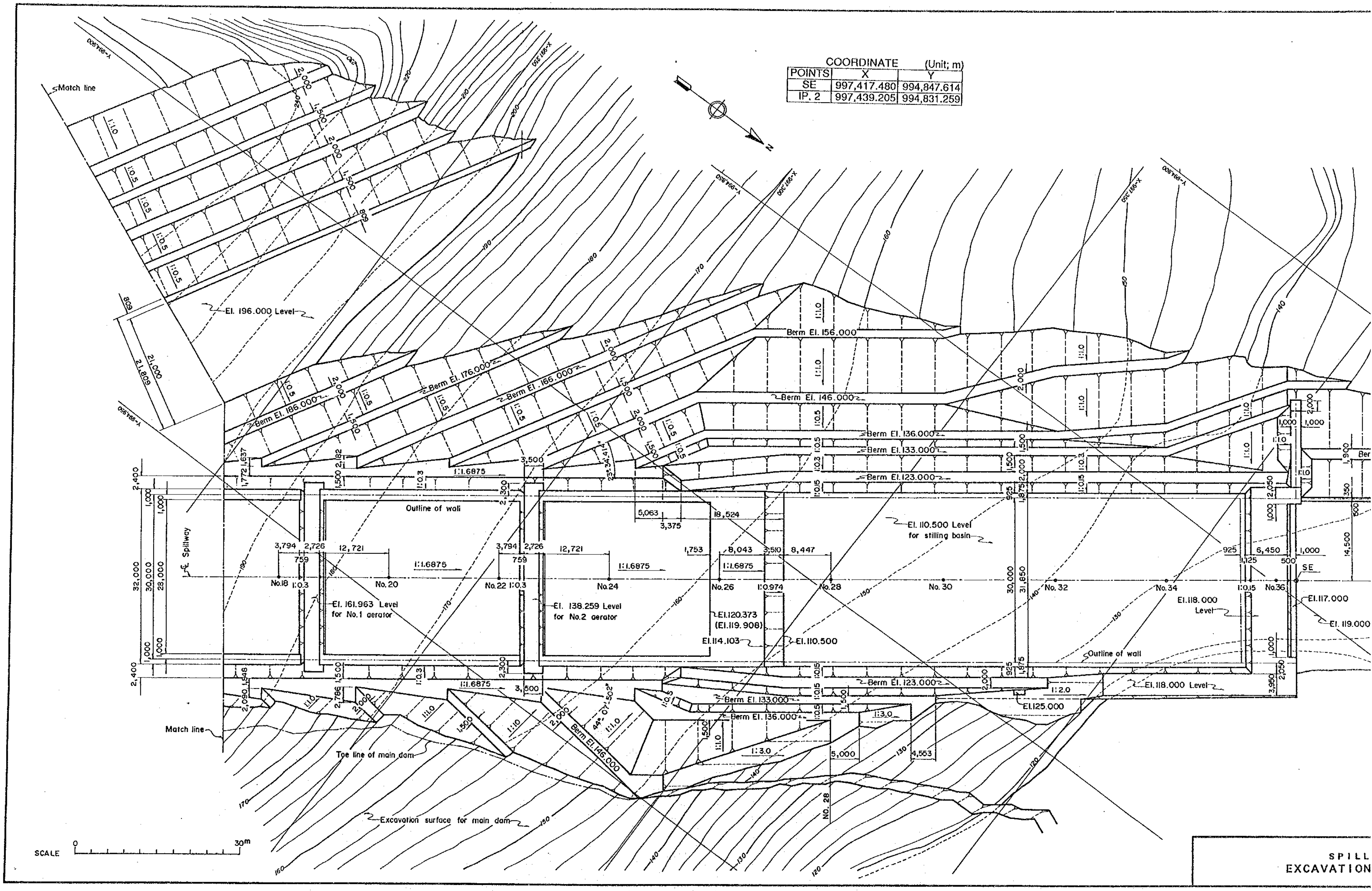


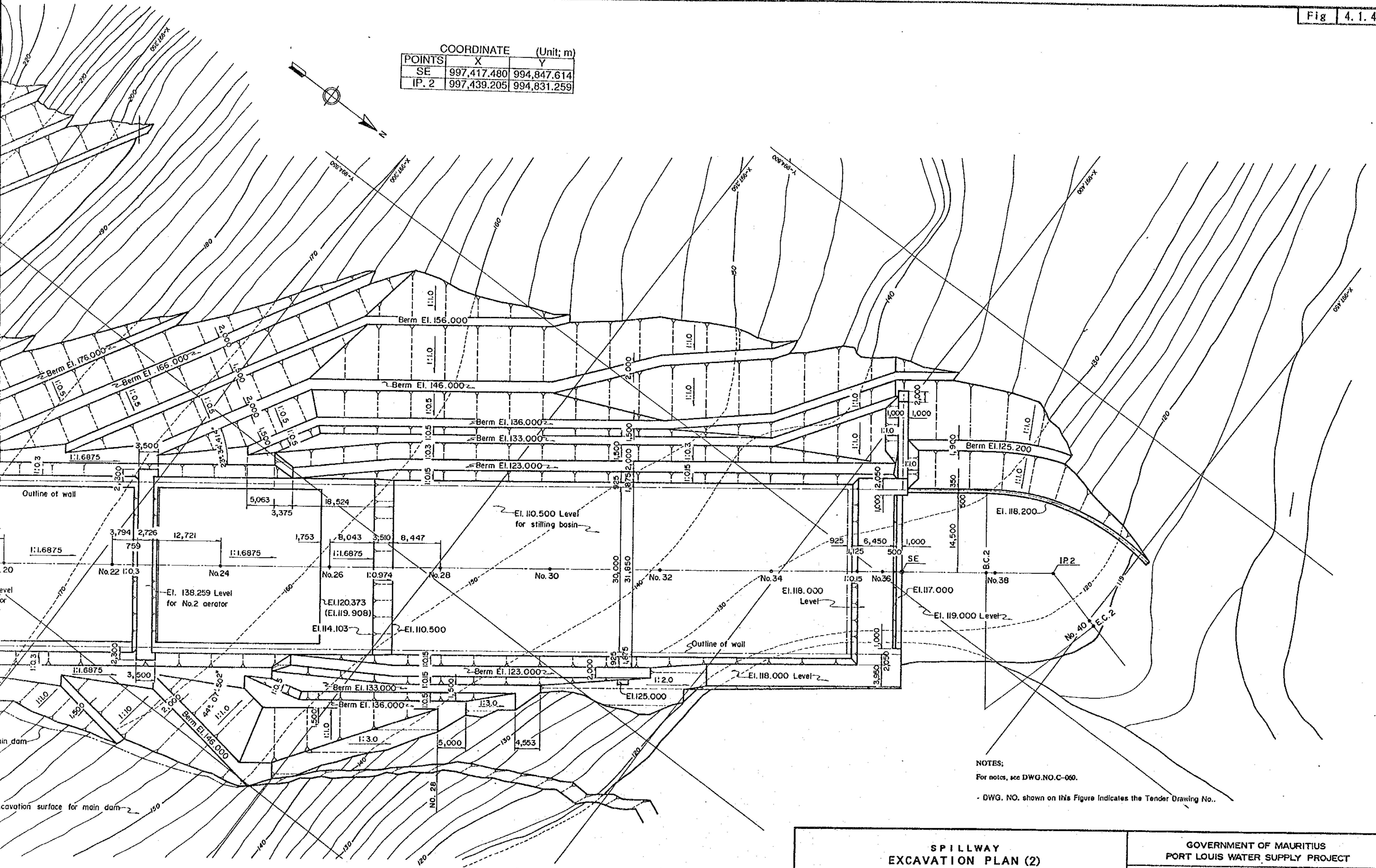
COORDINATE (Unit; m)

POINTS	X	Y
SE	997,417.480	994,847.614
IP. 2	997,439.205	994,831.259

Fig 4.1.4

COORDINATE (Unit; m)

POINTS	X	Y
SE	997,417.480	994,847.614
IP. 2	997,439.205	994,831.259



NOTES;

For notes, see DWG.NO.C-060.

- DWG. NO. shown on this Figure indicates the Tender Drawing No..

SPILLWAY
EXCAVATION PLAN (2)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

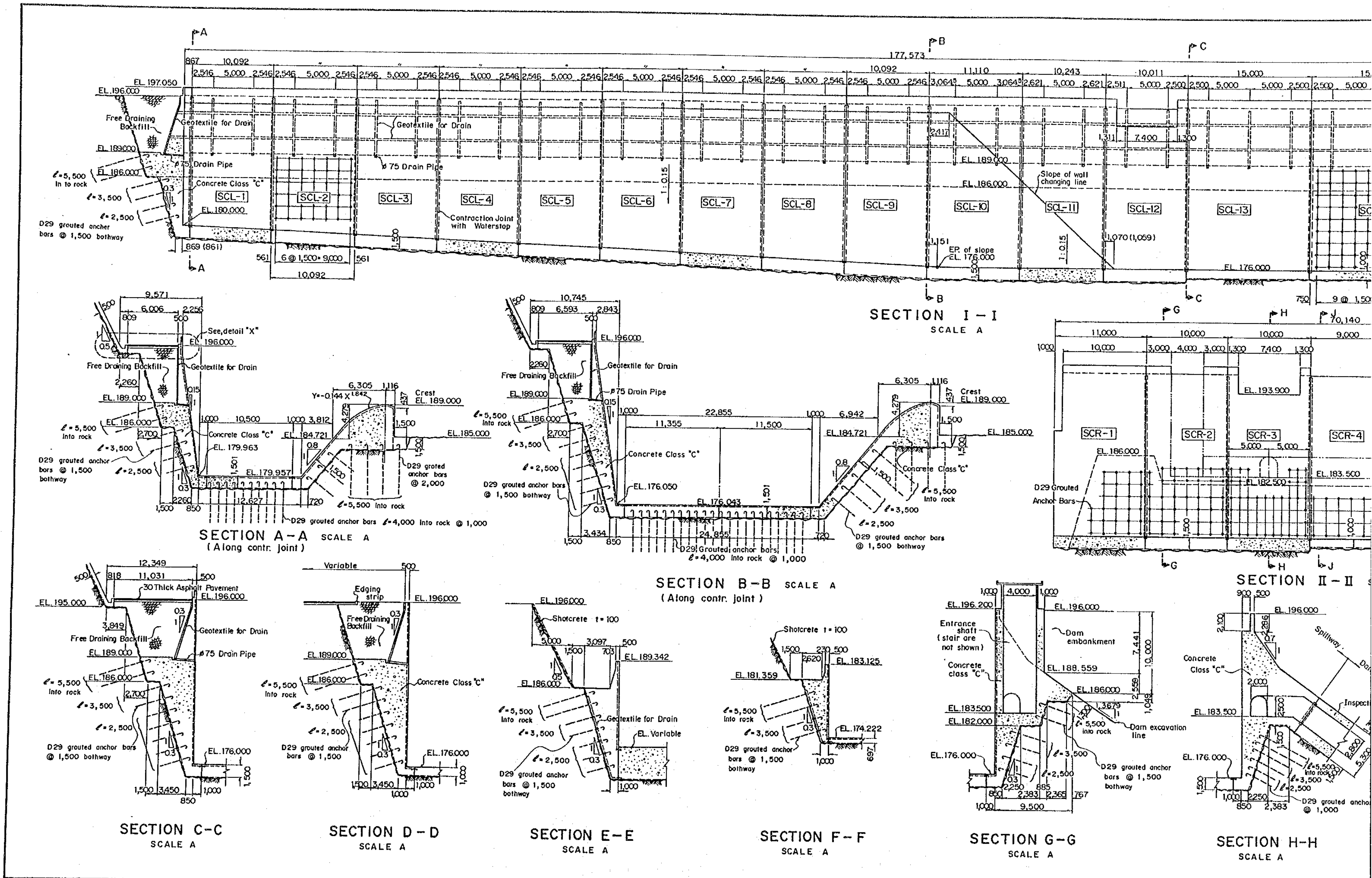
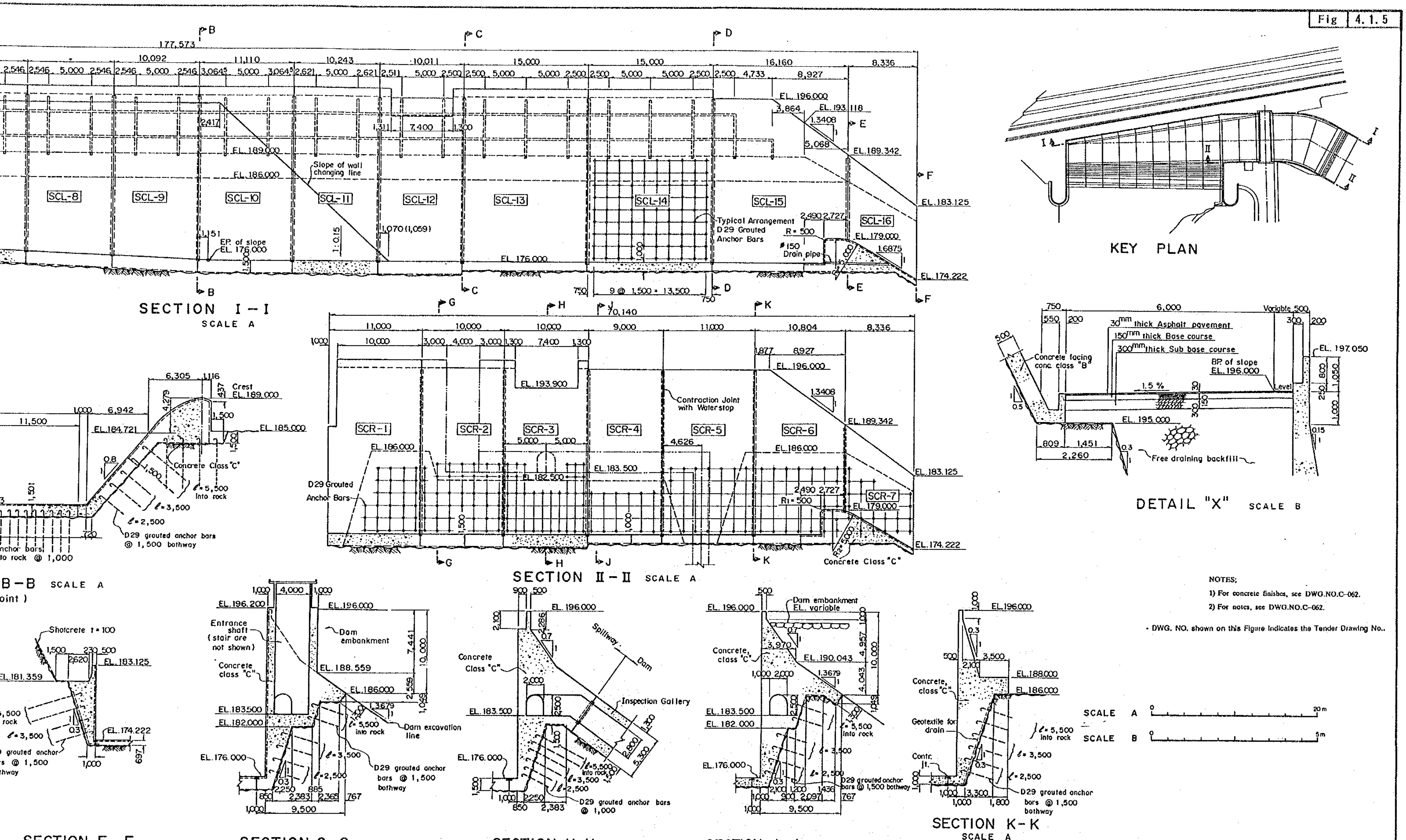

SECTION I – I
SCALE A
SECTION II – II
SECTION A – A SCALE A
(Along contr. joint)
SECTION B – B SCALE A
(Along contr. joint)
SECTION C – C
SCALE A
SECTION D – D
SCALE A
SECTION E – E
SCALE A
SECTION F – F
SCALE A
SECTION G – G
SCALE A
SECTION H – H
SCALE A
SCL-1
SCL-2
SCL-3
SCL-4
SCL-5
SCL-6
SCL-7
SCL-8
SCL-9
SCL-10
SCL-11
SCL-12
SCL-13
SCR-1
SCR-2
SCR-3
SCR-4
177,573
EL. 197.050
EL. 196.000
EL. 189.000
EL. 186.000
EL. 180.000
EL. 176.000
Free Draining Backfill
Geotextile for Drain
ø75 Drain Pipe
Concrete Class "C"
Contraction Joint with Waterstop
Slope of wall changing line
EP. of slope EL. 176.000
D29 grouted anchor bars @ 1,500 bothway
ℓ=5,500 Into rock
ℓ=3,500
ℓ=2,500
See, detail "X"
Crest EL. 189.000
EL. 185.000
EL. 184.721
EL. 179.963
EL. 179.957
EL. 176.050
EL. 176.043
Y=-0.144 X^1.842
D29 groted anchor bars @ 2,000
D29 grouted anchor bars ℓ=4,000 into rock @ 1,000
30 Thick Asphalt Pavement
EL. 195.000
Edging strip
Variable
Shotcrete t=100
EL. Variable
EL. 189.342
EL. 183.125
EL. 181.359
EL. 174.222
EL. 196.200
Entrance shaft (stair are not shown)
Dam embankment
EL. 188.559
EL. 183.500
EL. 182.000
Dam excavation line
EL. 193.900
EL. 182.500
D29 Grouted Anchor Bars
Spillway
Inspect

Fig 4.1.5

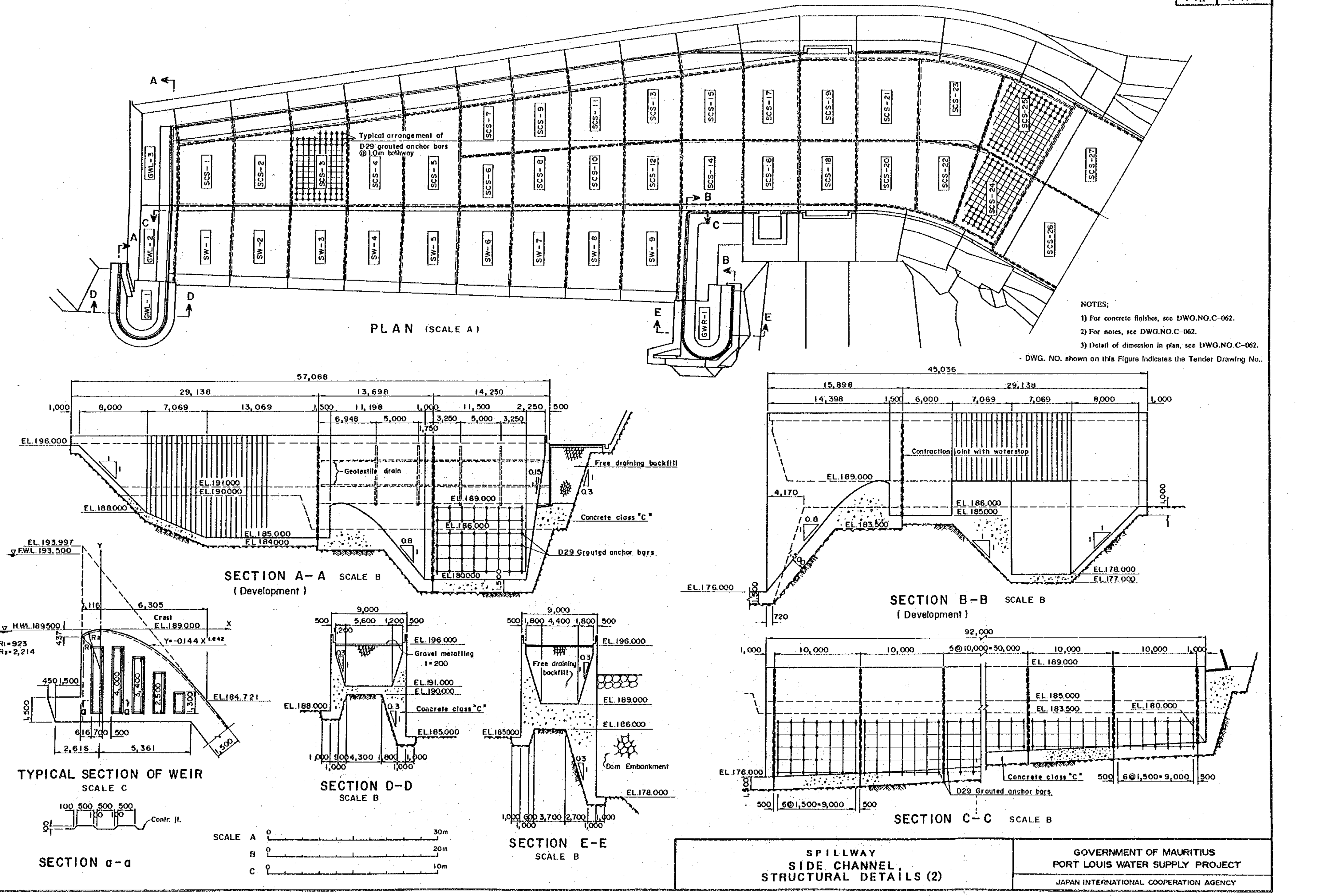


SPILLWAY
SIDE CHANNEL
STRUCTURAL DETAILS (1)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig 4.1.6



NOTES;

1) For concrete finishes, see DWG.NO.C-062.

2) For notes, see DWG.NO.C-062.

3) Detail of dimension in plan, see DWG.NO.C-062.

- DWG. NO. shown on this Figure Indicates the Tender Drawing No.

