quarters for the engineer	0.3
2.	Contractor's office and quarters	0.5
3.	Aggregate plant	2.5
4.	Concrete batcher plant	0.3
5.	Grouting work	0.6
6.	Diversion tunnel site	0.5
7.	Spillway site	0.3
8.	Repairshop and motor pool	0.2
9.	Others	0.3
	Total	5.5 m^3/min.

In the above, the diversion tunnel site work is considered not to overlap with other works. However, total water requirement at peak is determined at 5.5 m^3/min. provided with some allowance.

The water requirement for offices and quarters is estimated on the assumption that about fifty (50) persons and ten (10) to fifteen (15) persons will work as the contractor's staffs and the Engineer's staff respectively.

The requirement for aggregate plant and concrete batcher plant considers that they should have the production capacity of 90 ton/hour and 30 m^3/hour, respectively.

Out of this water requirement, the water supply for the offices and quarters of the contractor and engineer should be made with the treated water. Thus, its supply is planned to be made from the CWA's existing water supply service main passing near the Martindate Bridge.

The water supply for construction work is considered to be made from a reservoir located near the project site. The reservoir is located beside the trunk road (eastern side of the trunk road), into which the water taken from the Profonde river is being supplied. The water level of the reservoir is measured at El. 273. The facilities requiring the water supply are situated at altitudes lower than the water level of the reservoir, thus making it possible to supply the water by gravity flow. There is the existing culvert crossing the trunk road, and therefore, a particular troublesome work is considered not necessary for the pipeline to cross the trunk road: that is, the water supply pipeline will be connected to the existing culvert.

The required diameter of water supply pipe is obtained on the basis of the relationship among the required water supply discharge, gradient and pipe diameter.

Fig. 3.4.17 presents the graphs to find the necessary diameter of pipe based on the required water supply discharge and gradient between the water source and facility to be supplied the water. The diagram of pipe to each facility which is thus obtained is given in Fig. 3.4.18.

The following gives detailed calculations to obtain the water supply diagram shown in Fig. 3.4.18. Designs of the water supply system are presented in Fig. 3.4.19.

(a) Condition of pipelines

	Route	Required Discharge (m^3/min)	Length (m)	Difference of Level (m)
(1)	Source to tunnel	0.5	1,460	143
(2)	Source to spillway	0.3	1,260	78
(3)	Source to miscellaneous water	0.3	1,050	75
(4)	Source to grouting (left bank)	0.2	1,020	73
(5)	Source to grouting (right bank + riverbed)	0.4	640	33
(6)	Source to aggregate plant	2.5	580	28
(7)	Source to concrete batcher plant	0.3	560	28
(8)	Source to repairshop & motor pool	0.2	430	28
(9)	Existing pipe to Engineer's office and quarters	0.3	2,100	50
(10)	Existing pipe to Contractor's office and quarters	0.5	2,100	52

(b) Calculations of required diameter

(i) Point I to tunnel:

$I = H/l = 143/1{,}460 = 1/10$ .... ø80 (Ref. Fig. 3.4.18)

(ii) Point I to spillway:

$I = H/l = 78/1{,}260 = 1/16$ ø75

(iii) Point H to Point I:

A sectional area equal to the sum of (i) and (ii) is provided as follows:

$D = \sqrt{80^2 + 75^2} = 110$ mm ø125

(iv) Point H to miscellaneous water:

$I = H/l = 75/1,050 = 1/14$ ø75

(v) Point G to Point H:

A sectional area equal to the sum of (i), (ii) and (iv) is provided as follows:

$D = \sqrt{80^2 + 75^2 + 75^2} = 133$ mm ø150

(vi) Point G to grouting (left bank):

$I = H/l = 73/1,020 = 1/14$ ø75

(vii) Source to Point G:

A sectional area equal to the sum of (i), (ii), (iv) and (vi) is provided:

$D = \sqrt{80^2 + 75^2 + 75^2 + 75^2} = 153$ ø175

(viii) Point D to grouting (right bank + riverbed):

$I = H/l = 33/640 = 1/19$ ø80

(ix) Point E to concrete batcher plant:

$I = H/l = 28/560 = 1/20$ ø75

(x) Point E to aggregate plant:

$I = H/l = 28/580 = 1/21$ ø175

(xi) Point D to Point E:

A sectional area equal to the sum of (ix) and (x) is provided:

$D = \sqrt{75^2 + 175^2} = 190$ ø200

(xii) Point C to Point D:

A sectional area equal to the sum of (viii), (ix) and (x) is provided:

$D = \sqrt{80^2 + 75^2 + 175^2} = 207$ ø250

(xiii) Point C to repairshop of motor pool:

$I = H/l = 28/430 = 1/15$ ø60

(xiv) Source to Point C:

A sectional area equal to the sum of (viii), (ix), (x) and (xiii) is provided:

$D = \sqrt{80^2 + 75^2 + 175^2 + 60^2} = 215$ ø250

(xv) Point B to engineer's office & quarter:

$I = 50/2,100 = 1/42$ ø100

(xvi) Point B to contractor's office & quarter:

$I = 52/2,100 = 1/40$ ø100

(xvii) Point A to Point B:

A sectional area equal to the sum of (xv) and (xvi) is provided:

$D = \sqrt{100^2 + 100^2} = 140$ ø150

3.4.8 Electric Power Supply System

(1) General

Electrical works will be designed for supplying power to the respective work sites for construction use. Some of the electric power supply system for the Project are to be used for permanent installation such as office and quarter, dam site plant, etc. The design of the electrical works is made for the followings:

(i) Electric power requirements for construction work
(ii) Power receiving design
(iii) Distribution line design
(iv) Receiving station design

The design of the electric power supply system is given in Fig. 3.4.20 to Fig. 3.4.23.

Details are mentioned hereafter.

(2) Electric power requirements for construction use

The electric power required is estimated as follows:

No.	Working Area	Estimated Capacity (kw)
I)	Right Bank Side	
	a) Office and quarters area	
	1. Office & quarters for Employer and Engineer	150
	2. Contractor's office and quarters	160
	Subtotal (1)	310
	b) Concrete plants	
	1. Aggregate plant	400
	2. Concrete batcher plant	90
	3. Laboratory	10
	4. Water supply system	-
	Subtotal (2)	500
	c) Repair shop, work shop, etc.	
	1. Motor pool & repair shop	100
	2. Assembly yard & metal work shop	150
	3. Dam site lighting	40
	4. Grouting work	100
	5. Miscellaneous installations	30
	Subtotal (3)	420
	d) Quarry and borrow pit area	
	1. Quarry site	30
	2. Borrow pit	10
	3. Miscellaneous works	20
	Subtotal (4)	60
	Total (I)	1,290
II)	Left Bank Side	
	1. Dam site lighting	40
	2. Diversion tunnel	100
	3. Grouting work	100
	4. Valve & pipe site	120
	5. Intake gate site	80
	6. Miscellaneous works	20
	Total (II)	460
	Grand-Total (I + II)	1,750

In consideration of various demand factors, diversity factors, power factors, etc. among the said loads, the required receiving capacity is roughly estimated as follows:

$$\text{Total receiving capacity} = \frac{1{,}750\ (kW)}{0.8 \times 0.7} \times \frac{0.6}{1.1} = \text{ca. } 1{,}700\ kVA$$

where,	demand factor	:	0.6,
	diversity factor	:	1.1,
	average motor efficiency	:	0.8, and
	average power factor of motors	:	0.7.

(3) Power receiving design

In the Basic Design Report the power receiving design has been decided as to receive power from the existing 22 kV distribution line as a result of study of economical and technical bases. One branch line is constructed for receiving power from the existing 22 kV line and one power receiving switching station is constructed for supplying power received to the respective work sites where are separated each other.

The receiving switching station will consist of outdoor type metal clad switchgear which is arranged as one incoming feeder line, three outgoing feeder lines and one station service line.

(4) Distribution line design

Considering the location of the respective work sites, where are separated at three area, three feeders of 22 kV distribution line are constructed for supplying power to the respective work sites. The destination of the respective feeders are as follows:

(i)	Feeder line No. 1	For quarry site through water treatment plant
(ii)	Feeder line No. 2	For dam site plant
(iii)	Feeder line No. 3	For borrow area plant through repair shop/ware house, office and quarter area

In addition to the above, 400 - 230 V distribution line is constructed for the office and quarter area which are used by the Employer permanently.

Extension lines from the above-mentioned lines to each work site are to be constructed by Lot-I contractor during the construction period.

The existing 22 kV main distribution line is located close to the existing 66 kV transmission line and the line passes the land planed for the main dam of the Project.

Therefore, this portion of the existing 22 kV distribution line around the dam site should be relocated to another place so as not to disturb the dam construction works.

The receiving switching station and a part of the 22 kV distribution line feeder No. 3 from receiving switching station to office and quarter area are used permanently even after the completion of the construction work for the Employer's facilities.

(5) Receiving station design

Six receiving stations are to be constructed for the construction work of the Project. Required capacity of step-down transformers at the receiving stations is calculated as follows:

		Working Area	Required Capacity (kW)	Step-down Transformer (kVA)
I)	Right Bank Side			
	a)	Office and quarters area	310	300
	b)	Concrete plants	500	500
	c)	Repair shop, work shop, etc.	420	400
	d)	Quarry area	30	30
	e)	Borrow pit area	30	30
II)	Left Bank Side			
	Dam site, diversion tunnel, grouting work, valve & pipe site, intake gate site, etc.		460	400
	Total		1,750	1,660

Table 3.2.1: PRINCIPAL FEATURES OF TUNNEL TYPE

Item		Type I	Type II
1.	Internal Diameter (cm)	680	680
2.	Lining Thickness (cm)	50	80
3.	Rock Properties		
	• Rock class	$C_M \sim C_H$	$C_L \sim C_M$
	• Elastic modulus E_r (kg/cm^2)	30,000	5,000
	• Poisson's ratio ν_r	0.2	0.3

Table 3.2.2: LOADING CONDITIONS OF DIVERSION TUNNEL

Item	Upstream Section from Plug	Downstream Section from Plug	Note	Study
1. During diversion, normal	Pe = GWL. - Tunnel center EL. = 140 - 131 = 9.0 t/m^2	Pe = 140 - 128.4 = 11.6 t/m^2		Check
	Pi = 0	- do -		
2. During diversion, flood	Pe = FWL - Tunnel center EL. = 154.5 - 131.0 = 23.5 t/m^2 (just after flowing out)	Pe = 140 - 128.4 = 11.6 t/m^2		No-check
	Pi = FWL - Tunnel center EL. - $v^2/2g$ = 154.5 - 131.0 - 10.5 = 13.0 t/m^2	Pi = FWL - Tunnel center EL. - $v^2/2g$ = 154.5 - 128.4 - 10.5 = 15.6 t/m^2		Check
3. After completion, normal	Pe = 0 Pi = 0	Pe = 0 (drained by weep holes) Pi = 0		No-check
4. After completion, abnormal	Pe = HWL. - Tunnel center EL. = 208.0 - 131.0 = 77.0 t/m^2 (dewatered condition)	Pe = 0 (drained by weep holes)	65% increment of allowable stresses	Check
	Pi = 208.0 - 131.0 = 77.0 t/m^2 (abnormal condition)	Pi = 0	65% increment of allowable stresses	Check
5. Grout pressure	The grout pressure of 2 kg/cm^2 is imposed locally around the grout holes for consolidation and curtain.		Concrete strength σ_{28} = 210 Yield strength	Check
6. Others	Rock loads are taken by the tunnel supports erected during construction so that no rock load is imposed on the concrete lining. Deal load is neglected because it is rather small than others.			

Table 3.2.3: CONCRETE AND STEEL PROPERTIES

Increment of Stress (%)	Concrete		Steel
	Compression (kg/cm^2)	Shear (kg/cm^2)	Tension (kg/cm^2)
0	70	8.5	1,800
65	116	14	2,970
for grout pressure	210	18	3,000

Concrete	Strength	$\sigma_{28} = 210\ kg/cm^2$
	Elastic modulus	$E_c = 255{,}000\ kg/cm^2$
	Poisson's ratio	$\nu_c = 0.2$
Steel	Elastic modulus	$E_s = 2{,}100{,}000\ kg/cm^2$

Table 3.2.4: RESULTS OF STRUCTURAL ANALYSES FOR DIVERSION TUNNEL

Item		Type I	Type II U/S	Type II D/S
Lining thickness (cm)		50	80	80
Reinforcement		D16 @300 (inside)	D22 @200 (both sides)	D16 @300 (both sides)
Stress against Internal pressure				
• re-bar	(kg/cm^2)	602	2,675	710
Stress against External pressure				
• concrete	(kg/cm^2)	64	43	7
Stress against Grout pressure				
• concrete	inside (kg/cm^2)	32	41	53
• concrete	outisde	4		
• re-bar	inside	-		
• re-bar	outside	-	547	1,106

Table 3.2.5(1) :TUNNEL ANALYSIS BY OTTO-FREY-BEAR'S THEORY
(Tunnel Type-I)

```
Elastic modulus (rock)    = 30000    (kg/cm2)
Elastic modulus (steel)   = 2100000   (kg/cm2)
Elastic modulus (conc.)   = 255000   (kg/cm2)
Poisson's ratio (rock)    = .2
Poisson's ratio (conc.)   = .2
Lining thickness   (cm)   = 50
Inner diameter     (cm)   = 680
Internal pressure(kg/cm2)= 7.7
External pressure(kg/cm2)= 7.7
Pitch of rein-bar  (mm)   = 300
```

(Unit:kg/cm2)	TENSION(*)		COMPRESSION(**)	
Plain conc.	-33.5		64.2	
Rein-bars	SGL	DBL	SGL	DBL
D 13 @ 300	605.1	599.4	63.7	63.3
D 16 @ 300	601.8	593.1	63.6	63.0
D 19 @ 300	597.9	585.4	63.1	62.3
D 22 @ 300	593.2	576.9	62.9	61.8
D 25 @ 300	587.9	567.0	62.5	60.9
D 29 @ 300	582.0	556.2	61.9	60.1

Note : (*) gives the case of internal pressure
(**) gives the case of external pressure

Table 3.2.5(2) :TUNNEL ANALYSIS BY OTTO-FREY-BEAR'S THEORY
(Tunnel Type-II, Upstream of Plug)

```
Elastic modulus (rock)     = 5000    (kg/cm2)
Elastic modulus (steel)    = 2100000   (kg/cm2)
Elastic modulus (conc.)    = 255000   (kg/cm2)
Poisson's ratio (rock)     = .3
Poisson's ratio (conc.)    = .2
Lining thickness    (cm)   = 80
Inner diameter      (cm)   = 680
Internal pressure(kg/cm2)= 7.7
External pressure(kg/cm2)= 7.7
Pitch of rein-bar   (mm)   = 200
```

(Unit:kg/cm2)	TENSION(*)		COMPRESSION(**)	
Plain conc.	-34.7		44.7	
Rein-bars	SGL	DBL	SGL	DBL
D 13 @ 200	3795.3	3529.5	44.5	44.1
D 16 @ 200	3607.2	3243.4	44.3	43.8
D 19 @ 200	3401.1	2950.8	44.1	43.6
D 22 @ 200	3192.7	2674.9	43.7	43.0
D 25 @ 200	2975.5	2406.6	43.6	42.7
D 29 @ 200	2762.6	2161.0	43.1	42.0

Note : (*) gives the case of internal pressure
(**) gives the case of external pressure

Table 3.2.5(3) :TUNNEL ANALYSIS BY OTTO-FREY-BEAR'S THEORY
(Tunnel Type-II, Downstream of Plug)

```
Elastic modulus (rock)       = 5000     (kg/cm2)
Elastic modulus (steel)      = 2100000    (kg/cm2)
Elastic modulus (conc.)      = 255000   (kg/cm2)
Poisson's ratio (rock)       = .3
Poisson's ratio (conc.)      = .2
Lining thickness    (cm)     = 80
Inner diameter      (cm)     = 680
Internal pressure(kg/cm2)= 1.56
External pressure(kg/cm2)= 1.16
Pitch of rein-bar   (mm)     = 300
```

(Unit:kg/cm2)	TENSION (*)		COMPRESSION (**)	
Plain conc.	-7.0		6.7	
Rein-bars	SGL	DBL	SGL	DBL
D 13 @ 300	793.3	754.1	6.8	6.8
D 16 @ 300	765.7	710.1	6.8	6.6
D 19 @ 300	734.6	662.7	6.8	6.6
D 22 @ 300	702.2	615.8	6.6	6.7
D 25 @ 300	666.8	567.9	6.6	6.5
D 29 @ 300	631.1	522.0	6.7	6.6

Note : (*) gives the case of internal pressure
(**) gives the case of external pressure

Table 3.2.5(4) :TUNNEL ANALYSIS BY OTTO-FREY-BEAR'S THEORY
(Tunnel Type-I, During River Diversion)

Elastic modulus (rock) = 30000 (kg/cm2)
Elastic modulus (steel) = 2100000 (kg/cm2)
Elastic modulus (conc.) = 255000 (kg/cm2)
Poisson's ratio (rock) = .2
Poisson's ratio (conc.) = .2
Lining thickness (cm) = 50
Inner diameter (cm) = 680
Internal pressure(kg/cm2)= 0
External pressure(kg/cm2)= 1.16
Pitch of rein-bar (mm) = 300

(Unit:kg/cm2)	TENSION(*)		COMPRESSION(**)	
Plain conc.	0.0		9.7	
Rein-bars	SGL	DBL	SGL	DBL
D 13 @ 300	0.0	0.0	9.7	9.5
D 16 @ 300	0.0	0.0	9.7	9.6
D 19 @ 300	0.0	0.0	9.5	9.5
D 22 @ 300	0.0	0.0	9.6	9.4
D 25 @ 300	0.0	0.0	9.5	9.3
D 29 @ 300	0.0	0.0	9.3	9.2

Note : (*) gives the case of internal pressure
(**) gives the case of external pressure

Table 3.2.6(1) :TUNNEL ANALYSIS FOR GROUT PRESSURE

(Tunnel Type-I)

Elastic modulus (rock) = 30000 (kg/cm2)
Elastic modulus (conc) = 255000 (kg/cm2)
Poisson's ratio (rock) = .2
Poisson's ratio (Conc) = .2
Lining thickness (cm) = 50
Inner diameter (cm) = 680
Grouting press.(kg/cm2)= 2

PHAI (deg)	M (tm)	S (t)	N (t)	sig1 (kg/cm2)	sig2
0	0.7	0.0	-69.0	15.1	12.4
5	0.7	0.0	-69.0	15.3	12.5
10	0.7	0.0	-69.0	15.3	12.5
15	0.6	0.0	-69.0	15.2	12.3
20	0.6	0.2	-69.0	15.4	12.2
25	0.8	0.2	-68.8	15.5	12.1
30	0.7	0.2	-68.8	15.5	12.0
35	0.8	0.1	-68.8	15.8	11.8
40	1.0	0.1	-68.9	16.0	11.8
45	0.9	0.2	-68.9	16.0	11.6
50	1.0	0.0	-68.9	16.3	11.3
55	1.0	-0.0	-68.7	16.3	11.3
60	1.1	-0.3	-68.9	16.2	11.4
65	0.9	-0.4	-68.8	15.8	12.0
70	0.6	-0.7	-69.0	14.9	12.6
75	-0.2	-1.2	-69.0	13.9	13.8
80	-0.8	-1.6	-69.4	15.8	12.0
85	-2.0	-1.8	-69.5	18.5	9.4
90	-3.1	-2.1	-70.0	21.5	6.4
95	-4.7	-2.2	-70.4	25.0	3.2
100	-6.0	-2.0	-70.8	28.5	-0.4
105	-7.1	-0.9	-71.1	31.4	-3.0
110	-7.4	1.0	-71.2	32.2	-3.8
115	-6.6	4.7	-70.9	29.8	-1.3
120	-5.1	4.5	-70.5	26.0	2.1
125	-3.7	4.4	-70.0	22.7	5.4
130	-2.4	4.1	-69.6	19.5	8.6
135	-1.0	3.8	-69.3	16.5	11.5
140	0.2	3.5	-69.0	14.0	13.7
145	1.2	3.1	-68.7	16.5	11.1
150	2.1	2.6	-68.6	18.6	8.9
155	2.9	2.2	-68.4	20.4	7.0
160	3.5	1.9	-68.2	21.9	5.6
165	4.0	1.5	-68.1	22.9	4.2
170	4.4	0.9	-68.0	23.9	3.5
175	4.6	0.6	-67.8	24.4	2.8
180	4.5	0.0	-67.9	24.6	2.8

Note: M : Moment, S : Shear, N : Axial Force
Sig 1 : Inside Stress, Sig 2 : Outside Stress

Table 3.2.6(2) :TUNNEL ANALYSIS FOR GROUT PRESSURE

(Tunnel Type-II)

Elastic modulus (rock) = 5000 (kg/cm2)
Elastic modulus (conc) = 255000 (kg/cm2)
Poisson's ratio (rock) = .3
Poisson's ratio (Conc) = .2
Lining thickness (cm) = 80
Inner diameter (cm) = 680
Grouting press.(kg/cm2)= 2

PHAI (deg)	M (tm)	S (t)	N (t)	sig1 (kg/cm2)	sig2 (kg/cm2)
0	18.8	0.0	-62.5	25.3	-9.7
5	18.6	-1.1	-62.4	25.1	-9.5
10	17.9	-2.2	-62.6	24.6	-8.8
15	16.6	-3.3	-62.9	23.6	-7.7
20	15.2	-4.3	-63.3	22.0	-6.3
25	13.0	-5.3	-64.0	20.2	-4.2
30	10.6	-6.2	-64.5	18.0	-2.0
35	7.9	-7.0	-65.4	15.6	1.0
40	4.6	-7.8	-66.2	12.7	3.9
45	1.1	-8.3	-67.0	9.4	7.3
50	-2.6	-8.6	-68.1	10.9	6.0
55	-6.5	-8.6	-69.0	14.7	2.5
60	-10.6	-8.3	-70.2	18.7	-1.2
65	-14.5	-7.5	-71.2	22.5	-4.7
70	-18.2	-6.6	-72.2	26.1	-7.9
75	-21.5	-4.9	-72.9	29.3	-10.9
80	-24.1	-2.8	-73.8	31.8	-13.4
85	-26.2	-0.1	-74.3	33.7	-15.3
90	-26.9	3.2	-74.5	34.7	-16.1
95	-26.6	7.2	-74.4	34.2	-15.5
100	-24.3	12.1	-73.7	32.0	-13.7
105	-20.1	12.8	-72.7	27.8	-9.8
110	-15.9	12.6	-71.6	23.7	-6.0
115	-11.7	12.0	-70.5	19.9	-2.3
120	-7.8	11.6	-69.5	16.0	1.3
125	-4.1	11.0	-68.5	12.4	4.8
130	-0.6	10.3	-67.6	9.0	8.0
135	2.6	9.5	-66.6	10.9	6.0
140	5.7	8.5	-65.8	13.6	3.1
145	8.4	7.6	-65.1	16.0	0.5
150	10.6	6.6	-64.5	18.0	-1.9
155	12.8	5.6	-64.1	20.0	-4.0
160	14.5	4.5	-63.5	21.5	-5.5
165	15.8	3.4	-63.3	22.7	-6.9
170	16.6	2.3	-62.9	23.6	-7.7
175	17.3	1.3	-62.9	24.1	-8.4
180	17.5	0.0	-62.7	24.1	-8.6

Note : M : Moment, S : Shear , N : Axial Force

Sig 1 : Inside Stress, Sig 2 : Outside Stress

Table 3.2.6(3): CALCULATION OF INTERNAL STRESS IN REINFORCED CONCRETE STRUCTURE: DIVERSION TUNNEL (TYPE-II) FOR GROUT PRESSURE

Member Spot		D/S	D/S	U/S	U/S
M	t.m	26.90	20.10	26.90	20.10
Q	t	3.20	12.80	3.20	12.80
N	t	74.50	72.70	74.50	72.70
b	cm	100.00	100.00	100.00	100.00
h	cm	80.00	80.00	80.00	80.00
u	cm	30.00	30.00	30.00	30.00
d	cm	70.00	70.00	70.00	70.00
d'	cm	10.00	10.00	10.00	10.00
d'/ d		0.14	0.14	0.14	0.14
M'= M+N.u	t.m	49.25	41.91	49.25	41.91
M'/(b.d.d)	kg/cm2	10.05	8.55	10.05	8.55
Q /(b.d)	kg/cm2	0.46	1.83	0.46	1.83
f = M/N+u	cm	66.11	57.65	66.11	57.65
f / d		0.94	0.82	0.94	0.82
As		D16@300	D16@300	D22@200	D22@200
	cm2	6.61	6.61	19.40	19.40
As'		D16@300	D16@300	D22@200	D22@200
	cm2	6.61	6.61	19.40	19.40
As' / As		1.00	1.00	1.00	1.00
n		15.00	15.00	15.00	15.00
np=n.As/(bd)		0.014	0.014	0.042	0.042
C		5.31	3.98	4.09	3.43
S		7.34	2.57	3.63	1.61
Z		1.16	1.25	1.21	1.28
Sigma c	kg/cm2	53.3	34.0	41.1	29.4
Sigma s	kg/cm2	1106.2	329.7	546.6	206.6
Tau	kg/cm2	0.5	2.3	0.6	2.3
Sigma ca	kg/cm2	210.0	210.0	210.0	210.0
Sigma sa	kg/cm2	3000.0	3000.0	3000.0	3000.0
Tau a	kg/cm2	18.0	18.0	18.0	18.0
Case Note					

As, As'	:	Sectional area of reinforcement bar (cm^2)
Sigma C	:	Stress in concrete (kg/cm^2)
Sigma S	:	Stress in reinforcement bar (kg/cm^2)
Tau	:	Shearing stress in concrete (kg/cm^2)
Sigma Ca	:	Allowable stress for concrete (kg/cm^2)
Sigma Sa	:	Allowable stress for reinforcement bar (kg/cm^2)
Tau a	:	Allowable shearing stress for concrete (kg/cm^2)

Table 3.2.7(1): STRUCTURAL ANALYSIS OF INLET PORTAL (SECTION A-A)