SPILLWAY
SIDE CHANNEL
STRUCTURAL DETAILS (2)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

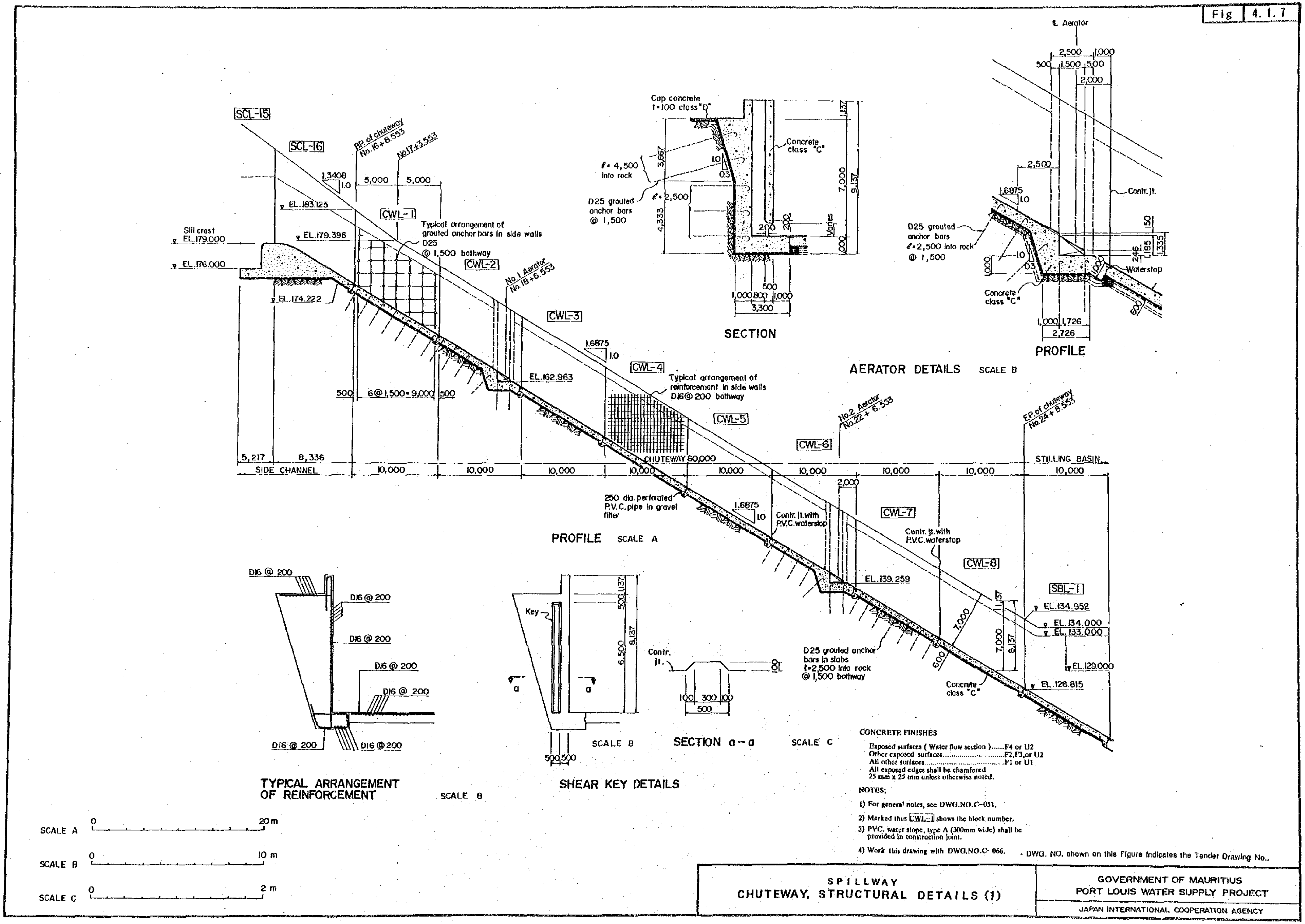
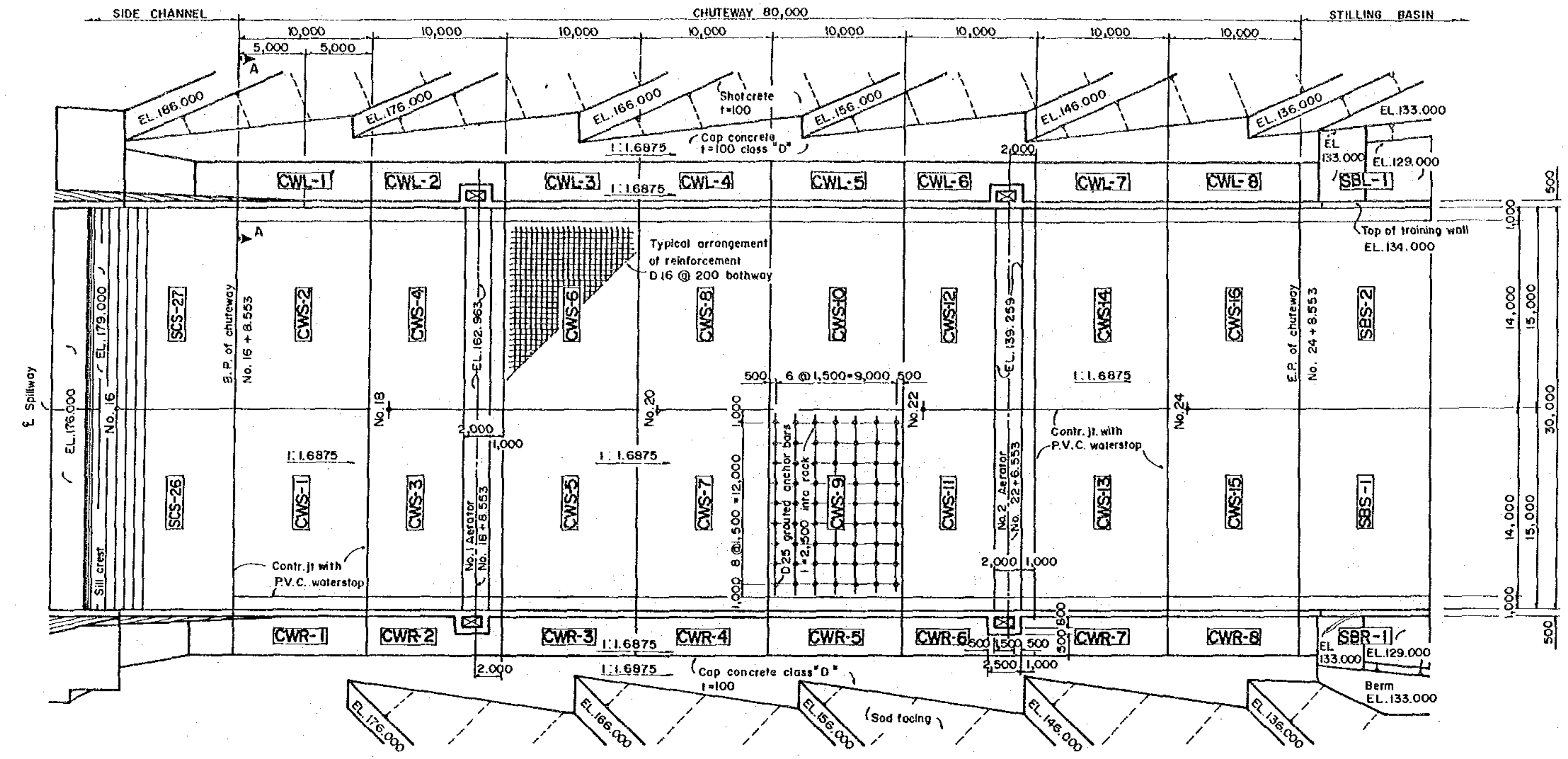
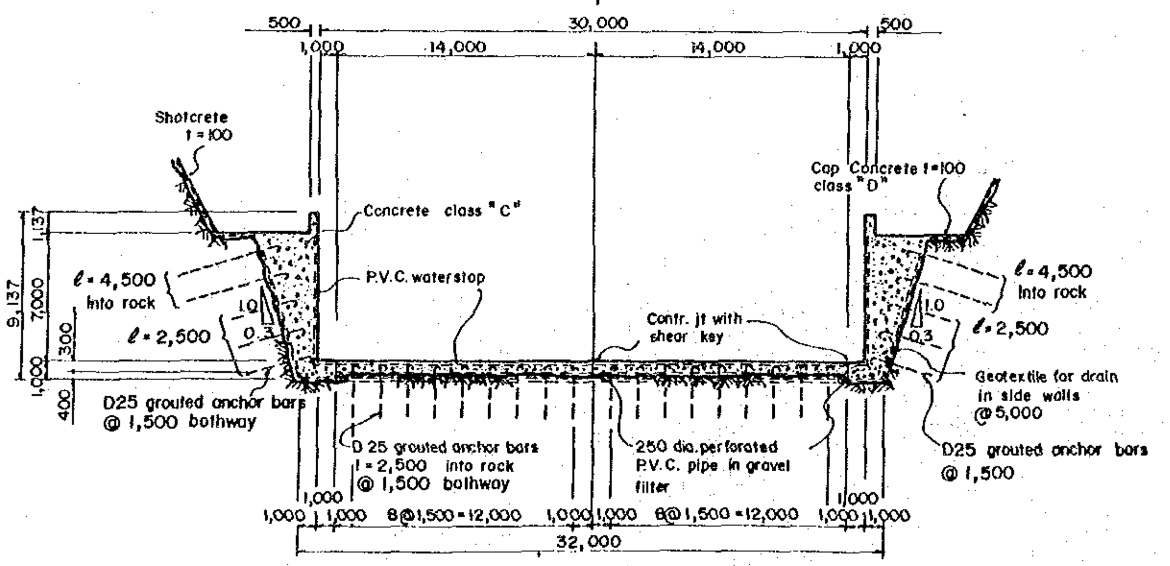


Fig 4.1.7
SCL-15
SCL-16
BP. of chuteway No.16+8.553
No.17+3.553
1.3408
1.0
5,000
5,000
EL.183.125
CWL-1
Sill crest EL.179.000
EL.179.396
EL.176.000
Typical arrangement of grouted anchor bars in side walls D25 @ 1,500 bothway
CWL-2
EL.174.222
No.1 Aerator No.18+6.553
CWL-3
1.6875
1.0
CWL-4
EL.162.963
Typical arrangement of reinforcement in side walls D16@ 200 bothway
500
6@1,500=9,000
500
CWL-5
No.2 Aerator No.22+6.553
CWL-6
EP. of chuteway No.24+8.553
5,217
8,336
CHUTEWAY 80,000
STILLING BASIN
SIDE CHANNEL
10,000
250 dia. perforated P.V.C. pipe in gravel filter
1.6875
1.0
Contr. jt. with P.V.C. waterstop
2,000
CWL-7
Contr. jt. with P.V.C. waterstop
CWL-8
PROFILE SCALE A
EL.139.259
SBL-1
EL.134.952
EL.134.000
EL.133.000
EL.129.000
EL.126.815
D25 grouted anchor bars in slabs ℓ=2,500 into rock @ 1,500 bothway
Concrete class "C"
7,000
8,137
Cap concrete t=100 class "D"
Concrete class "C"
ℓ=4,500 into rock
ℓ=2,500
D25 grouted anchor bars @ 1,500
3,667
4,333
7,000
9,137
1,137
Varies
1,000
200
500
1,000 800 1,000
3,300
SECTION
℄ Aerator
2,500
1,000
500
1,500
500
2,000
2,500
1.6875
1.0
Contr. jt.
D25 grouted anchor bars ℓ=2,500 into rock @ 1,500
Concrete class "C"
Waterstop
1,000
1,726
2,726
PROFILE
AERATOR DETAILS SCALE B
D16 @ 200
TYPICAL ARRANGEMENT OF REINFORCEMENT SCALE B
Key
Contr. jt.
6,500
8,137
500
1,137
a
500 500
SCALE B
SHEAR KEY DETAILS
100 300 100
500
SECTION a-a SCALE C
CONCRETE FINISHES
Exposed surfaces (Water flow section) ...... F4 or U2
Other exposed surfaces ...... F2, F3, or U2
All other surfaces ...... F1 or U1
All exposed edges shall be chamfered 25 mm x 25 mm unless otherwise noted.
NOTES;
1) For general notes, see DWG.NO.C-051.
2) Marked thus CWL-1 shows the block number.
3) PVC. water stops, type A (300mm wide) shall be provided in construction joint.
4) Work this drawing with DWG.NO.C-066.
- DWG. NO. shown on this Figure indicates the Tender Drawing No..
SCALE A 0 20 m
SCALE B 0 10 m
SCALE C 0 2 m
SPILLWAY
CHUTEWAY, STRUCTURAL DETAILS (1)
GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig 4.1.8

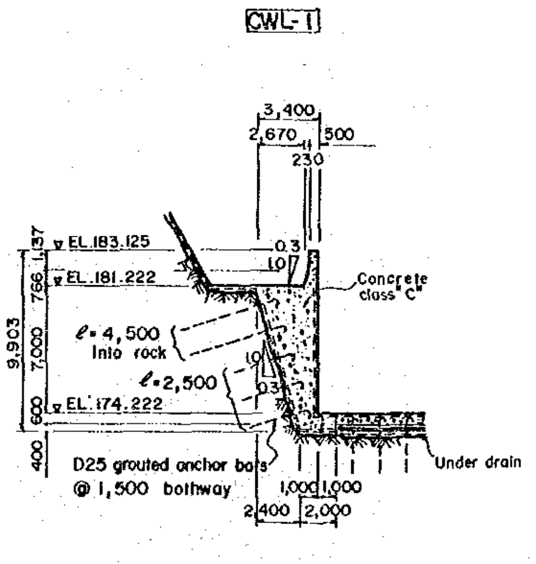


PLAN



TYPICAL SECTION

SCALE 0 20m



SECTION A-A
(No.16 + 8.553)

NOTES;

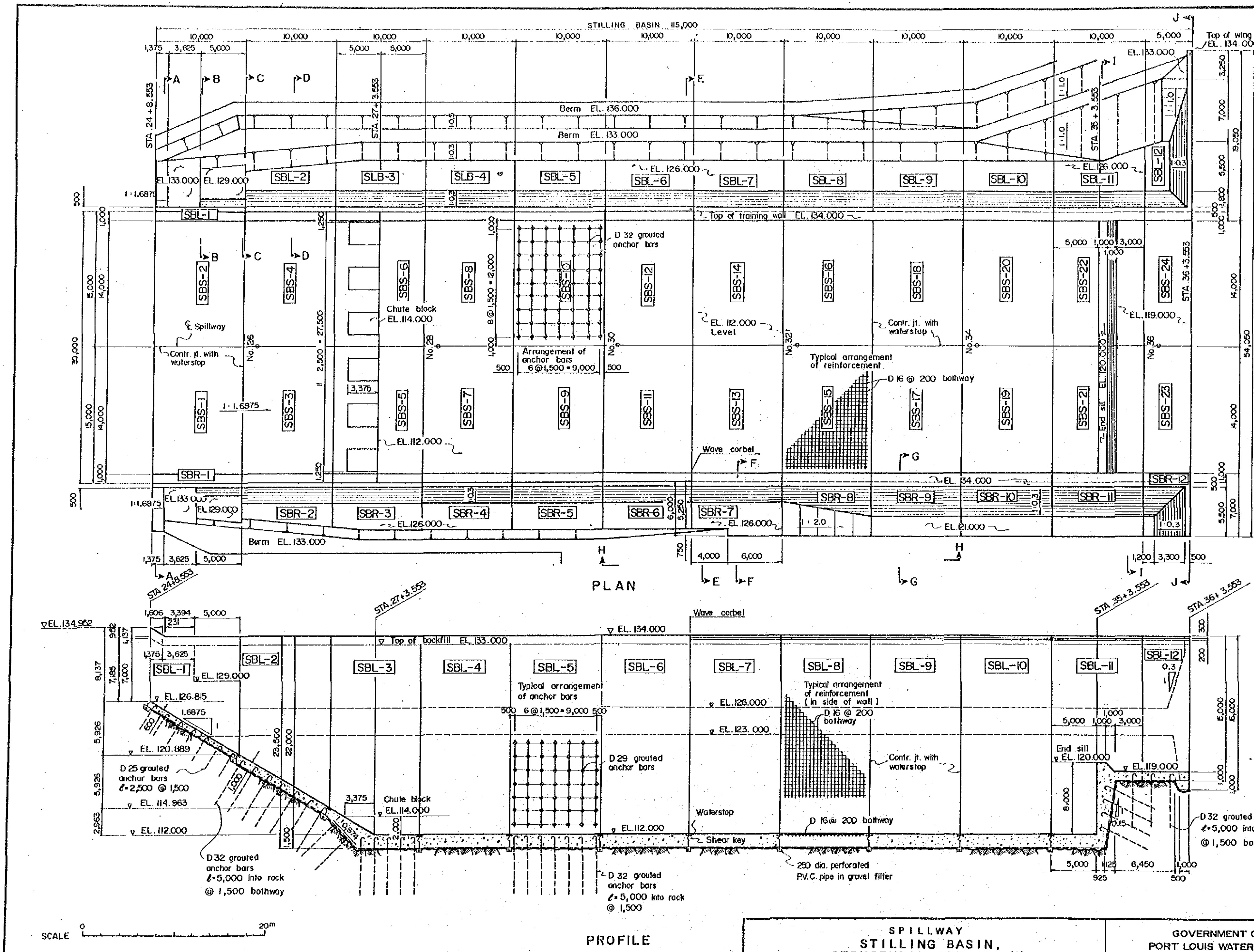
1) For concrete finishes, see DWG.NO.C-067.

2) For notes, see DWG.NO.C-067.

- DWG. NO. shown on this Figure indicates the Tender Drawing No..

SPILLWAY CHUTEWAY, STRUCTURAL DETAILS (2)	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT
	JAPAN INTERNATIONAL COOPERATION AGENCY

Fig 4.1.9



CONCRETE FINISHES

Exposed surfaces(Water flow section)..... F4 or U2
Other exposed surfaces............F2,F3,or U2
All other surfaces............F1 or U1
All exposed edges shall be chamfered 25 mm x 25 mm unless otherwise noted.

NOTES;

1) For general notes, see DWG.NO.C-051.
2) Construction of curved surface in chord length will not be permitted.
3) Marked thus [SBL-1] shows the block number.
4) For sections A-A to H-H, see DWG.NO.C-068. For sections I-I to J-J, see DWG.NO.C-069.
5) PVC. water stop type A (300mm wide) Shall be provided in contraction joint.
6) Work this drawing with DWG.NO.C-068 and C-069.

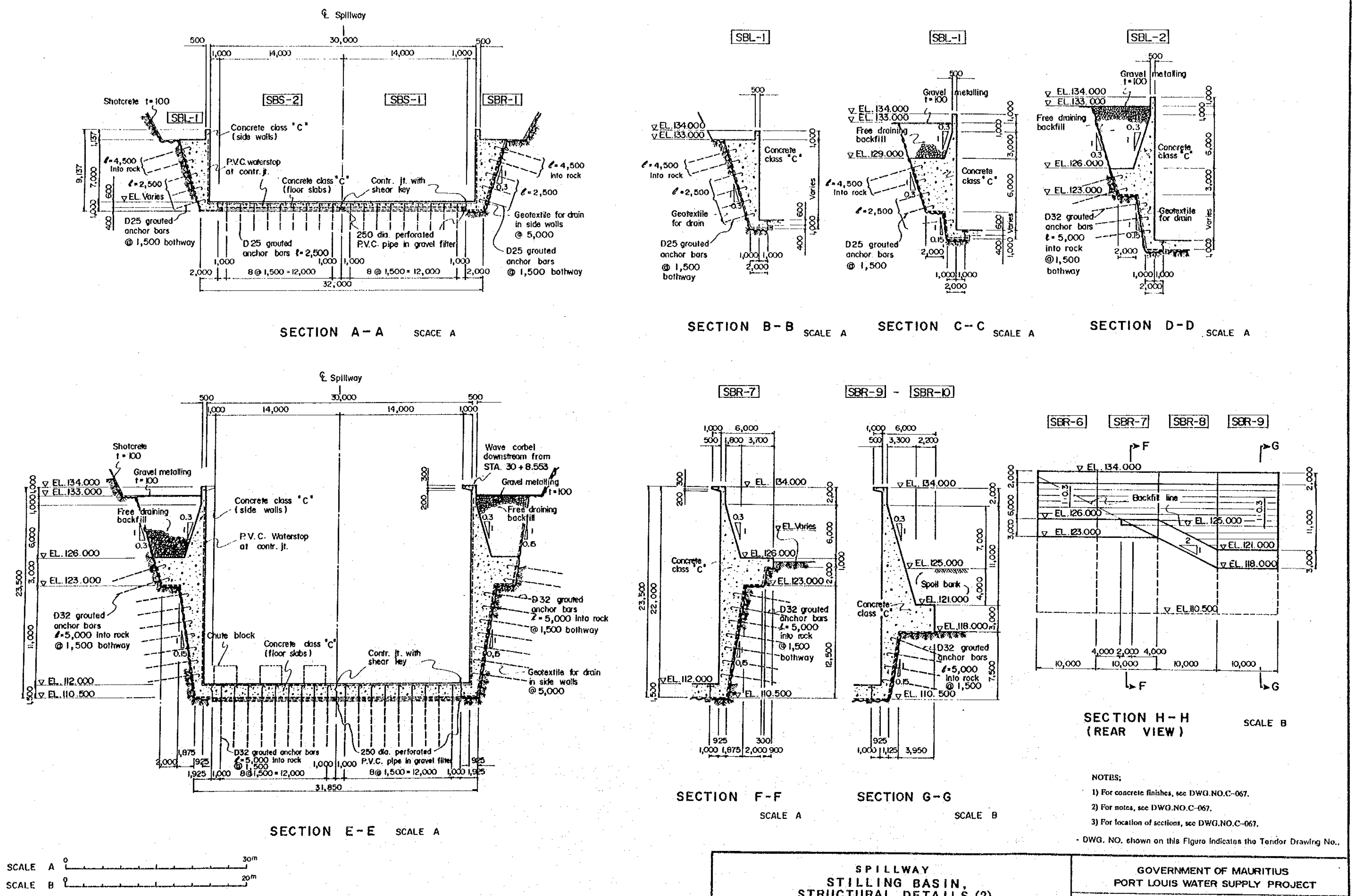
• DWG. NO. shown on this Figure indicates the Tender Drawing No.

SPILLWAY
STILLING BASIN,
STRUCTURAL DETAILS (1)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig 4.1.10



NOTES;

1) For concrete finishes, see DWG.NO.C-067.

2) For notes, see DWG.NO.C-067.

3) For location of sections, see DWG.NO.C-067.

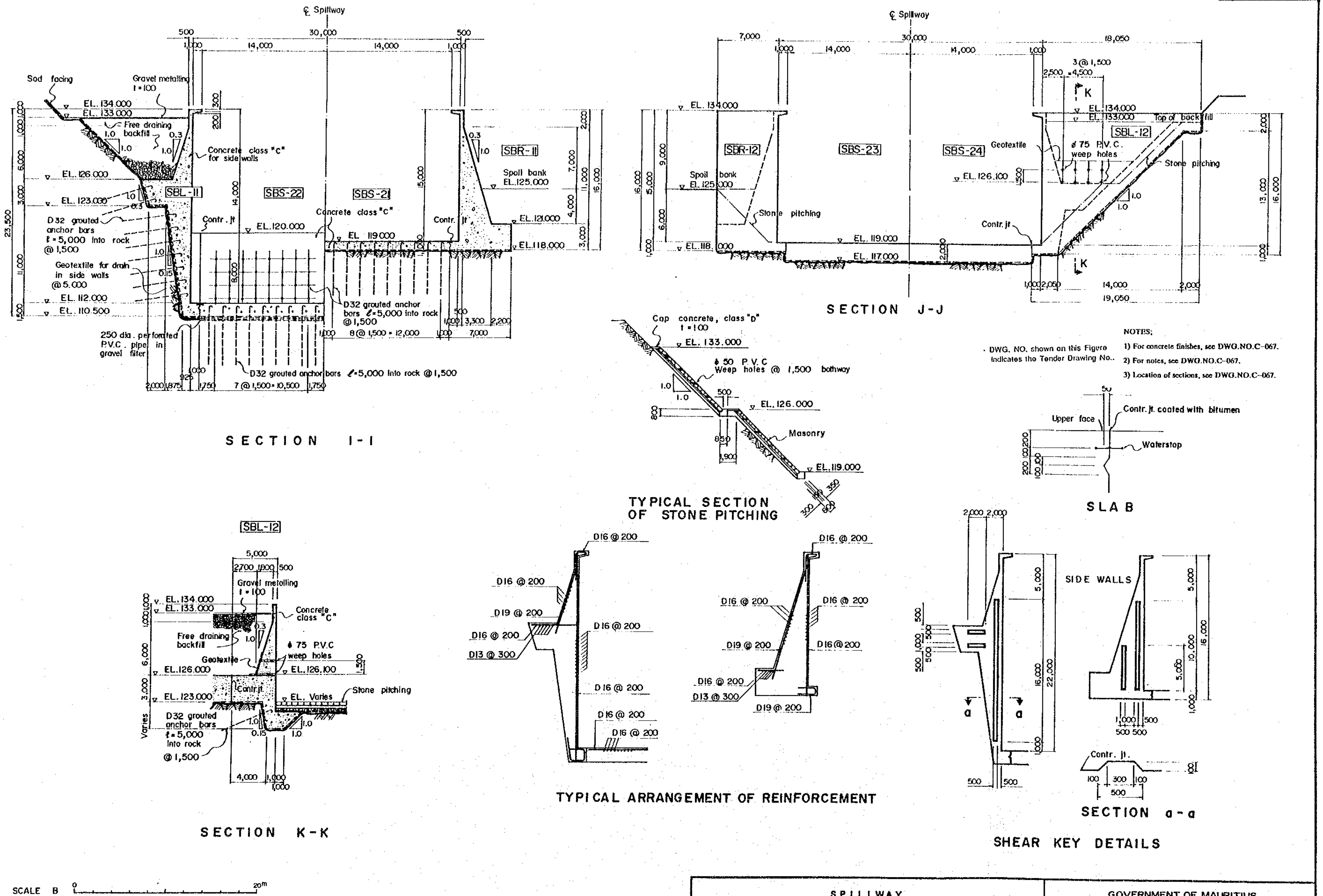
- DWG. NO. shown on this Figure indicates the Tender Drawing No..

SPILLWAY STILLING BASIN, STRUCTURAL DETAILS (2)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

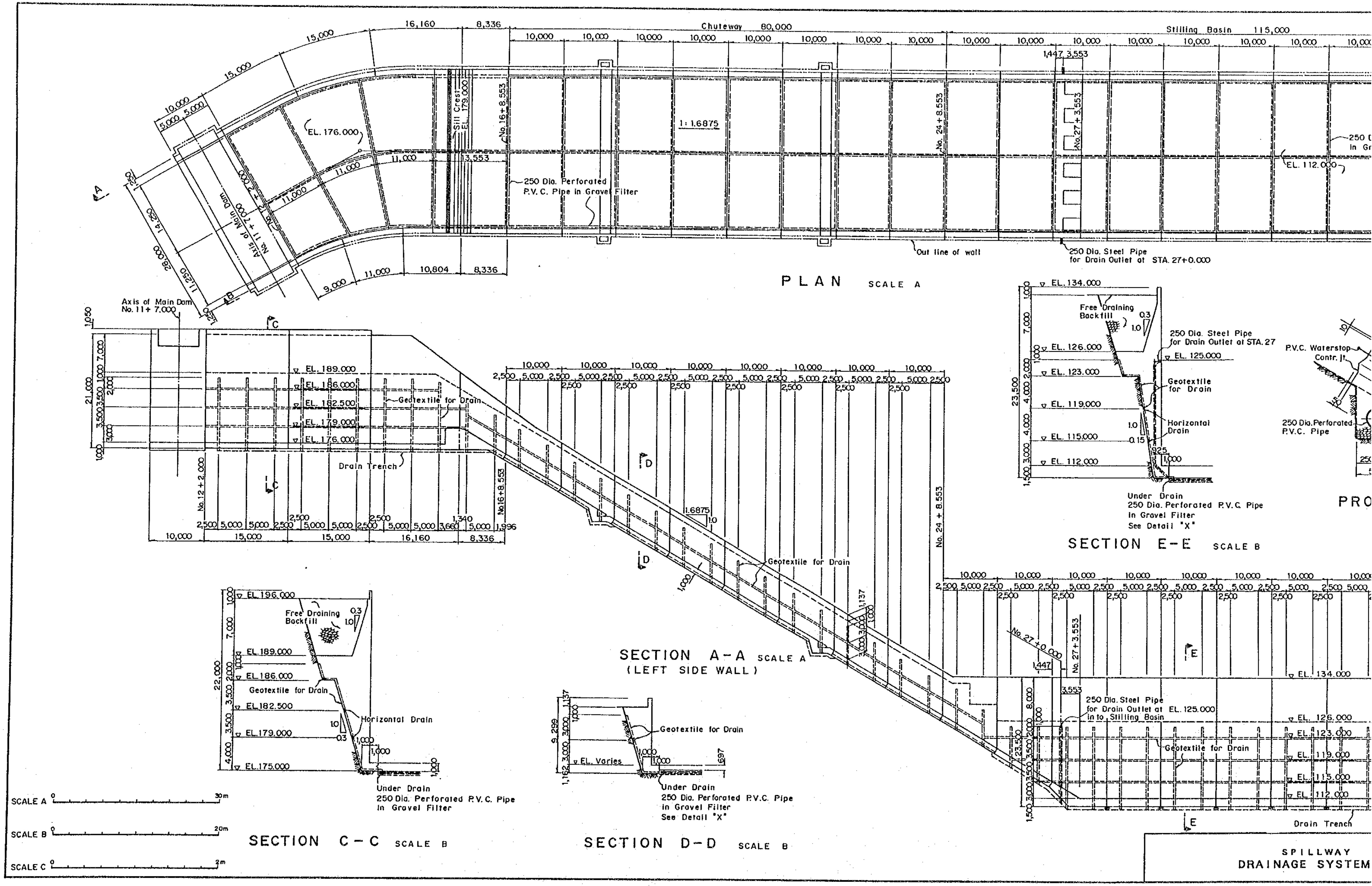
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig 4.1.11



SPILLWAY
STILLING BASIN,
STRUCTURAL DETAILS (3)

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


PLAN SCALE A
Chuteway 80,000
Stilling Basin 115,000
Sill Crest EL. 179.000
EL. 176.000
EL. 112.000
1: 1.6875
No. 16+8.553
No. 24+8.553
No. 27+3.553
No. 11+7.000
Axis of Main Dam
250 Dia. Perforated P.V.C. Pipe in Gravel Filter
Out line of wall
250 Dia. Steel Pipe for Drain Outlet at STA. 27+0.000
Axis of Main Dam No. 11+7.000
EL. 189.000
EL. 186.000
EL. 182.500
EL. 179.000
EL. 176.000
Geotextile for Drain
Drain Trench
No. 12+2.000
SECTION A-A SCALE A
(LEFT SIDE WALL)
Geotextile for Drain
No. 27+0.000
250 Dia. Steel Pipe for Drain Outlet at EL. 125.000 in to Stilling Basin
EL. 134.000
EL. 126.000
EL. 123.000
EL. 119.000
EL. 115.000
EL. 112.000
Drain Trench
SECTION E-E SCALE B
EL. 134.000
Free Draining Backfill
250 Dia. Steel Pipe for Drain Outlet at STA. 27
EL. 125.000
EL. 126.000
EL. 123.000
EL. 119.000
EL. 115.000
EL. 112.000
Geotextile for Drain
Horizontal Drain
Under Drain
250 Dia. Perforated P.V.C. Pipe In Gravel Filter
See Detail "X"
P.V.C. Waterstop
Contr. Jt.
250 Dia. Perforated P.V.C. Pipe
PRO
SECTION C-C SCALE B
EL. 196.000
Free Draining Backfill
EL. 189.000
EL. 186.000
Geotextile for Drain
EL. 182.500
Horizontal Drain
EL. 179.000
EL. 175.000
Under Drain
250 Dia. Perforated P.V.C. Pipe in Gravel Filter
SECTION D-D SCALE B
Geotextile for Drain
EL. Varies
Under Drain
250 Dia. Perforated P.V.C. Pipe in Gravel Filter
See Detail "X"
SCALE A 0 30m
SCALE B 0 20m
SCALE C 0 2m
SPILLWAY
DRAINAGE SYSTEM

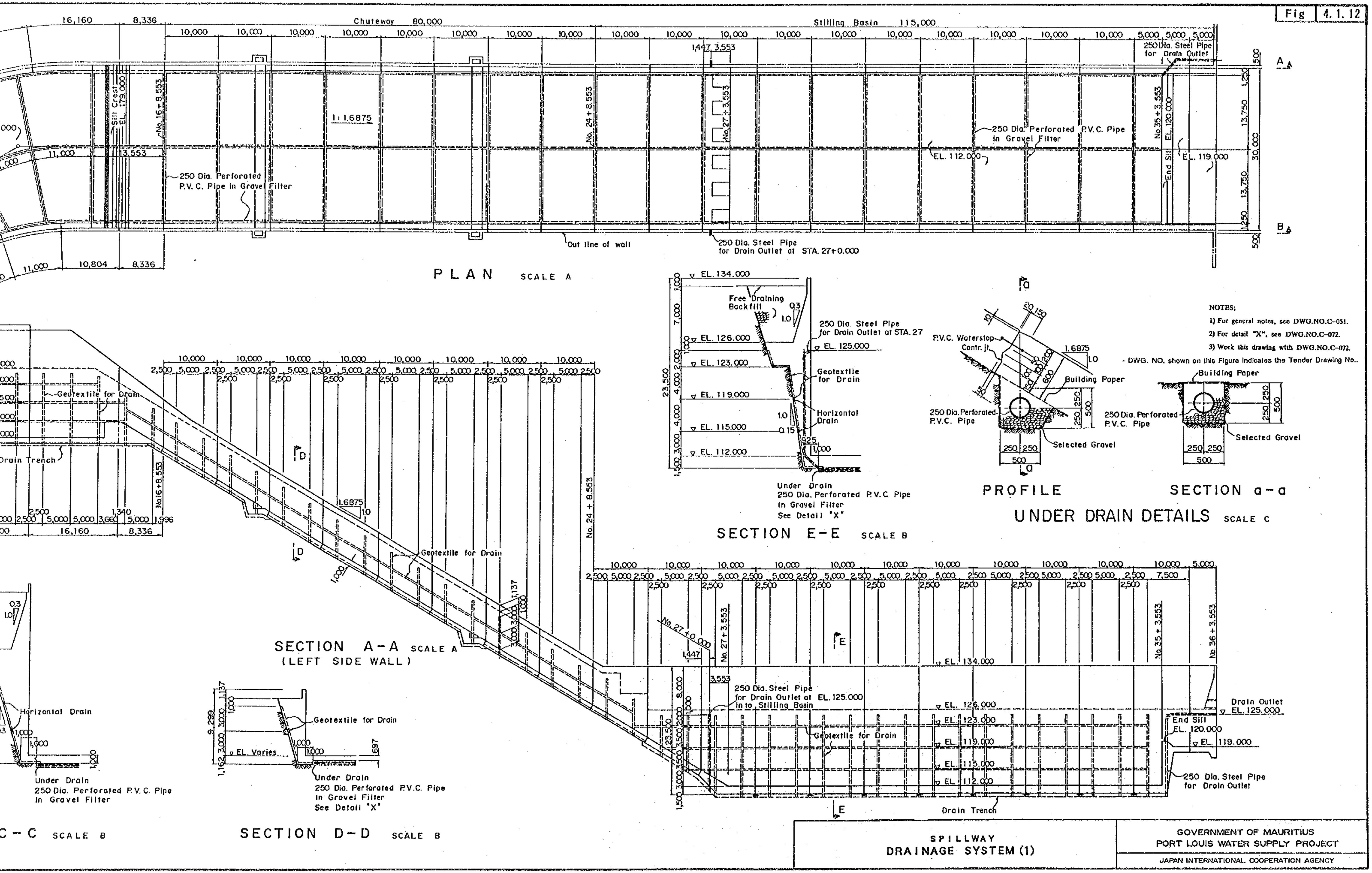


Fig 4.1.12
Chuteway 80,000
Stilling Basin 115,000
Sill Crest EL. 179.000
No. 16+8.553
No. 24+8.553
No. 27+3.553
No. 35+3.553
End Sill EL. 120.000
EL. 119.000
EL. 112.000
1: 1.6875
250 Dia. Perforated P.V.C. Pipe in Gravel Filter
250 Dia. Steel Pipe for Drain Outlet
Out line of wall
250 Dia. Steel Pipe for Drain Outlet at STA. 27+0.000
PLAN SCALE A
Free Draining Backfill
250 Dia. Steel Pipe for Drain Outlet at STA. 27
EL. 134.000
EL. 126.000
EL. 125.000
EL. 123.000
EL. 115.000
Geotextile for Drain
Horizontal Drain
Under Drain
250 Dia. Perforated P.V.C. Pipe in Gravel Filter
See Detail "X"
SECTION E-E SCALE B
P.V.C. Waterstop
Contr. Jt.
Building Paper
250 Dia. Perforated P.V.C. Pipe
Selected Gravel
PROFILE
SECTION a-a
UNDER DRAIN DETAILS SCALE C
NOTES;
1) For general notes, see DWG.NO.C-051.
2) For detail "X", see DWG.NO.C-072.
3) Work this drawing with DWG.NO.C-072.
- DWG. NO. shown on this Figure indicates the Tender Drawing No..
Drain Trench
SECTION A-A SCALE A
(LEFT SIDE WALL)
No. 27+0.000
No. 36+3.553
250 Dia. Steel Pipe for Drain Outlet at EL. 125.000 in to Stilling Basin
Drain Outlet EL. 125.000
EL. Varies
C-C SCALE B
SECTION D-D SCALE B
SPILLWAY
DRAINAGE SYSTEM (1)
GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

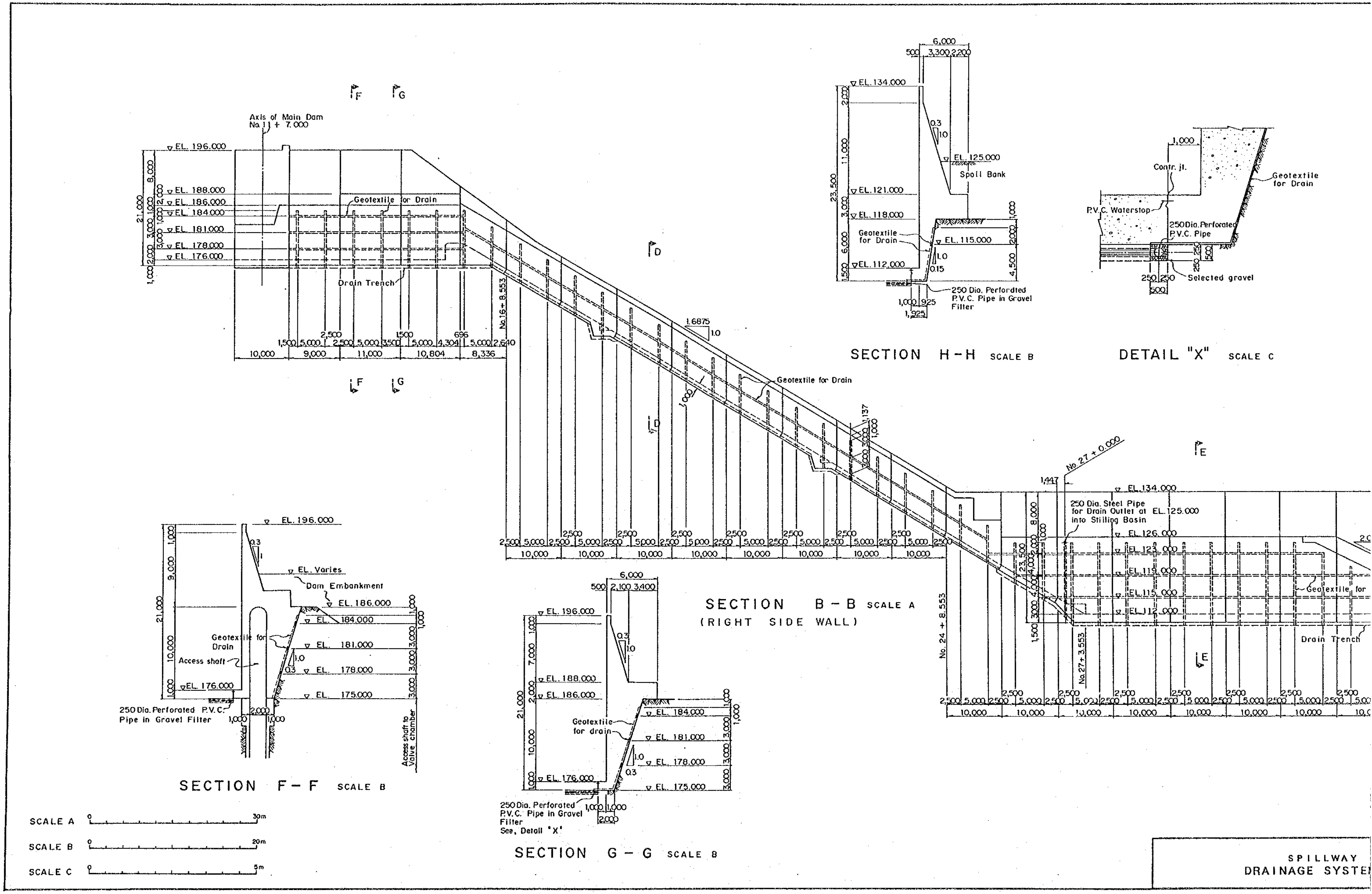
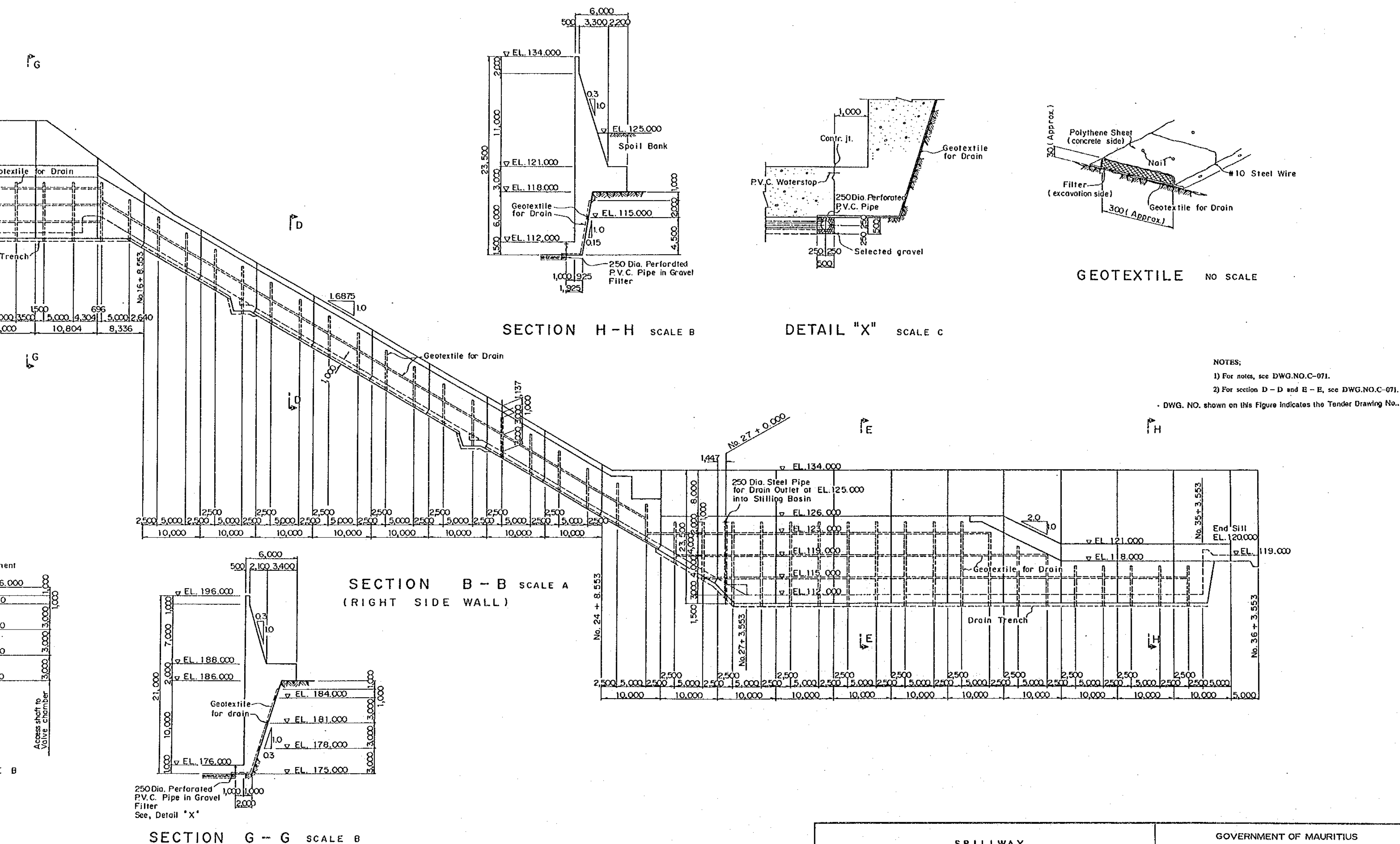

Axis of Main Dam
No.11 + 7.000
EL. 196.000
EL. 188.000
EL. 186.000
EL. 184.000
EL. 181.000
EL. 178.000
EL. 176.000
Geotextile for Drain
Drain Trench
No.16 + 8.553
1.6875
1.0
Geotextile for Drain
No 27 + 0.000
1,447
EL. 134.000
250 Dia. Steel Pipe for Drain Outlet at EL. 125.000 into Stilling Basin
EL. 126.000
EL. 123.000
EL. 119.000
EL. 115.000
EL. 112.000
Geotextile for
Drain Trench
No. 24 + 8.553
No. 27+ 3.553
SECTION B - B SCALE A
(RIGHT SIDE WALL)
6,000
500 3,300 2,200
EL. 134.000
EL. 125.000
Spoil Bank
EL. 121.000
EL. 118.000
Geotextile for Drain
EL. 115.000
EL. 112.000
250 Dia. Perforated P.V.C. Pipe in Gravel Filter
SECTION H - H SCALE B
1,000
Contr. jt.
Geotextile for Drain
P.V.C. Waterstop
250 Dia. Perforated P.V.C. Pipe
Selected gravel
DETAIL "X" SCALE C
EL. 196.000
EL. Varies
Dam Embankment
EL. 186.000
EL. 184.000
Geotextile for Drain
EL. 181.000
Access shaft
EL. 178.000
EL. 176.000
EL. 175.000
250 Dia. Perforated P.V.C. Pipe in Gravel Filter
Access shaft to Valve chamber
SECTION F - F SCALE B
6,000
500 2,100 3,400
EL. 196.000
EL. 188.000
EL. 186.000
EL. 184.000
Geotextile for drain
EL. 181.000
EL. 178.000
EL. 176.000
EL. 175.000
250 Dia. Perforated P.V.C. Pipe in Gravel Filter
See, Detail "X"
SECTION G - G SCALE B
SCALE A 0 30m
SCALE B 0 20m
SCALE C 0 5m
SPILLWAY
DRAINAGE SYSTE

Fig 4.1.13



NOTES;

1) For notes, see DWG.NO.C-071.

2) For section D – D and E – E, see DWG.NO.C-071.

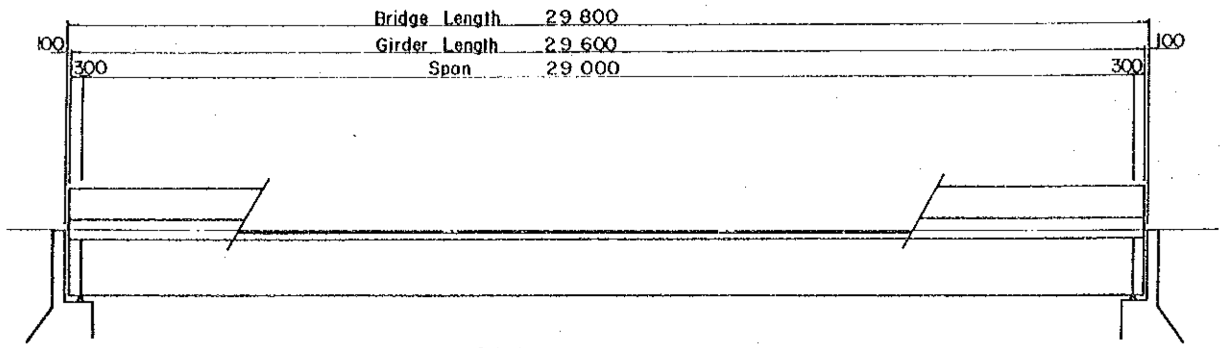
- DWG. NO. shown on this Figure indicates the Tender Drawing No..

SPILLWAY
DRAINAGE SYSTEM (2)

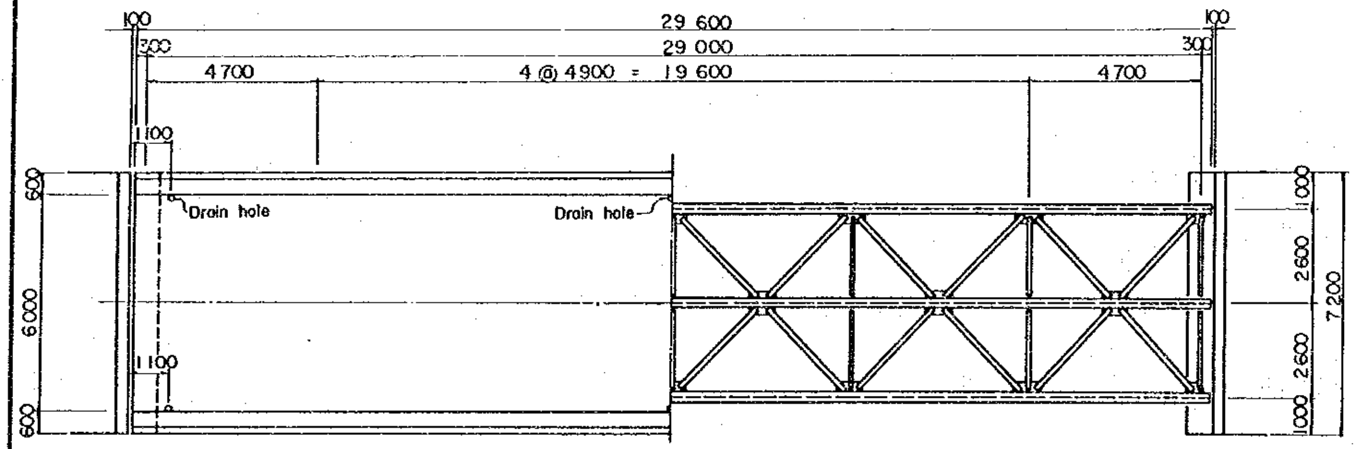
GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

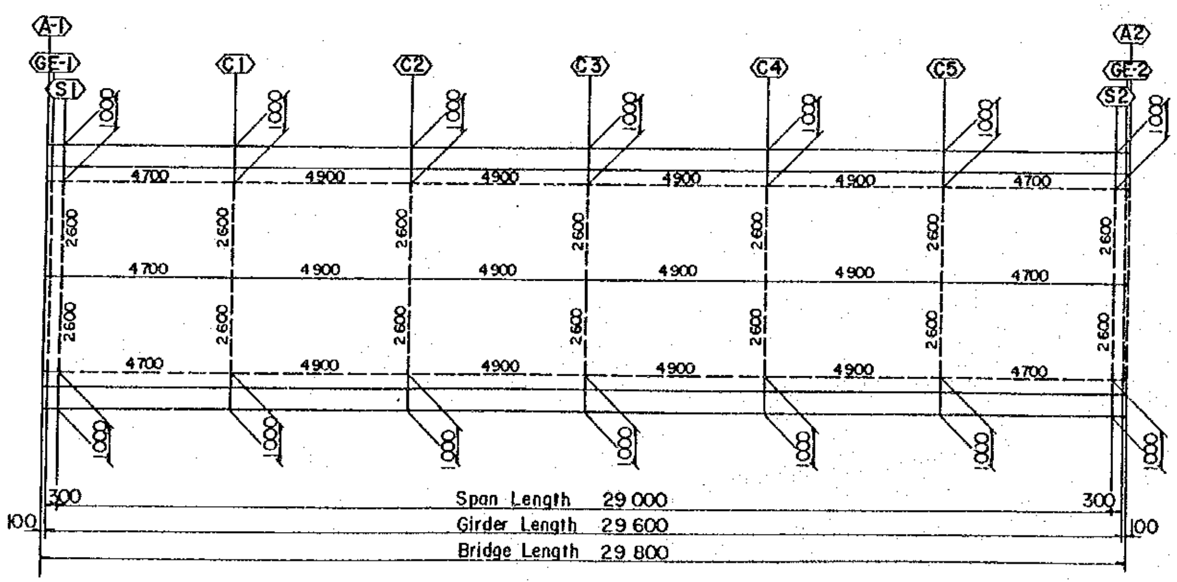
Fig 4.1.14



PROFILE
SCALE A

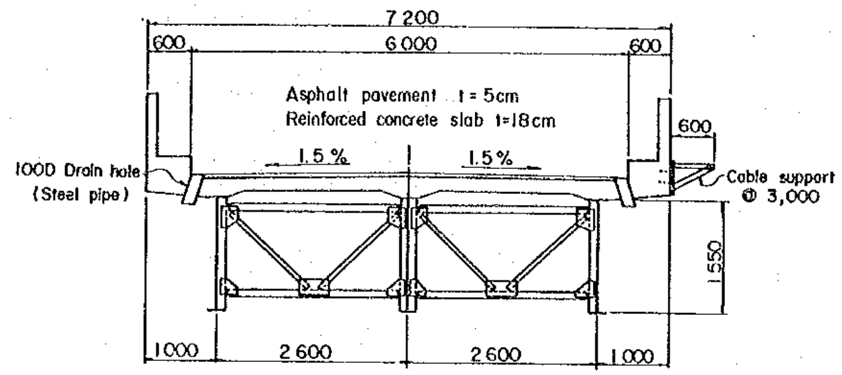


PLAN
SCALE A

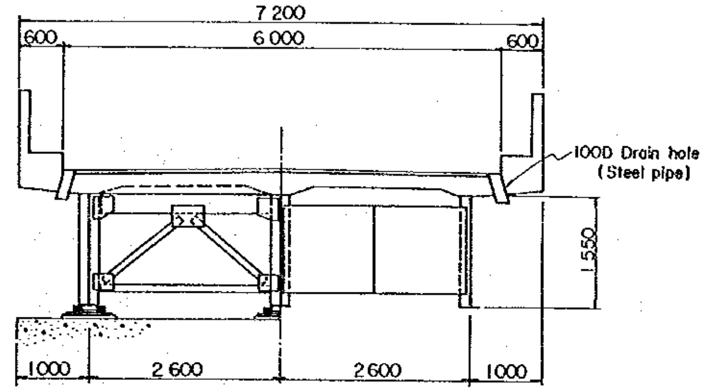


FRAMING PLAN

CROSS SECTION
SCALE B



MIDDLE PORTION



END PORTION

CROSS BEAM

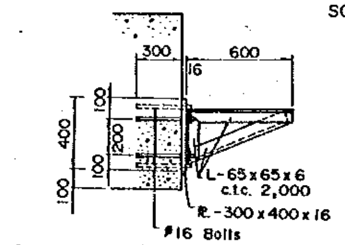
- DWG. NO. shown on this Figure indicates the Tender Drawing No..