NOTES; * MEANS MAXIMUM STEEL AREA

MEM	CASE	POINT	SIGN	B	H	D1	D2	N	S	M	AS	ASD	SIGC	SIGS	TAU	SIGCA	SIGSA	SIGTAU
1	1	(1)		100.0	200.0	190.0	10.0	67.4	5.5	23.3	0.00	0.00	6.9	0.0	0.4	105.0	2700.0	12.8
1	1	MAX						68.7	0.0	22.1	0.00	0.00	6.8	0.0	0.0			
1	1	(2)						71.2	22.1	38.3	0.00	0.00	9.3	0.0	1.6			
1	2	(1)		100.0	200.0	190.0	10.0	354.7	84.8	149.2	0.01	0.00	40.8	56.9	6.4	105.0	2700.0	12.8
1	2	MAX						352.8	0.0	106.4	0.00	0.00	33.6	0.0	0.0			
1	2	(2)	*					349.6	82.8	146.1	0.01	0.00	40.0	52.9	6.3			
2	1	(2)		100.0	200.0	190.0	10.0	66.0	34.7	38.3	0.00	0.00	9.0	0.0	2.5	105.0	2700.0	12.8
2	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
2	1	(3)						62.6	20.9	5.0	0.00	0.00	3.9	0.0	1.4			
2	2	(2)	*	100.0	200.0	190.0	10.0	305.7	188.6	146.1	0.01	0.00	39.0	124.8	13.7	105.0	2700.0	12.8
2	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
2	2	(3)						299.9	112.5	34.4	0.00	0.00	20.2	0.0	7.7			
3	1	(3)		100.0	200.0	190.0	10.0	62.6	20.9	5.0	0.00	0.00	3.9	0.0	1.4	105.0	2700.0	12.8
3	1	MAX						57.1	0.0	15.1	0.00	0.00	5.1	0.0	0.0			
3	1	(4)						52.5	15.8	1.9	0.00	0.00	2.9	0.0	1.0			
3	2	(3)		100.0	200.0	190.0	10.0	299.9	112.5	34.4	0.00	0.00	20.2	0.0	7.7	105.0	2700.0	12.8
3	2	MAX	*					291.1	0.0	137.2	0.01	0.00	36.7	109.0	0.0			
3	2	(4)						282.7	102.4	46.5	0.00	0.00	21.1	0.0	7.3			
4	1	(4)		100.0	200.0	190.0	10.0	52.5	15.8	1.9	0.00	0.00	2.9	0.0	1.0	105.0	2700.0	12.8
4	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
4	1	(5)						48.9	27.3	26.2	0.00	0.00	6.4	0.0	2.0			
4	2	(4)		100.0	200.0	190.0	10.0	282.7	102.4	46.5	0.00	0.00	21.1	0.0	7.3	105.0	2700.0	12.8
4	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
4	2	(5)	*					276.4	175.1	134.2	0.01	0.00	35.8	123.9	12.6			
5	1	(5)		100.0	220.0	190.0	10.0	53.9	15.2	26.2	0.00	0.00	5.7	0.0	1.2	105.0	2700.0	12.8
5	1	MAX						52.3	0.0	17.4	0.00	0.00	4.5	0.0	0.0			
5	1	(6)						51.0	10.4	21.7	0.00	0.00	5.0	0.0	0.9			
5	2	(5)		100.0	220.0	190.0	10.0	319.3	71.7	134.2	0.00	0.00	31.1	0.0	5.9	105.0	2700.0	12.8
5	2	MAX						318.0	0.0	101.4	0.00	0.00	27.0	0.0	0.0			
5	2	(6)	*					315.8	82.5	145.4	0.00	0.00	32.4	0.0	6.6			
6	1	(6)		100.0	140.0	130.0	10.0	43.4	28.7	21.7	0.00	0.00	9.7	0.0	3.0	105.0	2700.0	12.8
6	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
6	1	(7)						43.4	17.8	6.2	0.00	0.00	5.0	0.0	1.9			
6	2	(6)	*	100.0	140.0	130.0	10.0	281.6	164.9	145.4	0.01	0.01	102.2	2081.0	14.8	105.0	2700.0	12.8
6	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
6	2	(7)						281.6	99.7	13.4	0.00	0.00	24.2	0.0	9.8			
7	1	(7)		100.0	140.0	130.0	10.0	43.4	17.8	6.2	0.00	0.00	5.0	0.0	1.9	105.0	2700.0	12.8
7	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
7	1	(8)						43.4	6.8	21.0	0.00	0.00	9.5	0.0	0.7			
7	2	(7)		100.0	140.0	130.0	10.0	281.6	99.7	13.4	0.00	0.00	24.2	0.0	9.8	105.0	2700.0	12.8
7	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
7	2	(8)	*					281.6	34.4	93.8	0.01	0.00	51.2	138.9	3.7			
8	1	(8)		100.0	220.0	210.0	10.0	43.4	6.8	21.0	0.00	0.00	4.6	0.0	0.5	105.0	2700.0	12.8
8	1	MAX						43.4	0.0	23.3	0.00	0.00	4.9	0.0	0.0			
8	1	(9)						43.4	17.6	8.0	0.00	0.00	3.0	0.0	1.1			
8	2	(8)		100.0	220.0	210.0	10.0	281.6	34.4	93.8	0.00	0.00	24.4	0.0	2.5	105.0	2700.0	12.8
8	2	MAX						281.6	0.0	104.3	0.00	0.00	25.7	0.0	0.0			
8	2	(9)	*					281.6	100.7	14.2	0.00	0.00	14.6	0.0	6.0			
9	1	(9)		100.0	220.0	210.0	10.0	43.4	17.6	8.0	0.00	0.00	3.0	0.0	1.1	105.0	2700.0	12.8
9	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			

N : Axial force (t)

S : Shearing force (t)

M : Bending moment (t 0m)

AS, ASD : Sectional area of reinforcement bar (cm^2)

SIGC : Stress in concrete kg/cm^2)

SIGS : Stress in reinforcement bar (kg/cm^2)

TAU : Shearing stress in concrete (kg/cm^2)

SIGCA : Allowable stress for concrete (kg/cm^2)

SIGSA : Allowable stress for reinforcement bar (kg/cm^2)

SIGTAU : Allowable shearing stress for concrete (kg/cm^2)

Table 3.2.7 (2): STRUCTURAL ANALYSIS OF INLET PORTAL (SECTION A-A)

NOTES; * MEANS MAXIMUM STEEL AREA

MEM	CASE	POINT	SIGN	B	H	D1	D2	N	S	M	AS	ASD	SIGC	SIGS	TAU	SIGCA	SIGSA	SIGTAU
9	1	(10)						43.4	29.9	20.5	0.00	0.00	4.5	0.0	2.1			
9	2	(9)		100.0	220.0	210.0	10.0	281.6	100.7	14.2	0.00	0.00	14.6	0.0	6.0	105.0	2700.0	12.8
9	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
9	2	(10)	*					281.6	168.3	147.2	0.01	0.00	32.5	103.9	11.1			
10	1	(10)		100.0	220.0	210.0	10.0	51.8	9.5	20.5	0.00	0.00	4.9	0.0	0.7	105.0	2700.0	12.8
10	1	MAX						53.0	0.0	16.9	0.00	0.00	4.5	0.0	0.0			
10	1	(11)						54.7	16.1	26.8	0.00	0.00	5.8	0.0	1.1			
10	2	(10)		100.0	220.0	210.0	10.0	318.1	80.1	147.2	0.00	0.00	32.7	0.0	5.6	105.0	2700.0	12.8
10	2	MAX						320.3	0.0	105.7	0.00	0.00	27.7	0.0	0.0			
10	2	(11)	*					321.6	74.0	140.7	0.00	0.00	32.1	0.0	5.2			
11	1	(11)		100.0	200.0	190.0	10.0	50.1	27.3	26.8	0.00	0.00	6.5	0.0	2.0	105.0	2700.0	12.8
11	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
11	1	(12)						53.7	15.8	1.4	0.00	0.00	2.9	0.0	1.0			
11	2	(11)	*	100.0	200.0	190.0	10.0	279.8	175.1	140.7	0.01	0.00	37.5	154.3	12.5	105.0	2700.0	12.8
11	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
11	2	(12)						286.0	102.4	40.0	0.00	0.00	20.3	0.0	7.2			
12	1	(12)		100.0	200.0	190.0	10.0	53.7	15.8	1.4	0.00	0.00	2.9	0.0	1.0	105.0	2700.0	12.8
12	1	MAX						58.3	0.0	14.6	0.00	0.00	5.1	0.0	0.0			
12	1	(13)						63.8	20.9	5.6	0.00	0.00	4.0	0.0	1.4			
12	2	(12)		100.0	200.0	190.0	10.0	286.0	102.4	40.0	0.00	0.00	20.3	0.0	7.2	105.0	2700.0	12.8
12	2	MAX	*					294.4	0.0	130.7	0.01	0.00	35.3	73.4	0.0			
12	2	(13)						303.3	112.5	27.8	0.00	0.00	19.3	0.0	7.6			
13	1	(13)		100.0	200.0	190.0	10.0	63.8	20.9	5.6	0.00	0.00	4.0	0.0	1.4	105.0	2700.0	12.8
13	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
13	1	(14)						67.2	34.7	38.9	0.00	0.00	9.2	0.0	2.5			
13	2	(13)		100.0	200.0	190.0	10.0	303.3	112.5	27.8	0.00	0.00	19.3	0.0	7.6	105.0	2700.0	12.8
13	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
13	2	(14)	*					309.0	188.6	152.6	0.01	0.00	40.7	153.5	13.5			
14	1	(14)		100.0	200.0	190.0	10.0	72.1	22.9	38.9	0.00	0.00	9.4	0.0	1.7	105.0	2700.0	12.8
14	1	MAX						69.3	0.0	21.3	0.00	0.00	6.7	0.0	0.0			
14	1	(15)						68.3	4.7	22.2	0.00	0.00	6.7	0.0	0.4			
14	2	(14)		100.0	200.0	190.0	10.0	351.9	85.1	152.6	0.01	0.00	41.4	73.6	6.4	105.0	2700.0	12.8
14	2	MAX						355.3	0.0	110.6	0.00	0.00	34.3	0.0	0.0			
14	2	(15)	*					357.1	82.4	151.0	0.01	0.00	41.3	60.4	6.2			
15	1	(16)		100.0	200.0	190.0	10.0	51.6	25.0	17.9	0.00	0.00	5.3	0.0	2.0	105.0	2700.0	12.8
15	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
15	1	(15)						51.6	41.8	22.2	0.00	0.00	5.9	0.0	3.2			
15	2	(16)		100.0	200.0	190.0	10.0	310.8	113.3	30.2	0.00	0.00	20.1	0.0	7.7	105.0	2700.0	12.8
15	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
15	2	(15)	*					310.8	188.7	151.0	0.01	0.00	40.3	140.3	13.6			
16	1	(17)		100.0	200.0	190.0	10.0	51.6	25.4	17.3	0.00	0.00	5.2	0.0	2.1	105.0	2700.0	12.8
16	1	MAX						51.6	0.0	40.3	0.00	0.00	8.6	0.0	0.0			
16	1	(16)						51.6	25.0	17.9	0.00	0.00	5.3	0.0	2.0			
16	2	(17)		100.0	200.0	190.0	10.0	310.8	112.7	31.3	0.00	0.00	20.2	0.0	7.7	105.0	2700.0	12.8
16	2	MAX	*					310.8	0.0	132.5	0.01	0.00	36.1	56.3	0.0			
16	2	(16)						310.8	113.3	30.2	0.00	0.00	20.1	0.0	7.7			
17	1	(1)		100.0	200.0	190.0	10.0	51.6	42.2	23.3	0.00	0.00	6.1	0.0	3.2	105.0	2700.0	12.8
17	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
17	1	(17)						51.6	25.4	17.3	0.00	0.00	5.2	0.0	2.1			
17	2	(1)	*	100.0	200.0	190.0	10.0	310.8	188.1	149.2	0.01	0.00	39.8	130.3	13.6	105.0	2700.0	12.8
17	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
17	2	(17)						310.8	112.7	31.3	0.00	0.00	20.2	0.0	7.7			

Table 3.2.8 (1): STRUCTURAL ANALYSIS OF INLET PORTAL (SECTION B-B)

NOTES; * MEANS MAXIMUM STEEL AREA

MEM	CASE	POINT	SIGN	B	H	D1	D2	N	S	M	AS	ASD	SIGC	SIGS	TAU	SIGCA	SIGSA	SIGTAU
1	1	(1)		100.0	200.0	190.0	10.0	67.2	43.3	76.4	-3.62	0.00	42.4	2700.0	2.4	105.0	2700.0	12.8
1	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
1	1	(2)						64.4	36.8	36.3	0.00	0.00	8.7	0.0	2.7			
1	2	(1)	*	100.0	200.0	190.0	10.0	290.4	273.8	402.5	-38.05	38.05	100.9	2700.0	16.4	105.0	2700.0	12.8
1	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
1	2	(2)						285.6	213.3	159.0	0.01	0.00	42.9	275.9	14.6			
1	3	(1)		100.0	200.0	190.0	10.0	92.4	25.9	78.9	0.01	0.00	42.0	2089.7	1.5	91.0	2340.0	11.1
1	3	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
1	3	(2)						87.6	25.9	53.0	0.01	0.00	14.8	133.7	1.7			
2	1	(2)		100.0	200.0	190.0	10.0	64.4	36.8	36.3	0.00	0.00	8.7	0.0	2.7	105.0	2700.0	12.8
2	1	MAX						54.6	0.0	26.1	0.00	0.00	6.6	0.0	0.0			
2	1	(3)						45.3	28.4	22.5	0.00	0.00	5.6	0.0	2.1			
2	2	(2)		100.0	200.0	190.0	10.0	285.6	213.3	159.0	0.01	0.00	42.9	275.9	14.6	105.0	2700.0	12.8
2	2	MAX						269.2	0.0	200.9	0.01	0.00	70.7	1583.0	0.0			
2	2	(3)						253.0	192.6	129.5	0.01	0.00	34.5	153.9	13.6			
2	3	(2)	*	100.0	200.0	190.0	10.0	87.6	25.9	53.0	0.01	0.00	14.8	133.7	1.7	91.0	2340.0	11.1
2	3	MAX						69.9	0.0	9.2	0.00	0.00	4.9	0.0	0.0			
2	3	(3)						55.0	11.5	29.5	0.00	0.00	7.2	0.0	0.8			
3	1	(3)		100.0	200.0	190.0	10.0	45.3	28.4	22.5	0.00	0.00	5.6	0.0	2.1	105.0	2700.0	12.8
3	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
3	1	(4)						42.2	36.6	58.3	-4.20	0.00	34.8	2700.0	2.0			
3	2	(3)		100.0	200.0	190.0	10.0	253.0	192.6	129.5	0.01	0.00	34.5	153.9	13.6	105.0	2700.0	12.8
3	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
3	2	(4)	*					247.7	251.5	373.9	-40.69	0.00	103.3	2700.0	15.1			
3	3	(3)		100.0	200.0	190.0	10.0	55.0	11.5	29.5	0.00	0.00	7.2	0.0	0.8	91.0	2340.0	11.1
3	3	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
3	3	(4)						49.7	13.3	43.2	0.01	0.00	25.3	1459.9	0.8			
4	1	(4)		100.0	220.0	210.0	10.0	36.6	42.2	58.3	-4.04	0.00	30.9	2700.0	2.1	105.0	2700.0	12.8
4	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
4	1	(5)						36.6	32.6	20.8	0.00	0.00	4.2	0.0	2.2			
4	2	(4)	*	100.0	220.0	210.0	10.0	251.5	247.7	373.9	-31.35	0.00	93.6	2700.0	13.3	105.0	2700.0	12.8
4	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
4	2	(5)						251.5	191.4	154.4	0.01	0.00	34.5	227.2	11.9			
4	3	(4)		100.0	220.0	210.0	10.0	13.3	49.7	43.2	6.31	0.00	21.8	2340.0	2.5	91.0	2340.0	11.1
4	3	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
4	3	(5)						13.3	38.4	0.8	0.00	0.00	0.7	0.0	2.3			
5	1	(5)		100.0	220.0	210.0	10.0	36.6	32.6	20.8	0.00	0.00	4.2	0.0	2.2	105.0	2700.0	12.8
5	1	MAX						36.6	0.0	34.6	0.00	0.00	6.0	0.0	0.0			
5	1	(6)						36.6	32.6	20.8	0.00	0.00	4.2	0.0	2.2			
5	2	(5)		100.0	220.0	210.0	10.0	251.5	191.4	154.4	0.01	0.00	34.5	227.2	11.9	105.0	2700.0	12.8
5	2	MAX						251.5	0.0	171.1	0.01	0.00	39.9	399.4	0.0			
5	2	(6)						251.5	191.4	154.4	0.01	0.00	34.5	227.2	11.9			
5	3	(5)		100.0	220.0	210.0	10.0	13.3	38.4	0.8	0.00	0.00	0.7	0.0	2.3	91.0	2340.0	11.1
5	3	MAX	*					13.3	0.0	66.1	11.30	0.00	26.3	2340.0	0.0			
5	3	(6)						13.3	38.4	0.8	0.00	0.00	0.7	0.0	2.3			
6	1	(6)		100.0	220.0	210.0	10.0	36.6	32.6	20.8	0.00	0.00	4.2	0.0	2.2	105.0	2700.0	12.8
6	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
6	1	(7)						36.6	42.2	58.3	-4.04	0.00	30.9	2700.0	2.1			
6	2	(6)		100.0	220.0	210.0	10.0	251.5	191.4	154.4	0.01	0.00	34.5	227.2	11.9	105.0	2700.0	12.8
6	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			

Table 3.2.8 (2): STRUCTURAL ANALYSIS OF INLET PORTAL (SECTION B-B)

NOTES; * MEANS MAXIMUM STEEL AREA

MEM	CASE	POINT	SIGN	B	H	D1	D2	N	S	M	AS	ASD	SIGC	SIGS	TAU	SIGCA	SIGSA	SIGTAU
6	2	(7)	*					251.5	247.7	373.9	31.35	0.00	93.6	2700.0	13.3			
6	3	(6)		100.0	220.0	210.0	10.0	13.3	36.4	0.8	0.00	0.00	0.7	0.0	2.3	91.0	2340.0	11.1
6	3	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
6	3	(7)						13.3	49.7	43.2	6.31	0.00	21.8	2340.0	2.5			
7	1	(7)		100.0	200.0	190.0	10.0	42.2	36.6	58.3	4.20	0.00	34.8	2700.0	2.0	105.0	2700.0	12.8
7	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
7	1	(8)						45.3	28.4	22.5	0.00	0.00	5.6	0.0	2.1			
7	2	(7)	*	100.0	200.0	190.0	10.0	247.7	251.5	373.9	40.69	0.00	103.3	2700.0	15.1	105.0	2700.0	12.8
7	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
7	2	(8)						253.0	192.6	129.5	0.01	0.00	34.5	153.9	13.6			
7	3	(7)		100.0	200.0	190.0	10.0	49.7	13.3	43.2	0.01	0.00	25.3	1459.9	0.8	91.0	2340.0	11.1
7	3	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
7	3	(8)						55.0	11.5	29.5	0.00	0.00	7.2	0.0	0.8			
8	1	(8)		100.0	200.0	190.0	10.0	45.3	28.4	22.5	0.00	0.00	5.6	0.0	2.1	105.0	2700.0	12.8
8	1	MAX						54.6	0.0	26.1	0.00	0.00	6.6	0.0	0.0			
8	1	(9)						64.4	36.8	36.3	0.00	0.00	8.7	0.0	2.7			
8	2	(8)		100.0	200.0	190.0	10.0	253.0	192.6	129.5	0.01	0.00	34.5	153.9	13.6	105.0	2700.0	12.8
8	2	MAX						269.2	0.0	200.9	0.01	0.00	70.7	1583.0	0.0			
8	2	(9)						285.6	213.3	159.0	0.01	0.00	42.9	275.9	14.6			
8	3	(8)		100.0	200.0	190.0	10.0	55.0	11.5	29.5	0.00	0.00	7.2	0.0	0.8	91.0	2340.0	11.1
8	3	MAX						69.9	0.0	9.2	0.00	0.00	4.9	0.0	0.0			
8	3	(9)	*					87.6	25.9	53.0	0.01	0.00	14.8	133.7	1.7			
9	1	(9)		100.0	200.0	190.0	10.0	64.4	36.8	36.3	0.00	0.00	8.7	0.0	2.7	105.0	2700.0	12.8
9	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
9	1	(10)						67.2	43.3	76.4	3.62	0.00	42.4	2700.0	2.4			
9	2	(9)		100.0	200.0	190.0	10.0	285.6	213.3	159.0	0.01	0.00	42.9	275.9	14.6	105.0	2700.0	12.8
9	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
9	2	(10)	*					290.4	273.8	402.5	-38.05	38.05	100.9	2700.0	16.4			
9	3	(9)		100.0	200.0	190.0	10.0	87.6	25.9	53.0	0.01	0.00	14.8	133.7	1.7	91.0	2340.0	11.1
9	3	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
9	3	(10)						92.4	25.9	78.9	0.01	0.00	42.0	2089.7	1.5			
10	1	(11)		100.0	200.0	190.0	10.0	43.3	44.5	25.3	0.00	0.00	6.0	0.0	3.2	105.0	2700.0	12.8
10	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
10	1	(10)						43.3	57.6	76.4	7.86	0.00	38.5	2700.0	3.2			
10	2	(11)		100.0	200.0	190.0	10.0	273.8	211.8	159.5	0.01	0.00	43.7	339.1	14.3	105.0	2700.0	12.8
10	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
10	2	(10)	*					273.8	274.1	402.5	40.61	40.61	98.7	2700.0	16.4			
10	3	(11)		100.0	200.0	190.0	10.0	25.9	58.8	11.4	0.00	0.00	3.0	0.0	4.5	91.0	2340.0	11.1
10	3	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
10	3	(10)						25.9	76.1	78.9	13.37	0.00	33.8	2340.0	4.3			
11	1	(12)		100.0	200.0	190.0	10.0	43.3	44.5	25.3	0.00	0.00	6.0	0.0	3.2	105.0	2700.0	12.8
11	1	MAX						43.3	0.0	50.4	2.33	0.00	33.4	2700.0	0.0			
11	1	(11)						43.3	44.5	25.3	0.00	0.00	6.0	0.0	3.2			
11	2	(12)		100.0	200.0	190.0	10.0	273.8	211.8	159.5	0.01	0.00	43.7	339.1	14.3	105.0	2700.0	12.8
11	2	MAX						273.8	0.0	200.6	0.01	0.00	68.2	1399.0	0.0			
11	2	(11)						273.8	211.8	159.5	0.01	0.00	43.7	339.1	14.3			
11	3	(12)		100.0	200.0	190.0	10.0	25.9	58.8	11.4	0.00	0.00	3.0	0.0	4.5	91.0	2340.0	11.1
11	3	MAX	*					25.9	0.0	88.6	15.75	0.00	35.6	2340.0	0.0			
11	3	(11)						25.9	58.8	11.4	0.00	0.00	3.0	0.0	4.5			
12	1	(1)		100.0	200.0	190.0	10.0	43.3	57.6	76.4	-7.86	0.00	38.5	2700.0	3.2	105.0	2700.0	12.8
12	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
12	1	(12)						43.3	44.5	25.3	0.00	0.00	6.0	0.0	3.2			
12	2	(1)	*	100.0	200.0	190.0	10.0	273.8	274.1	402.5	-40.61	40.61	98.7	2700.0	16.4	105.0	2700.0	12.8
12	2	MAX						-0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
12	2	(12)						273.8	211.8	159.5	0.01	0.00	43.7	339.1	14.3			
12	3	(1)		100.0	200.0	190.0	10.0	25.9	76.1	78.9	13.37	0.00	33.8	2340.0	4.3	91.0	2340.0	11.1
12	3	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
12	3	(12)						25.9	58.8	11.4	0.00	0.00	3.0	0.0	4.5			

Table 3.2.9 (1): CALCULATION OF INTERNAL STRESS IN REINFORCED CONCRETE STRUCTURE: INLET PORTAL SECTION B-B

Member		1	2	3	4	5
Spot		2(outside)	mid(inside)	3(outside)	5(outside)	mid(inside)
M	t.m	159.00	200.90	129.50	154.40	66.10
Q	t	213.30	0.00	192.60	191.40	0.00
N	t	285.60	269.20	253.00	251.50	13.30
b	cm	100.00	100.00	100.00	100.00	100.00
h	cm	200.00	200.00	200.00	220.00	220.00
u	cm	90.00	90.00	90.00	100.00	100.00
d	cm	190.00	190.00	190.00	210.00	210.00
d'	cm					
d' / d		0.00	0.00	0.00	0.00	0.00
M'= M+N.u	t.m	416.04	443.18	357.20	405.90	79.40
M'/(b.d.d)	kg/cm2	11.52	12.28	9.89	9.20	1.80
Q /(b.d)	kg/cm2	11.23	0.00	10.14	9.11	0.00
f = M/N+u	cm	145.67	164.63	141.19	161.39	596.99
f / d		0.77	0.87	0.74	0.77	2.84
As		D19@150	D19@300	D19@150	D19@150	D19@150
	cm2	19.10	9.54	19.10	19.10	19.10
As'						
	cm2	0.00	0.00	0.00	0.00	0.00
As' / As		0.00	0.00	0.00	0.00	0.00
n		15.00	15.00	15.00	15.00	15.00
np=n.As/(bd)		0.015	0.008	0.015	0.014	0.014
C		3.61	4.91		3.63	11.67
S		1.31	5.20		1.36	52.26
Z		1.32	-		1.32	-
Sigma c	kg/cm2	41.6	60.3	32.1 -6.8	33.4	21.0
Sigma s	kg/cm2	225.8	957.1	618.6	188.3	1411.5
Tau	kg/cm2	14.9	0.0	11.6	12.0	0.0
Sigma ca	kg/cm2	105.0	105.0	105.0	105.0	91.0
Sigma sa	kg/cm2	2700.0	2700.0	2700.0	2700.0	2340.0
Tau a	kg/cm2	12.8	12.8	12.8	12.8	11.1
Case		2	2	2	2	3
Note		*				

Table 3.2.9 (2): **CALCULATION OF INTERNAL STRESS IN REINFORCED CONCRETE STRUCTURE: INLET PORTAL SECTION B-B**

Member		11	12
Spot		mid(inside)	12(outside)
M	t.m	88.60	159.50
Q	t	0.00	211.80
N	t	25.90	273.80
b	cm	100.00	100.00
h	cm	200.00	200.00
u	cm	90.00	90.00
d	cm	190.00	190.00
d'	cm		
d'/ d		0.00	0.00
M'= M+N.u	t.m	111.91	405.92
M'/(b.d.d)	kg/cm2	3.10	11.24
Q /(b.d)	kg/cm2	0.00	11.15
f = M/N+u	cm	432.08	148.25
f / d		2.27	0.78
As		3.00	D19@150
	cm2	19.10	19.10
As'			
	cm2	0.00	0.00
As' / As		0.00	0.00
n		15.00	15.00
np=n.As/(bd)		0.015	0.015
C		10.62	3.72
S		41.94	1.58
Z		-	1.31
Sigma c	kg/cm2	32.9	41.8
Sigma s	kg/cm2	1950.4	266.5
Tau	kg/cm2	0.0	14.6
Sigma ca	kg/cm2	91.0	105.0
Sigma sa	kg/cm2	2340.0	2700.0
Tau a	kg/cm2	11.1	12.8
Case		3	2
Note			stirrup *