DESIGN CONDITION

CLASS	2nd. Class
BRIDGE TYPE	Simple Composite Girder
BRIDGE LENGTH	29.8m
SPAN	29.0m
WIDTH	6.0m
ANGLE OF SKEW	90 degree
LIVE LOAD	TL-14
COEF. OF SLAB THICKNESS	1.1
SLAB THICKNESS	180mm
PAVING THICKNESS	50mm
SEISMIC COEFFICIENT	Kh= 0.05
COMPRESSIVE STRENGTH	270 kg/cm2
ALLOWABLE STRESS **	Concrete : 77 kg/cm2
	R.bar : 1,400 kg/cm2 (SD30)

** According to the "DESIGN STANDARD OF ROAD BRIDGE" in Japan.

DETAIL OF CABLE SUPPORT
SCALE C



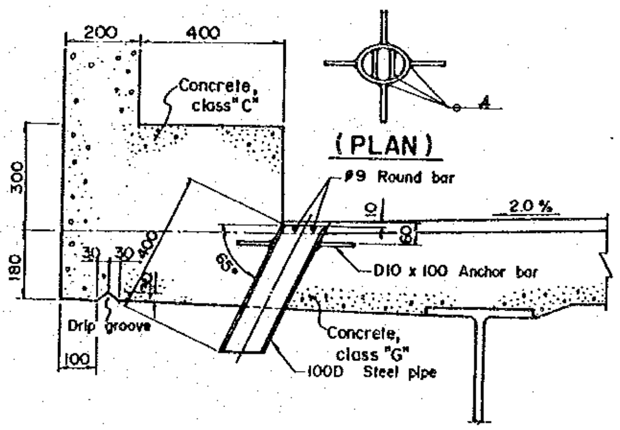
CONCRETE FINISHES

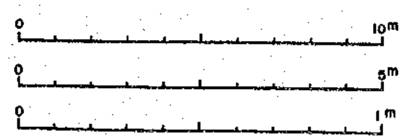
Exposed surfaces............F3
All other surfaces............F1
All exposed edges shall be chamfered 25 mm x 25 mm unless otherwise noted.

NOTES;

1) For general notes, see DWG.NO.C-051.
2) All steel materials to be JISS-SS41 unless otherwise noted.

DETAIL OF DRAIN HOLE
SCALE C





		A1	GE1	S1	C1	C2	C3	C4	C5	S2	GE2	A2
L1	X	0.0000	0.1000	0.4000	5.1000	10.0000	14.9000	19.8000	24.7000	29.4000	29.7000	29.8000
	Y	3.6000	3.6000	3.6000	3.6000	3.6000	3.6000	3.6000	3.6000	3.6000	3.6000	3.6000
L2	X	0.0000	0.1000	0.4000	5.1000	10.0000	14.9000	19.8000	24.7000	29.4000	29.7000	29.8000
	Y	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
G1	X	0.0000	0.1000	0.4000	5.1000	10.0000	14.9000	19.8000	24.7000	29.4000	29.7000	29.8000
	Y	2.6000	2.6000	2.6000	2.6000	2.6000	2.6000	2.6000	2.6000	2.6000	2.6000	2.6000
CL	X	0.0000	0.1000	0.4000	5.1000	10.0000	14.9000	19.8000	24.7000	29.4000	29.7000	29.8000
	Y	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
G2	X	0.0000	0.1000	0.4000	5.1000	10.0000	14.9000	19.8000	24.7000	29.4000	29.7000	29.8000
	Y	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
G3	X	0.0000	0.1000	0.4000	5.1000	10.0000	14.9000	19.8000	24.7000	29.4000	29.7000	29.8000
	Y	-2.6000	-2.6000	-2.6000	-2.6000	-2.6000	-2.6000	-2.6000	-2.6000	-2.6000	-2.6000	-2.6000
L3	X	0.0000	0.1000	0.4000	5.1000	10.0000	14.9000	19.8000	24.7000	29.4000	29.7000	29.8000
	Y	-3.0000	-3.0000	-3.0000	-3.0000	-3.0000	-3.0000	-3.0000	-3.0000	-3.0000	-3.0000	-3.0000
L4	X	0.0000	0.1000	0.4000	5.1000	10.0000	14.9000	19.8000	24.7000	29.4000	29.7000	29.8000
	Y	-3.6000	-3.6000	-3.6000	-3.6000	-3.6000	-3.6000	-3.6000	-3.6000	-3.6000	-3.6000	-3.6000

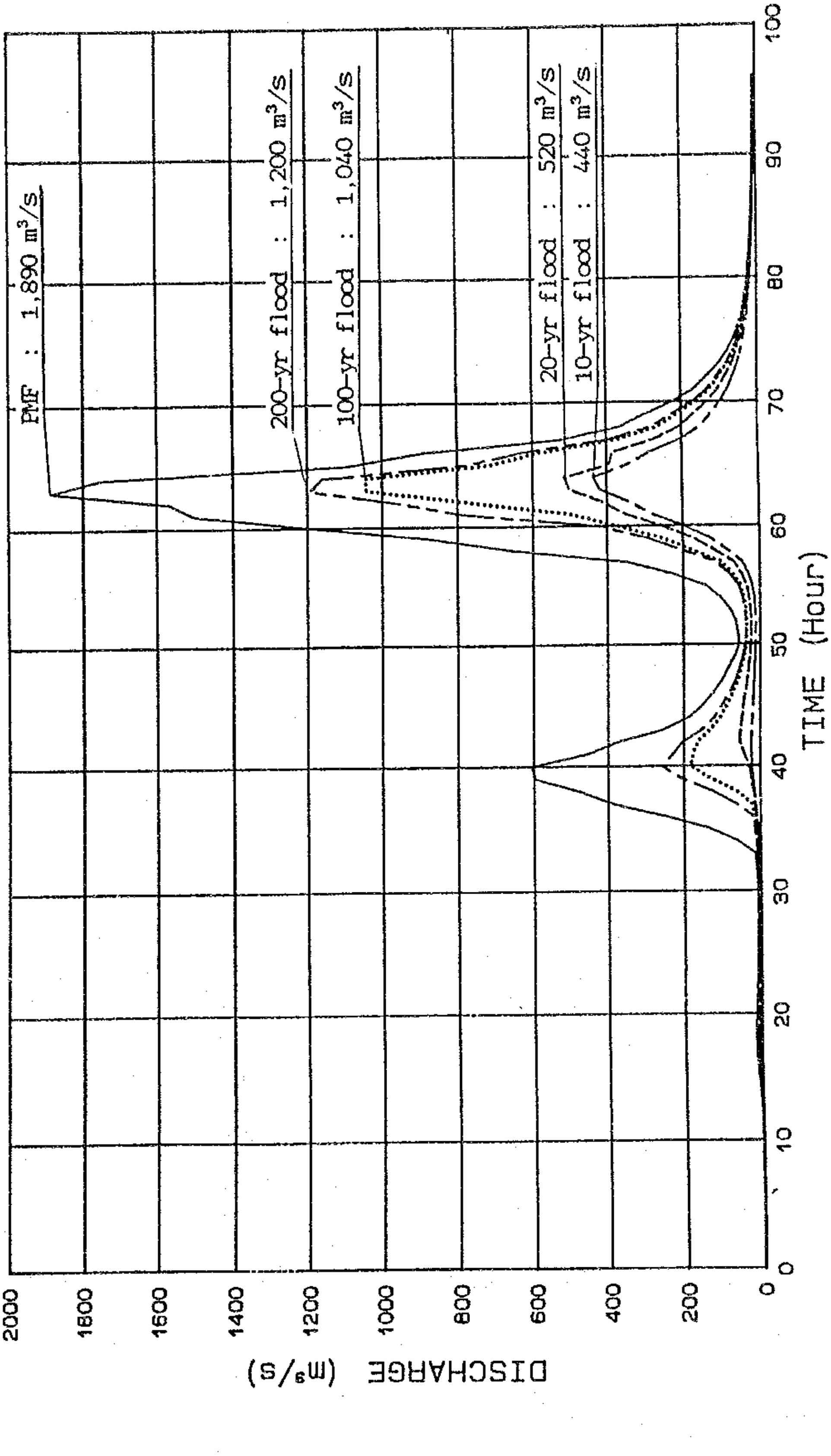
		A1	GE1	S1	C1	C2	C3	C4	C5	S2	GE2	A2
L1	Z	0.2050	0.2050	0.2050	0.2050	0.2050	0.2050	0.2050	0.2050	0.2050	0.2050	0.2050
L2	Z	-0.0450	-0.0450	-0.0450	-0.0450	-0.0450	-0.0450	-0.0450	-0.0450	-0.0450	-0.0450	-0.0450
G1	Z	-0.0390	-0.0390	-0.0390	-0.0390	-0.0390	-0.0390	-0.0390	-0.0390	-0.0390	-0.0390	-0.0390
	H			0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600		
	W			-0.3290	-0.3290	-0.3290	-0.3290	-0.3290	-0.3290	-0.3290		
CL	Z	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
G2	Z	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	H			0.0990	0.0990	0.0990	0.0990	0.0990	0.0990	0.0990		
	W			-0.3290	-0.3290	-0.3290	-0.3290	-0.3290	-0.3290	-0.3290		
G3	Z	-0.0390	-0.0390	-0.0390	-0.0390	-0.0390	-0.0390	-0.0390	-0.0390	-0.0390	-0.0390	-0.0390
	H			0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600		
	W			-0.3290	-0.3290	-0.3290	-0.3290	-0.3290	-0.3290	-0.3290		
L3	Z	-0.0450	-0.0450	-0.0450	-0.0450	-0.0450	-0.0450	-0.0450	-0.0450	-0.0450	-0.0450	-0.0450
L4	Z	0.2050	0.2050	0.2050	0.2050	0.2050	0.2050	0.2050	0.2050	0.2050	0.2050	0.2050

SPILLWAY BRIDGE, PLAN, PROFILE AND SECTIONS

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

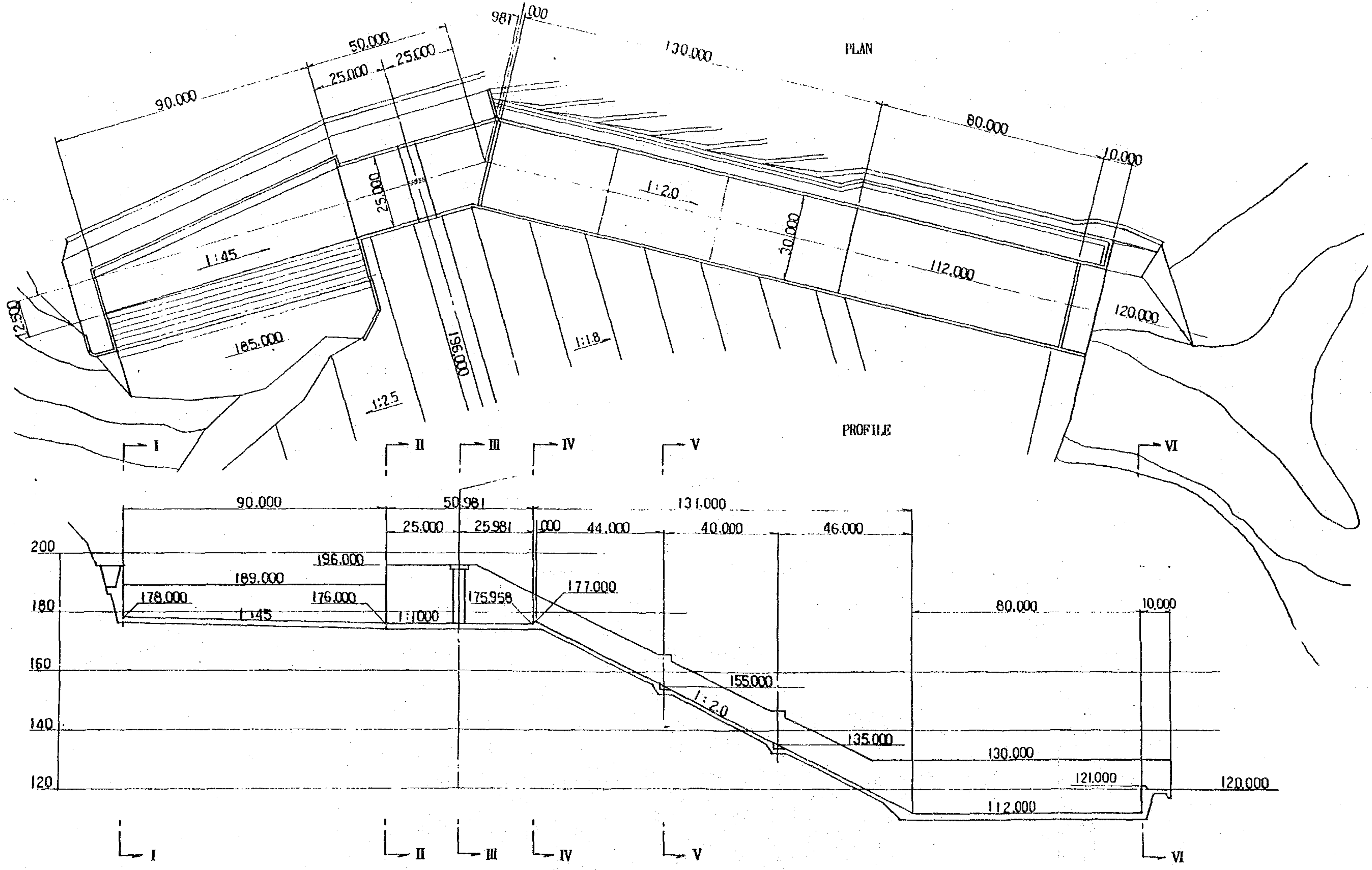
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 4.2.1



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

Fig. 4.2.2

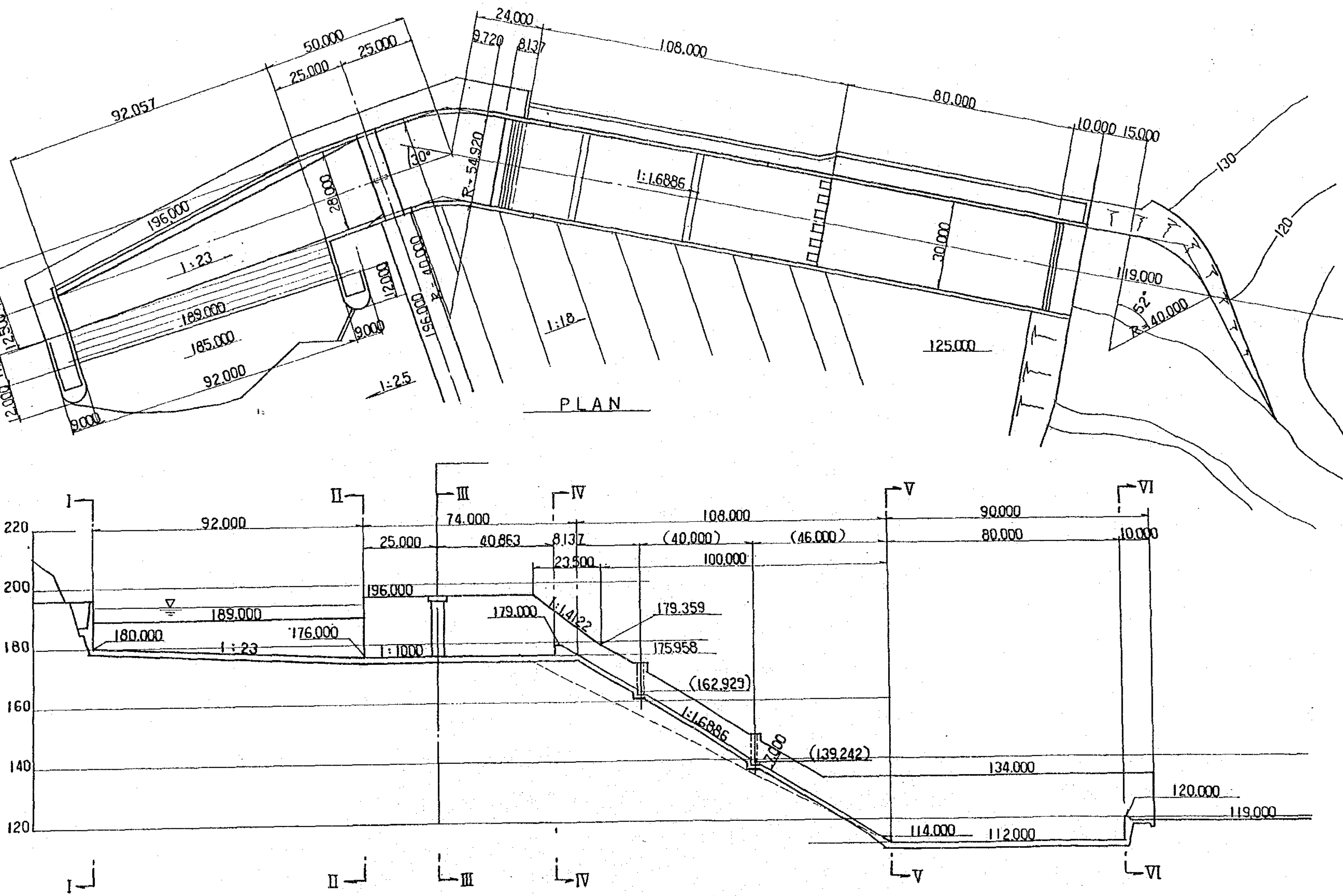


ORIGINAL DESIGN OF SPILLWAY

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 4.2.3

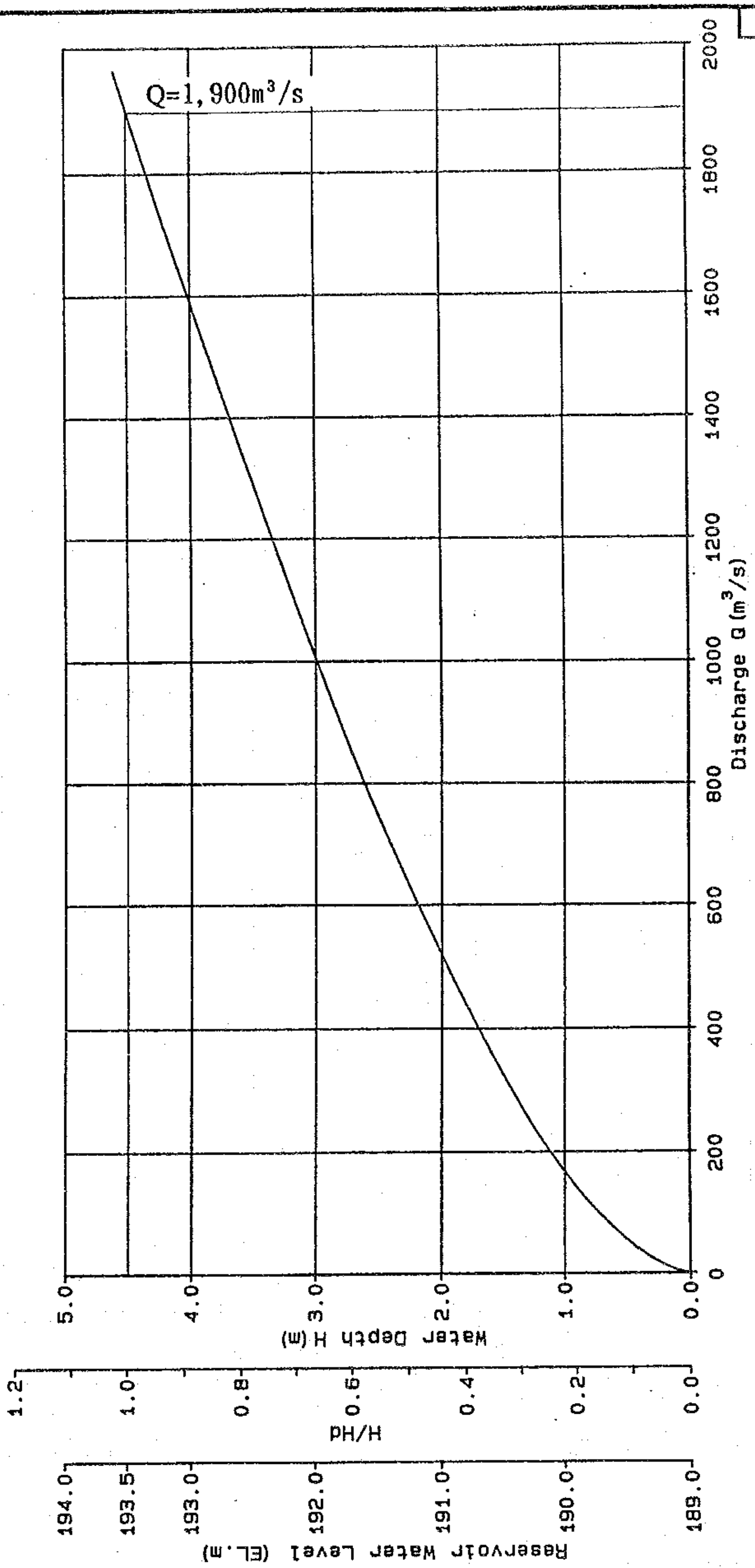


REVISED DESIGN OF SPILLWAY (FINAL DESIGN)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

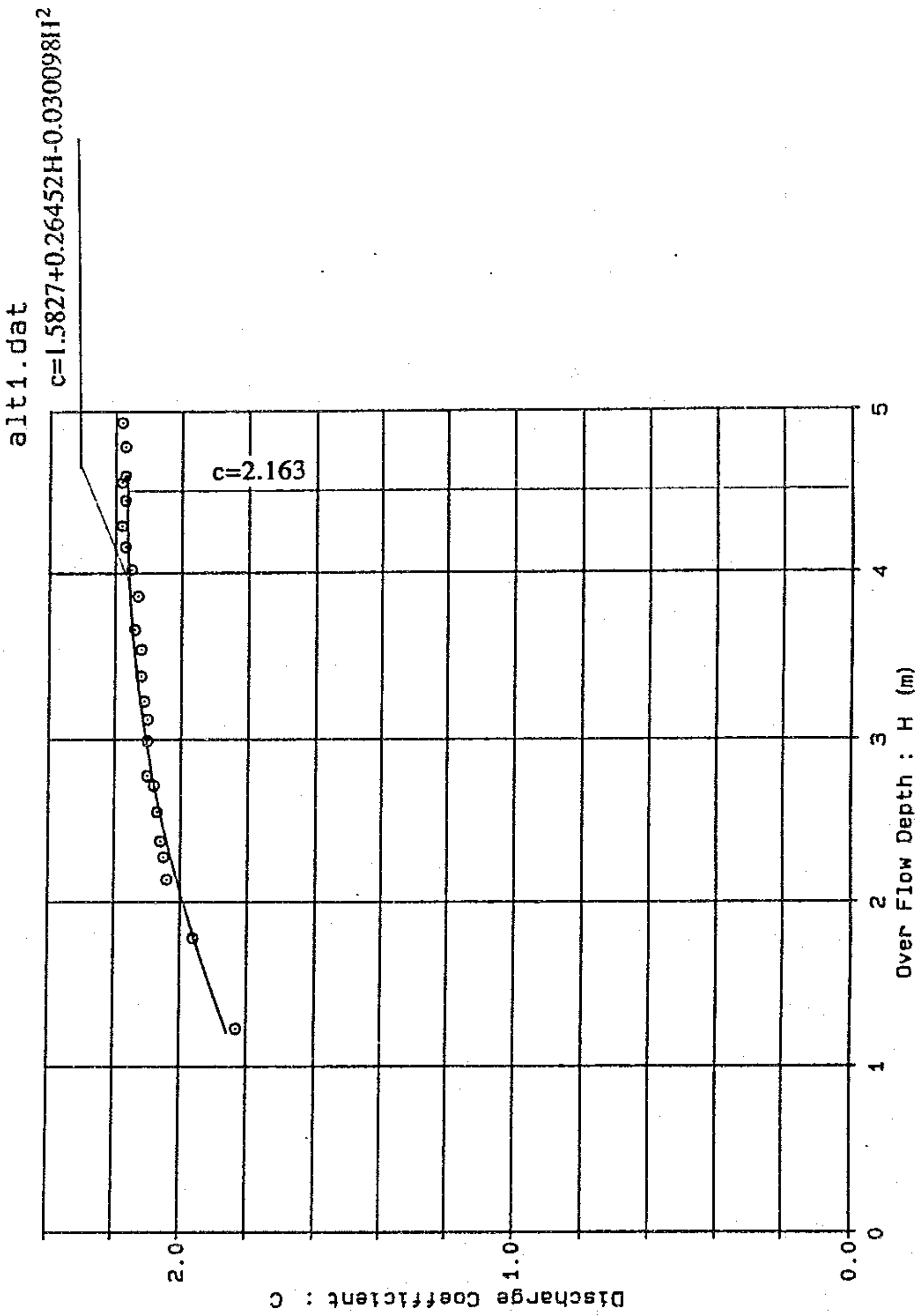
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 4.2.4



DEPTH-DISCHARGE RATING CURVE	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT
	JAPAN INTERNATIONAL COOPERATION AGENCY