Table 3.2.10 STRUCTURAL ANALYSIS OF OUTLET TRANSITION

NOTES: * MEANS MAXIMUM STEEL AREA

MEM	CASE	POINT	SIGN	B	H	D1	D2	N	S	M	AS	ASD	SIGC	SIGS	TAU	SIGCA	SIGSA	SIGTAU
1	1	(1)	*	100.0	100.0	90.0	10.0	69.1	39.8	68.0	21.63	0.00	79.1	2340.0	5.0	91.0	2340.0	11.1
1	1	MAX						60.9	0.0	0.4	0.00	0.00	6.3	0.0	0.0			
1	1	(2)						59.8	5.4	0.9	0.00	0.00	6.5	0.0	0.8			
1	2	(1)		100.0	100.0	90.0	10.0	77.3	5.0	41.5	3.69	0.00	73.2	3000.0	0.6	210.0	3000.0	18.0
1	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
1	2	(2)						67.9	5.0	60.8	13.45	0.00	82.4	3000.0	0.6			
2	1	(2)		100.0	100.0	90.0	10.0	59.1	10.2	0.9	0.00	0.00	6.5	0.0	1.4	91.0	2340.0	11.1
2	1	MAX						57.2	0.0	3.4	0.00	0.00	7.8	0.0	0.0			
2	1	(3)						54.5	14.4	5.1	0.00	0.00	8.5	0.0	2.3			
2	2	(2)	*	100.0	100.0	90.0	10.0	66.9	12.8	60.8	13.62	0.00	82.2	3000.0	1.6	210.0	3000.0	18.0
2	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
2	2	(3)						62.2	11.5	36.2	3.94	0.00	66.2	3000.0	1.4			
3	1	(3)		100.0	100.0	90.0	10.0	54.4	14.7	5.1	0.00	0.00	8.5	0.0	2.3	91.0	2340.0	11.1
3	1	MAX						52.5	0.0	3.0	0.00	0.00	7.1	0.0	0.0			
3	1	(4)						50.9	12.1	2.5	0.00	0.00	6.6	0.0	1.8			
3	2	(3)	*	100.0	100.0	90.0	10.0	48.1	41.1	36.2	6.28	0.00	62.5	3000.0	5.0	210.0	3000.0	18.0
3	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
3	2	(4)						44.7	17.3	32.9	5.48	0.00	59.4	3000.0	2.1			
4	1	(4)		100.0	100.0	90.0	10.0	50.2	15.0	2.5	0.00	0.00	6.5	0.0	2.2	91.0	2340.0	11.1
4	1	MAX						49.5	0.0	5.6	0.00	0.00	8.3	0.0	0.0			
4	1	(5)						48.9	13.1	0.6	0.00	0.00	5.2	0.0	1.8			
4	2	(4)		100.0	100.0	90.0	10.0	30.0	37.3	32.9	7.93	0.00	55.3	3000.0	4.5	210.0	3000.0	18.0
4	2	MAX	*					29.0	0.0	64.2	21.21	0.00	75.3	3000.0	0.0			
4	2	(5)						28.8	7.7	62.8	20.68	0.00	74.4	3000.0	0.9			
5	1	(5)		100.0	100.0	90.0	10.0	48.9	13.1	0.6	0.00	0.00	5.2	0.0	1.8	91.0	2340.0	11.1
5	1	MAX						49.5	0.0	5.6	0.00	0.00	8.3	0.0	0.0			
5	1	(6)						50.2	15.0	2.5	0.00	0.00	6.5	0.0	2.2			
5	2	(5)		100.0	100.0	90.0	10.0	28.8	7.7	62.8	20.68	0.00	74.4	3000.0	0.9	210.0	3000.0	18.0
5	2	MAX	*					29.0	0.0	64.2	21.21	0.00	75.3	3000.0	0.0			
5	2	(6)						30.0	37.3	32.9	7.93	0.00	55.3	3000.0	4.5			
6	1	(6)		100.0	100.0	90.0	10.0	50.9	12.1	2.5	0.00	0.00	6.6	0.0	1.8	91.0	2340.0	11.1
6	1	MAX						52.5	0.0	3.0	0.00	0.00	7.1	0.0	0.0			
6	1	(7)						54.4	14.7	5.1	0.00	0.00	8.5	0.0	2.3			
6	2	(6)		100.0	100.0	90.0	10.0	44.7	17.3	32.9	5.48	0.00	59.4	3000.0	2.1	210.0	3000.0	18.0
6	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
6	2	(7)	*					48.1	41.1	36.2	6.28	0.00	62.5	3000.0	5.0			
7	1	(7)		100.0	100.0	90.0	10.0	54.5	14.4	5.1	0.00	0.00	8.5	0.0	2.3	91.0	2340.0	11.1
7	1	MAX						57.2	0.0	3.4	0.00	0.00	7.8	0.0	0.0			
7	1	(8)						59.1	10.2	0.9	0.00	0.00	6.5	0.0	1.4			
7	2	(7)		100.0	100.0	90.0	10.0	62.2	11.5	36.2	3.94	0.00	66.2	3000.0	1.4	210.0	3000.0	18.0
7	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
7	2	(8)	*					66.9	12.8	60.8	13.62	0.00	82.2	3000.0	1.6			
8	1	(8)		100.0	100.0	90.0	10.0	59.8	5.4	0.9	0.00	0.00	6.5	0.0	0.8	91.0	2340.0	11.1
8	1	MAX						60.9	0.0	0.4	0.00	0.00	6.3	0.0	0.0			
8	1	(9)	*					69.1	39.8	68.0	21.63	0.00	79.1	2340.0	5.0			
8	2	(8)		100.0	100.0	90.0	10.0	67.9	5.0	60.8	13.45	0.00	82.4	3000.0	0.6	210.0	3000.0	18.0
8	2	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
8	2	(9)						77.3	5.0	41.5	3.69	0.00	73.2	3000.0	0.6			
9	1	(1)		100.0	100.0	90.0	10.0	39.8	65.5	68.0	27.58	0.00	72.9	2340.0	8.1	91.0	2340.0	11.1
9	1	MAX						39.8	0.0	59.7	22.96	0.00	68.3	2340.0	0.0			
9	1	(9)						39.8	65.5	68.0	27.58	0.00	72.9	2340.0	8.1			
9	2	(1)		100.0	100.0	90.0	10.0	-5.0	67.5	41.5	17.35	0.00	51.3	3000.0	8.0	210.0	3000.0	18.0
9	2	MAX	*					-5.0	0.0	90.1	37.79	0.00	82.5	3000.0	0.0			
9	2	(9)						-5.0	67.5	41.5	17.35	0.00	51.3	3000.0	8.0			

Table 3.2.11: CALCULATION OF INTERNAL STRESS IN REINFORCED CONCRETE STRUCTURE: OUTLET TRANSITION

Member		1	4	4	9	9
Spot		1(outside)	5(outside)	mid(inside)	9(outside)	mid(inside)
M	t.m	68.00	62.80	64.20	68.00	90.10
Q	t	39.80	7.70	0.00	65.50	0.00
N	t	69.10	28.80	29.00	39.80	-5.00
b	cm	100.00	100.00	100.00	100.00	100.00
h	cm	100.00	100.00	100.00	100.00	100.00
u	cm	40.00	40.00	40.00	40.00	40.00
d	cm	90.00	90.00	90.00	90.00	90.00
d'	cm					
d'/ d		0.00	0.00	0.00	0.00	0.00
M'= M+N.u	t.m	95.64	74.32	75.80	83.92	88.10
M'/(b.d.d)	kg/cm2	11.81	9.18	9.36	10.36	10.88
Q /(b.d)	kg/cm2	4.42	0.86	0.00	7.28	0.00
f = M/N+u	cm	138.41	258.06	261.38	210.85	-1762.00
f / d		1.54	2.87	2.90	2.34	-19.58
As		D22@150	D22@150	D22@150	D25@150	D29@150
	cm2	25.80	25.80	25.80	33.80	42.90
As'						
	cm2	0.00	0.00	0.00	0.00	0.00
As' / As		0.00	0.00	0.00	0.00	0.00
n		15.00	15.00	15.00	15.00	15.00
np=n.As/(bd)		0.043	0.043	0.043	0.056	0.072
C		6.33	7.48	7.49	6.56	7.24
S		11.30	17.70	17.80	12.48	16.30
Z		1.14	1.11	-	1.13	-
Sigma c	kg/cm2	74.7	68.6	70.1	67.9	78.8
Sigma s	kg/cm2	2000.5	2436.0	2498.1	1939.1	2659.1
Tau	kg/cm2	5.0	0.9	0.0	8.2	0.0
Sigma ca	kg/cm2	91.0	210.0	210.0	91.0	210.0
Sigma sa	kg/cm2	2340.0	3000.0	3000.0	2340.0	3000.0
Tau a	kg/cm2	11.1	18.0	18.0	11.1	18.0
Case		1	2	2	1	2
Note						

Table 3.2.12: STRUCTURAL ANALYSIS OF OUTLET PORTAL

NOTES: * MEANS MAXIMUM STEEL AREA

MEM	CASE	POINT	SIGN	B	H	D1	D2	N	S	M	AS	ASD	SIGC	SIGS	TAU	SIGCA	SIGSA	SIGTAU
1	1	(1)		100.0	100.0	90.0	10.0	49.3	7.4	6.9	0.00	0.00	9.0	0.0	1.2	70.0	1800.0	8.5
1	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
1	1	(2)	*					45.4	17.0	13.3	0.01	0.00	14.5	96.5	2.4			
2	1	(2)	*	100.0	100.0	90.0	10.0	44.1	20.1	13.3	0.01	0.00	14.7	111.7	2.9	70.0	1800.0	8.5
2	1	MAX						35.0	0.0	4.3	0.00	0.00	6.1	0.0	0.0			
2	1	(3)						29.5	11.9	4.4	0.00	0.00	5.6	0.0	2.0			
3	1	(3)		100.0	100.0	90.0	10.0	29.2	12.4	4.4	0.00	0.00	5.5	0.0	2.1	70.0	1800.0	8.5
3	1	MAX						29.2	0.0	5.7	0.00	0.00	6.3	0.0	0.0			
3	1	(4)	*					29.2	12.4	4.4	0.00	0.00	5.5	0.0	2.1			
4	1	(4)		100.0	100.0	90.0	10.0	29.5	11.9	4.4	0.00	0.00	5.6	0.0	2.0	70.0	1800.0	8.5
4	1	MAX						35.0	0.0	4.3	0.00	0.00	6.1	0.0	0.0			
4	1	(5)	*					44.1	20.1	13.3	0.01	0.00	14.7	111.7	2.9			
5	1	(5)	*	100.0	100.0	90.0	10.0	45.4	17.0	13.3	0.01	0.00	14.5	96.5	2.4	70.0	1800.0	8.5
5	1	MAX						0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0			
5	1	(6)						49.3	7.4	6.9	0.00	0.00	9.0	0.0	1.2			

Table 3.2.13: CALCULATION OF INTERNAL STRESS IN REINFORCED CONCRETE STRUCTURE: OUTLET PORTAL

Member		2
Spot		2(outside)
M	t.m	13.30
Q	t	20.10
N	t	44.10
b	cm	100.00
h	cm	100.00
u	cm	40.00
d	cm	90.00
d'	cm	
d'/ d		0.00
M'= M+N.u	t.m	30.94
M'/(b.d.d)	kg/cm2	3.82
Q /(b.d)	kg/cm2	2.23
f = M/N+u	cm	70.16
f / d		0.78
As		D16@300
	cm2	6.61
As'		
	cm2	0.00
As' / As		0.00
n		15.00
np=n.As/(bd)		0.011
C		3.75
S		1.65
Z		1.30
Sigma c	kg/cm2	14.3
Sigma s	kg/cm2	94.7
Tau	kg/cm2	2.9
Sigma ca	kg/cm2	70.0
Sigma sa	kg/cm2	1800.0
Tau a	kg/cm2	8.5
Case		
Note		

Table 3.2.14: STRUCTURAL ANALYSIS OF STEEL SUPPORT (TUNNEL TYPE-I)

Point	α_i (Degree)	α_i (Radion)	θ_i (Radian)	X_i (m)	Y_i (m)	W_i (ton)	A_i (ton)	SIN $(\theta_i - \theta_{i+1})$	COS $(\theta_i - \alpha_i)$	COS $(\theta_{i+1} \alpha_i)$	$\overline{T}_i$ (ton)	$\overline{F}_i$ (ton)	$\frac{A_i}{\overline{F}_i}$	T_i (ton)
1	90.00	1.57	1.57	0.00	-0.00			0.1189	1.0000	0.9928	1.0000			
2	76.15	1.33	1.45	0.11	0.91	1.59	2.29	0.2393	0.9926	0.9928	0.9998	0.2410	9.51	24.12
3	62.31	1.09	1.21	0.43	1.76	3.08	3.52	0.2393	0.9926	0.9928	0.9996	0.2410	14.59	24.12
4	48.46	0.85	0.97	0.95	2.52	4.40	4.35	0.2393	0.9926	0.9928	0.9994	0.2409	18.06	24.11
5	34.62	0.60	0.73	1.64	3.13	5.47	5.03	0.2393	0.9926	0.9928	0.9992	0.2409	20.87	24.11
6	20.77	0.36	0.48	2.45	3.55	6.21	5.81	0.2393	0.9926	0.9928	0.9990	0.2408	24.13	24.10
7	6.92	0.12	0.14	3.34	3.77	4.92	4.89	0.2401	0.9926	0.9927	0.9989	0.2416	20.03	24.10
8	0.00	0.00		3.80	3.80	0.00								
												MAX	24.13	

where,

- W_i = $\Delta l_i \cdot H \cdot b \cdot \gamma$
- H : Height of rock to act as load (= 1.95 m)
- b : Interval of steel support (= 1.5 m)
- γ : Unit weight of rock (= 2.5 t/m^3)
- A_i : $A_i = W_i \cdot COS\ \alpha_i$ (For $\alpha_i \leqq \phi = 25°$)

$$A_i = \frac{SIN\ 65°}{SIN(115° - \alpha_i)} \cdot W_i \quad (\text{For } \alpha_i > \phi = 25°)$$

- $\overline{T}_{i+1}$ = $\overline{T}_i \cdot COS(\theta_i - \alpha_i) / COS(\theta_{i+1} - \alpha_i)$
- $\overline{F}_i$ = $\overline{T}_i \cdot SIN(\theta_i - \alpha_{i+1}) / COS(\theta_{i+1} - \alpha_i)$
- $\overline{T}_i$ = $\overline{T}_i \cdot (A_i / \overline{F}_i)max$
- Tmax = 24.12 (ton)
- Mmax = 0.86 x Tmax x h = 0.86 x 24.12 x 0.0277 = 0.57 (t•m)

Table 3.2.15: STRUCTURAL ANALYSIS OF STEEL SUPPORT

(TUNNEL TYPE-II)

Point	α_i (Degree)	α_i (Radion)	θ_i (Radian)	X_i (m)	Y_i (m)	W_i (ton)	A_i (ton)	SIN $(\theta_i\text{-}\theta_{i+1})$	COS $(\theta_i\text{-}\alpha_i)$	COS $(\theta_{i\text{-}+1}\alpha_i)$	$\overline{T}_i$ (ton)	$\overline{F}_i$ (ton)	$\frac{A_i}{\overline{F}_i}$	T_i (ton)
1	90.00	1.57	1.57	0.00	-0.00			0.1189	1.0000	0.9928	1.0000			
2	76.15	1.33	1.45	0.11	0.91	2.98	4.32	0.2393	0.9926	0.9928	0.9998	0.2410	17.89	50.98
3	62.31	1.09	1.21	0.43	1.76	5.80	6.61	0.2393	0.9926	0.9928	0.9996	0.2410	27.44	50.97
4	48.46	0.85	0.97	0.95	2.52	8.28	8.19	0.2393	0.9926	0.9928	0.9994	0.2409	33.98	50.96
5	34.62	0.60	0.73	1.64	3.13	10.29	9.45	0.2393	0.9926	0.9928	0.9992	0.2409	39.25	50.95
6	20.77	0.36	0.48	2.45	3.55	11.69	10.93	0.2393	0.9926	0.9928	0.9990	0.2408	45.38	50.94
7	6.92	0.12	0.14	3.34	3.77	12.41	12.32	0.2401	0.9926	0.9927	0.9989	0.2416	50.99	50.94
8	0.00	0.00		3.80	3.80	0.00								
												MAX	50.99	

where,

W_i = $\Delta l_i \cdot H \cdot b \cdot \gamma$

H : Height of rock to act as load (= 5.5 m)

b : Interval of steel support (= 1.50m)

γ : Unit weight of rock (= 2.5 t/m^3)

A_i : $A_i = W_i \cdot \text{COS}\ \alpha_i$ (For $\alpha_i \leqq \phi = 25°$)

$$A_i = \frac{\text{SIN } 65°}{\text{SIN}(115° - \alpha_i)} \cdot W_i \quad (\text{For } \alpha_i > \phi = 25°)$$

$\overline{T}_{i+1}$ = $\overline{T}_i \cdot \text{COS}(\theta_i - \alpha_i) / \text{COS}(\theta_{i+1} - \alpha_i)$

$\overline{F}_i$ = $\overline{T}_i \cdot \text{SIN}(\theta_i - \alpha_{i+1}) / \text{COS}(\theta_{i+1} - \alpha_i)$

$\overline{T}_i$ = $\overline{T}_i \cdot (A_i / \overline{F}_i)\text{max}$

Tmax = 50.98 (ton)

Mmax = 0.86 x Tmax x h = 0.86 x 50.98 x 0.0277 = 1.21 (t•m)

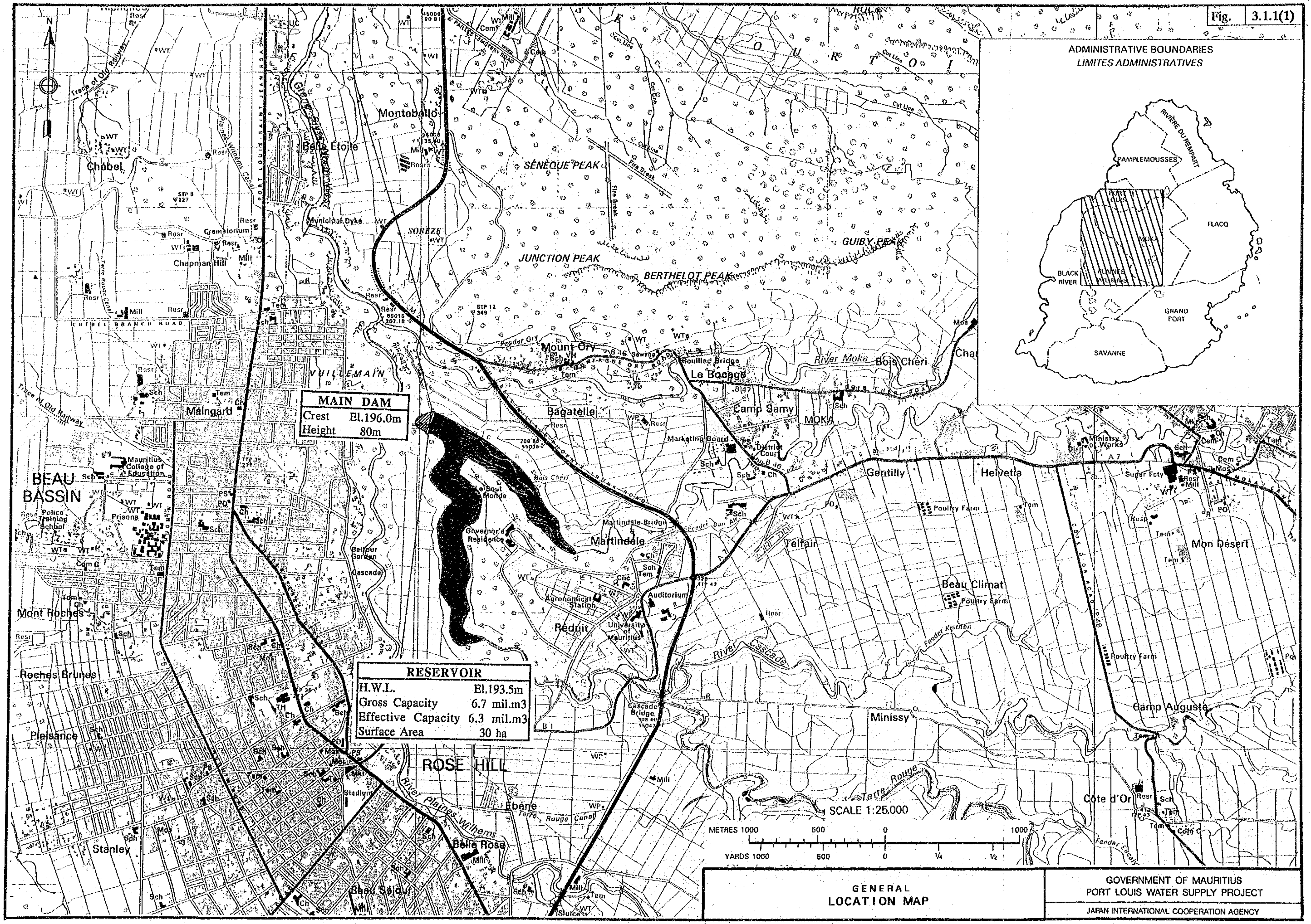
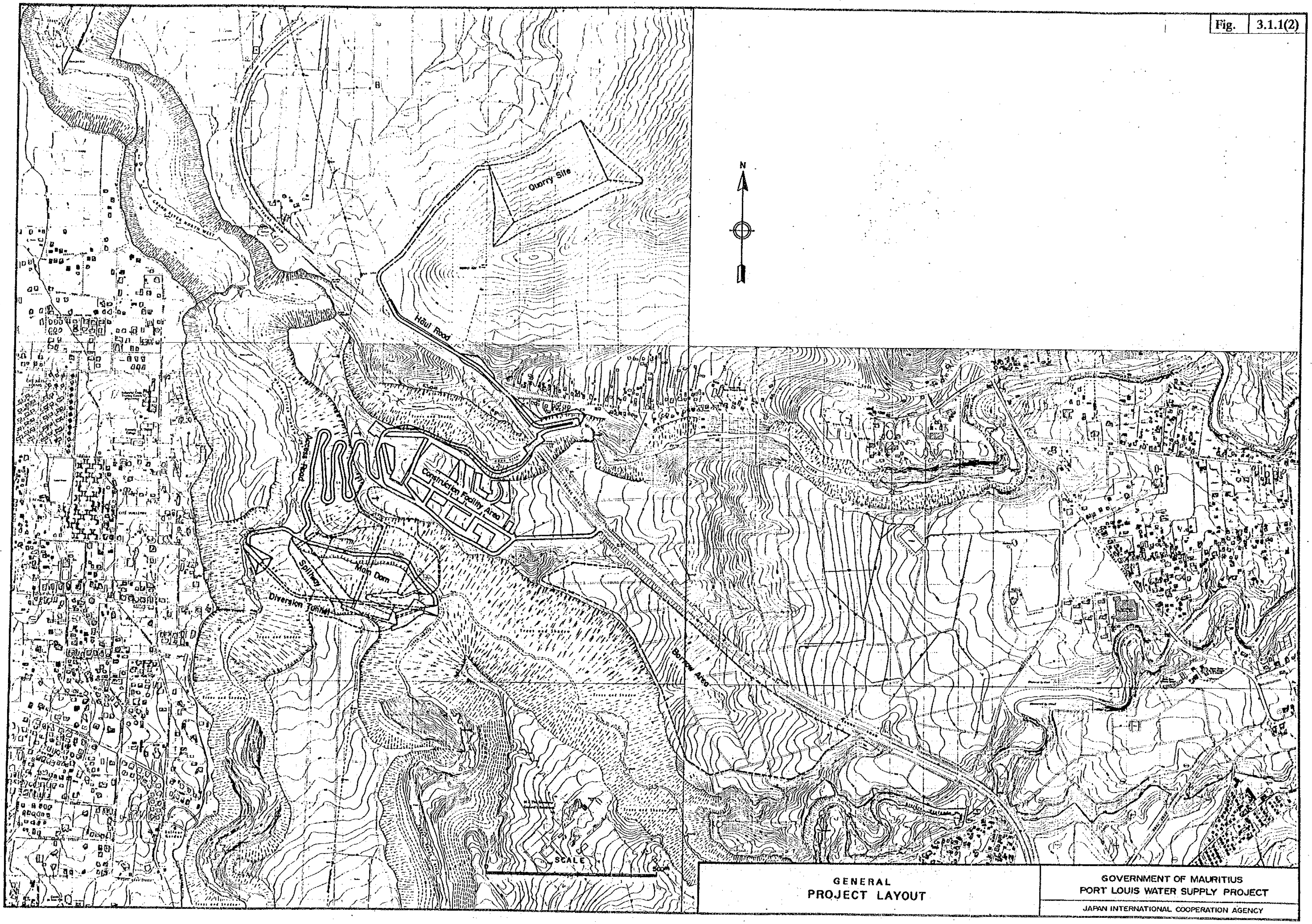


Fig. 3.1.1(1)
ADMINISTRATIVE BOUNDARIES
LIMITES ADMINISTRATIVES
PAMPLEMOUSSES
RIVIERE DU REMPART
FLACQ
MOKA
BLACK RIVER
PLAINES WILHEMS
GRAND PORT
SAVANNE
MAIN DAM
Crest El.196.0m
Height 80m
RESERVOIR
H.W.L. El.193.5m
Gross Capacity 6.7 mil.m3
Effective Capacity 6.3 mil.m3
Surface Area 30 ha
SENEQUE PEAK
JUNCTION PEAK
BERTHELOT PEAK
GUIBY PEAK
Monteballo
Belle Etoile
Chebel
Chapman Hill
Mount Ory
Le Bocage
Bois Cheri
Bagatelle
Camp Samy
MOKA
Gentilly
Helvetia
Telfair
Martindale
Mon Desert
Beau Climat
Reduit
University of Mauritius
Auditorium
Minissy
Camp Auguste
Cote d'Or
Ebene
BEAU BASSIN
Malngard
Mont Roches
Roches Brunes
Plaisance
Stanley
ROSE HILL
Belle Rose
Beau Sejour
River Moka
River Cascade
River Plaines Wilhems
SCALE 1:25,000
METRES 1000 500 0 1000
YARDS 1000 500 0 ¼ ½
GENERAL
LOCATION MAP
GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.1.1(2)