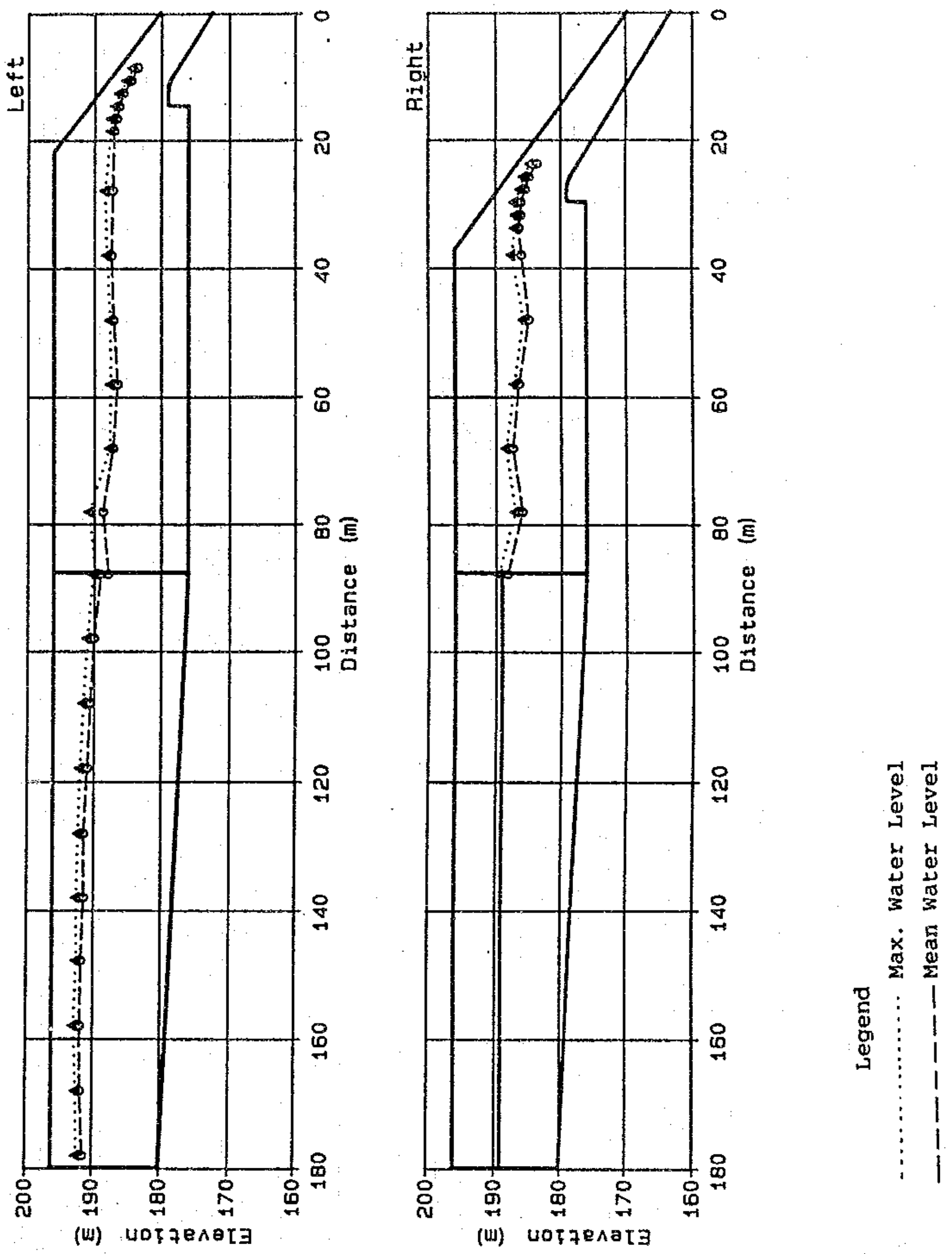
Fig. 4.2.5



DEPTH-DISCHARGE COEFFICIENT RAITNG CURVE

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

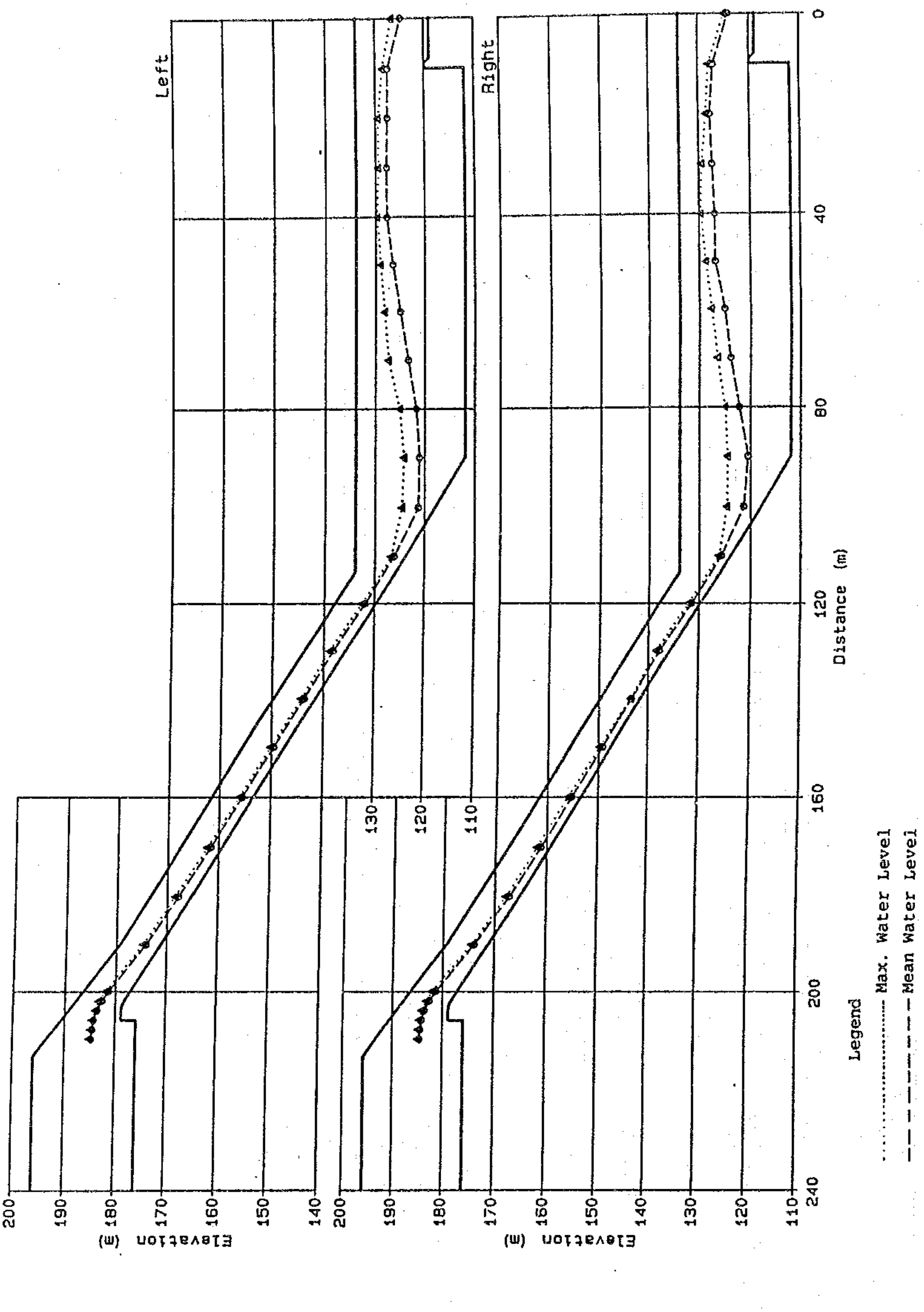


WATER SURFACE PROFILE IN SIDE CHANNEL AND TRANSITION Q=1,890(m3/s)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

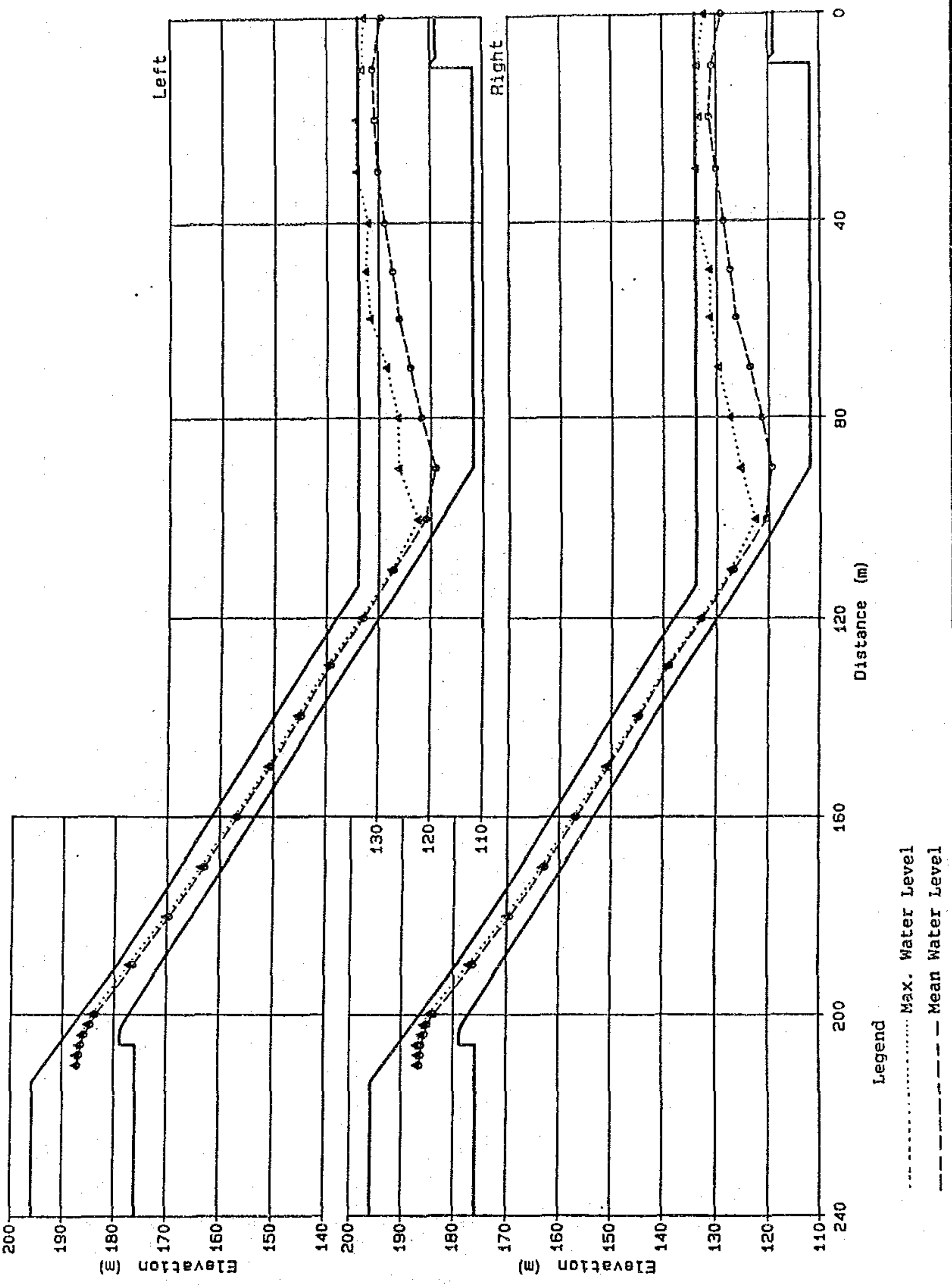
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 4.2.7



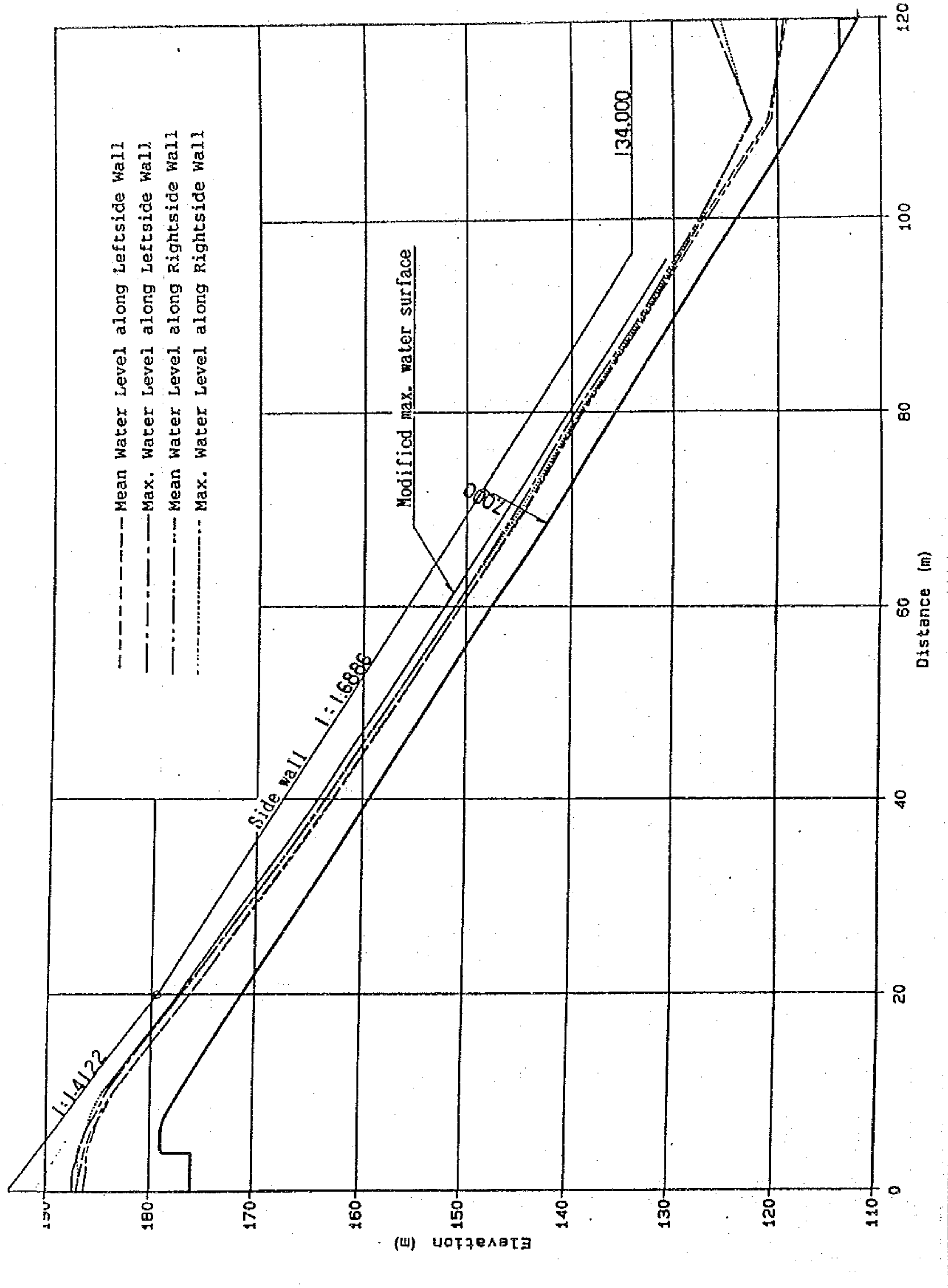
WATER SURFACE PROFILE IN CHUTEWAY AND STILING BASIN Q=1,040(m3/s)	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 4. 2. 8



WATER SURFACE PROFILE IN CHUTEWAY AND STILING BASIN Q=1,890(m3/s)	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT
	JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 4.2.9

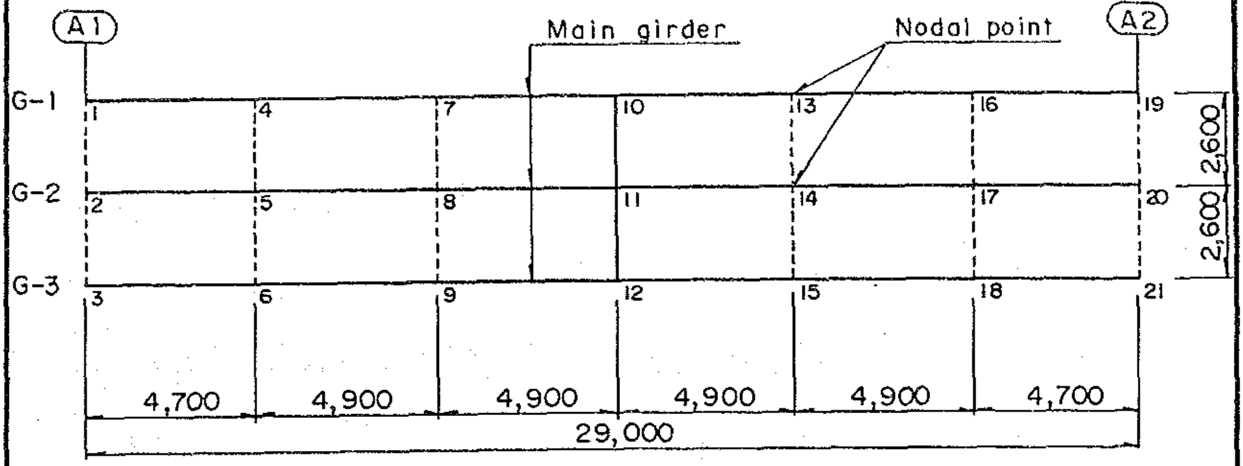


WATER SURFACE PROFILE IN CHUTEWAY

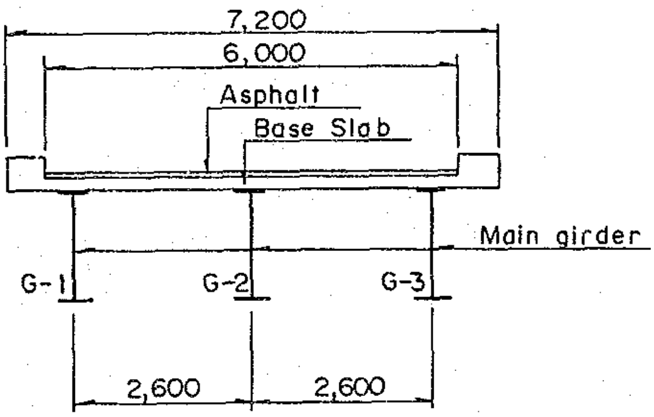
Q=1,890(m3/s)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY



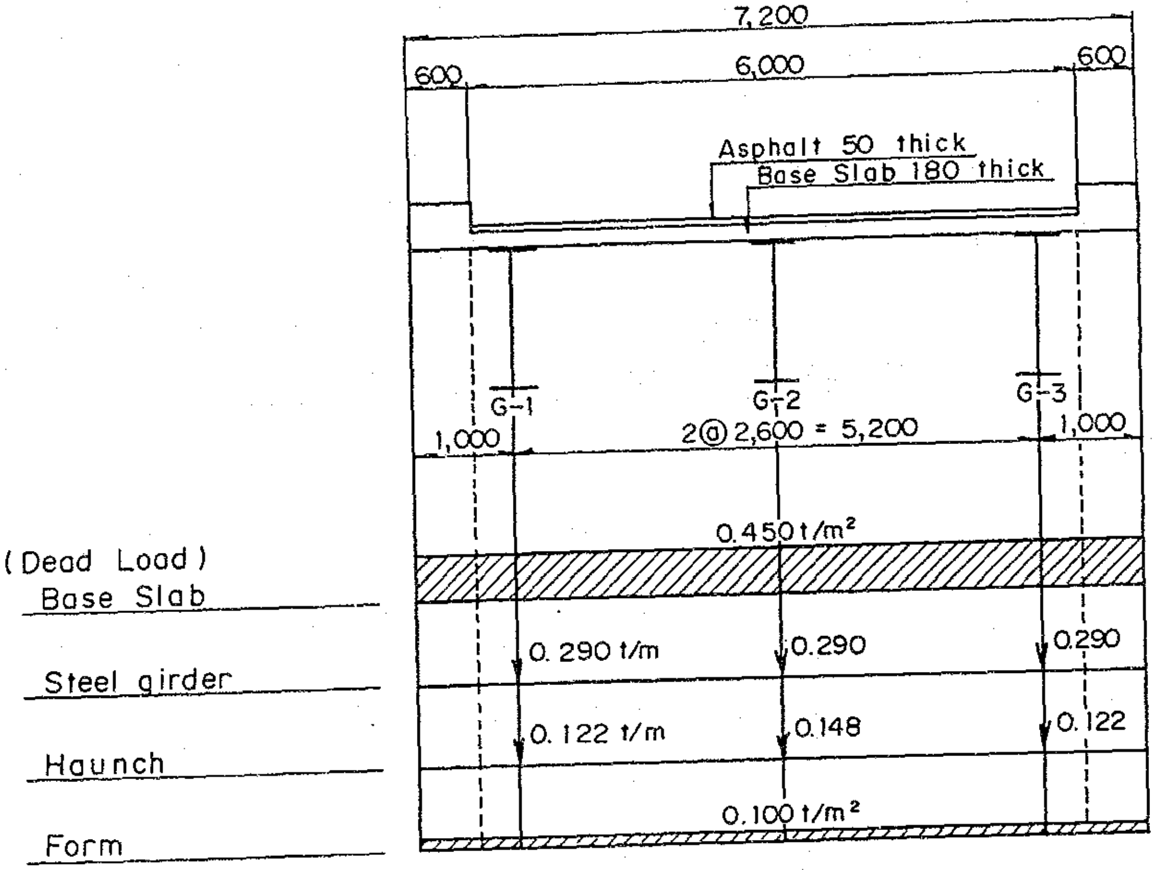
FRAME PLAN OF COMPOSITE GIRDER



SECTION OF COMPOSITE GIRDER

FRAME PLAN AND SECTION OF COMPOSITE GIRDER	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY

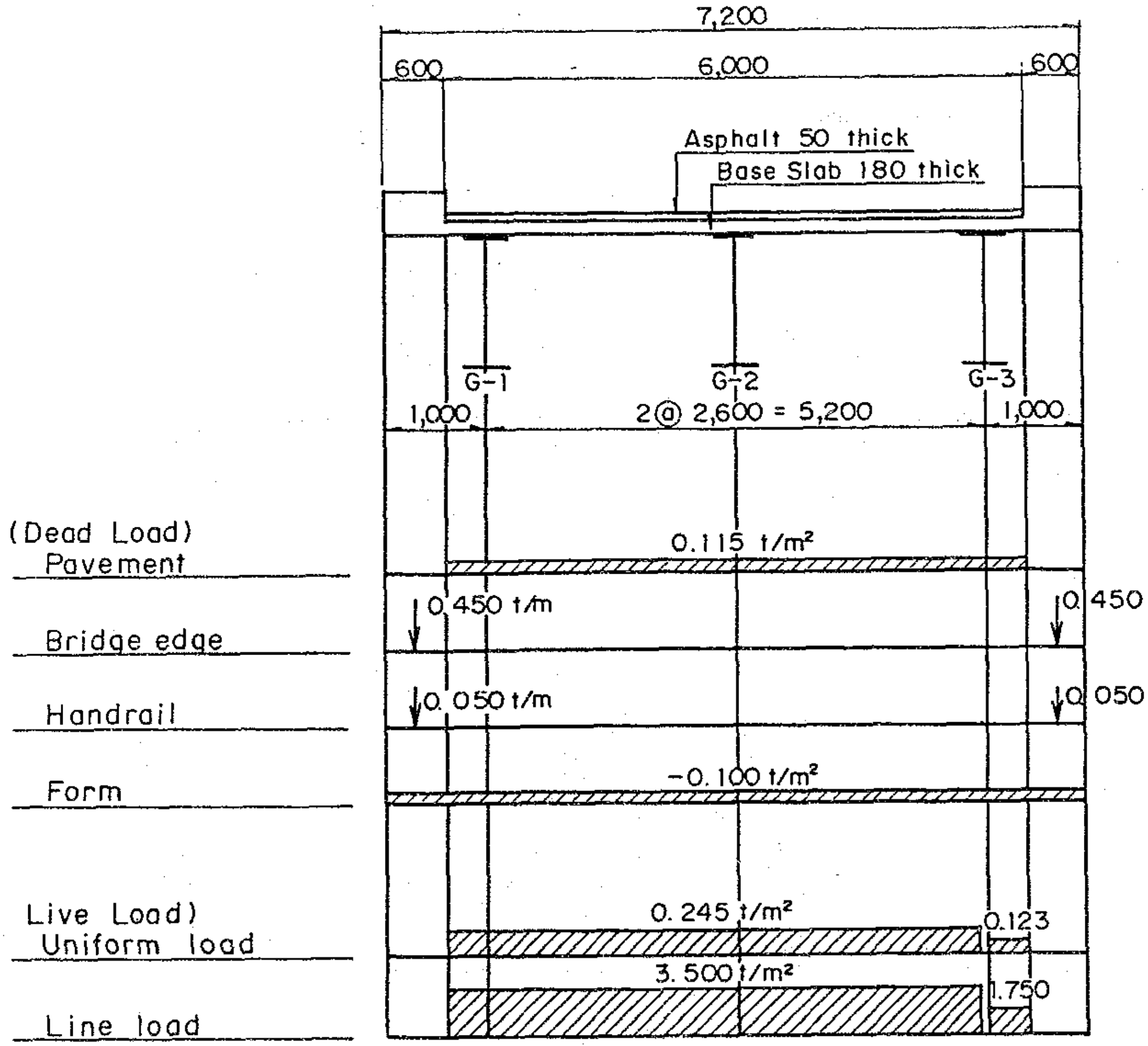
Fig. 4.4.2



LOADING ON COMPOSITE GIRDER
(BEFORE COMPOUNDING)

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

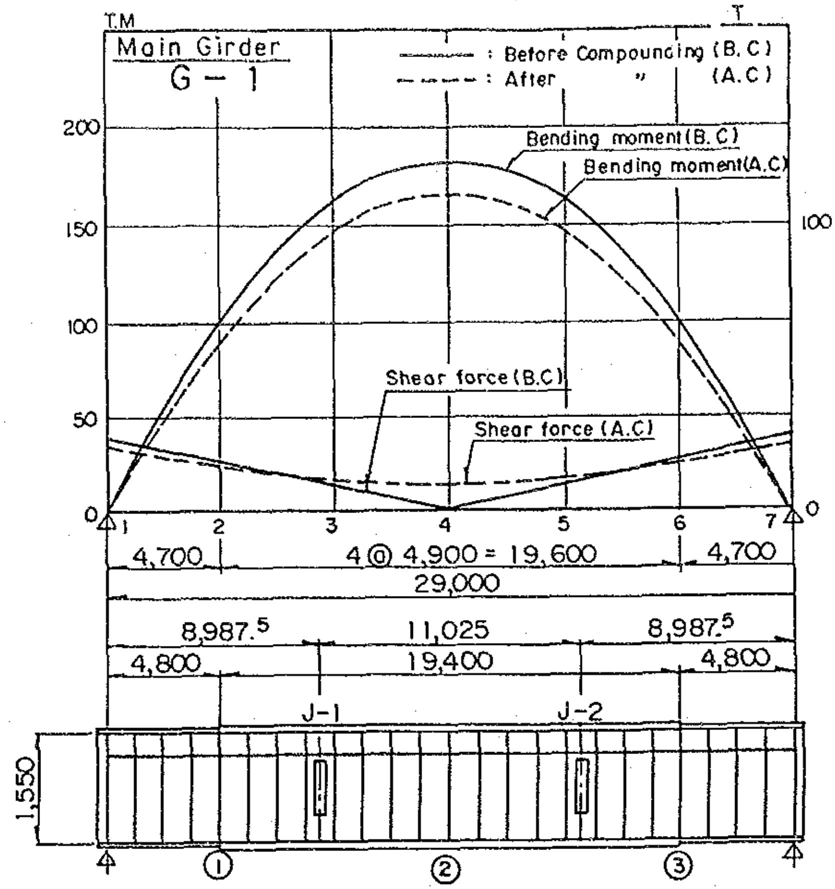
Fig. 4.4.3



LOADING ON COMPOSITE GIRDER
(AFTER COMPOUNDING)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY



		Section Nos.		
		①	②	③
UFLG	B	230	280	230
	T	11 (3)	14 (3)	11 (3)
WEB	H	1550	1550	1550
	T	9 (3)	9 (3)	9 (3)
LFLG	B	280	440	280
	T	11 (3)	19 (3)	11 (3)
SU		-1327	-1702	-1328
SUA		-1412	-1765	-1412
SUA-SU		85	63	84
SL		2068	2055	2068
SLA		2100	2100	2100
SLA-SL		32	45	32
TU		239	63	239
TUA		1200	1200	1200

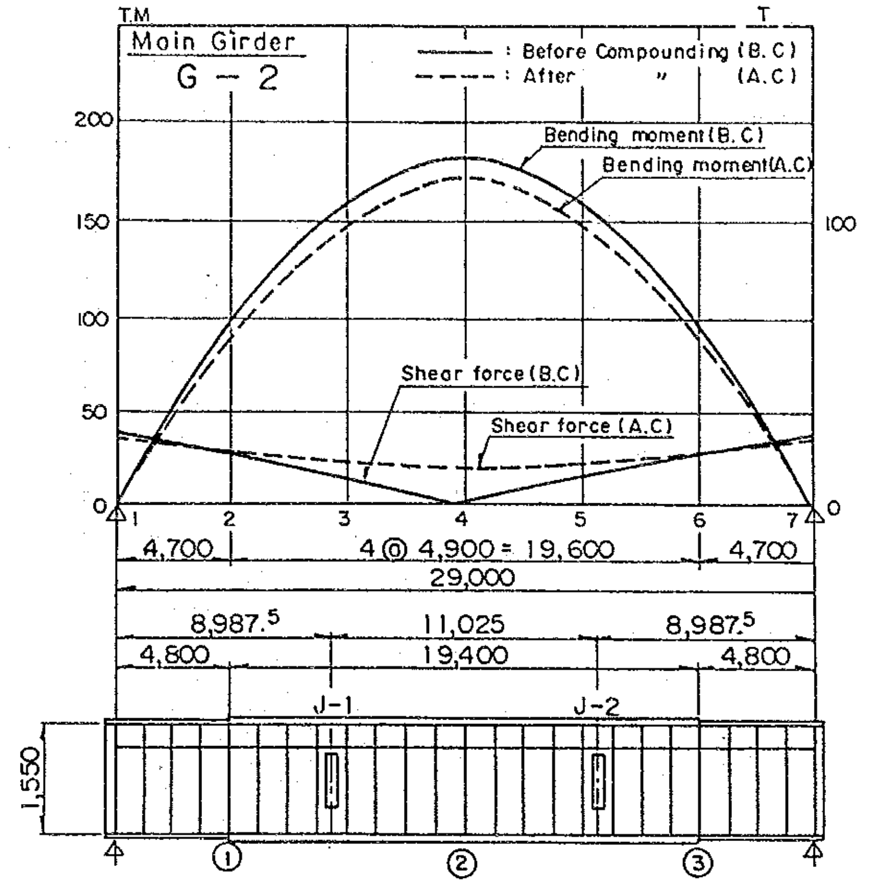
UFLG : Upper flange
WEB : Web
LFLG : Lower flange
B : Width of flange (mm)
H : Height of web (mm)
T : Thickness (mm)
( ) : Steel material
(1): SS41, (2): SM50,
(3): SM50Y, (4): SM58

SU : Stress in upper flange (kg/cm^2)
SUA : Allowable stress for upper flange (kg/cm^2)
SL : Stress in lower flange (kg/cm^2)
SLA : Allowable stress for lower flange (kg/cm^2)
TU Shearing stress (kg/cm^2)
TUA Allowable shearing stress (kg/cm^2)

RESULT OF ANALYSIS ON COMPOSITE GIRDER
(No. 1 Main Girder (G-1))

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

Fig. 4. 4. 5



		Section Nos.		
		①	②	③
UFLG	B	230	280	230
	T	10 (3)	14 (3)	10 (3)
WEB	H	1550	1550	1550
	T	9 (3)	9 (3)	9 (3)
LFLG	B	280	440	280
	T	11 (3)	19 (3)	11 (3)
SU		-1346	-1720	-1346
SUA		-1379	-1765	-1379
SUA-SU		33	45	33
SL		2033	2066	2033
SLA		2100	2100	2100
SLA-SL		67	34	67
TU		252	92	252
TUA		1200	1200	1200

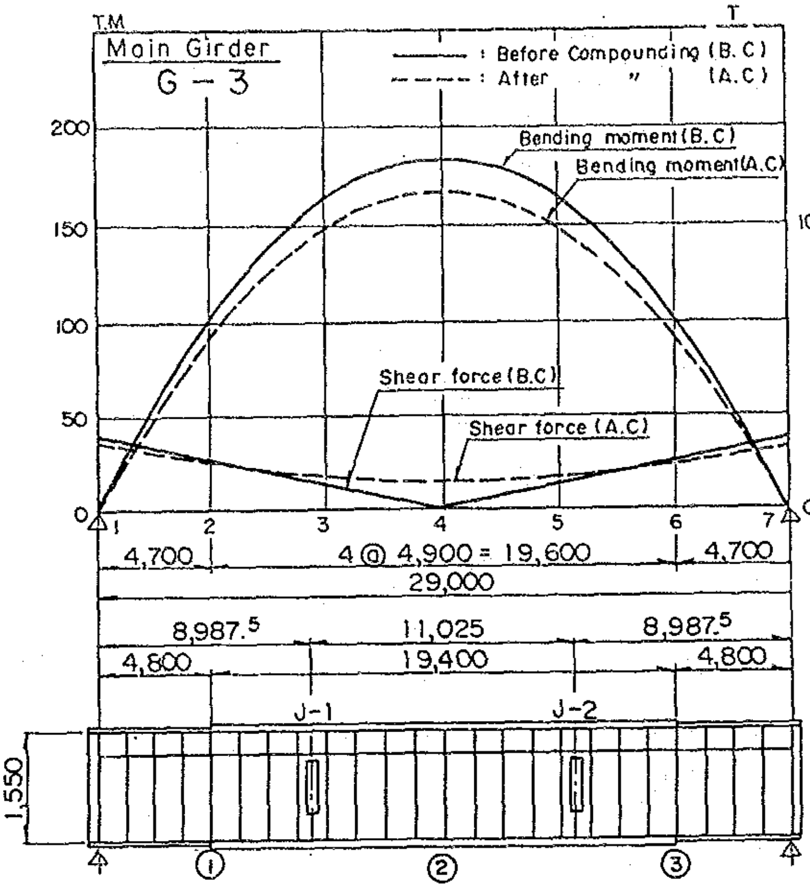
UFLG : Upper flange
WEB : Web
LFLG : Lower flange
B : Width of flange (mm)
H : Height of web (mm)
T : Thickness (mm)
( ) : Steel material
(1): SS41, (2): SM50,
(3): SM50Y, (4): SM58

SU : Stress in upper flange (kg/cm^2)
SUA : Allowable stress for upper flange (kg/cm^2)
SL : Stress in lower flange (kg/cm^2)
SLA : Allowable stress for lower flange (kg/cm^2)
TU Shearing stress (kg/cm^2)
TUA Allowable shearing stress (kg/cm^2)

RESULT OF ANALYSIS ON COMPOSITE GIRDER
(No. 2 Main Girder (G-2))

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY



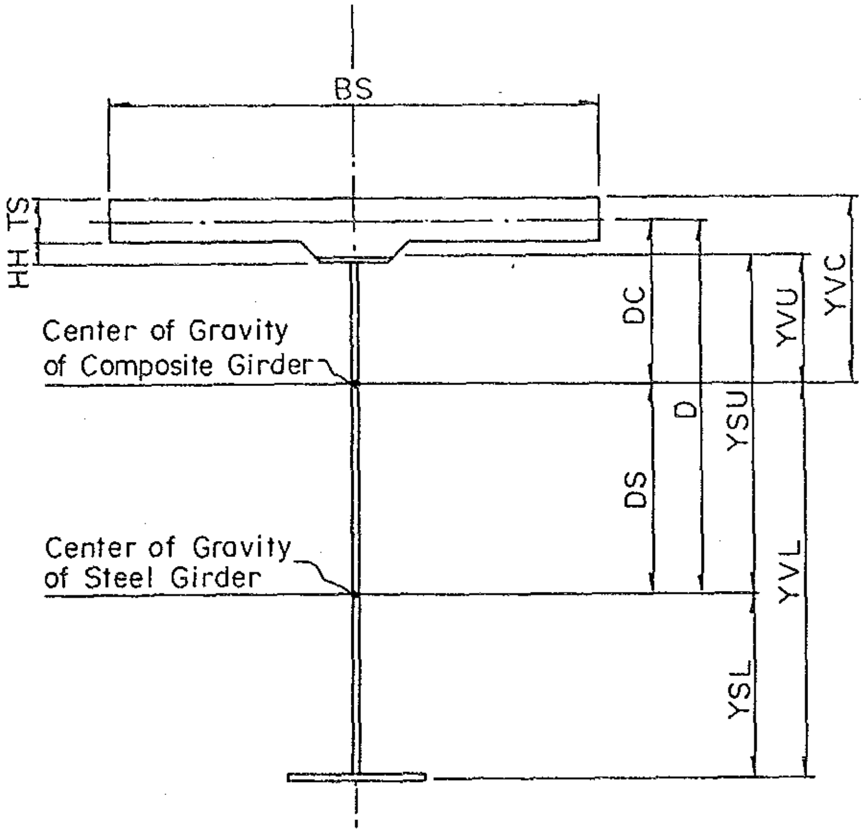
		Section Nos.		
		①	②	③
UFLG	B	230	280	230
	T	11 (3)	14 (3)	11 (3)
WEB	H	1550	1550	1550
	T	9 (3)	9 (3)	9 (3)
LFLG	B	280	440	280
	T	11 (3)	19 (3)	11 (3)
SU		-1327	-1702	-1328
SUA		-1412	-1765	-1412
SUA-SU		85	63	84
SL		2068	2055	2068
SLA		2100	2100	2100
SLA-SL		32	45	32
TU		239	66	239
TUA		1200	1200	1200

UFLG : Upper flange
WEB : Web
LFLG : Lower flange
B : Width of flange (mm)
H : Height of web (mm)
T : Thickness (mm)
( ) : Steel material
(1): SS41, (2): SM50,
(3): SM50Y, (4): SM58

SU : Stress in upper flange (kg/cm^2)
SUA : Allowable stress for upper flange
: (kg/cm^2)
SL : Stress in lower flange (kg/cm^2)
SLA : Allowable stress for lower flange
: (kg/cm^2)
TU Shearing stress (kg/cm^2)
TUA Allowable shearing stress (kg/cm^2)

RESULT OF ANALYSIS ON COMPOSITE GIRDER
(No. 3 Main Girder (G-3))

Fig. 4.4.7



TS	:	Base slab thickness
BS	:	Effective base slab width
HH	:	Haunch height
WSU	:	Section modulus at upper flange edge before compounding
WSL	:	Section modulus at lower flange edge before compounding
WVU	:	Section modulus at upper flange edge after compounding
WVL	:	Section modulus at lower flange edge after compounding

SYMBOLS OF COMPOSITE GIRDER

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

CHAPTER V. DESIGN OF WATER INTAKE, RIVER OUTLET AND HYDROMECHANICAL WORKS

5.1 General

The diversion tunnel is planned to be utilized as the water supply facilities, and therefore, the water intake is installed near the diversion tunnel inlet on the left bank.

From an economical point of view, the intake structure is designed as an inclined shaft type to be constructed on the slope of the left bank.

The project aims at supplying water to the Port Louis city and is required to always supply water with a high quality, and therefore, the multilevel intake is employed to selectively take water in the reservoir: the intake is provided at three levels of EL. 169.0 m, EL. 154.0 m and EL. 140.0 m.

The discharge capacity required for the water supply is 1.0 m^3/sec. However, the project has the plan of electric power installation in future. The rated discharge for its peak power generation is estimated at 9.0 m^3/sec. Therefore, the design of the intake is made in due consideration of the above future power installation.

Furthermore, it was determined that the project design be made so as to make the future expansion of the dam up to the dam crest level EL. 215.0 m possible. Thus, loading conditions for the design take the above future expansion into consideration.

The water taken at the inlet of the intake will be transmitted to a discharge valve installed at the downstream end of the main plug of tunnel through the inclined intake shaft and steel conduit installed in the tunnel, and then, the water will be released from the discharge valve which will control the discharge to be released.

River outlet facilities which intend to lower the reservoir water level at emergency are also planned to be installed in the tunnel. The river outlet facilities are composed of the river outlet inlet tower installed in the tunnel inlet portion, a conduit to be embedded in the tunnel main plug, and a discharge valve to be installed at the downstream end of the tunnel main plug. The facilities are provided with a capacity with which the reservoir water level can be lowered down to the low water level of EL. 139.0 m in about one week.

The water supply and river outlet facilities include various hydromechanical works. Those are intake trash racks, intake gates, intake gate hoists, water supply steel conduit, water supply discharge valve, water supply guard valve, river outlet trash racks, river outlet bulkhead gate, river outlet steel conduit, river outlet discharge valve and river outlet guard valve, etc.

The diversion closing gate and hoist are also required for diversion tunnel closure works. The diversion closing gate and hoist, however, are to be manufactured under Lot-I. Thus, this design is presented in the Design Report for Lot-I.

The designs of the water intake, river outlet and hydromechanical works are detailed hereunder. Design drawings are provided in Fig.5.1.1 to Fig.5.1.13.

5.2 Design of Intake Structure

5.2.1 Dimension

The dimensions of the intake structure are determined on the basis of the discharge of 9.0 m^3/sec as follows:

Intake Trash Rack:

Dimensions of the intake trash rack are determined to be 3.0 m x 3.0 m in accordance with the design standard which mentions that the flow velocity at screen should not be larger than 1.0 m/sec to make head loss small.

Inclined Shaft:

Water from the inclined shaft flows into the tunnel and then into the water supply steel conduit in a different flow direction. The flow condition is considerably complicated as mentioned, and thereby, a high flow velocity will not only make head loss large but also may cause some unfavourable hydraulic phenomena. Therefore, the flow velocity in the inclined shaft is desirable to limit to as small as possible. In view of the above, the flow area of the inclined shaft is determined to be 4.5 m^2 so that the flow velocity will not be larger than 2.0 m/sec.

Water Supply Steel Conduit:

The diameter of the water supply steel conduit is determined at 1.5 m which is the most economical diameter defined as one to make the sum of head loss and cost minimum. Examinations are made in Table 5.2.3.

5.2.2 Structural Analysis of Inclined Shaft

Structural analyses of the inclined shaft are made with the following considerations:

(a) The high water level of EL. 209.0 m after the future expansion of dam is taken as loading to the structure.

(b) Structural analyses are made at the lowest elevation of the structure of EL. 142.2 m.

(c) Internal and external water pressures will nearly be balanced in the normal condition. Thus, no structural analyses are required for the normal condition.

(d) The case that the structure is subject to the full external pressure under the inclined shaft empty will determine the structural design, even if some increase of allowable stress for rare or temporary case is taken into account.

(e) The following allowable stresses are applied in accordance with the standard:

$$\sigma_{sa} = 1{,}800 \text{ kg/cm}^2$$
$$\sigma_{ca} = 60 \text{ kg/cm}^2$$
$$\tau_a = 8 \text{ kg/cm}^2$$

where,

σ_{sa} : Allowable stress for reinforcement steel bar
σ_{ca} : Allowable compressive stress of concrete
τ_a : Allowable shearing stress of concrete

(f) Increase of the allowable stresses by 30% is allowed by the reason that the assumed case of loading will be very rare and tentative: that is, the assumed case of loading is limited to (i) before filling water into the inclined shaft after impounding of the reservoir and (ii) the case that the inclined shaft and water supply conduit are made empty for maintenance or inspection, etc.

The allowable stresses are taken as follows:

$$\sigma_{sa} = 1{,}800 \times 1.3 = 2{,}340 \text{ kg/cm}^2$$
$$\sigma_{ca} = 60 \times 1.3 = 78 \text{ kg/cm}^2$$
$$\tau_a = 8 \times 1.3 = 10.4 \text{ kg/cm}^2$$

The section of the inclined shaft and frame structure for analyses together with the loading condition are shown in Fig. 5.2.1.

The structural analyses are made by the Slope-Deflection Method of which calculations are given in Table 5.2.1. Fig. 5.2.2 indicates diagrams of bending moments and shear forces calculated.

Based on the obtained moments and shear forces, the stresses are analyzed in Table 5.2.2, provided with reinforcement bar of D22 @200. As seen in Table 5.2.2, the shearing stress (τ = 10.6 kg/cm^2) exceeds the allowable shearing stress of τ_a = 10.4 kg/cm^2, requiring stirrups to withstand the shearing stress beyond the allowable shearing stress, although the compressive stress of concrete and the tensile stress by reinforcement bar are within the allowable stresses.

Necessary stirrups are calculated as follows:

$$A_w = \frac{V_s \cdot S}{\sigma_{sa} \cdot j \cdot d}$$

$$V_s = V - V_c$$

A_w : Total sectional area of stirrups in the section of S
S : Interval of stirrups in the direction of member axis
V_s : Shearing force to be borne by stirrups
V : Total shearing force
V_c : Shearing force to be borne by concrete
($V_c = \frac{1}{2}\tau_a \cdot b \cdot j \cdot d$)

V = 78.7t (Ref. Fig. 5.2.3)
$V_c = \frac{1}{2}\tau_a \cdot b \cdot j \cdot d = \frac{1}{2} \times 10.4 \times 100 \times 0.875 \times 86.6 = 39.4\text{t}$
$V_s = V - V_c = 78.7 - 39.4 = 39.3\text{t}$

$$A_w = \frac{V_s \cdot S}{\sigma_{sa} \cdot j \cdot d} = \frac{39.3 \times 10^3 \times 30}{2{,}340 \times 0.875 \times 86.6} = 6.6\ \text{cm}^2$$

Based on the above, stirrups are provided as shown in Fig. 5.2.4 in which reinforcement bar arrangement is given.

5.3 Hydromechanical Works

5.3.1 General

This volume of the design report deals with the design of the hydromechanical equipment and structures which are to be installed in the Port Louis Water Supply Project.

The design is carried out in accordance with the Basic Design and Design Criteria prepared in earlier stage of the Detailed Design works.

The design in this report does not include that for the diversion closing gate which will be manufactured under Lot-I and is presented in the Design Report for Lot-I.

The hydromechanical equipment and structures to be provided in the Project are as listed below.

(1) Water Supply Facilities

(a) Intake Structure

The following equipment are to be provided at intake structure:

- Intake gates and hoists
- Intake trash racks

(b) Diversion Tunnel

The following equipment are to be provided in the diversion tunnel:

- Water supply steel conduit
- Water supply discharge valve
- Water supply guard valve

(2) River Outlet Facilities

(a) Inlet of Diversion Tunnel

- River outlet trash racks
- River outlet inlet bulkhead gate

(b) Diversion Tunnel

- River outlet steel conduit
- River outlet discharge valve
- River outlet guard valve

The results of design of each equipment are described in the subsequent sections. Design calculations are given in Section 5.3.4.

5.3.2 Water Supply Facilities

5.3.2.1 Intake Structure

(1) Intake Gates and Hoists

Three intakes are provided in the intake structure and an oblique lift type fixed wheel gate is installed in each intake which is provided in the different elevation of the intake structure for selecting the intake according to the water level of the reservoir.

The type of the fixed wheel gate is selected in view of reduction of hoist operation load and smooth operation of the gates. Each gate consists of skin plate, main horizontal beams, wheel assemblies, rubber seals, side rollers, lifting lugs and other necessary components, and the gate is capable of overcoming all loads at any upstream full supply water level (F.S.L.) of EL. 209.00 meters. The skin plate and rubber seals are provided at the downstream face of the gate leaf according to the gate installation condition. The caisson type of rubber seals is selected to lintel, bottom and side seal portion considering the design head of the gate leaf.

A 150 mm dia. by-pass valve system is provided in only No. 3 gate leaf for achieving the water balance between upstream and downstream sides of the gate when the water supply conduit is required to dewater.

The corrosion allowance of 2 mm is applied to the gate leaf.

An electrically driven screwed spindle type hoist is selected to ensure smooth operation of the gate. All hoists are located at the most top elevation (EL. 196.00 meters) of the intake structure and are housed in the intake control house.

The guide frame is provided in each intake gate slot to transmit the water load from the gate wheels to the concrete structure and consists of the sill beam, track frames, side guide frame, lintel frame, and all other components necessary for the satisfactory operation of intake gate. The corrosion resisting steel plates are attached to all exposed surface of guide frames to avoid excessive wear thereof. The height of the guide frame is decided according to the gate operation requirement.

The hoist consists of bearings, spindle, spindle supports, position indicator, manual operating device, motor with magnet brake, limit switches, controls, structural steel base frames and all necessary components.

The position of the spindle supports are arranged at interval of 8.0 meter in minimum on the concrete wall of the intake structure to keep the space of gate maintenance work.

Each gate is controlled and operated with only local control cabinet considering the operation frequency of the gate.

The design data for the intake gates and hoists are summarized as follows:

Type	:	Fixed wheel gate
Quantity	:	3 sets
Clear span	:	2.1 m
Clear height	:	2.1 m
High water level (H.W.L.)	:	EL. 209.00 m
Design head		
No. 1 gate	:	40.640 m
No. 2 gate	:	55.640 m
No. 3 gate	:	69.213 m
Water seal	:	4 edges rubber seal on downstream face of gate
Type of hoist	:	Electrically operated spindle hoist
Control system	:	Local
Gradient	:	37.568°
Water filling device to water supply conduit	:	Bypass valve on gate No. 3 having diameter of 150 mm

(2) Intake Trash Racks

Each three sets of front and top trash racks are provided at every intake inlet and top of the intake gate slot for preventing debris from entering into the water supply conduit and its discharge valve. The dimensions of each front and top trash racks have 3.0 meters width by 3.0 meters vertical height with inclination of 37.568 degrees and 3.10 meters span by 0.9 meter width, respectively. These dimensions are decided so as to keep the water velocity of 1 m/sec under the maximum discharge of 9 m^3/sec.

The front trash rack comprises trash rack panel, top and bottom embedded beams, etc. The trash rack panel consists of rectangular bar elements, tie rods with nuts and spacing pipes and is fixed on the supporting frames using corrosion-resisting bolts, nuts and washers.

The trash racks are designed to have a sufficient strength and suitable structure against the impact force, static and all other loads, and vibration phenomena which would likely to occur due to the inflow of water.

The design head of the trash rack is employed 2.0 meters of water head difference in consideration of the volume of debris to be estimated at the dam reservoir and the pitch of bar elements is decided as 75 millimeters to protect water supply discharge valve.

The design data of the intake trash racks are summarized as follows:

Type	:	Fixed trash rack	
		Front trash rack	Top trash rack
Quantity	:	3 sets	3 sets
Clear span	:	3.00 m	3.10 m
Height/Width	:	3.00 m (Inclined height)	0.90 m (Width)
Design head	:	Water difference of 2.00 m	
Bar pitch	:	75 mm (center to center)	
Gradient for front trash rack	:	37.568°	

5.3.2.2 Diversion Tunnel

(1) Water Supply Conduit

One (1) complete lane of embedded type steel conduit having 1.50 meters to 0.40 meters in diameter by approximately 210.2 meters in total length is provided in the diversion tunnel for supplying the maximum water discharge of 9.0 m^3/sec to the downstream area through discharge valve for municipal water supply. The conduit will be connected with steel penstocks at end portion of the conduit to lead water to the hydro power plant expected to be constructed in the future.

The internal pressure and mean inside diameter of steel conduit were conformed to Chapter IV of the Basic Design Report. The steel conduit extends from bell-mouth pipe of plug No. 2 to the water supply discharge valve. The shell thickness of steel conduit is designed to have a sufficient strength by shell proper itself against to those design internal pressure. The design external pressure is assumed to be as a water head equivalent to the difference between the center line of conduit and elevations of F.S.L. 209.00 meters for encased portion, respectively. Since the pipe shell can withstand the design external pressure, no stiffener rings to reinforce the pipe shell against buckling are provided.