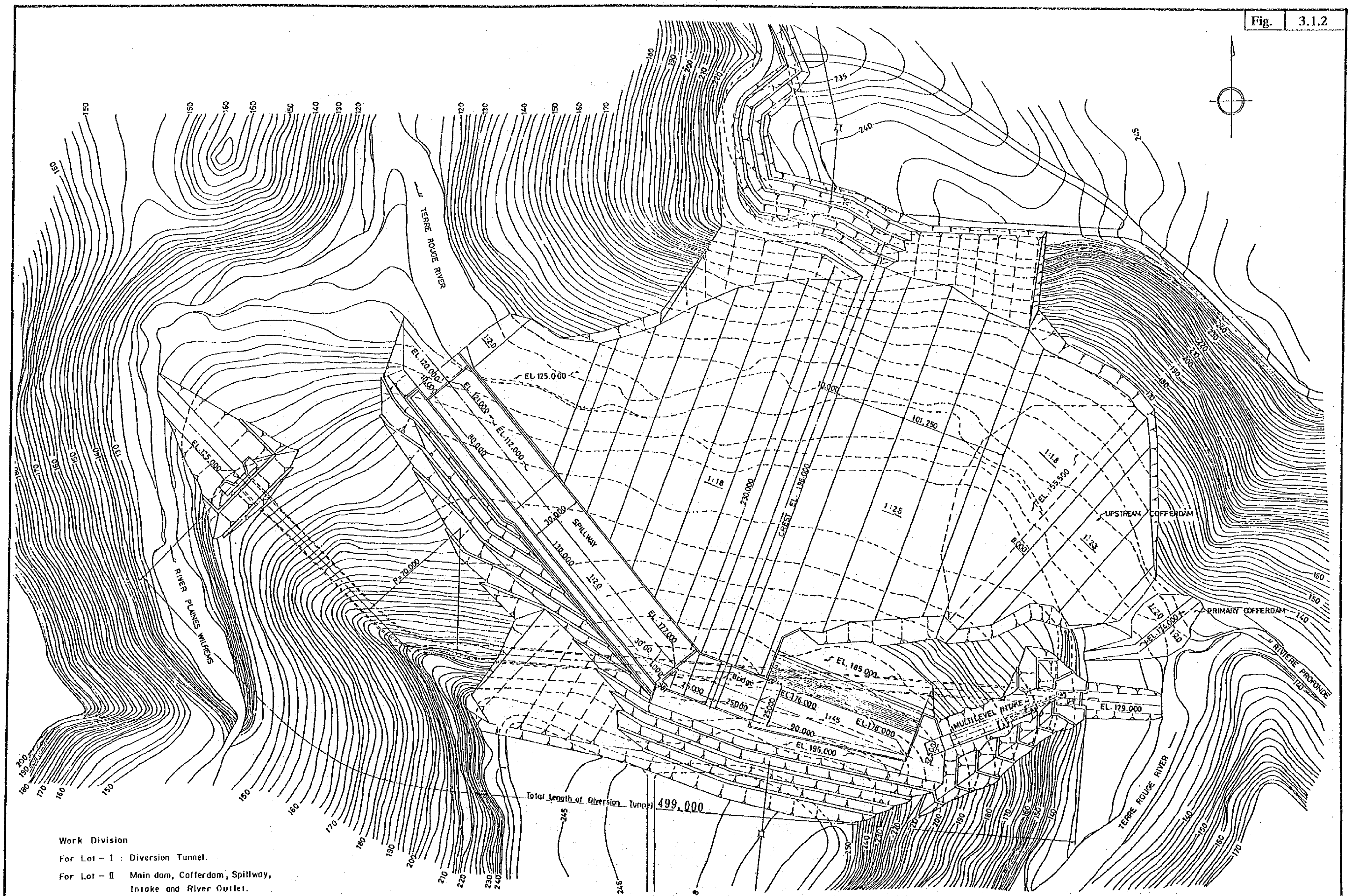


GENERAL
PROJECT LAYOUT

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.1.2



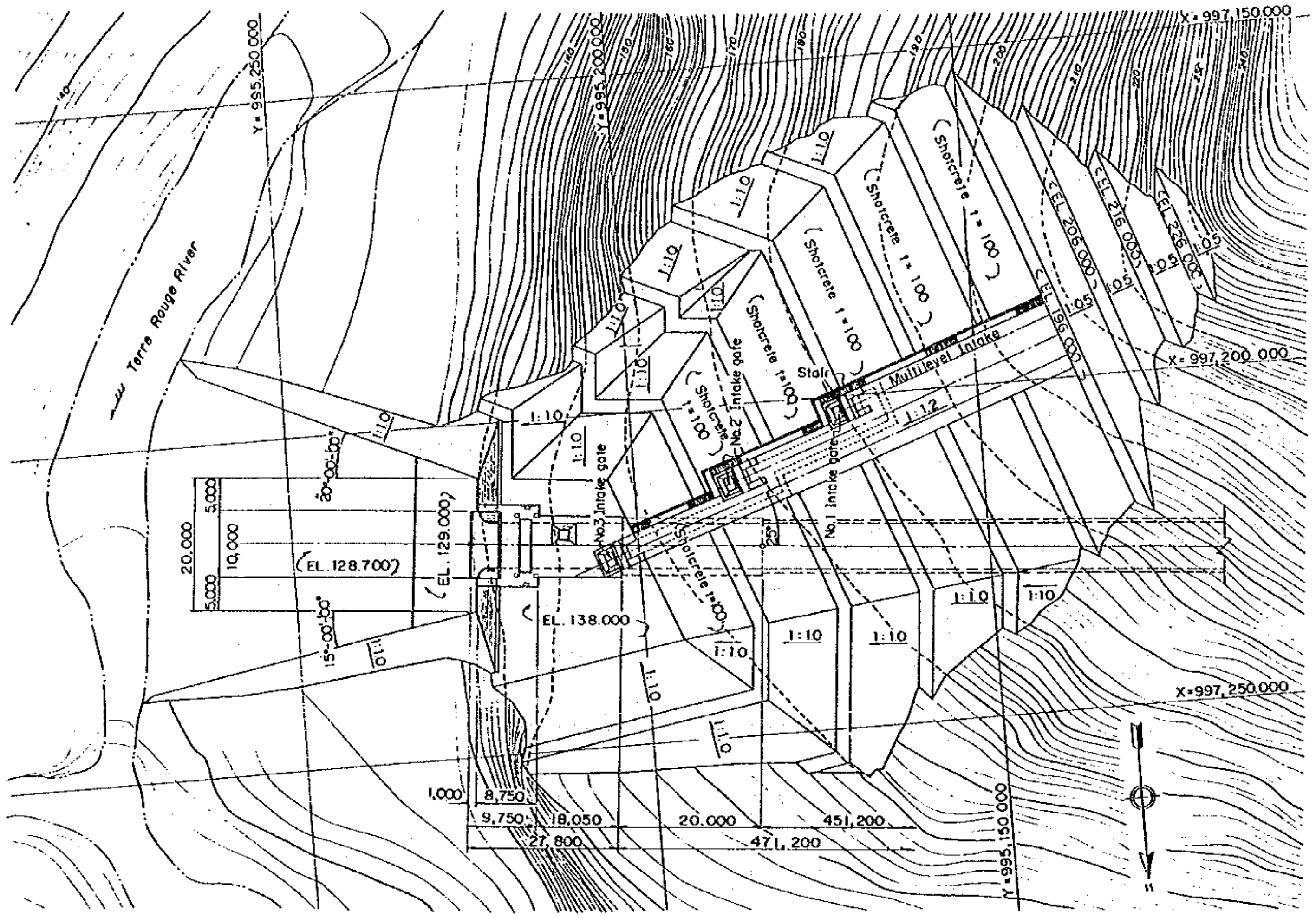
Work Division

For Lot – I : Diversion Tunnel.

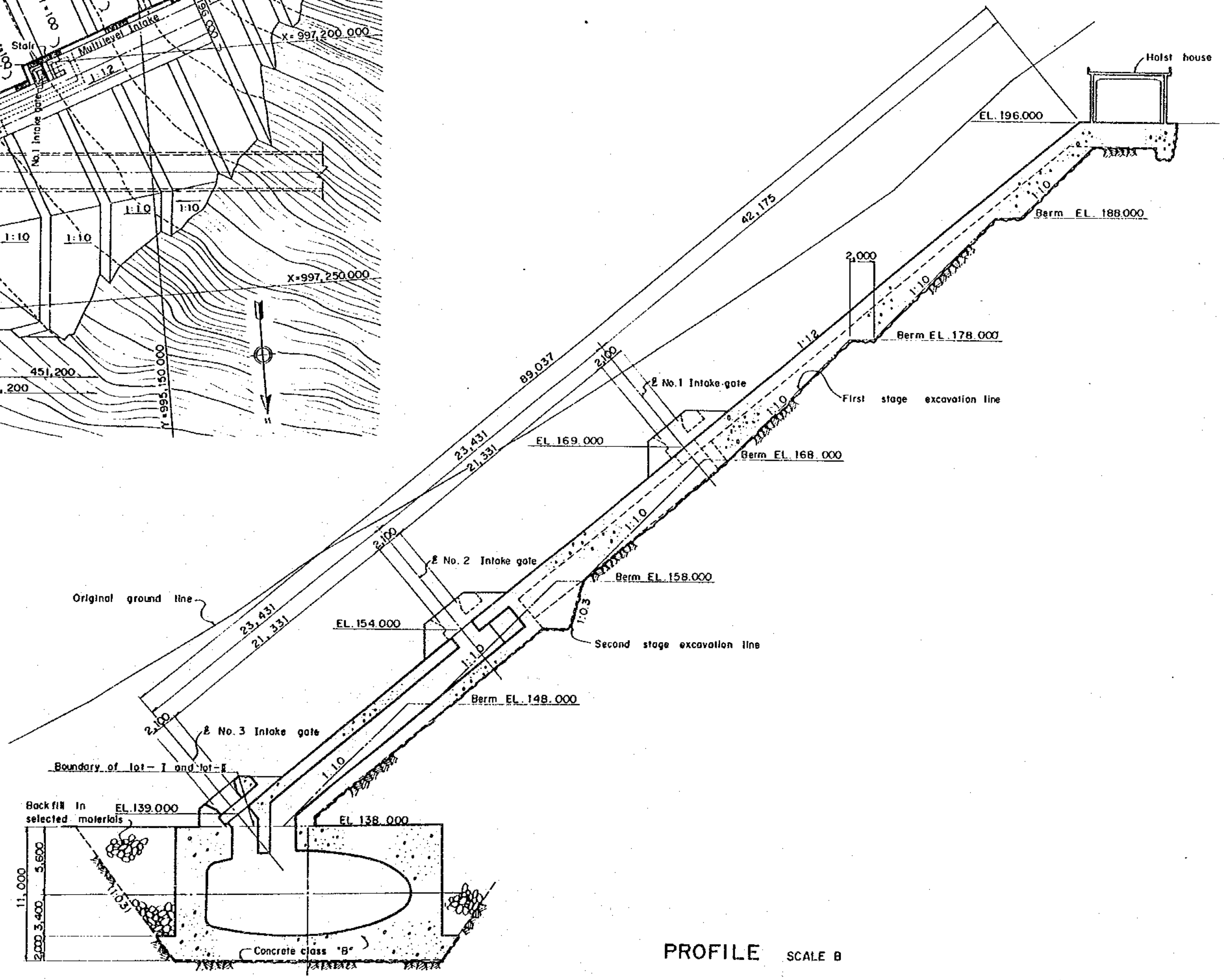
For Lot – II Main dam, Cofferdam, Spillway, Intake and River Outlet.

GENERAL GENERAL PLAN	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.1.3



PLAN SCALE A



PROFILE SCALE B

Note :

The first stage excavation and construction below EL. 138.0m are including Lot - I Contract.

The second stage excavation and construction above EL. 138.0m including intake gate and hoist will be done by Lot-II Contract.

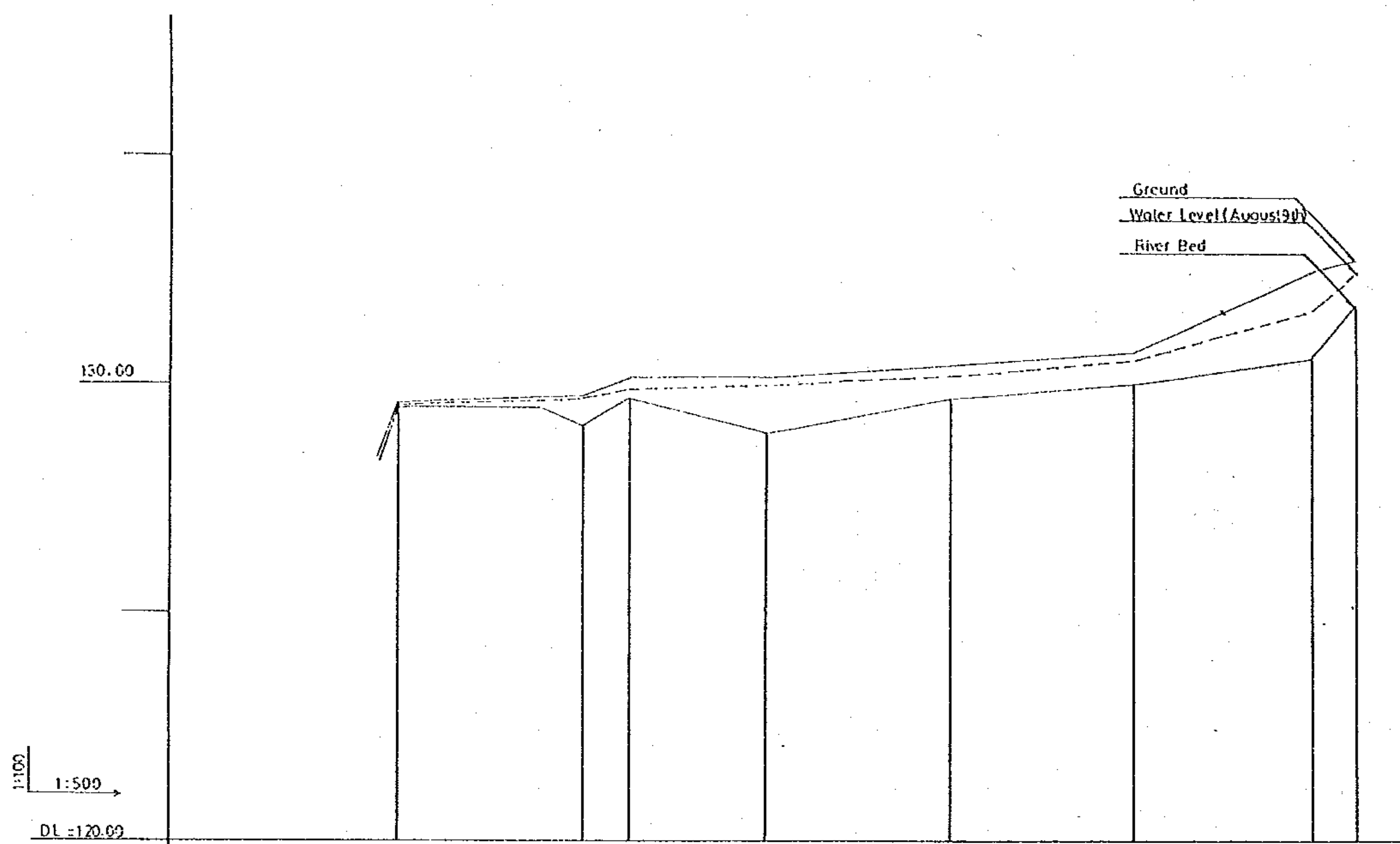
SCALE A 0 — 50m

SCALE B 0 — 20m

GENERAL
INTAKE, PLAN AND PROFILE

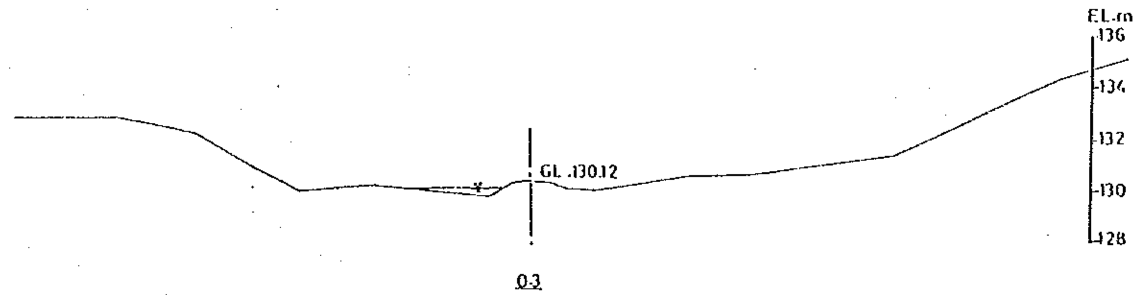
GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY



	0-1	0-2	0-3	0-4	0-5	0-6	0-7	0-8
Ground Elevation	129.55	129.73	130.12	130.14	130.39	130.66	132.40	132.66
River Bed Elevation	129.48	129.05	129.57	128.90	129.56	129.34	130.54	131.70
Cumulated Distance	0.00	20.00	25.00	40.00	60.00	80.00	100.00	105.00
Distance	0.00	20.00	5.00	15.00	20.00	20.00	20.00	5.00
Number	0-1	0-2	0-3	0-4	0-5	0-6	0-7	0-8

Section No. is referred to Fig. 3.2.3

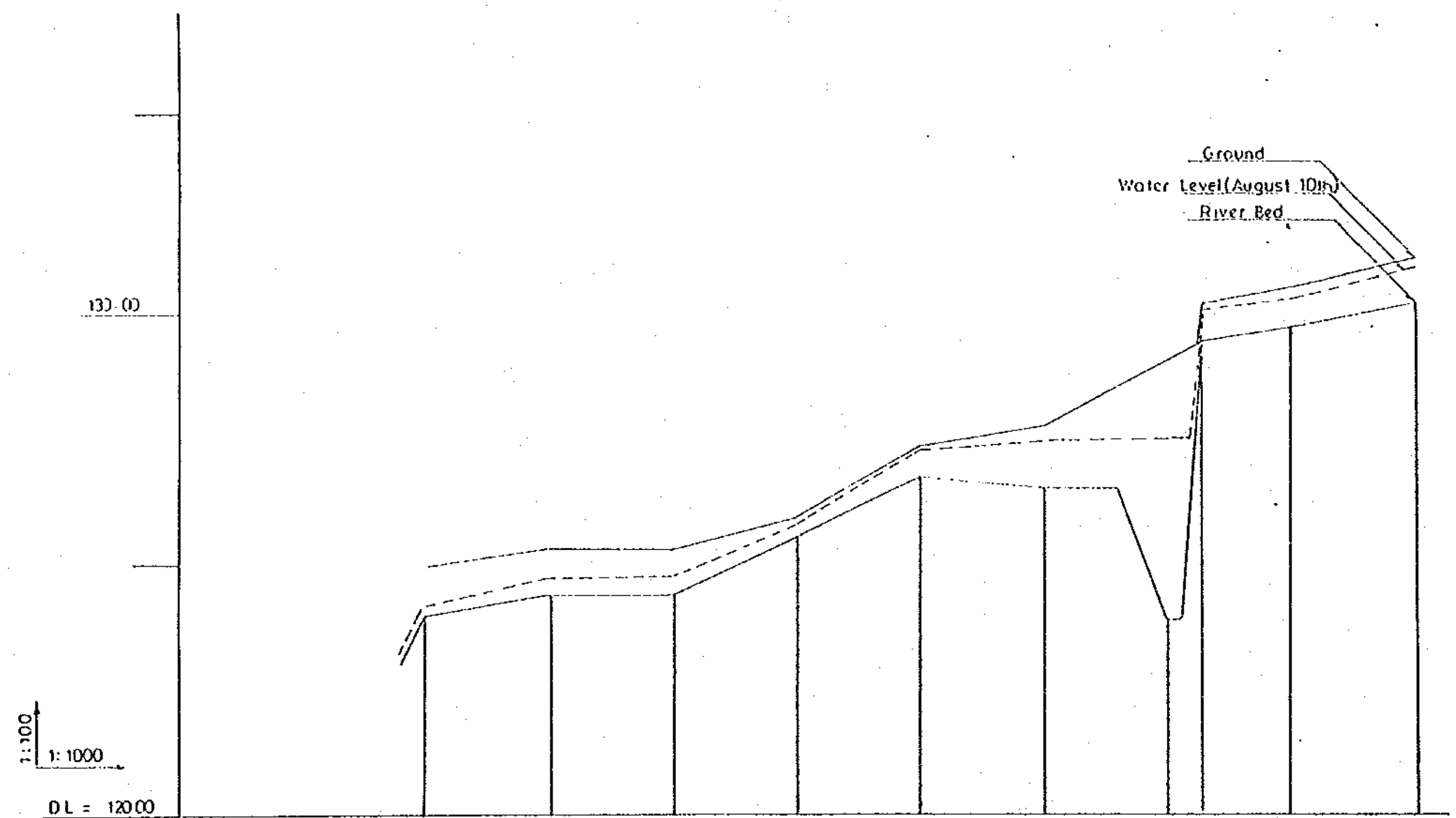


SECTION

TERRE ROUGE RIVER AT DIVERSION
PROFILE AND SECTION

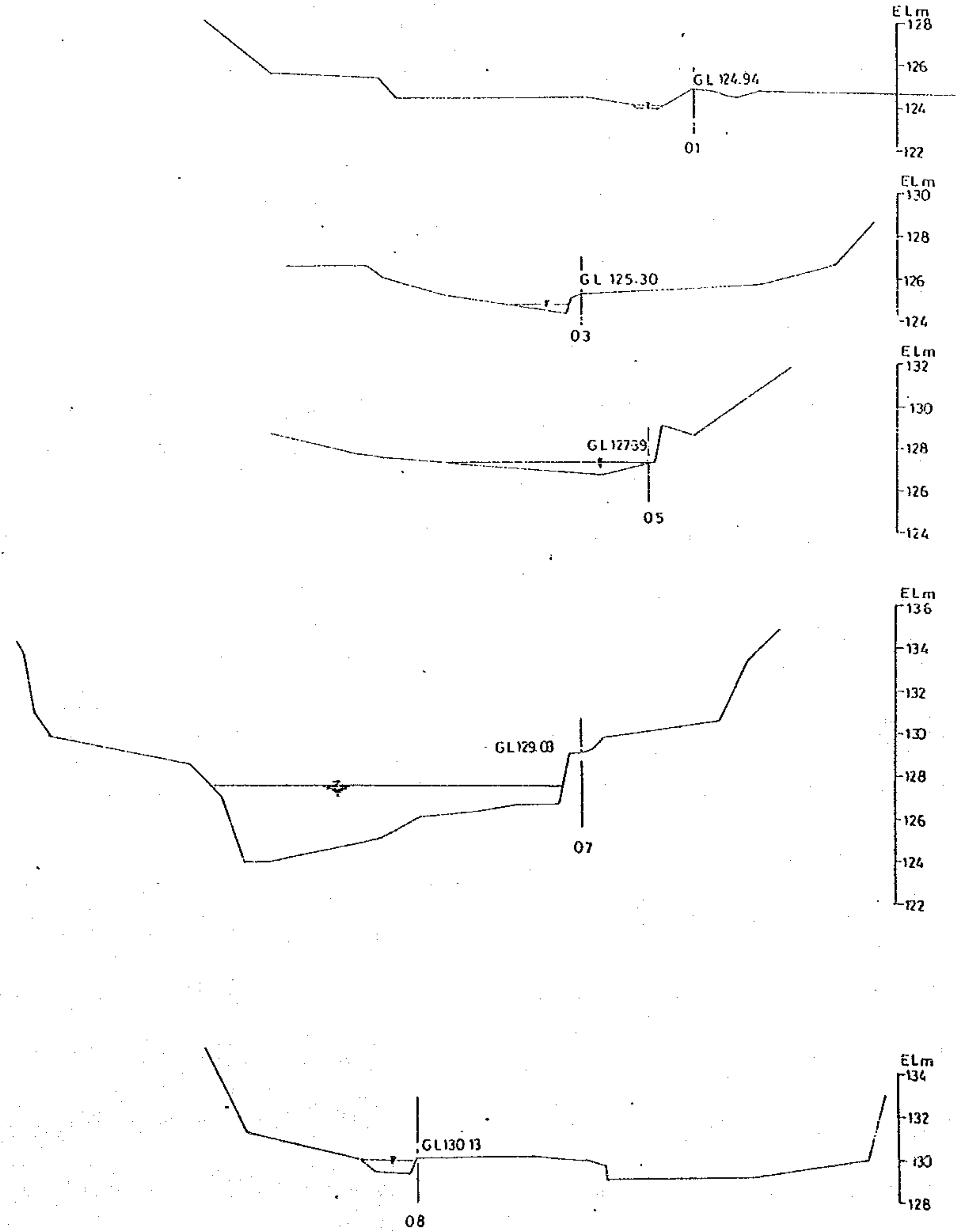
GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.2



	01	02	03	04	05	06	07	08	09	10
Ground Elevation	124.94	125.32	125.30	125.95	127.30	127.73	129.03	130.13	130.49	131.09
River Bed Elevation	123.99	124.42	124.47	125.59	126.77	126.51	123.80	129.42	129.86	130.20
Cumulated Distance	0.00	25.00	50.00	75.00	100.00	125.00	150.00	157.00	175.00	200.00
Distance	0.00	25.00	25.00	25.00	25.00	25.00	25.00	7.00	18.00	25.00
Number	01	02	03	04	05	06	07	08	09	10

Section No. is referred to Fig. 3.2.3

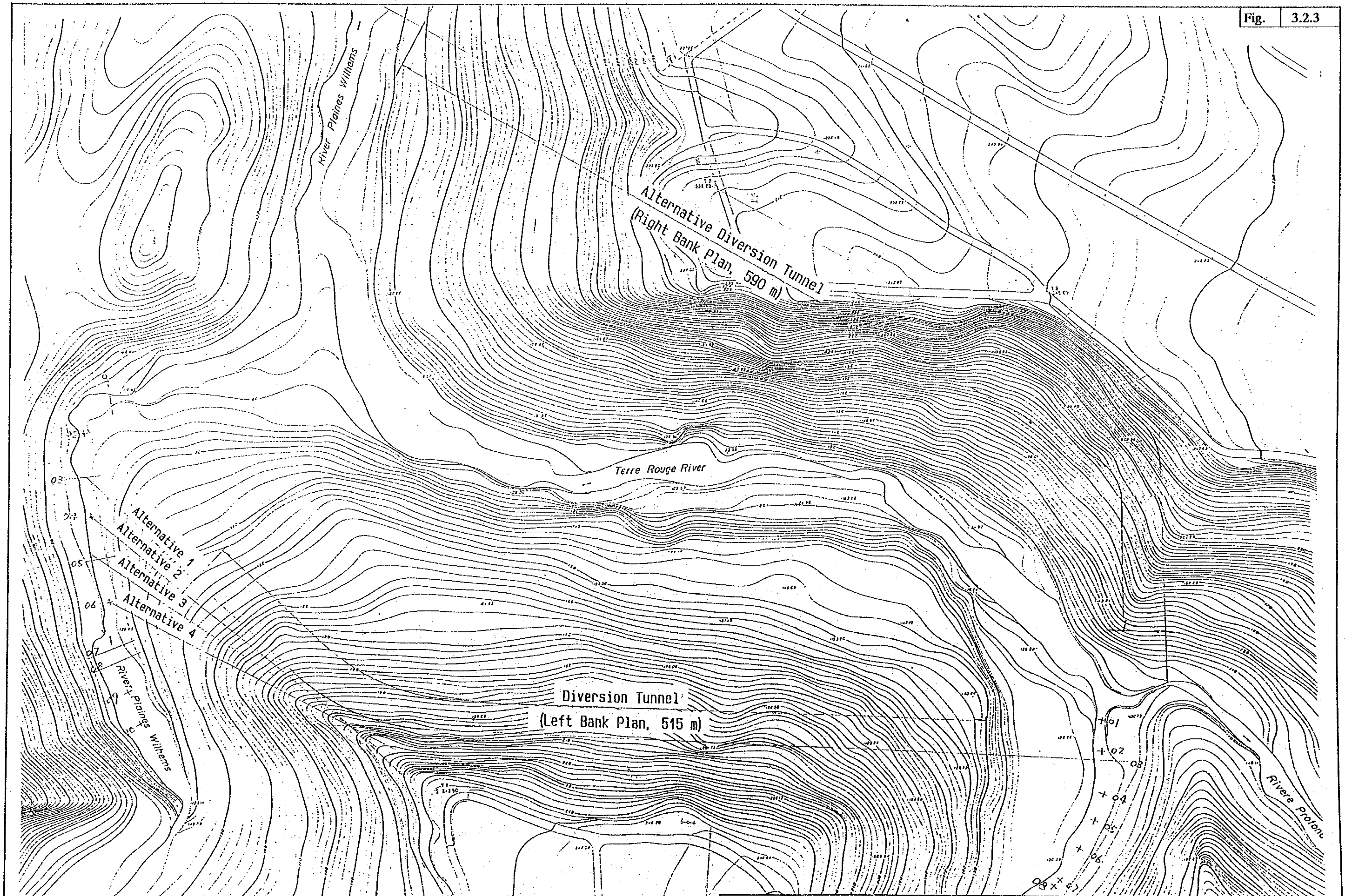


SECTION

RIVER PLAINES WILHEMS AT DIVERSION
PROFILE AND SECTION

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

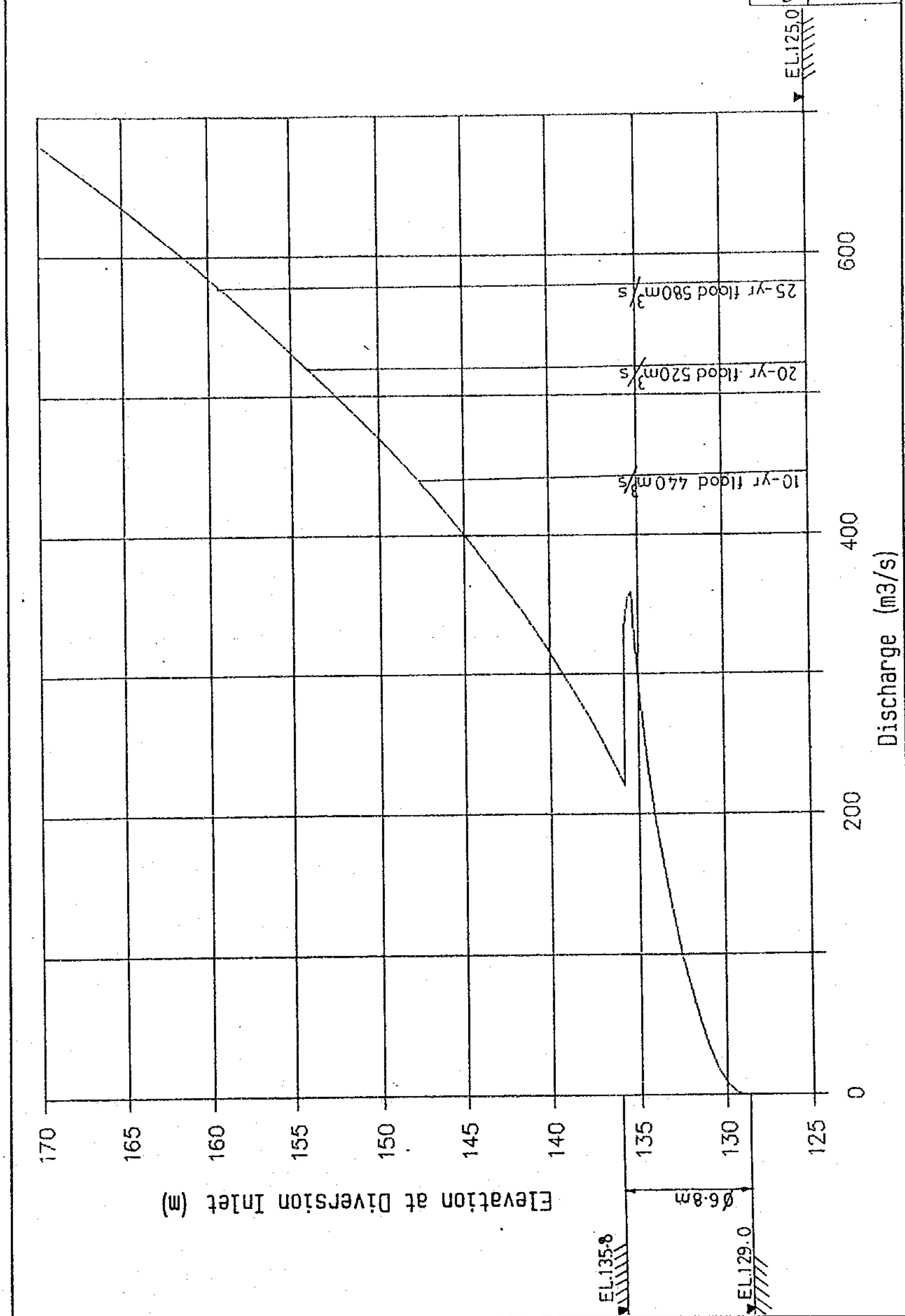
Fig. 3.2.3



RIVER DIVERSION (1)
ALTERNATIVE ALIGNMENT

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.4

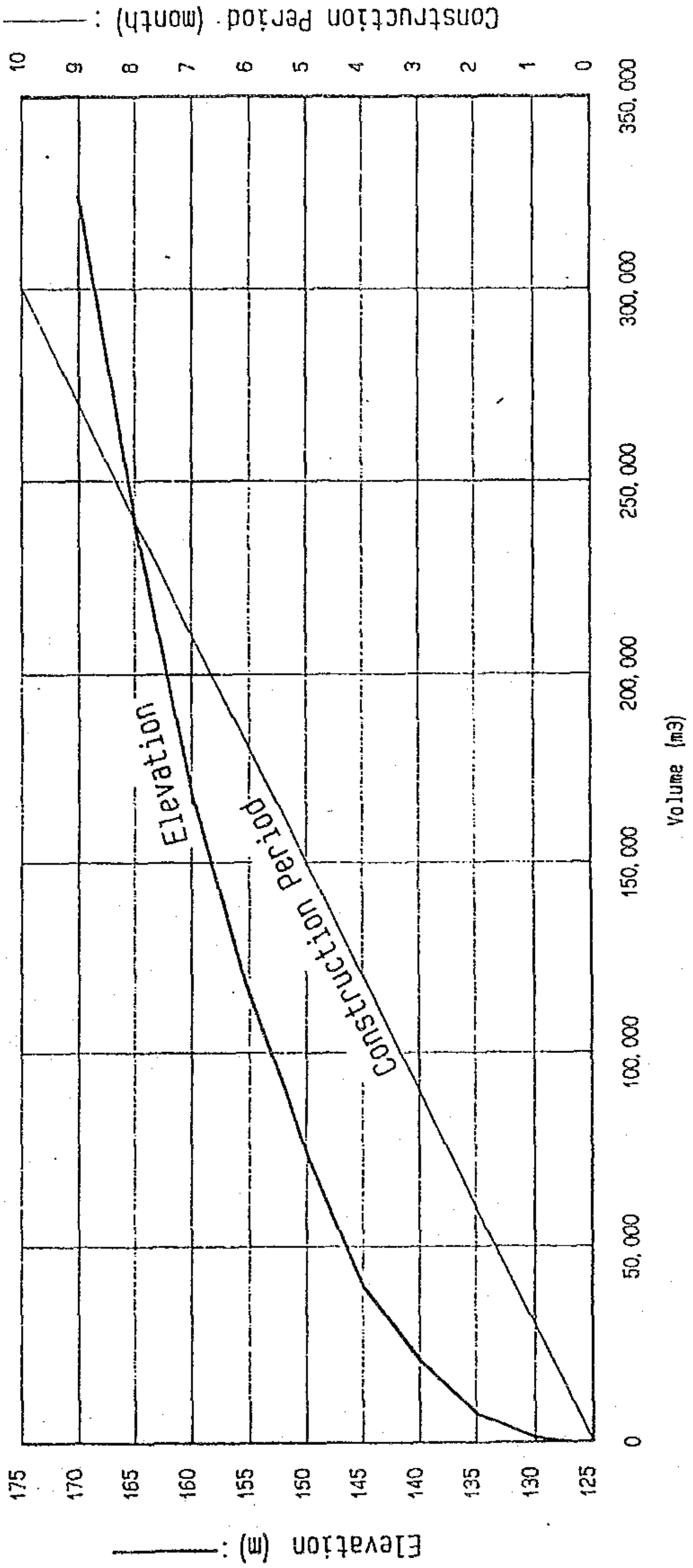


Tunnel Discharge Curve

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.5

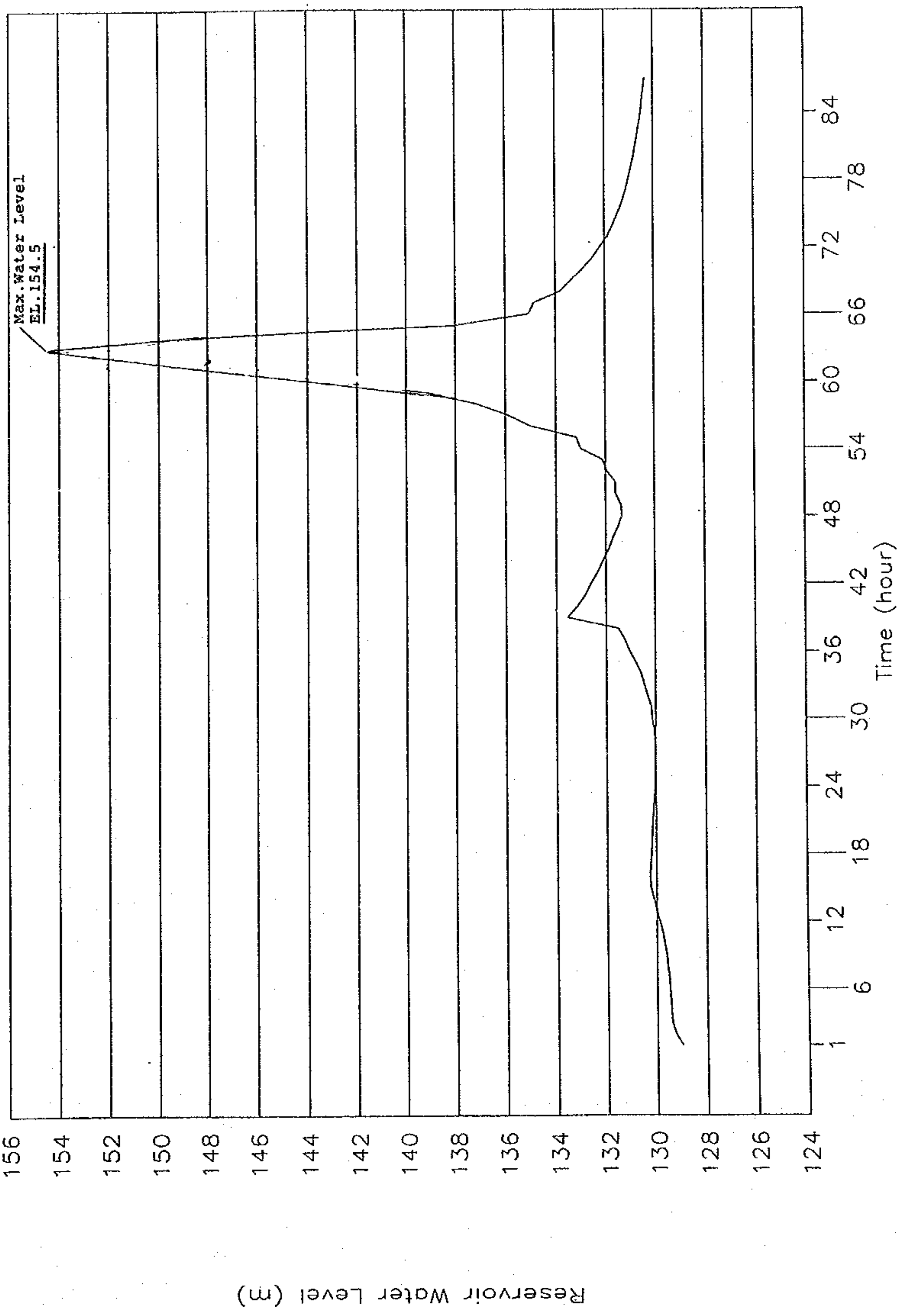


Cofferdam Volume Curve

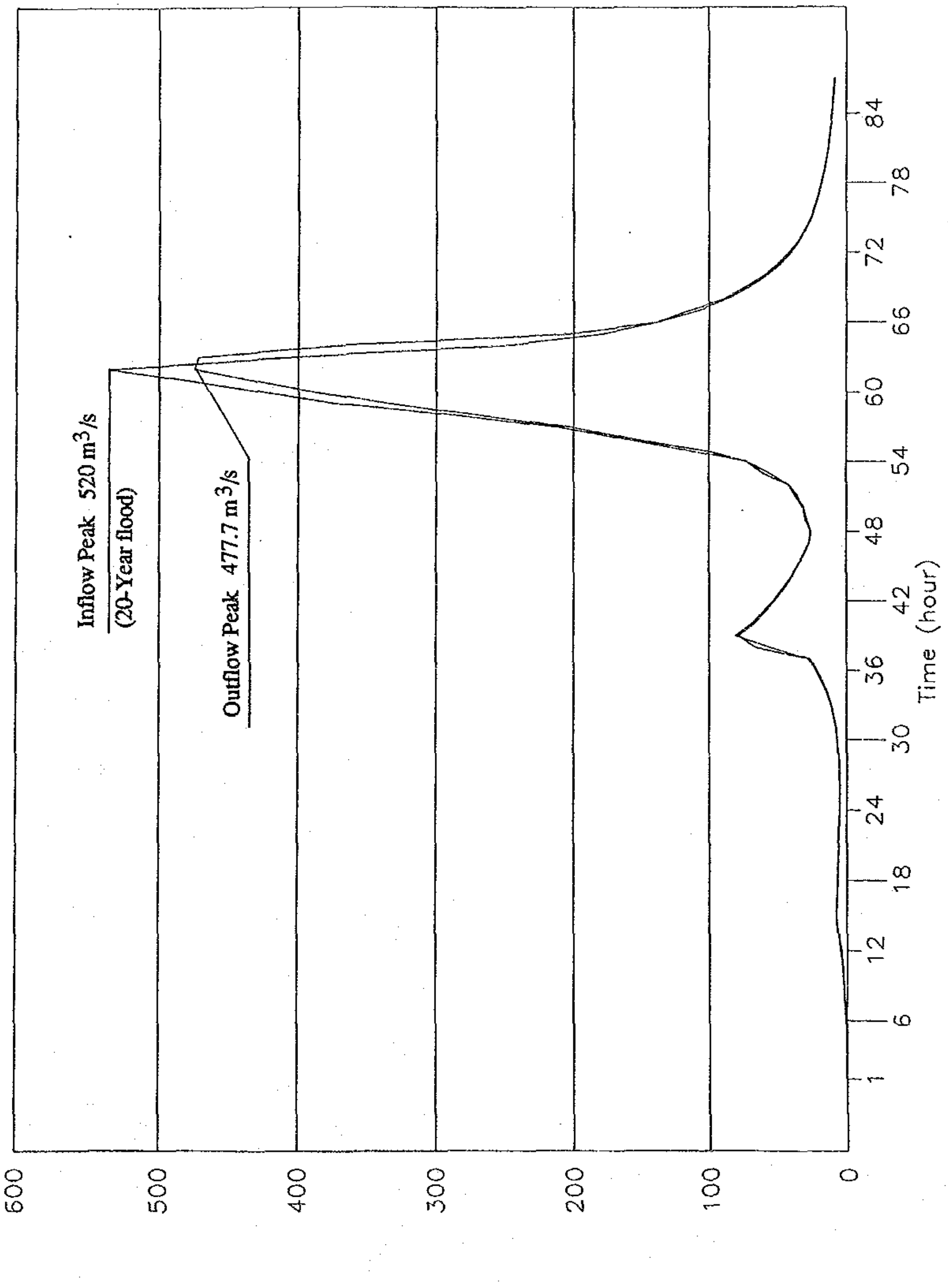
GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.6



WATER LEVEL RISE FOR DIVERSION DESIGN FLOOD	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY

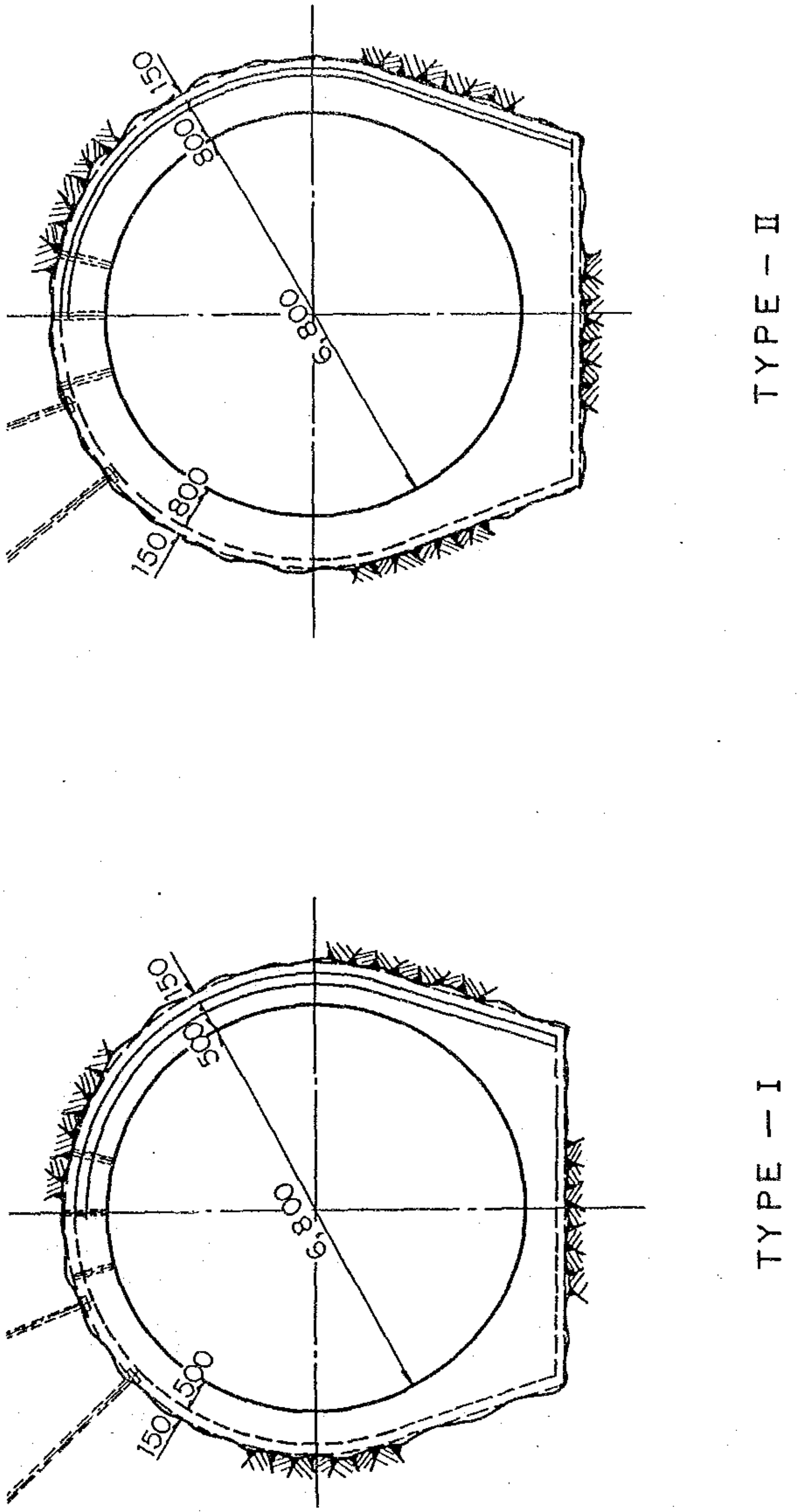


DIVERSION TUNNEL DISCHARGE FOR DIVERSION DESIGN FLOOD

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

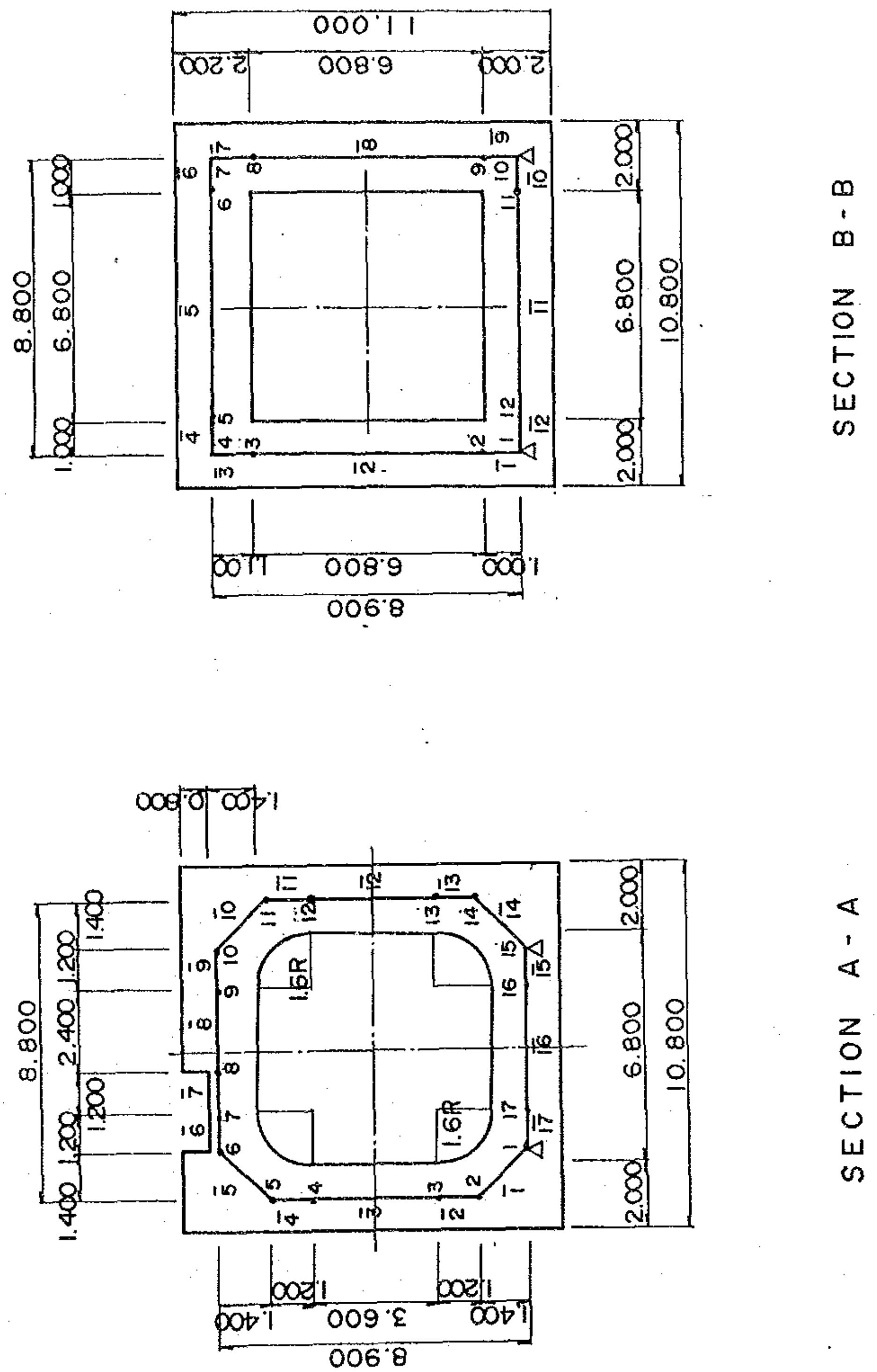
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.8