In addition to the above, the steel conduit is also designed for the following conditions:

(a) to resist the external pressure due to contact grouting pressure of 2.0 kgf/cm^2 for horizontal portions.

(b) to resist the axial force.

(c) to resist the load due to handling during fabrication, transportation and field fabrication based on the minimum shell thickness.

(d) to reduce hydraulic friction losses in the conduit to a minimum.

The steel conduit consists of straight pipes, reducing pipes, bend pipes, seepage rings, thrust rings, external bracing, grout holes and plugs, manholes and all other necessary components. Seepage rings are of two or more parallel collars, and they are provided at the beginning portion of steel conduit for concrete plug. Thrust rings are provided at the straight pipe of steel conduit for plug end portion to resist trust force. Grout holes and plugs having diameter of 1-1/2 inches for the contact grout work between the other surface of conduit and backfill concrete are provided at lower half of the conduit in the plug concrete portion. Circular manholes are provided at upstream side of guard valve for inspection and service of the conduit.

As mentioned above, the conduit will be used as penstock in the future. Therefore, the reducing pipe portion at the valve chamber is not embedded in the concrete in order to facilitate the connection work with penstock.

The design data of the steel conduit are summarized as follows:

Type	:	Embedded type
Quantity	:	1 lane
Diameter	:	1.5 m and 0.4 m
Length	:	Approximately 210.20 m
Maximum internal pressure	:	90.00 m at center line of conduit considering the pressure rise which will occur from the water turbine in the future hydro power scheme.
Maximum external pressure	:	80.00 m
Grout pressure	:	2.5 kgf/cm^2
Joint efficiency	:	95% at shop and 90% at site welds
Corrosion allowance	:	2.0 mm
Gradient for pipe line	:	1 : 117.8

(2) Water Supply Discharge Valve and Its Guard Valve

One set of water supply hollow jet type discharge valve and its guard valve is provided at the end portion of water supply conduit for controlling the municipal water supply. The type and mean inside diameter of these valves were determined by the study as mentioned in Chapter IV of the Basic Design Report.

The discharge valve consists of upstream and downstream bodies, needle, operating device, seal, position indicator, drainage system and other necessary components. The inner cylinder in the downstream body is centrally positioned by four or more equally space radial splitters. The needle is moved along the center line of the body by the operating device.

The guard valve is provided in front of the discharge valve to shut off the water flow when the discharge valve is not in service or is required for inspection and maintenance of discharge valve. The valve is normally used at either fully opened and closed condition and is operated under the balanced water head condition between the guard valve and the discharge valve, by using at 50 millimeters in diameter bypass pipe and valves. The valve shall be capable of shutting off the water flow in case the discharge valve cannot be closed by some reasons. The hydraulic servomotor is provided a mechanical locking device to maintain the valve fully opened position.

The valve consists of valve body, valve leaf, stem, bonnet, hydraulic servomotors, drain pipe and valve and all other necessary components.

The discharge valve and its guard valve are operated and controlled by hydraulic servomotors and a comm-use hydraulic unit located at the valve chamber. This hydraulic unit is utilized commonly to operate the river outlet discharge valves. In the hydraulic unit, one oil supply tank and two motor units, one for use as standby, are provided complete with all hydraulic controls necessary for operating the discharge valve and its guard valve. The oil pump has sufficient capacity to operate a discharge valve or its guard valve of river outlet facility whichever greater.

The design data of the discharge valve and its guard valve are summarized as follows:

(a) Discharge Valve

Type	:	Hollow jet valve
Quantity	:	1 set
Diameter	:	0.40 m
Design head	:	80 m
Center elevation	:	129.016 m
Type of driving unit	:	Hydraulic servomotor
Operation system	:	Local and remote control

(b) Guard Valve

Type	:	Sluice valve
Quantity	:	1 set

Diameter	:	0.40 m
Design head	:	80 m
Center elevation	:	129.016 m
Type of driving unit	:	Hydraulic servomotor
Operation system	:	Local and remote control

5.3.3 River Outlet Facilities

5.3.3.1 Inlet of Diversion Tunnel

(1) River Outlet Trash Rack

A river outlet cage type fixed trash rack is provided at inlet structure of diversion tunnel for preventing debris from entering into the diversion outlet conduit and discharge valves. Each trash rack panel having 2.60 meters width by 2.50 meters height is provided in the steel supporting frame which is installed rigidly to the concrete structure. The dimension of trash rack is decided so as to keep within the water velocity of 1 m/sec under the maximum discharge of 25 m^3/sec.

The trash rack comprises trash rack panels, bottom embedded beams, steel frame structures, etc. Each trash rack panel consists of rectangular bar elements, tie rods with nuts and spacing pipes.

The trash rack is designed to have a sufficient strength and suitable structure against the impact force, static and all other loads, and vibration phenomena which would likely to occur due to the inflow of water.

The design head of the trash rack is employed 2.0 meters of water head difference in consideration of the volume of debris to be estimated at the dam reservoir and the pitch of bar element is decided as 100 millimeters to protect river outlet discharge valve.

The design data of the river outlet trash rack are summarized as follows:

Type	:	Cage type fixed trash rack
Quantity	:	1 set
Dimensions	:	2.60 m W x 2.60 m B x 2.50 m H
Design head	:	2.00 m
Bar pitch	:	100 mm (center to center)

(2) River Outlet Inlet Bulkhead Gate

One set of river outlet slide type bulkhead gate is provided at the inlet structure of diversion tunnel in order to ensure the installation work of river outlet and water supply facilities after closure of the diversion gate.

During the installation of river outlet and water supply facilities, the gate is closed completely in the gate slot for preventing dam water from entering into the diversion tunnel. After completion of all installation works in the diversion tunnel, the gate is opened by using a temporary winch which will be located near intake structure of EL. 196.00 meters through the rope sheaves to be fixed on the launching slope.

The gate consists of skin plate, main horizontal beams, rubber seals, side rollers, sliding shoes, lifting lugs and other necessary components, and the gate is capable of overcoming all loads at any upstream supply water level of EL. 189.00 meters. Considering the reduce of gate operation loads, a 150 millimeters dia. by-pass valve system is provided in the gate leaf for achieving the water balance between upstream and downstream sides of the gate.

The design data for diversion in let bulkhead gate are summarized as follows:

Type	:	Slide gate
Quantity	:	1 set
Clear opening	:	1.50 m x 1.50 m
Supply water level	:	EL. 189.00 m
Design head	:	51.80 m
Water seal	:	4 edges rubber seal on downstream face of gate
Type of hoist	:	Temporary winch

5.3.3.2 Diversion Tunnel

(1) River Outlet Steel Conduit

Each one (1) complete lane of embedded type steel conduit is provided in plug Nos. 1 and 2 and main plug of diversion tunnel as the dam low level outlet. The steel conduit to be embedded into Nos. 1 and 2 plugs have 1.5 meters in diameter by approximately 20.3 meters in total length and the steel conduit to be embedded into main plug have 1.5 meters to 1.0 meters in diameters by approximately 37.0 meters in total length. The internal pressure and mean inside diameter of steel conduit were confomed to Chapter IV of the Basic Design Report.

The steel conduit of plug Nos. 1 and 2 extends from the inlet bell-mouth at plug No. 1 to the end of plug No. 2 and the steel conduit of main plug extends from the inlet bell-mouth at main plug to the discharge valve. The shell thickness of these steel conduit is designed to have a sufficient strength by shell proper itself against to those design internal pressure. The design external pressure is assumed to be as a water head equivalent to the difference between the center line of conduit and elevations of F.S.L. 209.00 meters for encased portion, respectively.

Since the pipe shell can withstand the design external pressure, no stiffener rings to reinforce the pipe shell against buckling are provided.

The steel conduit consists of bell-mouth pipe, straight pipes, reducing pipes, bend pipes, seepage rings, thrust rings, external bracing, grout holes and plugs, manholes and all other necessary components. Seepage rings are of two or more parallel collars, and they are provided at the beginning portion of the steel conduit for the concrete plug. Thrust rings are provided at the straight pipe of the steel conduit for transferring axial thrust to the surrounding concrete. Grout holes and plugs having diameter of 1-1/2 inches for the contact grout work between the outer surface of conduit and backfill concrete are provided at lower half of the conduit at the plug portion. Circular manholes are provided at the steel conduit portion between the guard valve and discharge valve for inspection and service of conduit.

The design data of the steel conduit are summarized as follows:

Type	:	Embedded type
Quantity		
Plug Nos. 1 and 2	:	1 lane
Main plug	:	1 lane
Diameter		
Plug Nos. 1 and 2	:	1.5 m
Main plug	:	1.5 m to 1.0 m

Length		
Plug Nos. 1 and 2	:	20.3 m
Main plug	:	37.0 m
Maximum internal pressure	:	80.0 m at center line of conduit
Maximum external pressure	:	80.0 m
Grout pressure	:	2.5 kgf/cm^2
Joint efficiency	:	95% at shop and 90% at site welds
Corrosion allowance	:	2.0 mm

(2) River Outlet Discharge Valve and Its Guard Valve

One set of hollow jet type discharge valve and its guard valve is provided at the end portion of river outlet conduit for regulating the discharge water. The type and mean inside diameter of valves were determined by the study as mentioned in Chapter IV of the Basic Design Report.

The discharge valve consist of upstream and downstream bodies, needle, operating device, seal, position indicator, drainage system and other necessary components. The inner cylinder in the downstream body is centrally positioned by six or more equally space radial splitters. The needle is moved along the center line of the body by the operating device.

The guard valve is provided in front of the discharge valve to shut off the water flow when the discharge valve is not in service or is required for inspection and maintenance of discharge valve. The valve is normally used at either fully opened or closed condition and is operated under the balanced water head condition between the guard valve and the discharge valve, by using a 100 millimeters in diameter bypass pipe and valves. The valve shall be capable shutting off the water flow in case the discharge valve cannot be closed for some reason.

The valve consists of valve body, valve leaf, stem, bonnet, hydraulic servomotor, drain pipe and valve and all other necessary components.

The discharge valve and its guard valve are operated and controlled by the hydraulic servomotor and an common-use hydraulic unit located at the valve chamber. This hydraulic unit is utilized commonly to operate the water supply valves.

The design data of the discharge valve and its guard valve are summarized as follows:

(a) Discharge Valve

Type	:	Hollow jet valve
Quantity	:	1 set
Diameter	:	1.00 m
Design head	:	80 m
Center elevation	:	129.016 m
Type of driving unit	:	Hydraulic servomotor
Operation system	:	Local and remote control

(b) Guard Valve

Type	:	Sluice valve
Quantity	:	1 set
Diameter	:	1.00 m
Design head	:	80 m
Center elevation	:	129.016 m
Type of driving unit	:	Hydraulic servomotor
Operation system	:	Local and remote control

5.3.4 Design Calculations

5.3.4.1 Intake Gates & Hoist

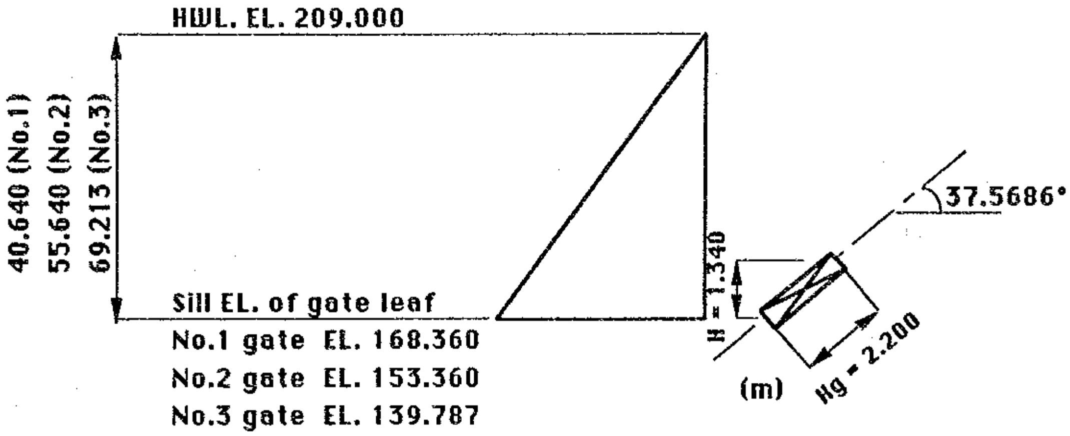
(1) Design Conditions

Type :		
No. 1 gate		Oblique lifted fixed wheel gate
No. 2 gate		Oblique lifted fixed wheel gate
No. 3 gate		Oblique lifted fixed wheel gate with by-pass valve
Quantity	:	3 sets
Clear span	:	2.1 m
Clear height	:	2.1 m (Oblique height)
Gradient	:	37.5686° (1:1.3)
Max. design head :		
No. 1 gate		40.640 m
No. 2 gate		55.640 m
No. 3 gate		69.213 m
Elevation of gate center :		
No. 1 gate		EL. 169.000
No. 2 gate		EL. 154.000
No. 3 gate		EL. 140.427
Elevation of gate sill :		
No. 1 gate		EL. 168.360
No. 2 gate		EL. 153.360
No. 3 gate		EL. 139.787
Max. deflection	:	1/800 of Supporting span
Sealing method	:	4 edges rubber seal at down stream face of gate
Corrosion allowance	:	2 mm for plate 80% of section modulus effective for steel shapes
Type of hoists	:	Electric driven, spindle rod type hoist

Operation speed : 0.3 m/min. ±10%

Control system : Local

(2) Total Hydraulic Load



$$Pt = (h - \frac{H}{2}) \times Hg \cdot B$$

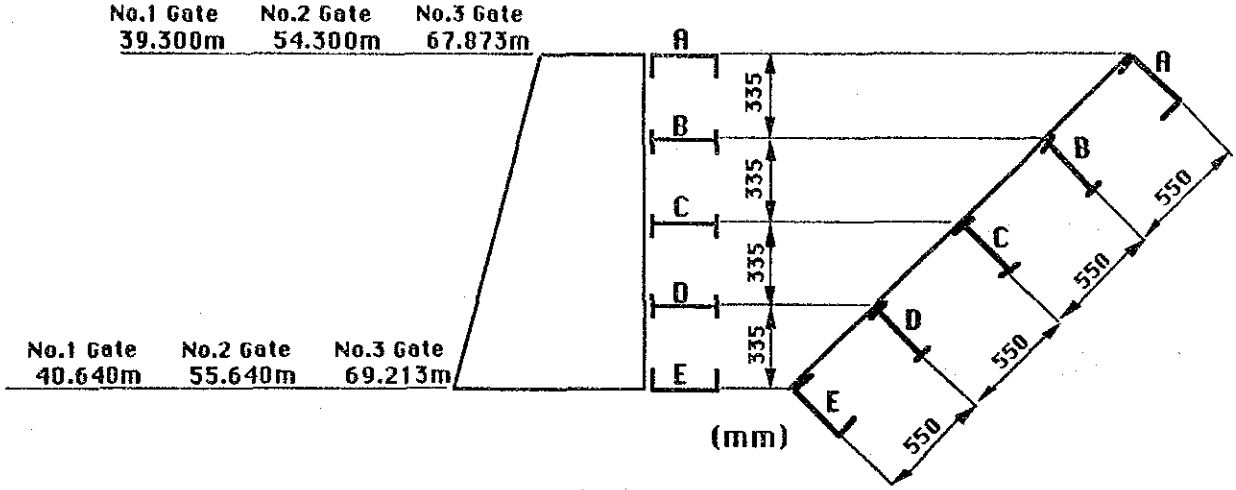
where,

Pt	=	Total hydraulic load		
h	=	Max. design head		
		No. 1 gate	:	40.640 (m)
		No. 2 gate	:	55.640 (m)
		No. 3 gate	:	69.213 (m)
H	=	Sealing height		1.34 (m)
Hg	=	Inclined sealing height		2.20 (m)
B	=	Sealing span		2.20 (m)

No. 1 gate	:	Pt = 193.5 (tf)
No. 2 gate	:	Pt = 266.1 (tf)
No. 3 gate	:	Pt = 331.7 (tf)

(3) Main Horizontal Beams

(a) Arrangement and reaction force (w) of main horizontal beams



No. 1 gate

A-beam	0.5 x (39.330 + 39.468) x 0.275 = 10.83 (tf/m)
B-beam	0.5 x (39.468 + 39.803) x 0.550 = 21.80 (tf/m)
C-beam	0.5 x (39.803 + 40.138) x 0.550 = 21.98 (tf/m)
D-beam	0.5 x (40.138 + 40.473) x 0.550 = 22.17 (tf/m)
E-beam	0.5 x (40.473 + 40.640) x 0.275 = 11.15 (tf/m)

No. 2 gate

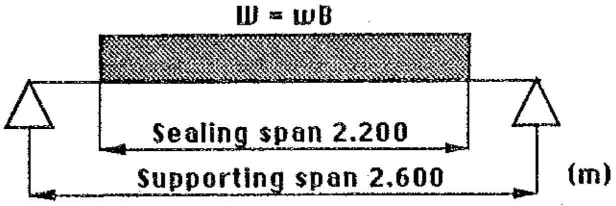
A-beam	0.5 x (54.330 + 54.468) x 0.275 = 14.96 (tf/m)
B-beam	0.5 x (54.468 + 54.803) x 0.550 = 30.05 (tf/m)
C-beam	0.5 x (54.803 + 55.138) x 0.550 = 30.23 (tf/m)
D-beam	0.5 x (55.138 + 55.473) x 0.550 = 30.42 (tf/m)
E-beam	0.5 x (55.473 + 55.640) x 0.275 = 15.28 (tf/m)

No. 3 gate

A-beam	0.5 x (67.873 + 68.041) x 0.275 = 18.69 (tf/m)
B-beam	0.5 x (68.041 + 68.376) x 0.550 = 37.51 (tf/m)
C-beam	0.5 x (68.376 + 68.711) x 0.550 = 37.70 (tf/m)
D-beam	0.5 x (68.711 + 69.046) x 0.550 = 37.88 (tf/m)
E-beam	0.5 x (69.046 + 69.213) x 0.275 = 19.01 (tf/m)

The strength calculation has to be made for D-beam and E-beam which maximum load for each type beam respectively.

(b) Bending moment and shearing force



Mm = W x (2 x L - B) / 8

Sm = W / 2

where,

Mm	=	Max bending moment	
Sm	=	Max. shearing force	
W	=	Water pressure load on each beams (tf)	
B	=	Sealing span	2.200 (m)
L	=	Supporting span	2.600 (m)

D-beam

No.1 gate

W = 21.17 x 2.200 = 46.574 (tf)

Mm = 46.574 x (2 x 2.600 - 2.200) / 8 = 17.4653 (tf-m)
= 1746530 (kgf-cm)

Sm = 46.574 / 2 = 23.287 (tf)
= 23287 (kgf)

No.2 gate

W = 30.42 x 2.200 = 66.924 (tf)

Mm = 66.924 x (2 x 2.600 - 2.200) / 8 = 25.0965 (tf-m)
= 2509650 (kgf-cm)

Sm = 66.924 / 2 = 33.462 (tf)
= 33462 (kgf)

No.3 gate

W = 37.88 x 2.200 = 83.336 (tf)

Mm = 83.336 x (2 x 2.600 - 2.200) / 8 = 31.251 (tf-m)
= 3125100 (kgf-cm)

Sm = 83.336 / 2 = 41.668 (tf)
= 41668 (kgf)

E-beam

No.1 gate

W = 11.15 x 2.200 = 24.530 (tf)

Mm = 24.530 x (2 x 2.600 - 2.200) / 8 = 9.19875 (tf-m)
= 919875 (kgf-cm)

Sm = 24.530 / 2 = 12.265 (tf)
= 12265 (kgf)

No.2 gate

W = 15.28 x 2.200 = 33.616 (tf)

Mm = 33.616 x (2 x 2.600 - 2.200) / 8 = 12.606 (tf-m)
= 1260600 (kgf-cm)

Sm = 33.616 / 2 = 16.808 (tf)
= 16808 (kgf)

No.3 gate

W = 19.01 x 2.200 = 41.822 (tf)

Mm = 41.822 x (2 x 2.600 - 2.200) / 8 = 15.68325 (tf-m)
= 1568325 (kgf-cm)

Sm = 41.822 / 2 = 20.911 (tf)
= 20911 (kgf)

D-beam		
No.1 gate	Mm =	1746530 (kgf-cm)
	Sm =	23287 (kgf)
No.2 gate	Mm =	2509650 (kgf-cm)
	Sm =	33462 (kgf)
No.3 gate	Mm =	3125100 (kgf-cm)
	Sm =	41668 (kgf)

E-beam		
No.1 gate	Mm =	919875 (kgf-cm)
	Sm =	12265 (kgf)
No.2 gate	Mm =	1260600 (kgf-cm)
	Sm =	16808 (kgf)
No.3 gate	Mm =	1568325 (kgf-cm)
	Sm =	20911 (kgf)

(c) Bending stress and shearing stress

$\sigma m = Mm / Z$

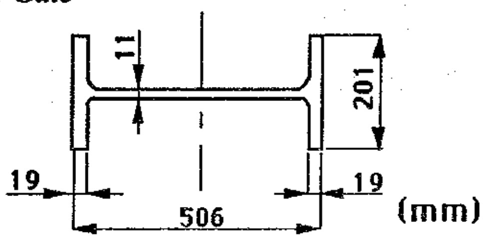
$\tau m = Sm / Aw$

where,

σm	=	Max bending stress
τm	=	Max. shearing stress
I	=	Moment of inertia (cm^4)
Z	=	Modulus of section (cm^3)
Aw	=	Area of web (cm^2)

D-beam

No. 1 Gate



$I = 56500 \times 0.8 = 45200$ (cm^4)

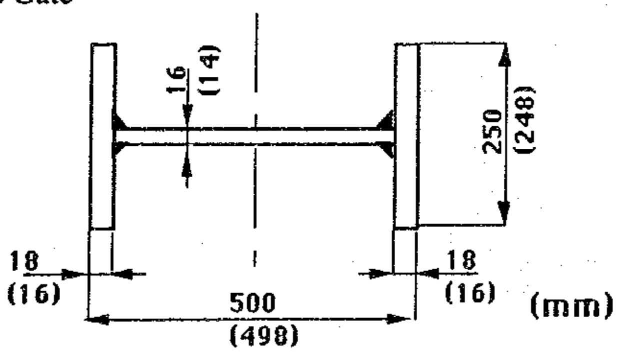
$Z = 2230 \times 0.8 = 1784$ (cm^3)

$Aw = 42$ (cm^2)

$\sigma m = 1746530 / 1784 = 979$ (kgf/cm^2) < 1200 (kgf/cm^2)

$\tau m = 23287 / 42 = 554$ (kgf/cm^2) < 700 (kgf/cm^2)

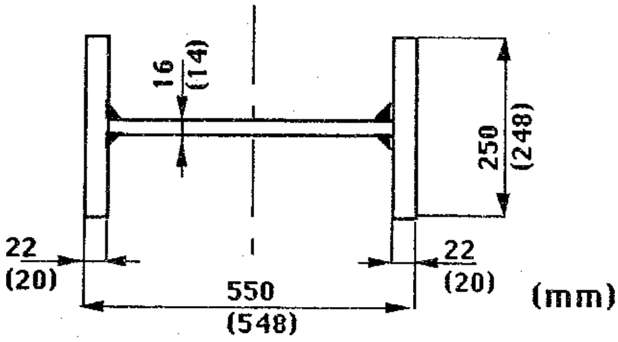
No. 2 Gate



$I = 57916\ (cm^4)$
$Z = 2326\ (cm^3)$
$Aw = 65\ (cm^2)$

$\sigma m = 2509650 / 2326 = 1079\ (kgf/cm^2) \quad < 1200\ (kgf/cm^2)$
$\tau m = 33462 / 65 = 515\ (kgf/cm^2) \quad < 700\ (kgf/cm^2)$

No. 3 Gate

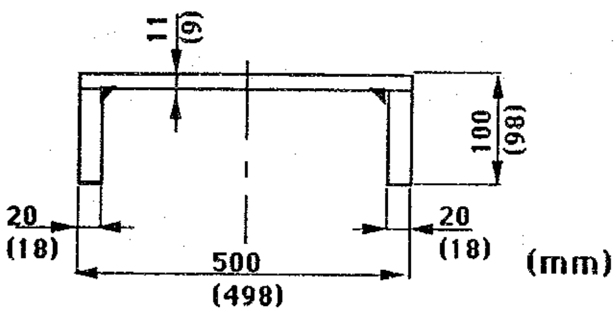


$I = 84466\ (cm^4)$
$Z = 3083\ (cm^3)$
$Aw = 71\ (cm^2)$

$\sigma m = 3125100 / 3083 = 1014\ (kgf/cm^2) \quad < 1200\ (kgf/cm^2)$
$\tau m = 41668 / 71 = 587\ (kgf/cm^2) \quad < 700\ (kgf/cm^2)$

E-beam

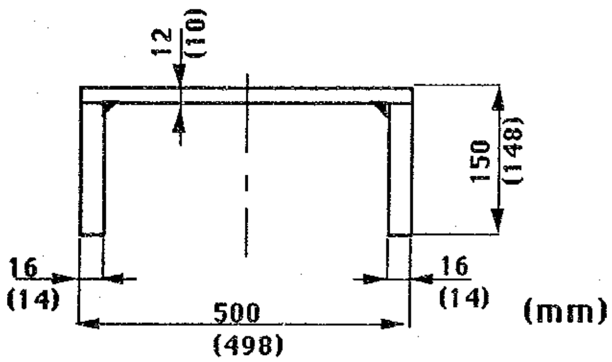
No. 1 Gate



$I = 27727\ (cm^4)$
$Z = 1114\ (cm^3)$
$Aw = 41\ (cm^2)$

$\sigma m = 919875 / 1114 = 826\ (kgf/cm^2) < 1200\ (kgf/cm^2)$
$\tau m = 12265 / 41 = 299\ (kgf/cm^2) < 700\ (kgf/cm^2)$