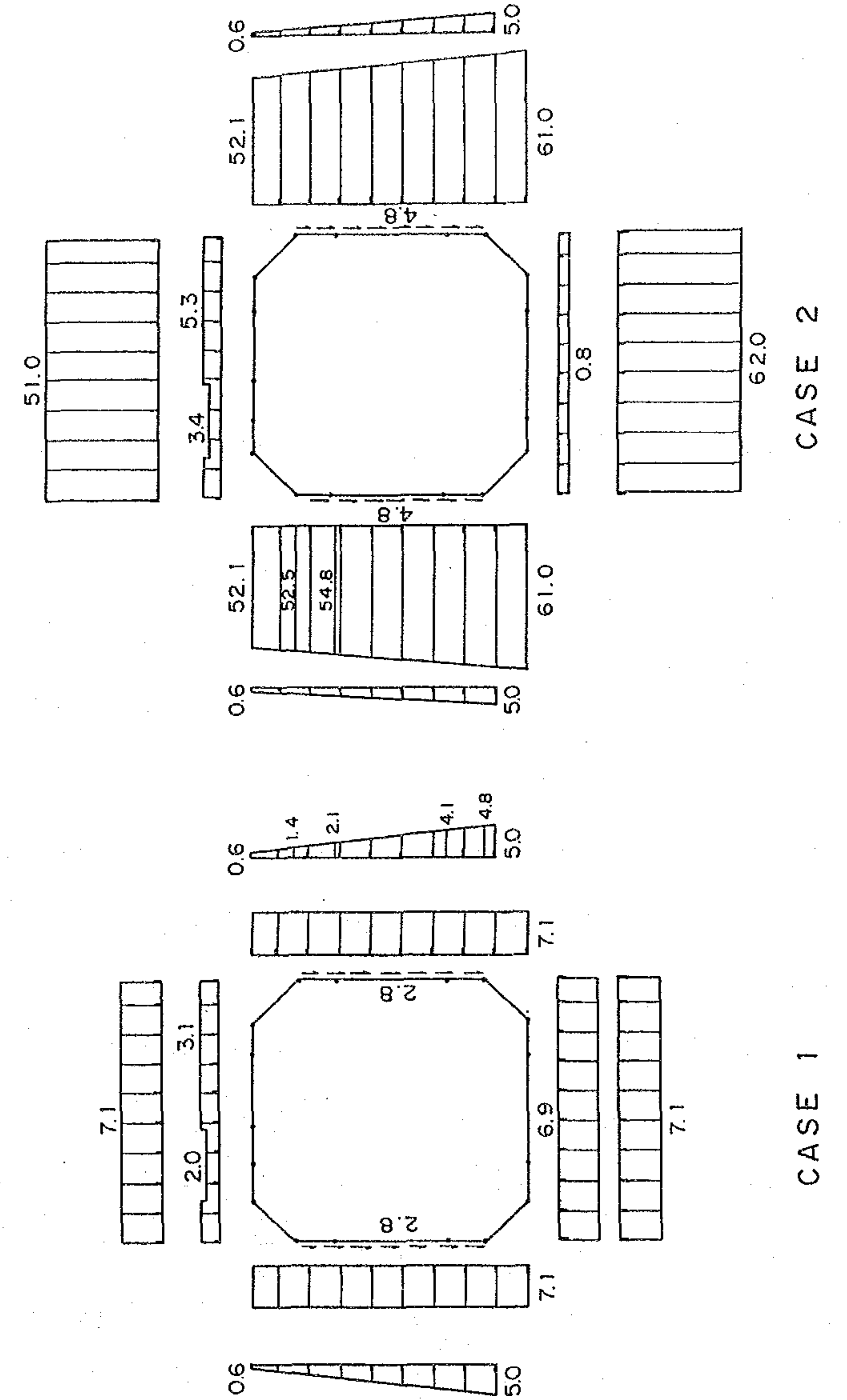
Types of diversion tunnel	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.	3.2.9



Section and dimension of inlet portal	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT
	JAPAN INTERNATIONAL COOPERATION AGENCY

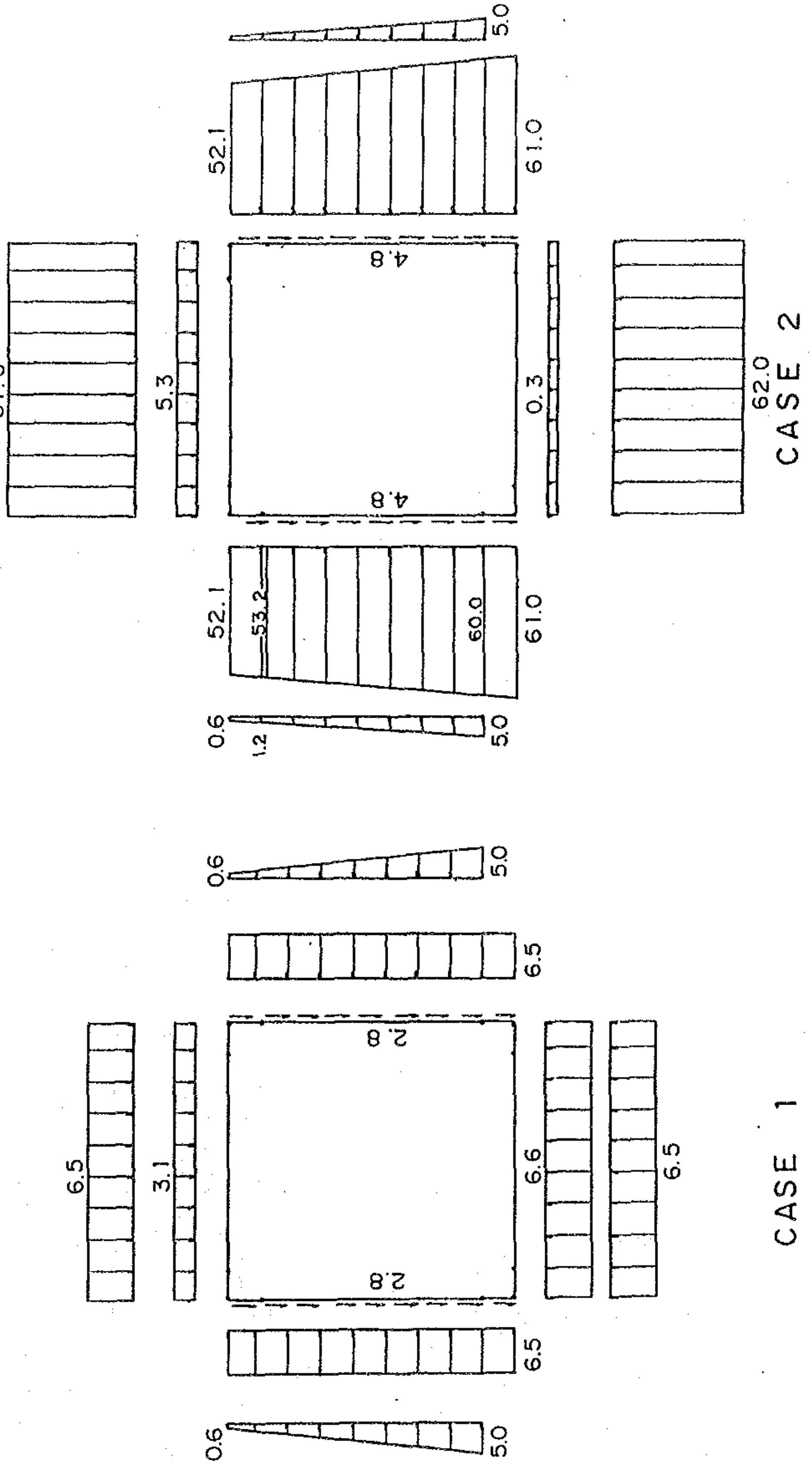
Fig. 3.2.10



Loading diagram of inlet portal (section A-A)

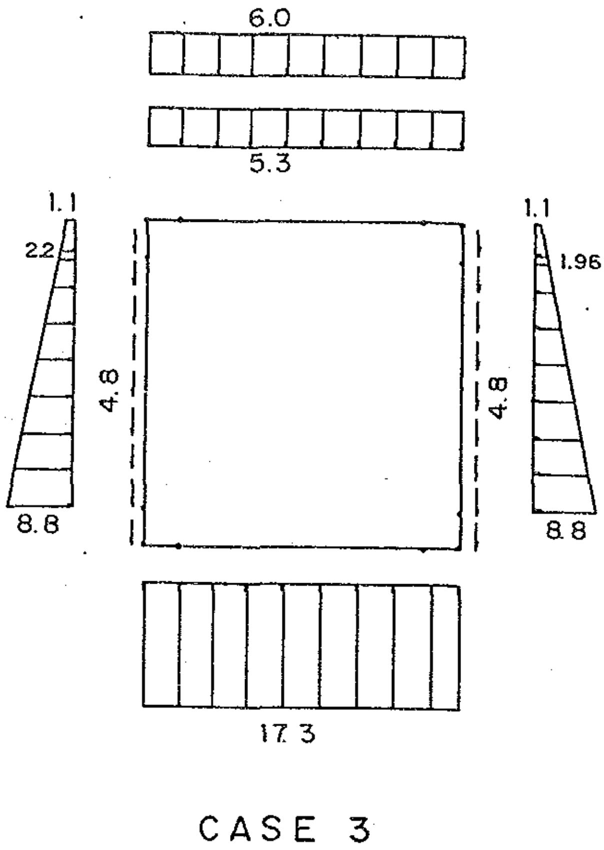
GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY



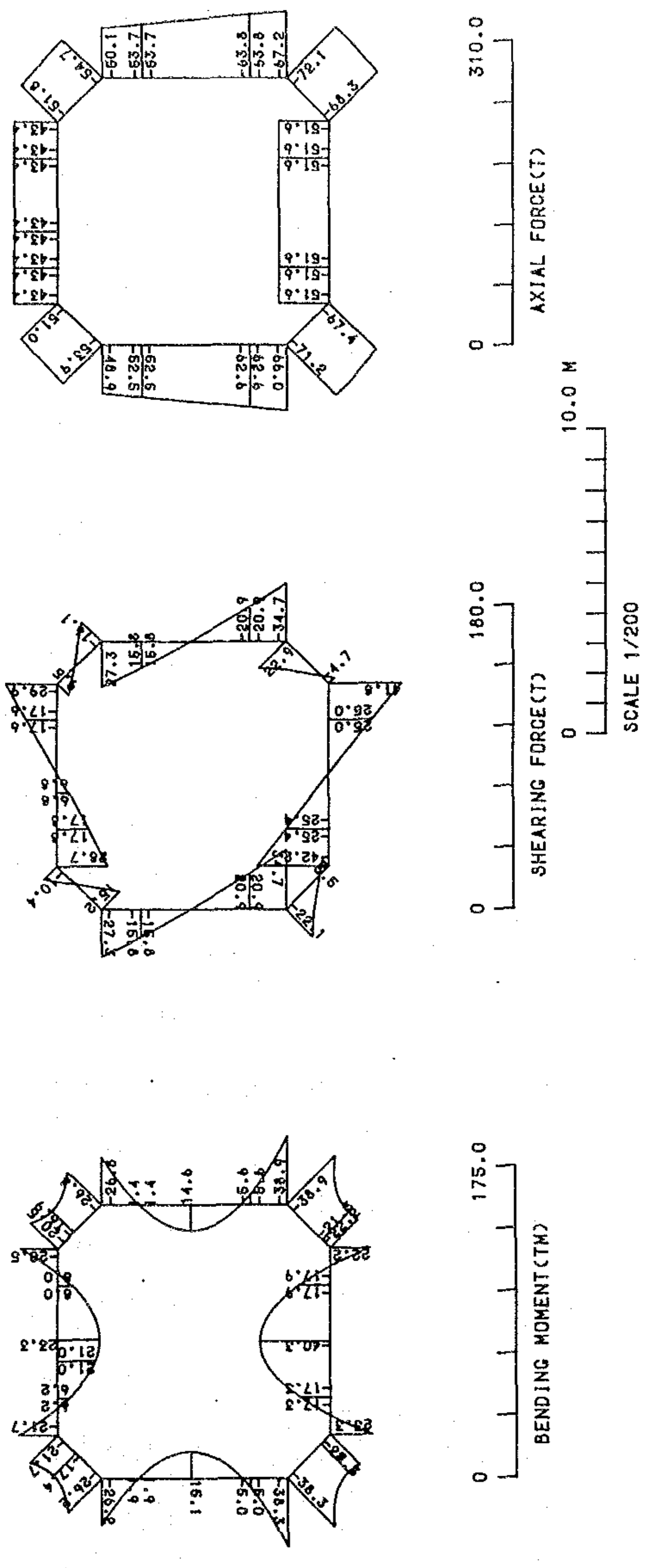
Loading diagram of inlet portal (section B-B)	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.	3.2.11(2)



Loading diagram of inlet portal (section B-B)	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT
	JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.12

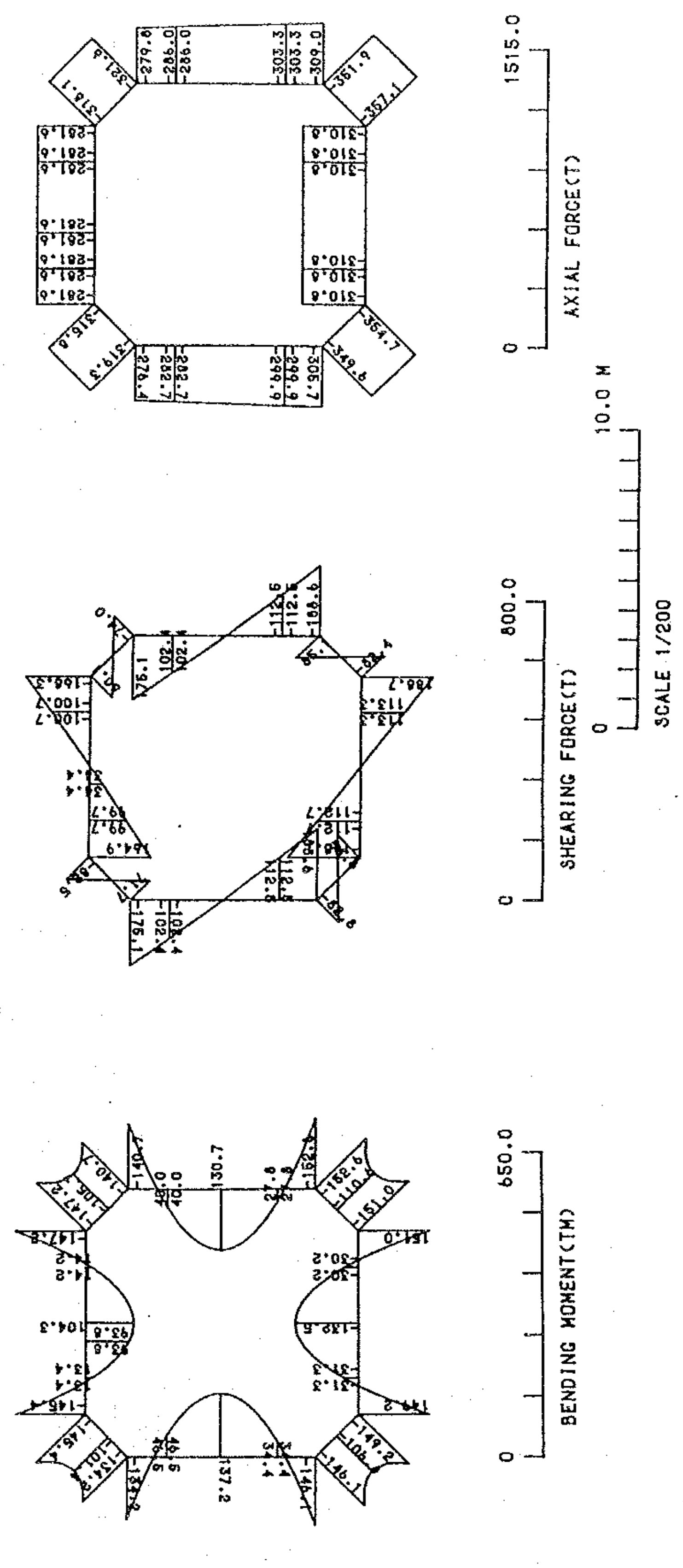


Bending moment shearing and axial force diagram
inlet portal section A-A (case -1)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

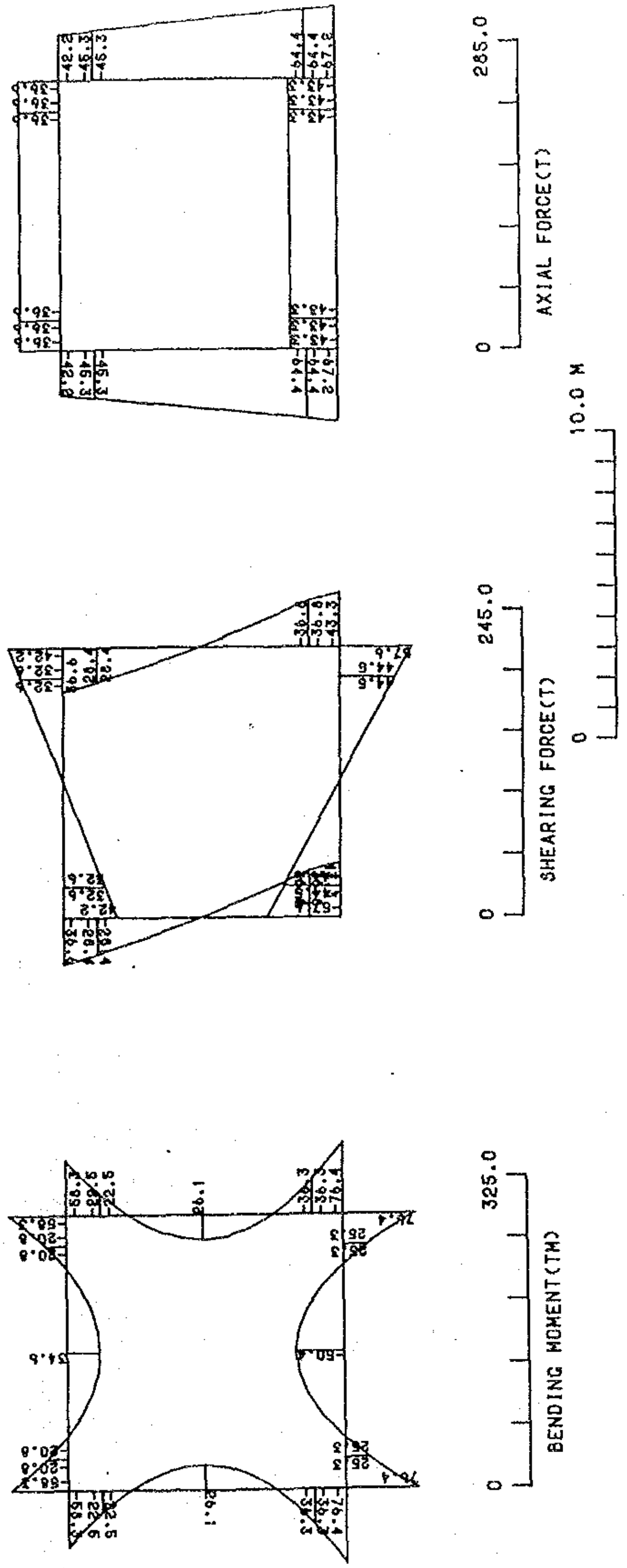
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.13



Bending moment shearing and axial force diagram inlet portal section A-A (case -2)	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.14

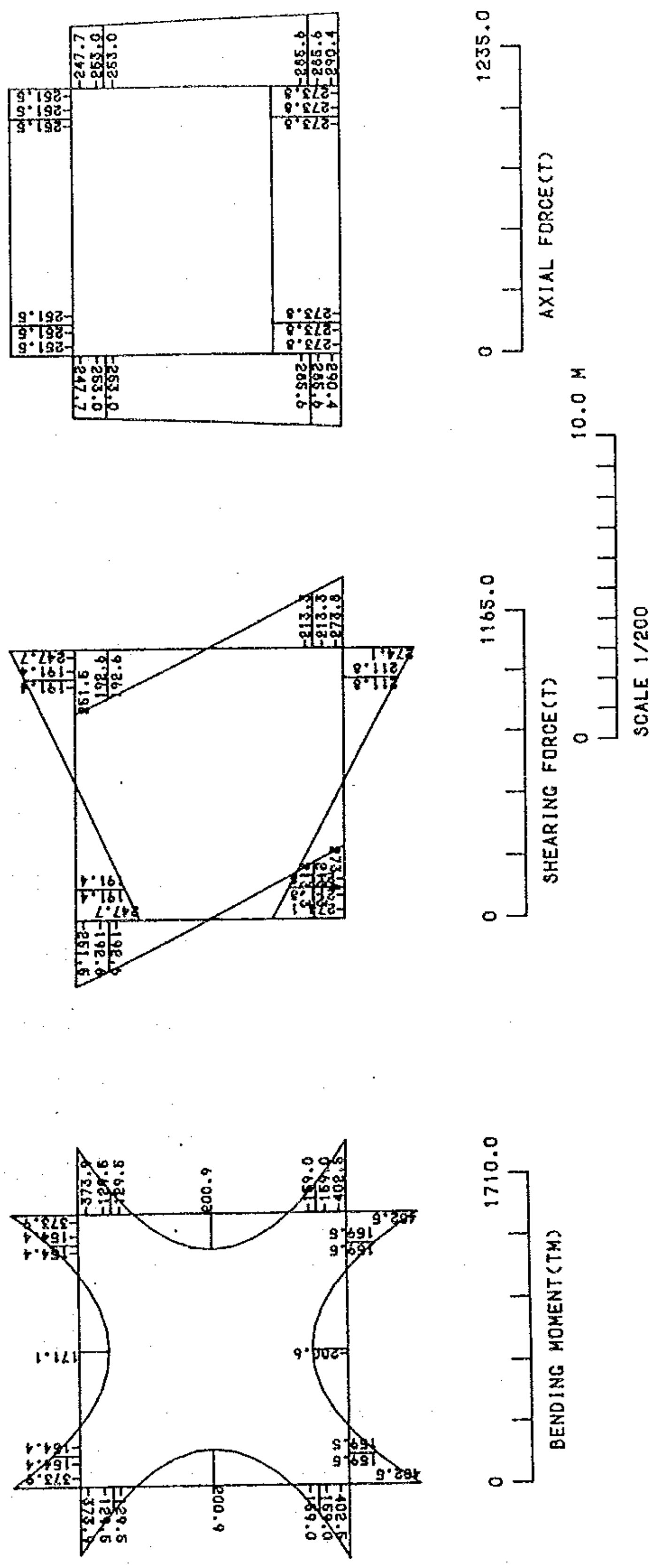


Bending moment shearing and axial force diagram
inlet portal section B-B (case -1)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.15

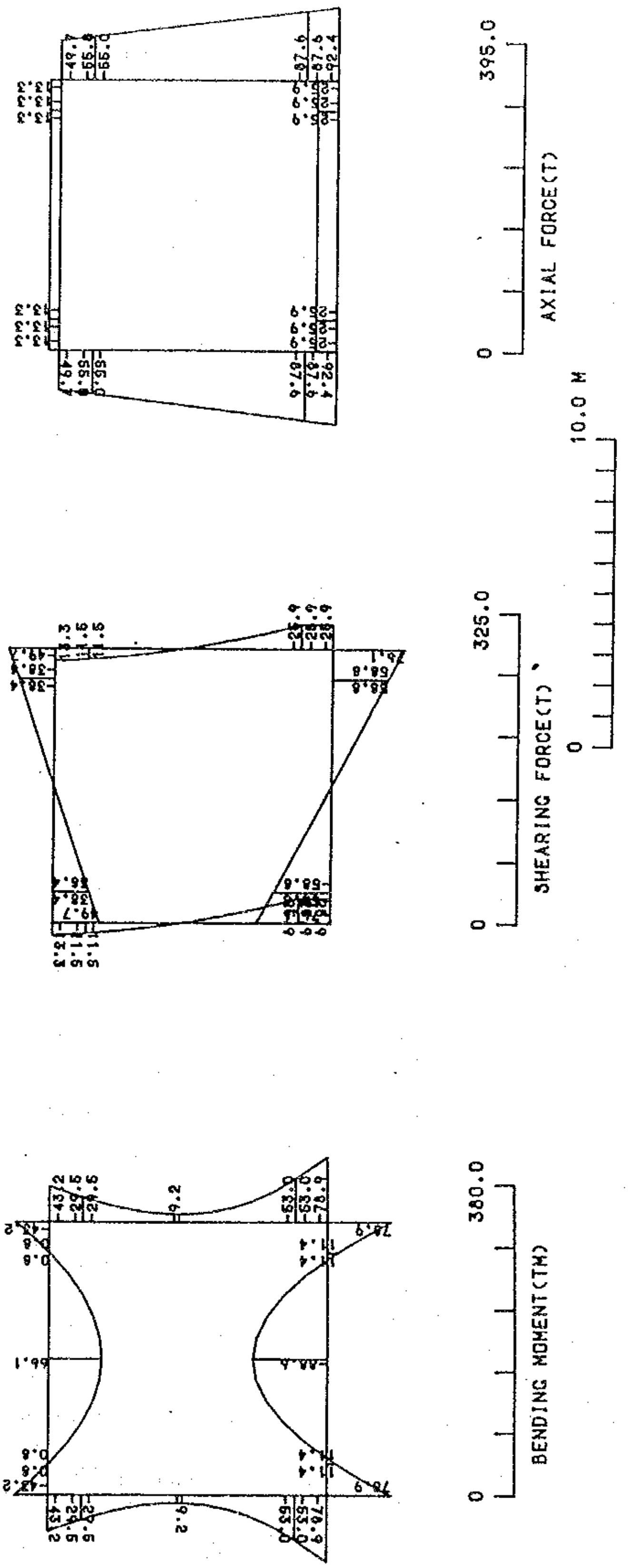


Bending moment shearing and axial force diagram
inlet portal section B-B (case -2)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.	3.2.16

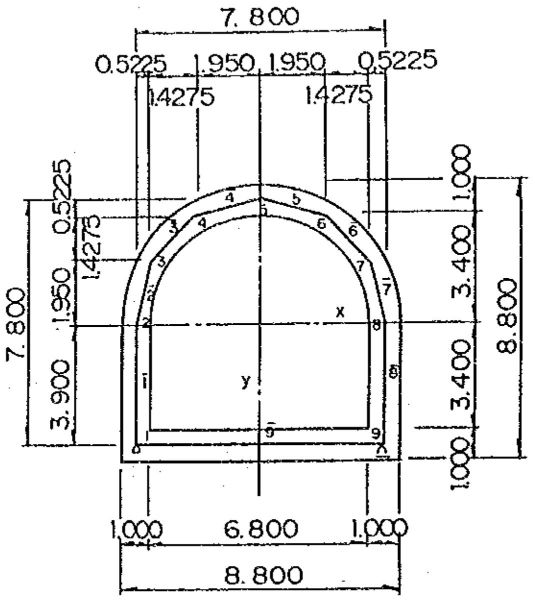


Bending moment shearing and axial force diagram
inlet portal section B-B (case -3)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

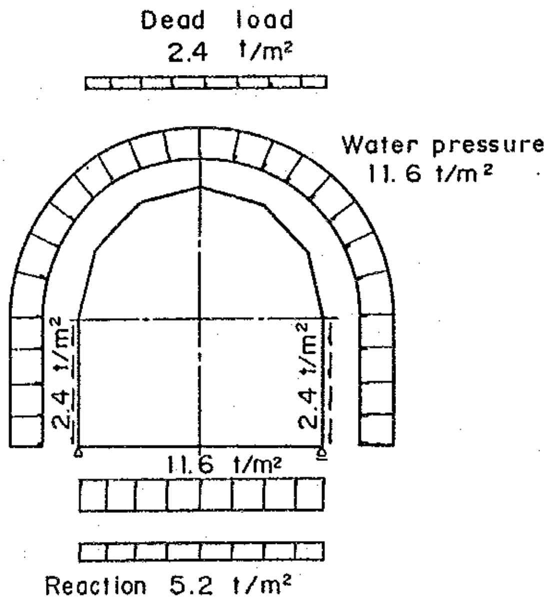
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.17

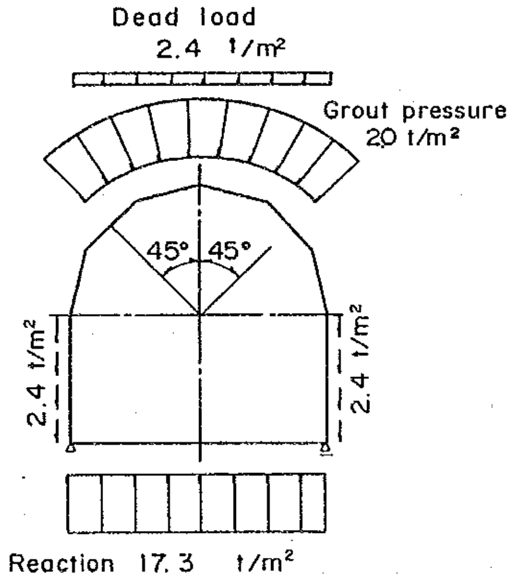


A = 1.0 m^2
I = 0.0833 m^2

	x (m)	y (m)
1	− 3.900	3.900
2	− 3.900	0.000
3	− 3.3775	− 1.950
4	− 1.950	− 3.3775
5	0.000	− 3.900
6	1.950	− 3.3775
7	3.3775	− 1.950
8	3.900	0.000
9	3.900	3.900



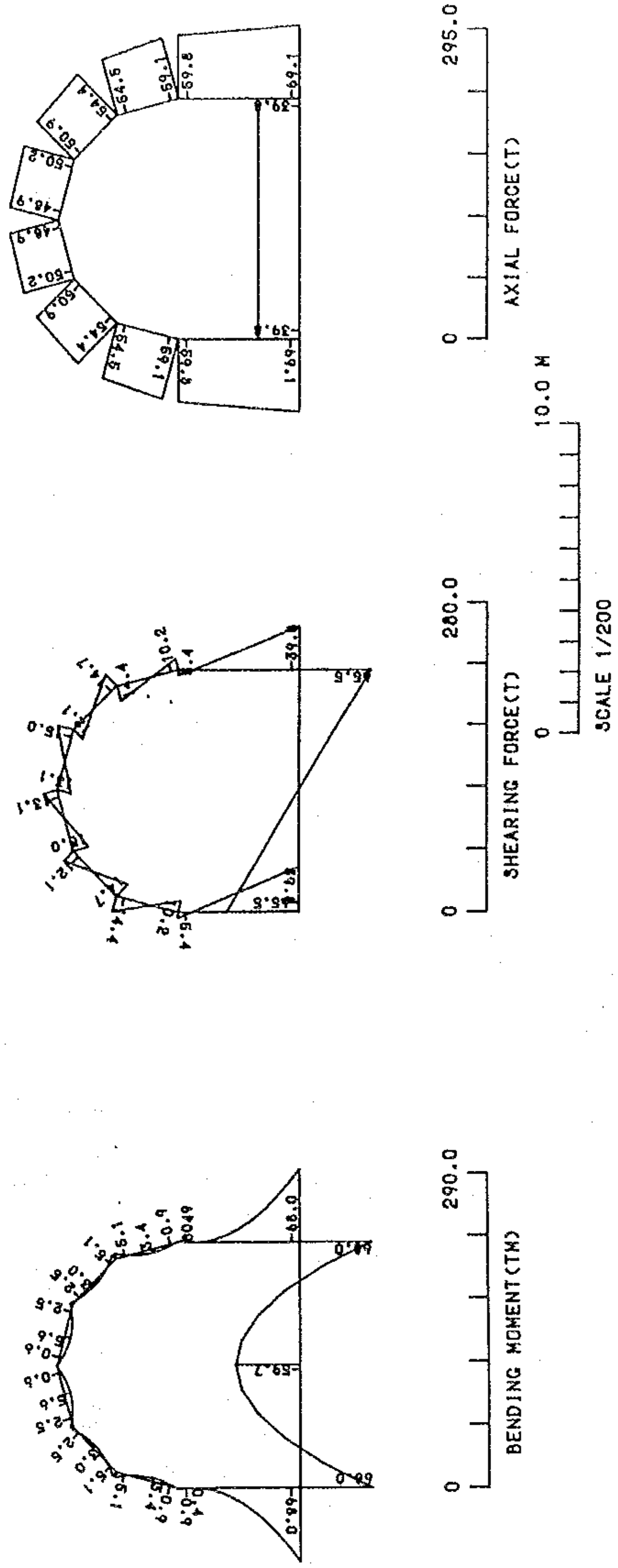
(1) During diversion



(2) Grouting condition

Load diagram outlet transition	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT
	JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.	3.2.18

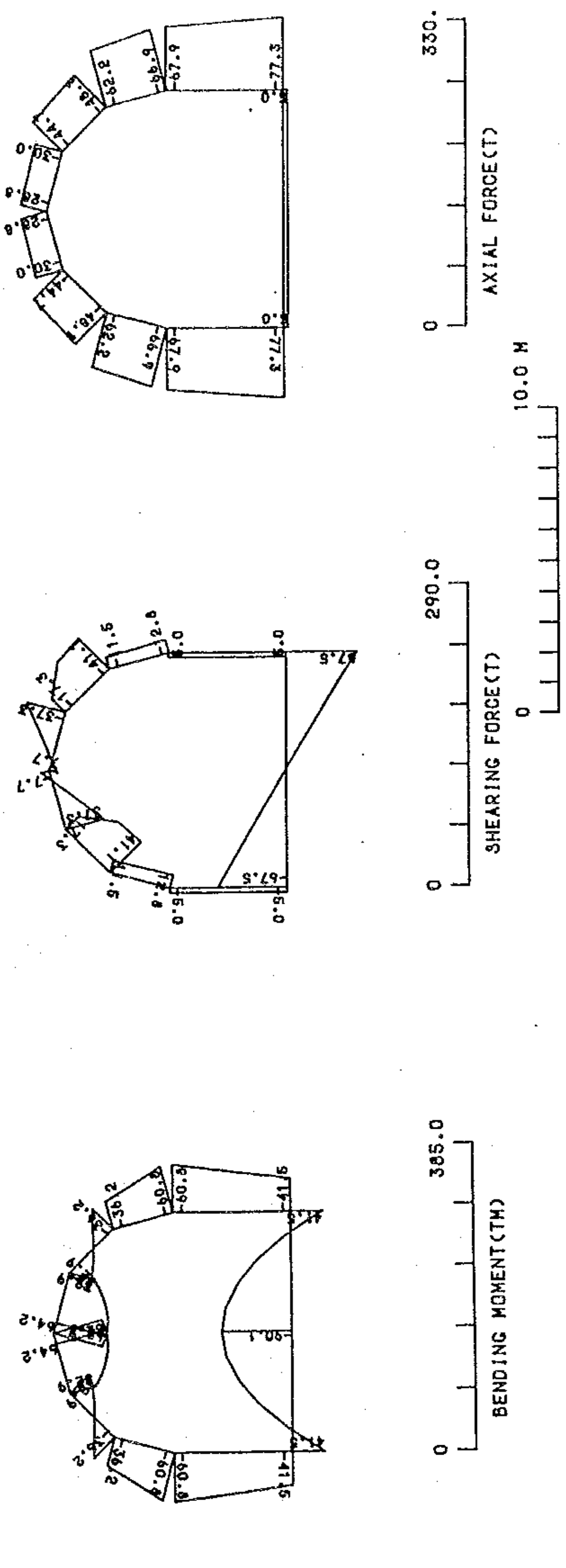


Bending moment shearing and axial force diagram
transition of diversion outlet (case-1)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

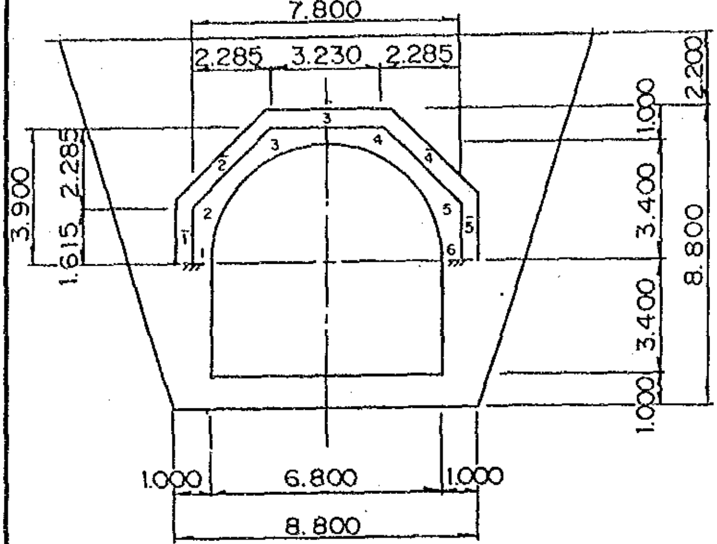
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.19



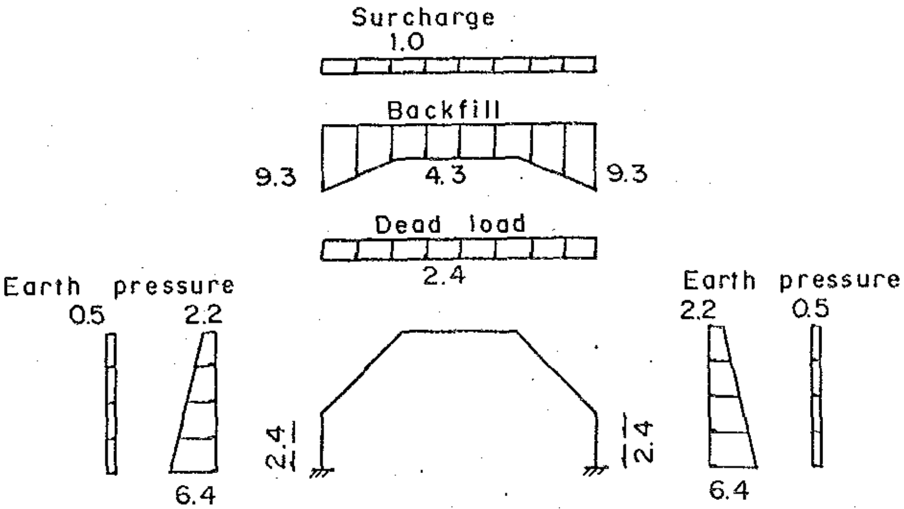
Bending moment shearing and axial force diagram transition of diversion outlet (case-2)	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.20



A = 1.0 m²
I = 0.0833 m⁴

	x (m)	y (m)
1	−3.900	3.900
2	−3.900	2.285
3	−1.615	0.000
4	1.615	0.000
5	3.900	2.285
6	3.900	3.900

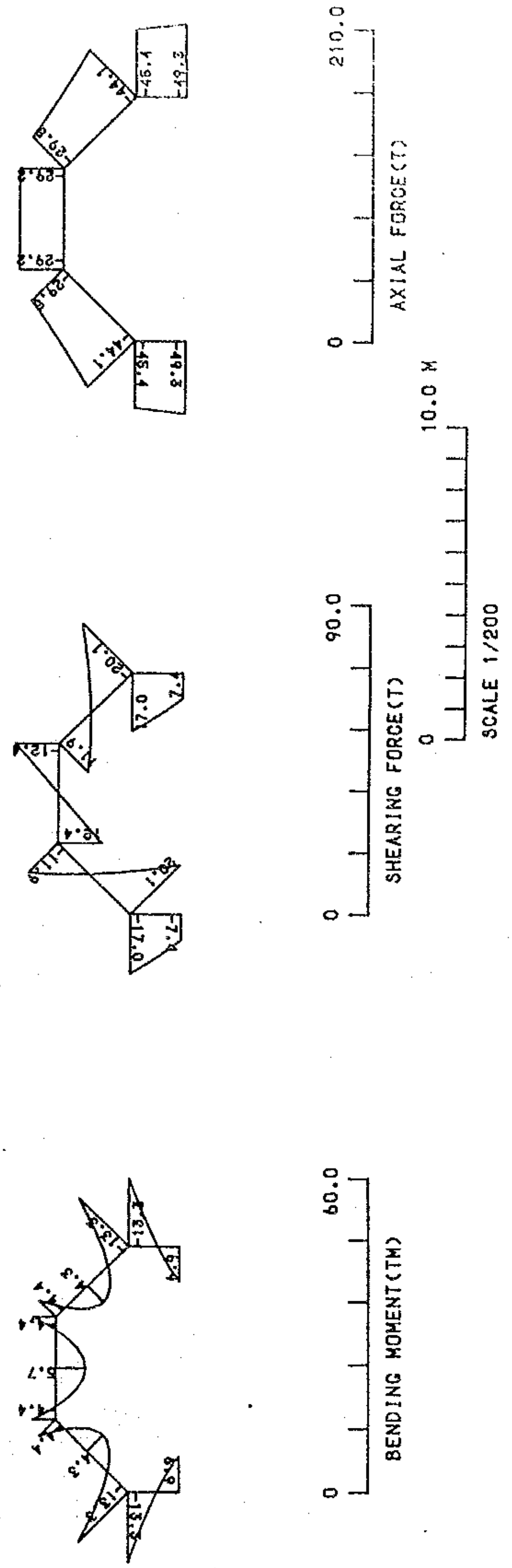


Load diagram of outlet portal

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.	3.2.21

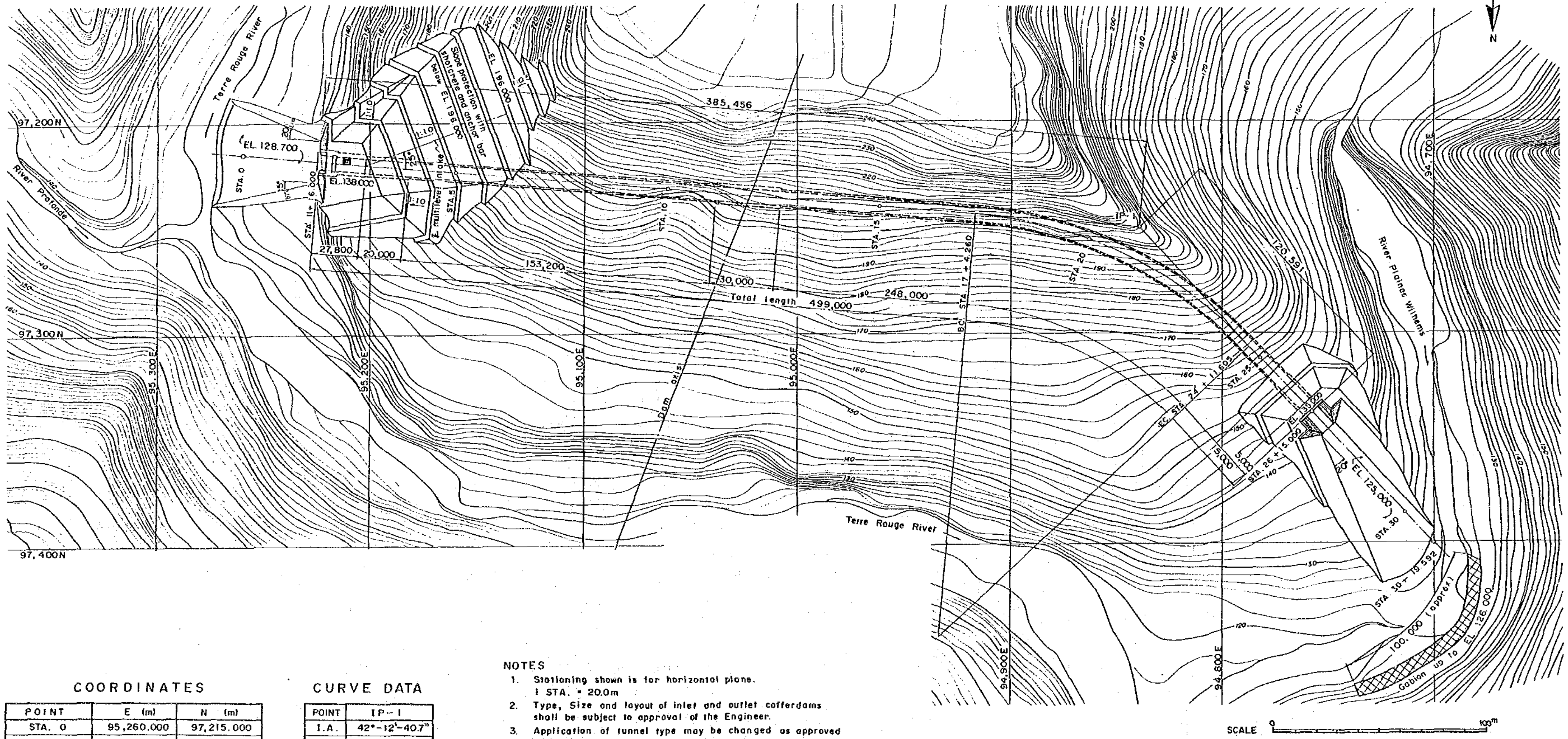


Bending moment shearing and axial force diagram, Outlet portal

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.22



COORDINATES

POINT	E (m)	N (m)
STA. 0	95,260.000	97,215.000
STA. 1+16.000	95,224.124	97,217.990
IP - 1	94,840.000	97,250.000
STA. 26+15.000	94,757.719	97,338.159
STA. 30+19.592	94,700.000	97,400.000

CURVE DATA

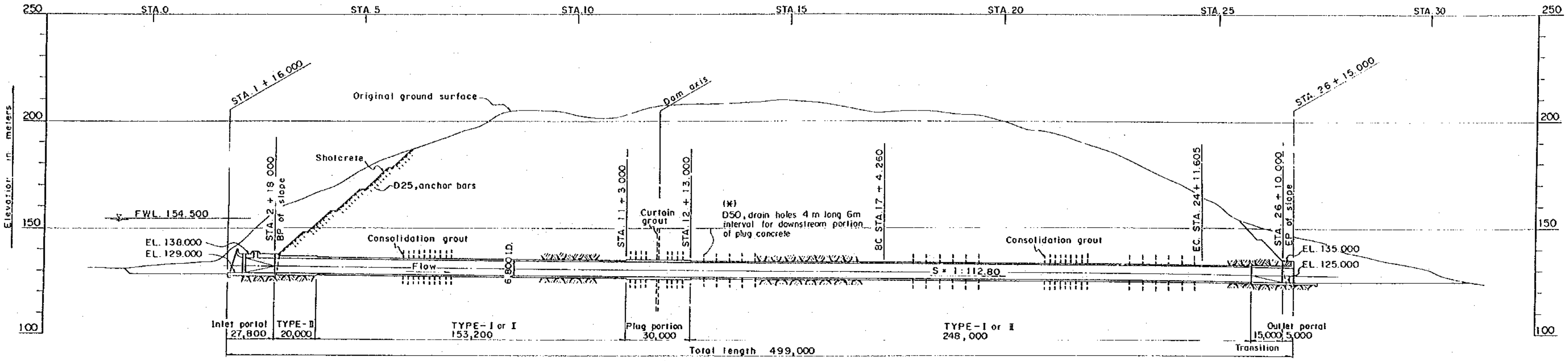
POINT	IP - 1
I.A.	42°-12'-40.7"
R	200,000
TL	77,196
CL	147,345

NOTES

1. Stationing shown is for horizontal plane. 1 STA. = 20.0m
2. Type, Size and layout of inlet and outlet cofferdams shall be subject to approval of the Engineer.
3. Application of tunnel type may be changed as approved or directed by the Engineer to suit actual geological condition to be encountered.
4. Application of consolidation grouting downstream of plug portion (STA. 12+13m) shall be directed by the Engineer.
5. Plug work shall be made by Lot-II.
6. Marked with (X) shall be made by Lot-II.

DIVERSION TUNNEL PLAN	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.23

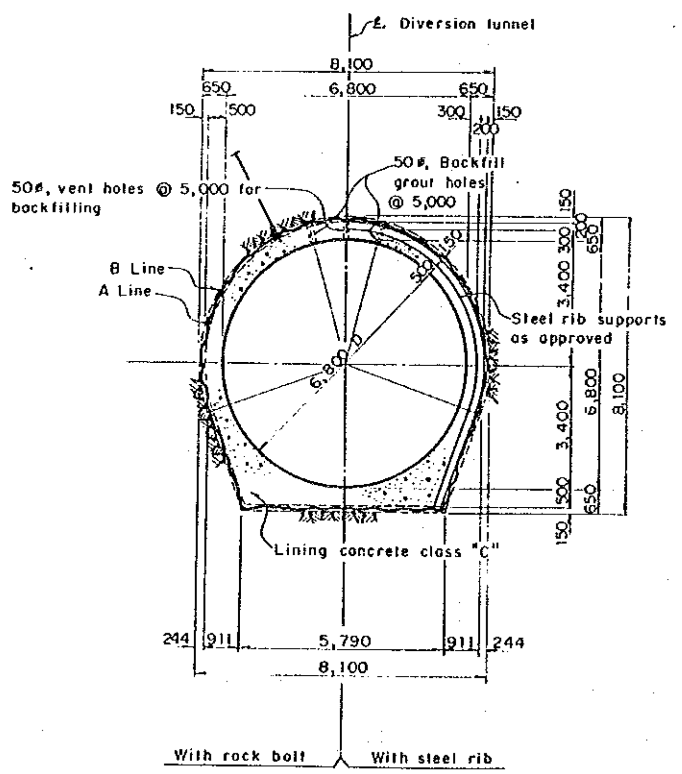


SCALE 0 100m

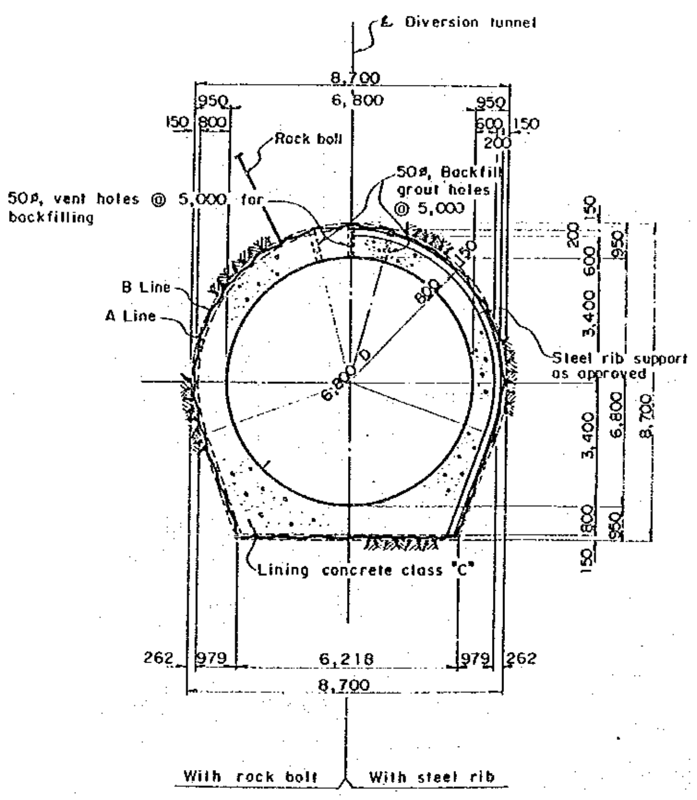
PROFILE

Remarks :

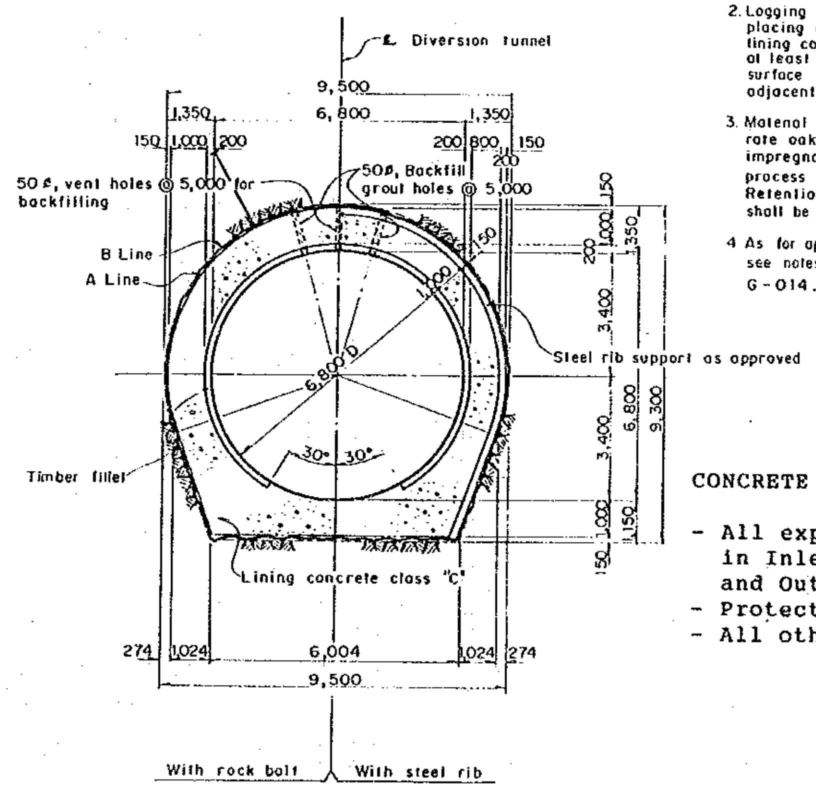
(*) D50, drain holes shall be constructed by Lot-II



TYPE - I



TYPE - II



PLUG PORTION

NOTES :

1. All wooden materials except blockings of steelribs shall be removed prior to placing of lining concrete.
2. Logging shall also be removed prior to placing of lining concrete so that the lining concrete will be in contact with at least 65% of the excavated rock surface bounded, by the center lines of adjacent steel ribs.
3. Material of timber fillet shall be 1st-rate oak of other equivalent hard timber impregnated with creosote by full-cell process pressure treatment. Retention of creosote after treatment shall be not less than 150 kg/m³.
4. As for application of tunnel type, see notes on DWG. No. D-C01 and G-014.