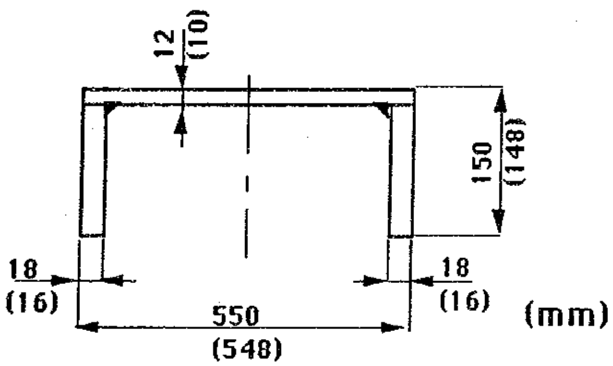
No. 2 Gate



I = 32928 (cm^4)
Z = 1322 (cm^3)
Aw = 47 (cm^2)

$\sigma m = 1260600 / 1322 = 954\ (kgf/cm^2) < 1200\ (kgf/cm^2)$
$\tau m = 16808 / 47 = 358\ (kgf/cm^2) < 700\ (kgf/cm^2)$

No. 3 Gate



I = 44969 (cm^4)
Z = 1641 (cm^3)
Aw = 52 (cm^2)

$\sigma m = 1568325 / 1641 = 956\ (kgf/cm^2) < 1200\ (kgf/cm^2)$
$\tau m = 20911 / 52 = 402\ (kgf/cm^2) < 700\ (kgf/cm^2)$

(d) Deflection

$$\delta m = W \times (L^3 - L \times B^2/2 + B^3/8) / (48 \times E \times I)$$

where,

δm	=	Max deflection (cm)	
W	=	Water pressure load on each beams (kgf)	
B	=	Sealing span	220 (cm)
L	=	Supporting span	260 (cm)
E	=	Young's modulus	2.1×10^6 (kgf/cm^2)

D-beam

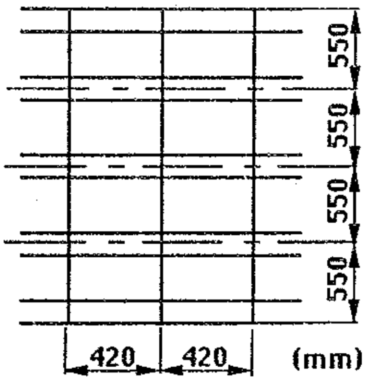
No. 1 Gate	$\delta m = 0.129$ (cm)	< 0.31 (cm) = 1/800 of Supporting span
No. 2 Gate	$\delta m = 0.145$ (cm)	< 0.31 (cm)
No. 3 Gate	$\delta m = 0.123$ (cm)	< 0.31 (cm)

E-beam

No. 1 Gate	$\delta m = 0.111$ (cm)	< 0.31 (cm) = 1/800 of Supporting span
No. 2 Gate	$\delta m = 0.128$ (cm)	< 0.31 (cm)
No. 3 Gate	$\delta m = 0.116$ (cm)	< 0.31 (cm)

(4) Vertical Girders

(a) Bending moment and shearing force

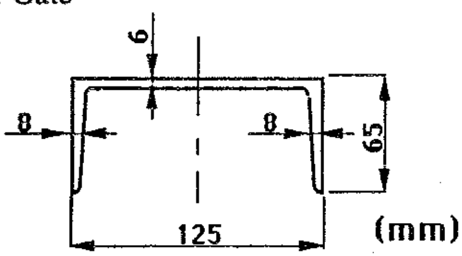


Gate No.	P(kgf/cm2)	a(cm)	b(cm)	Mm(kgf-cm)	Sm(kgf)
1	4.064	42	55	51995	2902
2	5.564	42	55	71187	3973
3	6.921	42	55	88549	4942

P = Water pressure
Mm = Max bending moment
Sm = Max. shearing force

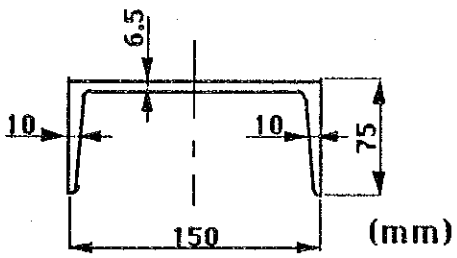
(b) Bending stress and shearing stress

No. 1 Gate



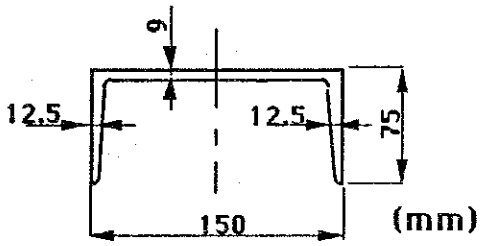
Z = Modulus of section 67.8 x 0.8 = 54.2 (cm^3)
Aw = Area of web 4.9 (cm^2)

No. 2 Gate



Z	=	Modulus of section	115.0 x 0.8 = 92.0 (cm^3)
Aw	=	Area of web	6.7 (cm^2)

No. 3 Gate



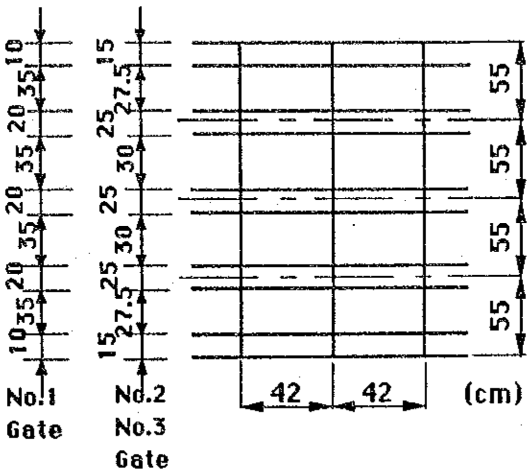
Z	=	Modulus of section	140.0 x 0.8 = 112.0 (cm^3)
Aw	=	Area of web	10.4 (cm^2)

Gate No.	Bending stress (kgf/cm2)	Shearing stress (kgf/cm2)
1	959	592
2	774	593
3	791	475

Allowable bending stress : 1200 (kgf/cm^2)

Allowable shearing stress : 700 (kgf/cm^2)

(5) Skin Plate



$\sigma = (k \times a^2 \times p / t^2) / 100$

where,

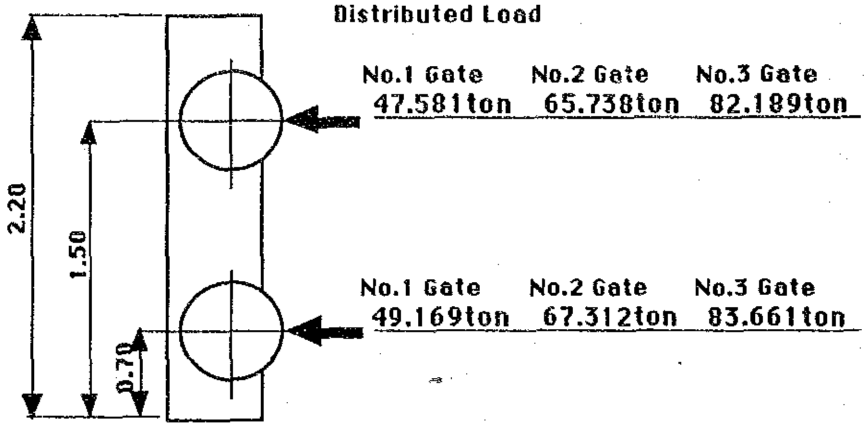
σ	=	Bending stress (kgf/cm^2)
k	=	Coefficient by "b/a"
a	=	Short span of plate (cm)
b	=	Long span of plate (cm)
p	=	Water pressure (kgf/cm^2)
t	=	Thickness of skin plate (cm)

Gate No.	a	b	b/a	k	p	t	σ
1	35	42	1.2	38.7	4.064	1.6	983
2	30	42	1.4	43.6	5.564	1.7	970
3	30	42	1.4	43.6	6.921	1.8	1061

Allowable bending stress : 1200 (kgf/cm^2)

(6) Main Roller

(a) Arrangement of main rollers and distributed load



(b) Material and size for roller

	Material of roller	Hardness (kgf/mm^2)	Diameter (cm)
No.1 gate	SSW-Q1S	250	55.0
No.2 gate	SSW-Q1S	250	56.0
No.3 gate	SSW-Q1S	250	64.0

(c) Strength of roller

$$Pc = 3 \times P / (2 \times \pi \times a \times b)$$

$$a = 1.109 \times m \times \sqrt[3]{P / ((A+B) \times E)}$$

$$b = 1.109 \times n \times \sqrt[3]{P / ((A+B) \times E)}$$

$$A + B = (1 / R + 1/R') / 2$$

$$Pa = 100 \times Hb / (2 \times \nu)$$

where,

Pc = Max contact pressure (kgf/cm^2)

P = Max. distributed load (kgf)

a = 0.5 of contact width (long) (cm)

b = 0.5 of contact width (short) (cm)
m = Coefficient
n = Coefficient
E = Young's modulus 2.1 x 10^6 (kgf/cm^2)
A = Coefficient
B = Coefficient
R = Radius of roller (cm)
R' = Radius of curvature of roller (cm)
Pa = Allowable contact pressure (kgf/cm^2)
Hb = Brinnel hardness 250 (kgf/mm^2)
v = Rate of safety 1.0

	No.1 gate	No.2 gate	No.3 gate
Pc (kgf/cm^2)	12341	12459	12254

Allowable contact pressure : 12500 (kgf/cm^2)

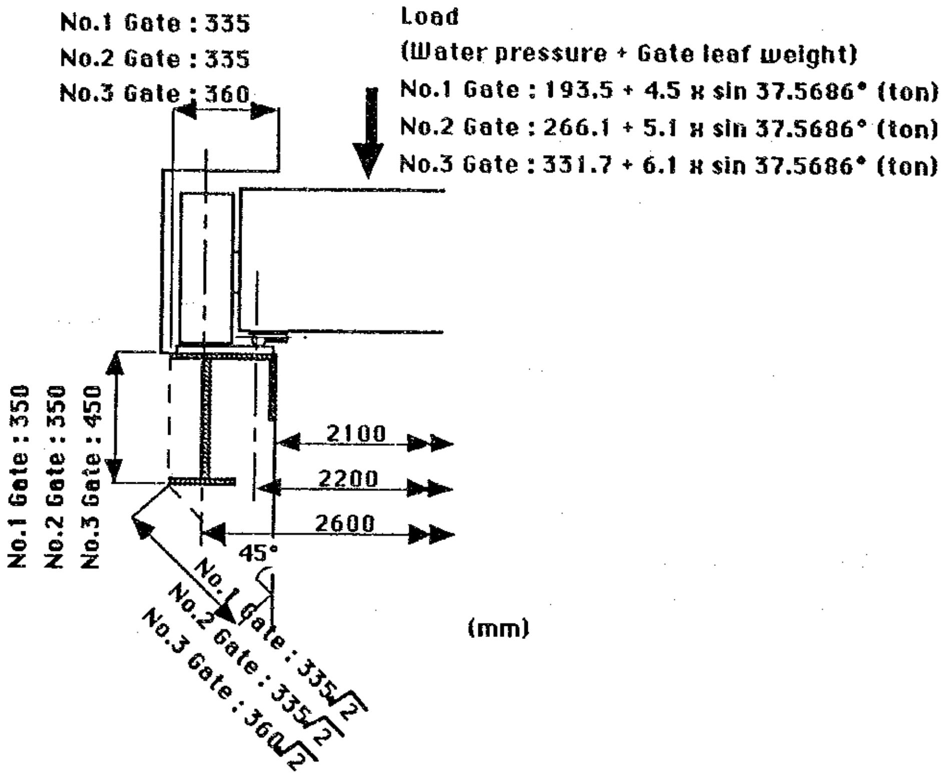
(7) Weight of Gate Leaf

		Unit Weight (kgf)	Q'ty	Weight (kgf)
(a) Main horizontal beams				
No.1 gate	506 x 201 x 11 x 19 x 2600	268	3	804
No.2 gate	500 x 250 x 16 x 18 x 2600	335	3	1005
No.3 gate	550 x 250 x 16 x 22 x 2600	390	3	1170
(b) Horizontal beams				
No.1 gate	500 x 100 x 11 x 20 x 2600	185	2	370
No.2 gate	500 x 150 x 12 x 16 x 2600	213	2	426
No.3 gate	550 x 150 x 12 x 18 x 2600	236	2	472
(c) Skin plate				
No.1 gate	2200 x 2600 x 16	718	1	718
No.2 gate	2200 x 2600 x 17	763	1	763
No.3 gate	2200 x 2600 x 18	808	1	808
(d) Vertical beams				
No.1 gate	125 x 65 x 6 x 8 x 2200	30	4	120
No.2 gate	150 x 75 x 6.5 x 10 x 2200	41	4	164
No.3 gate	150 x 75 x 9 x 12.5 x 2200	53	4	212
(e) Side beams				
No.1 gate	506 x 201 x 11 x 19 x 2200	227	2	454
No.2 gate	500 x 250 x 16 x 18 x 2200	284	2	568
No.3 gate	550 x 250 x 16 x 22 x 2200	330	2	660
(f) Roller and roller shaft				
No.1 gate	ϕ550 x 150, ϕ170 x 200	315	4	1260
No.2 gate	ϕ560 x 150, ϕ180 x 200	330	4	1320
No.3 gate	ϕ640 x 150, ϕ200 x 200	428	4	1712

(g) Total

No.1 gate	3726 x 1.2 ≒ 4500 (kgf)
No.2 gate	4246 x 1.2 ≒ 5100 (kgf)
No.3 gate	5034 x 1.2 ≒ 6100 (kgf)

(8) Shearing Stress of Concrete



$\tau c = P / Ac$

where,

τc = Max shearing stress of concrete (kgf/cm^2)

P = Total water pressure + gate leaf weight x sin 37.5686° (kgf)

Ac = Shearing area of concrete (cm^2)

	P (kgf)	Ac (cm^2)	τc (kgf/cm^2)
No.1 gate	196000	43180	4.54
No.2 gate	269210	43180	6.23
No.3 gate	335419	51273	6.54

Allowable shearing stress of concrete : 7.0 (kgf/cm^2)

(9) Hoisting Load

(a) Operating condition

The gates will be operated under water balanced conditions.

(b) Hoisting load

(b-1) Load due to gate leaf

$$Fw = W \times \sin 37.5686^\circ$$

where,

Fw = Load due to gate leaf (tf)

W = Weight of gate leaf (tf)

	W (tf)	Fw (tf)
No.1 gate	4.5	2.7
No.2 gate	5.1	3.1
No.3 gate	6.1	3.7

(b-2) Friction load due to gate roller

$$Fl = (\mu 1 + \mu 2 \times r) \times W \times \cos 37.5686^\circ / R$$

where,

Fl = Friction load due to gate roller (tf)

W = Weight of gate leaf (tf)

$\mu 1$ = Coefficient of rolling friction of the wheel 0.1

$\mu 2$ = Coefficient of sliding friction of the pin 0.01

r = Radius of wheel pin (cm)

R = Radius of roller (cm)

	W (tf)	r (cm)	R (cm)	Fl (tf)
No.1 gate	4.5	8.5	27.5	0.02
No.2 gate	5.1	9.0	28.0	0.03
No.3 gate	6.1	10.0	32.0	0.03

(b-3) Friction load due to rubber seal

$$F2 = \mu r \times (q + P \times b) \times \Sigma 1$$

where,

F2	=	Friction load due to rubber seal (tf)	
P	=	Mean hydraulic pressure working on the rubber (tf/m^2)	
μr	=	Coefficient of sliding friction between metal and rubber	1.2
q	=	Initial pressing force of rubber	0.05 (tf/m)
b	=	Clear width of rubber subject to pressure	0.03 (m)
$\Sigma 1$	=	Total sliding length of the rubber	7.0 (m)

	P (tf/m^2)	F2 (tf)
No.1 gate	17.0	4.70
No.2 gate	19.2	5.27
No.3 gate	23.0	6.22

(b-4) Buoyancy

$$Fb = \gamma 1 \times V \times \sin 37.5686°$$

where,

Fb	=	Buoyancy (tf)	
$\gamma 1$	=	Water unit volume weight	1.0 (tf/m^3)
V	=	Water volume displaced by the gate leaf (m^3)	

	V (m^3)	Fb (tf)
No.1 gate	0.57	0.35
No.2 gate	0.65	0.40
No.3 gate	0.78	0.47

(b-5) Load due to hoisting rod weight

$$Fr = Wr \times \sin 37.5686°$$

where,

Fr = Load due to hoisting rod weight (tf)

Wr = Weight of hoisting rod (tf)

Steel pipe ϕ114.3 x 6 mm thick (16 kgf/m) will be applied for hoisting rod

	Rod length (m)	Wr (tf)	Fr (tf)
No.1 gate	66	1.06	0.64
No.2 gate	90	1.44	0.88
No.3 gate	115	1.84	1.12

(b-6) Friction load due to hoisting rod weight

$$F3 = \mu s \times Wr \times \cos 37.5686°$$

where,

F3 = Friction load due to hoisting rod weight (tf)

Wr = Weight of hoisting rod (tf)

μs = Coefficient of sliding friction 0.1

	Wr (tf)	F3 (tf)
No.1 gate	1.06	0.08
No.2 gate	1.44	0.11
No.3 gate	1.84	0.15

(c) Operation load

(c-1) For opening operation (Open (-), Close (+))

	Fw (tf)	F1 (tf)	F2 (tf)	Fb (tf)	Fr (tf)	F3 (tf)	Opening load
No.1 gate	2.7	0.02	4.70	-0.35	0.64	0.08	7.79 (tf)
No.2 gate	3.1	0.03	5.27	-0.40	0.88	0.11	8.99 (tf)
No.3 gate	3.7	0.03	6.22	-0.47	1.12	0.15	10.75 (tf)

(c-2) For closing operation (Open (-), Close (+))

	Fw (tf)	F1 (tf)	F2 (tf)	Fb (tf)	Fr (tf)	F3 (tf)	Closing load
No.1 gate	2.7	-0.02	-4.70	-0.35	0.64	-0.08	-1.81 (tf)
No.2 gate	3.1	-0.03	-5.27	-0.40	0.88	-0.11	-1.83 (tf)
No.3 gate	3.7	-0.03	-6.22	-0.47	1.12	-0.15	-2.05 (tf)

(10) Screw Spindle Hoist

(a) Type of spindle hoist
Same Electrically driven single-stem spindle hoist will be applied to each gate.

(b) Load on one stem

$$W = 3 \times P / N$$

where,

W : Load on one stem (tf)
P : Operating load 11.0 (tf)
N : Number of spindle 1
"3" means 300% of rated output of motor

Thus,

$W = 33.0$ (tf)

(c) Supporting length of spindle

The gate will be lifted to the maintenance space for periodical maintenance. Thus, spindle support is provided on each intermediate stem of 8.0 m.

(d) Diameter of spindle

According to (b) and (c) above, the diameter of spindle is estimated at 90 (mm).

(e) Specification of screw

TM 90 x 4 trapezoidal thread of SUS 304 is used.

Angle of screw thread	30°	
Nominal diameter	90	(mm)
Root diameter	86	(mm)
Effective diameter	88	(mm)
Pitch	4	(mm)
Lead (double thread)	8	(mm)

(f) Torque of spindle hoist

$$T = \frac{P \times d1 \times (\theta \times L + \mu \times \pi \times d1)}{2 \times (\theta \times \pi \times d1 - \mu \times L)}$$

where,

T	:	Torque of spindle shaft (kgf-cm)		
P	:	Operating load	11,000	(kgf)
d1	:	Root diameter of screw	8.6	(cm)
θ	:	Correction coefficient of screw thread		
		$\theta = \mathrm{Cos}\frac{\alpha}{2} = \mathrm{Cos}\frac{30°}{2} = 0.966$	0.966	
α	:	Angle of screw thread	30°	
L	:	Lead	0.8	(cm)
μ	:	Frictional coefficient of screw	0.2	

Thus,

T = 11263 kgf-cm

(g) Revolution of spindle

$N = V/L$

where,

T	:	Revolution of spindle (rpm)	
V	:	Operating speed	300 (mm/min.)
L	:	Lead	8 (mm)

Thus,

$N = 37.5$ (rpm)

(h) Output of motor

$kW = (P \times V) / (6.12 \times \eta)$

where,

kW	:	Required output of motor (kW)	
P	:	Operating load	11.0 (tf)
V	:	Operating speed	0.3 (m/min.)
η	:	Efficiency of spindle hoist	
		$\eta = \eta w \times \eta g \times \eta s$	0.15
		ηw : Efficiency of worm gear	0.5
		ηg : Efficiency of gear	0.95
		ηs : Efficiency of spindle	0.315

Thus,

$kW = 3.59$ (kW)

Finally, 3.7 kW motor is adopted.

(i) Rated torque of motor

$Tm = 97400 \times Pm / n$

where,

Tm	:	Rated torque of motor (kgf-cm)	
Pm	:	Rated output of motor	3.7 (kW)
n	:	R.P.M. of motor (4 pole)	1450 (rpm)

Thus,

$Tm = 249$ (kgf-cm)

(j) Maximum Lowering torque

$$Td = M_{max} \times \frac{1}{ih} \times \eta$$

where,

Td	: Maximum lowering torque (kgf-cm)		
M_{max}	: 300% of rated torque of motor	3 x 249 =	747 (kgf-cm)
ih	: Reduction ratio		1/39
η	: Operating efficiency	0.5 x 0.95 =	0.475

Thus,

Td = 13838 (kgf-cm)

(k) Maximum lowering force

$$Pd = \frac{Td \times 2 \times (\theta \times \pi \times d1 - \mu \times L)}{d1 \times (\theta \times L + \mu \times \pi \times d1)}$$

where,

Pd	: Maximum lowering torque (kgf)		
Td	: Maximum lowering torque	13838	(kgf-cm)
	: Correction coefficient of screw thread	0.966	
d1	: Root diameter of screw	8.6	(cm)
	: Friction coefficient of screw	0.2	
L	: Lead	0.8	(cm)

Thus,

Pd = 13515 kgf

(l) Critical buckling distance of spindle

$$Lo = \sqrt{\frac{n \times \pi^2 \times E \times I \times ns}{Pd}}$$

where,

Lo	:	Critical buckling distance of spindle (cm)			
n	:	Coefficient due to both end fixed conditions		2	
E	:	Young's modules		2.1×10^6	(kgf/cm^2)
I	:	Moment of inertia	Rod potion :	243.1	(cm^4)
			Screw potion :	268.5	(cm^4)
ns	:	Number of spindle		1	
Pd	:	Maximum lowering force		13515	(kgf)

Thus,

Rod potion : Lo = 863 cm > 800 (cm)

Screw potion : Lo = 907 cm > 800 (cm)

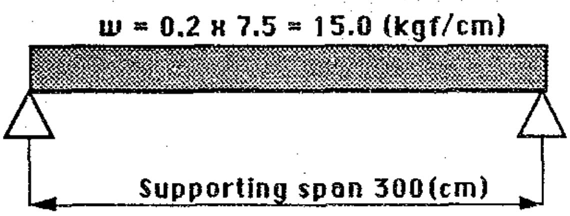
5.3.4.2 Intake Trash Racks

(1) Design Conditions

Type	Front trash rack	:	Fixed trash rack
	Top trash rack	:	Fixed trash rack
Quantity		:	3 sets
Clear span	Front trash rack	:	3.0 m
	Top trash rack	:	3.1 m
Clear height	Front trash rack	:	3.0 m
	Top trash rack	:	0.9 m
Design head		:	2.0 m
Steel bar		:	F.B. 12 mm thick by 100 mm wide
Bar pitch		:	75 mm
Corrosion allowance		:	2 mm

(2) Screen Bar

(a) Bending Moment and Shearing Force



$M = w \times l^2 / 8 =$ 16875 (kgf-cm)

$S = w \times l / 2 =$ 225 (kgf)

where,

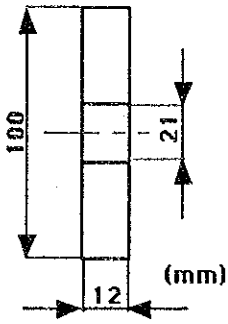
M = Max. bending moment (kgf-cm)

S = Max. shearing force (kgf)

w = Water pressure 0.2 x 7.5 = 1.5 (kgf/cm)

l = Supporting span 3.0 (m)

(b) Bending Stress and Shearing Stress



Corrosion Allowance = 2 (mm)

$Z =$ 16.01 (cm^3)
$A =$ 9.8 (cm^2)

$\sigma = M / Z =$ 1054 (kgf/cm^2) ($< \sigma_a$)
$\tau = S / A =$ 23 (kgf/cm^2) ($<$ 700 kg/cm^2)

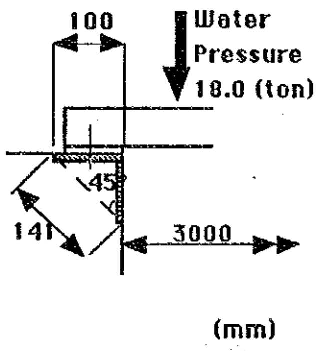
Critical Stress

$\sigma_a = 0.6 \times s_y \times (1.23 - 0.0153 \times L / t) = 1156$ (kgf/cm^2)

where,

σ = Bending stress (kgf/cm^2)
τ = Shearing stress (kgf/cm^2)
L = Laterally unsupported length of screen bar 30 (cm)
t = Thickness of screen bar 1.2 - 0.2 = 1.0 (cm)
s_y = Yield strength of material 2500 (kgf/cm^2)

(3) Guide Frame



(a