CONCRETE FINISHES :

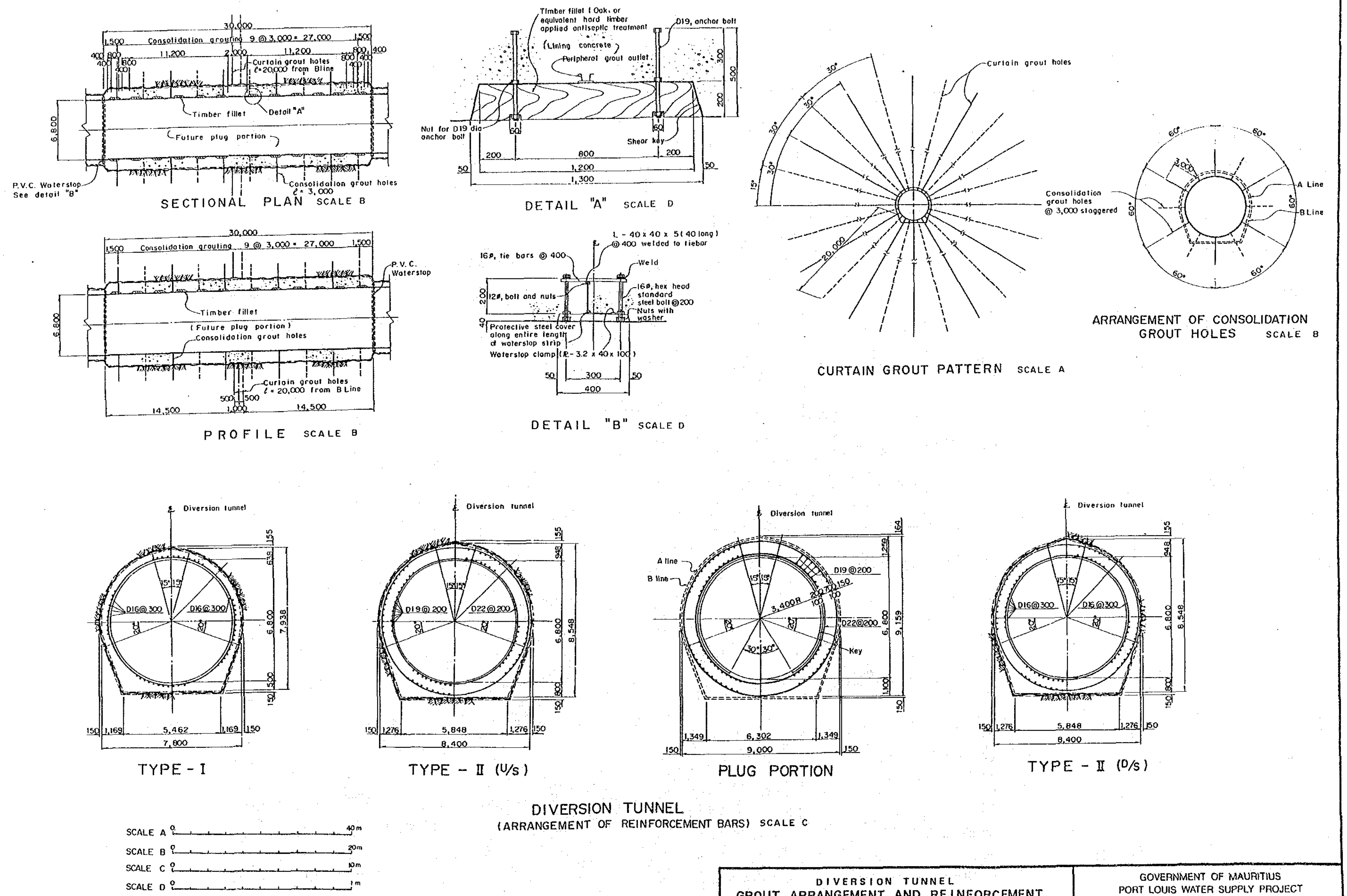
- All exposed surfaces in Inlet Portal, Tunnel and Outlet Portal...F4 or U2
- Protection wall...F2 or U2
- All other surface...F1 or U1

SCALE 0 10m

DIVERSION TUNNEL
PROFILE AND SECTIONS

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY



DIVERSION TUNNEL GROUT ARRANGEMENT AND REINFORCEMENT BAR DETAILS	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT
	JAPAN INTERNATIONAL COOPERATION AGENCY

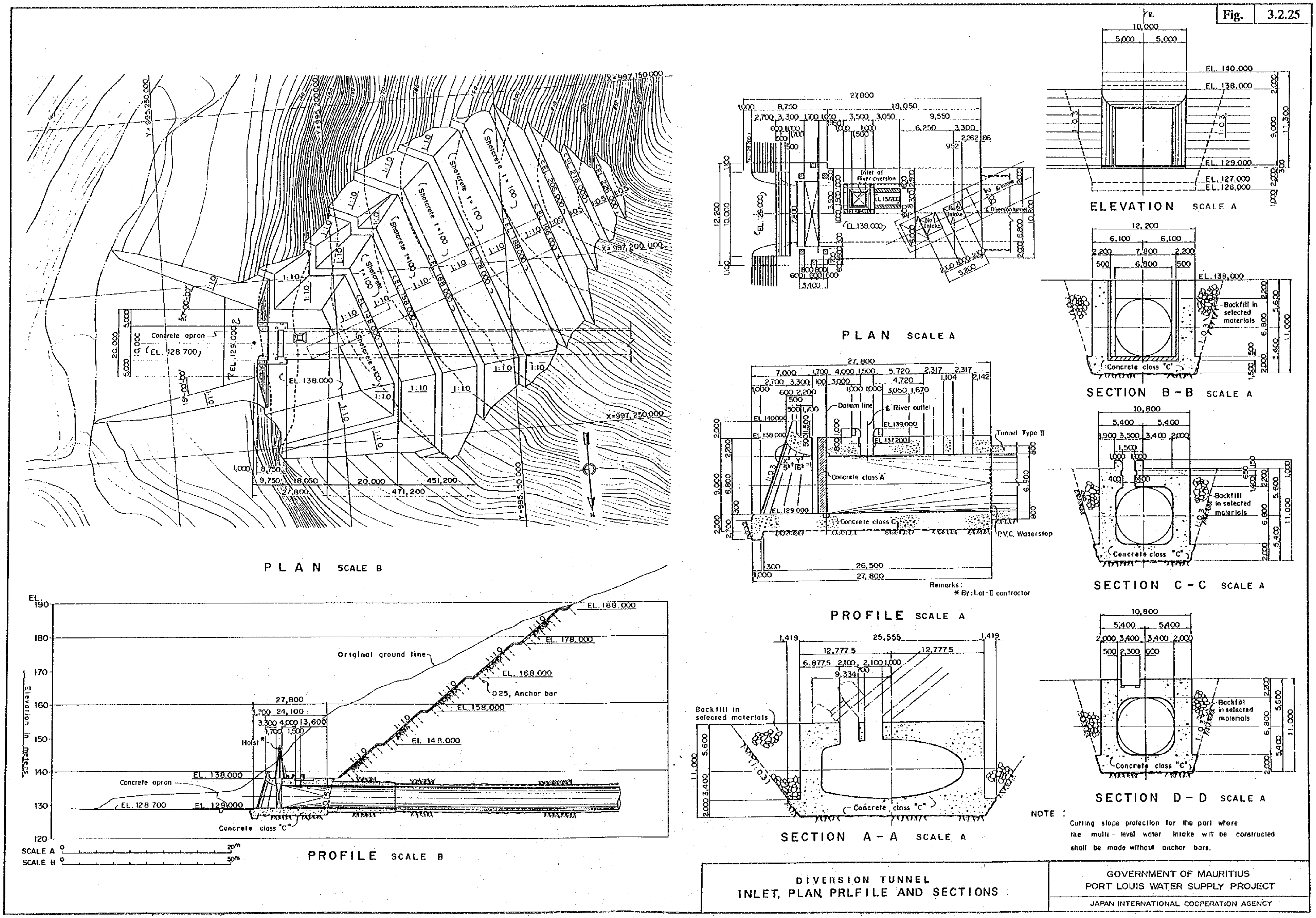
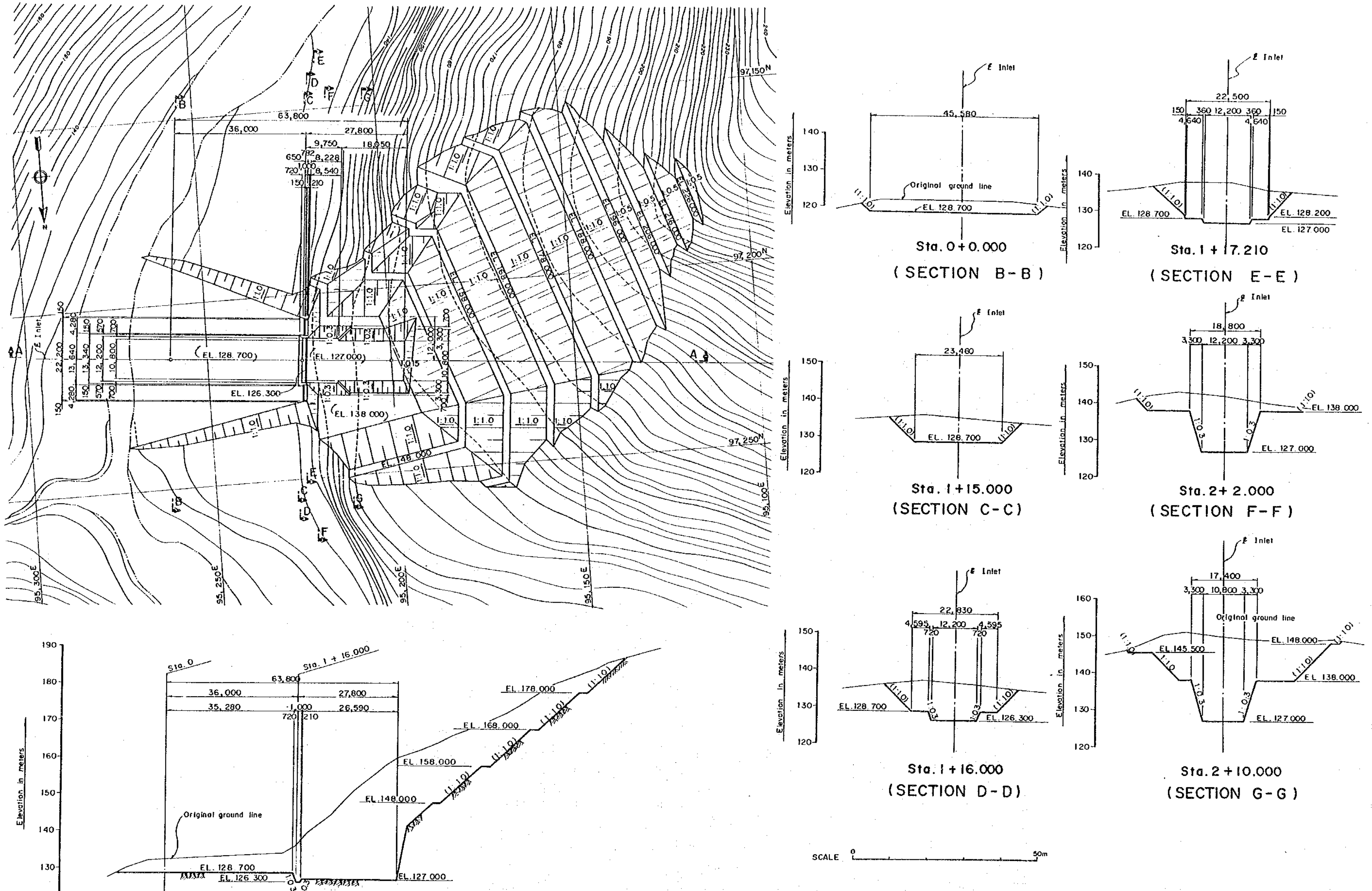


Fig. 3.2.25
PLAN SCALE B
PROFILE SCALE B
PLAN SCALE A
PROFILE SCALE A
ELEVATION SCALE A
SECTION B - B SCALE A
SECTION C - C SCALE A
SECTION D - D SCALE A
SECTION A - A SCALE A
Concrete apron
Original ground line
Ø25, Anchor bar
Hoist*
Concrete class "C"
Concrete class "A"
Backfill in selected materials
Tunnel Type II
P.V.C. Waterstop
Datum line
℄ River outlet
Elevation in meters
SCALE A 0 20m
SCALE B 0 50m
Remarks:
* By: Lot-II contractor
NOTE : Cutting slope protection for the part where the multi - level water intake will be constructed shall be made without anchor bars.
DIVERSION TUNNEL
INLET, PLAN, PRLFILE AND SECTIONS
GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.26

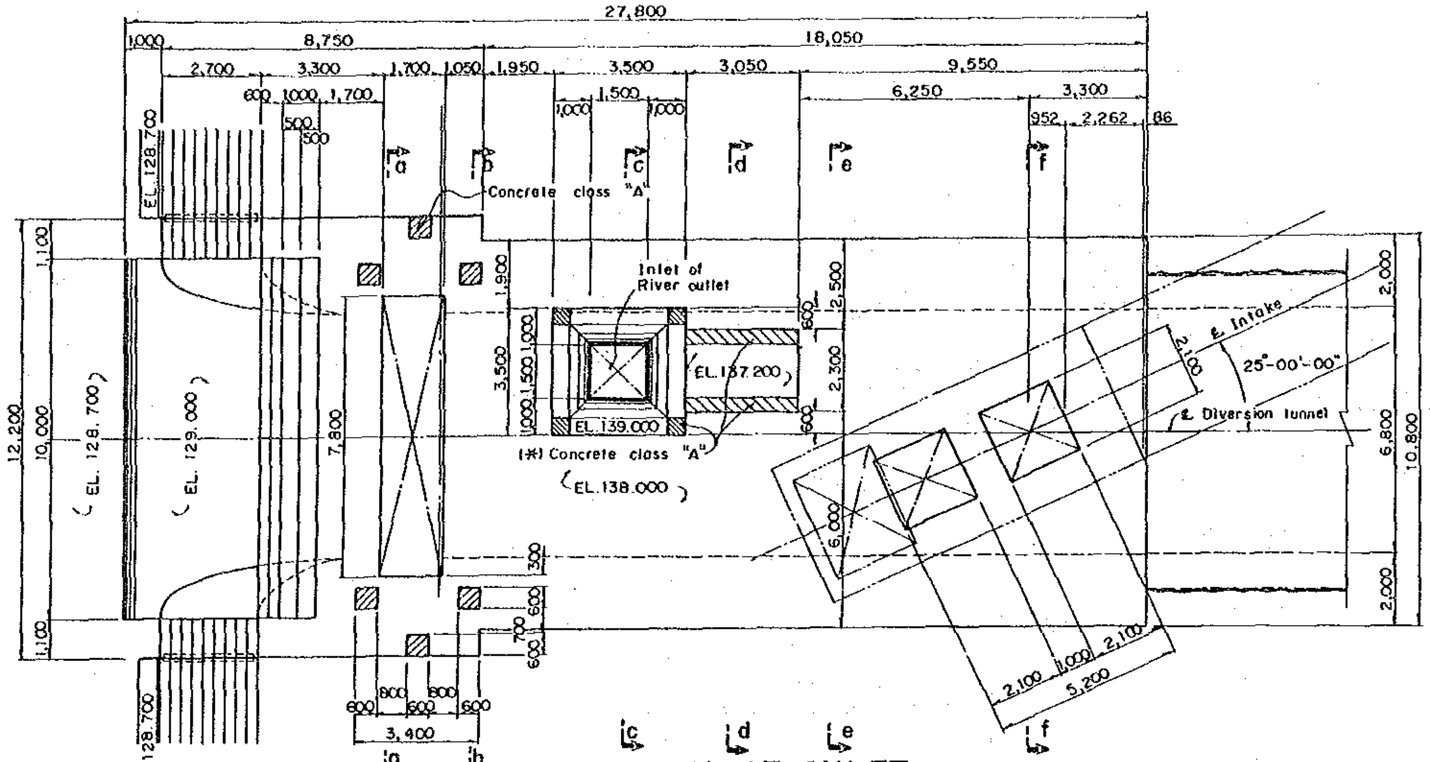


DIVERSION TUNNEL
INLET, EXCAVATION PLAN, PROFILE AND SECTIONS

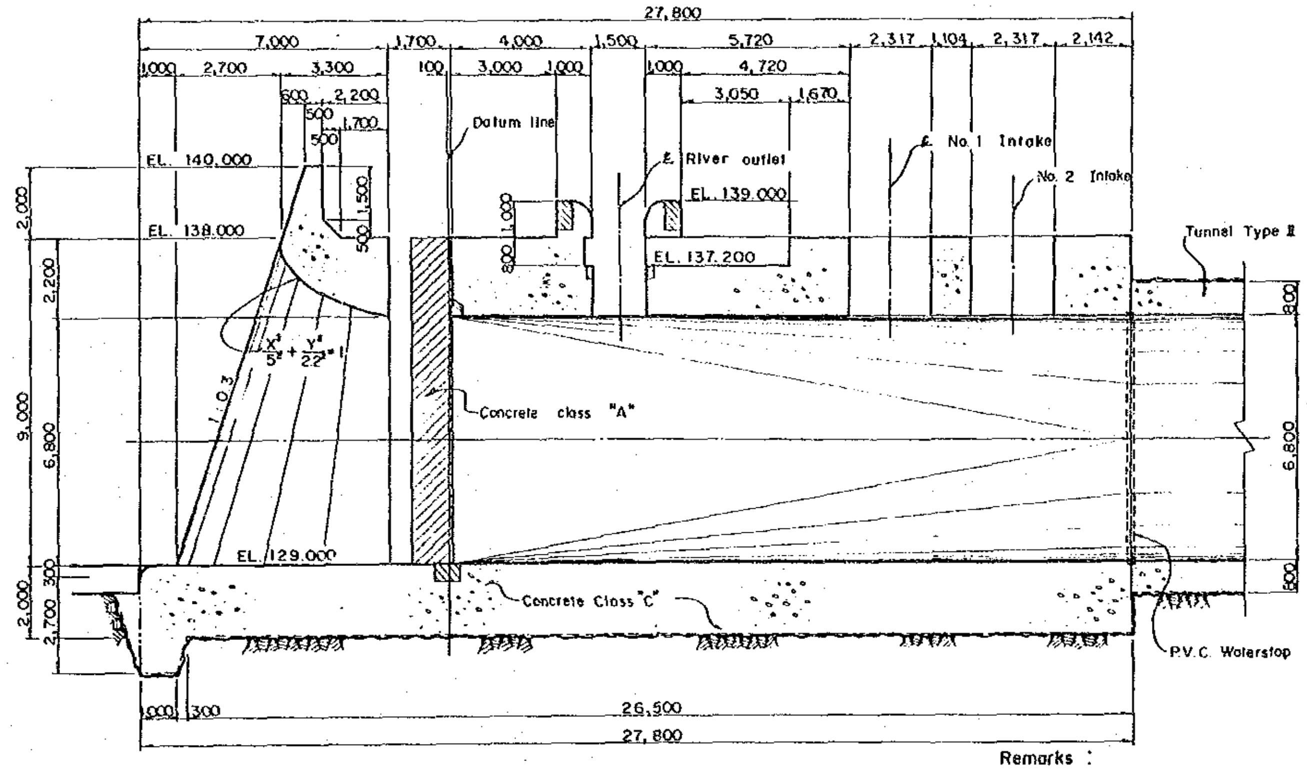
GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.27

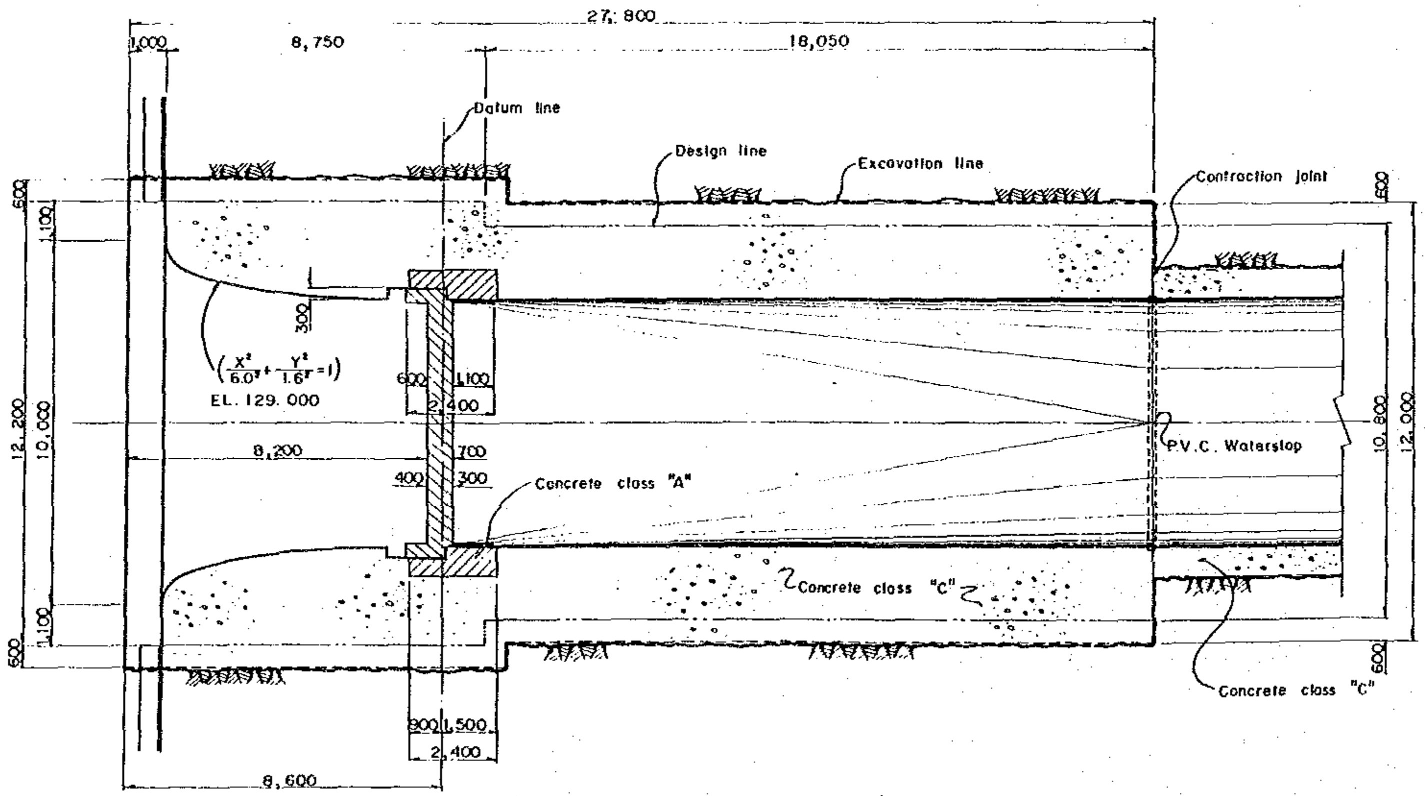


PLAN OF INLET



Remarks :
* : By Lot-II contractor

PROFILE OF INLET



SECTIONAL PLAN OF INLET AT EL. 129.000

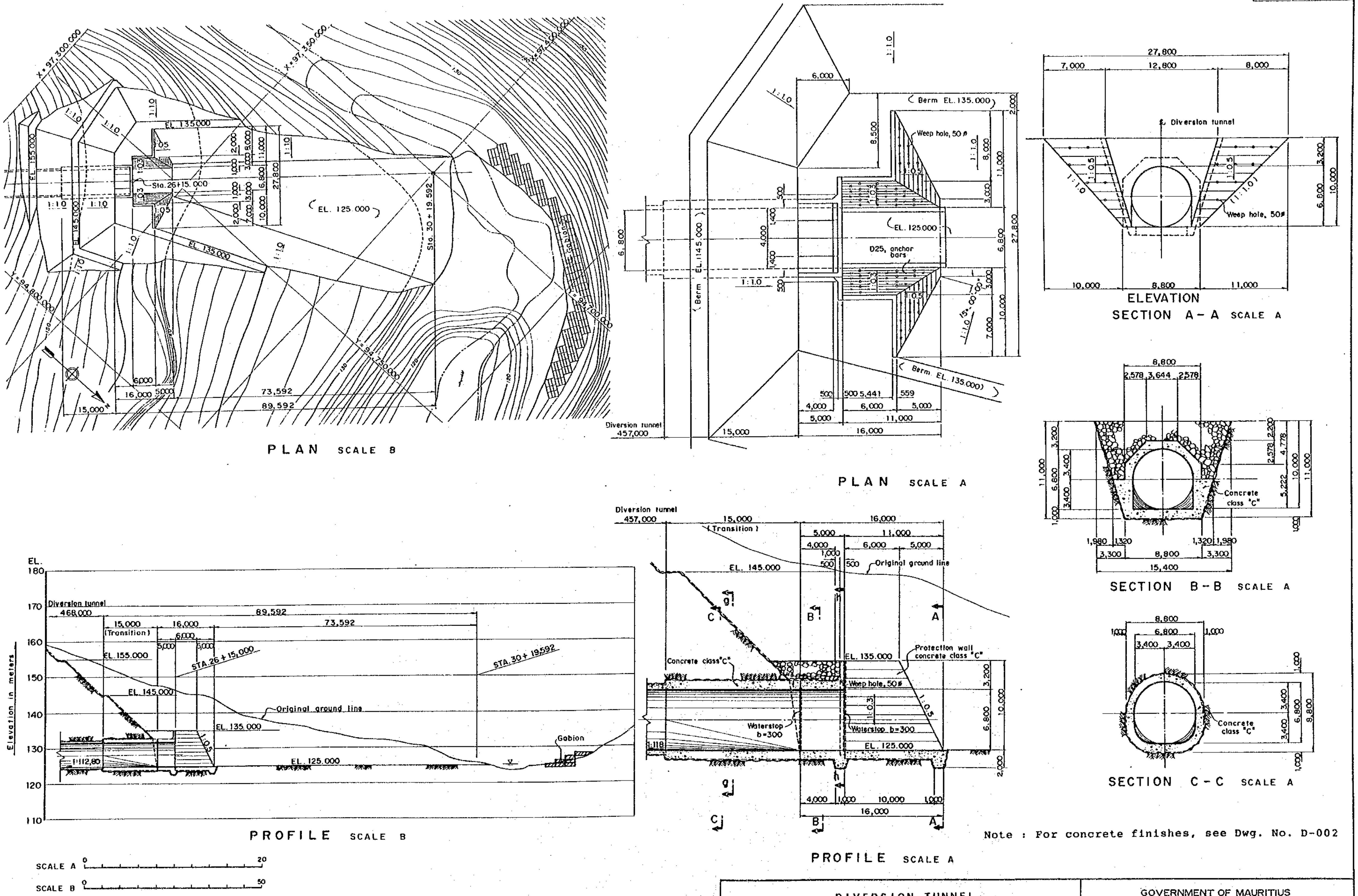
SCALE 0 10m

Notes :

1. For concrete finishes, see Dwg. No. D-002.
2. Marked with (*) shall be constructed by Lot-II.

DIVERSION TUNNEL INLET, STRUCTURAL DETAILS	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.2.28



DIVERSION TUNNEL
OUTLET, PLAN, PROFILE AND SECTIONS

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY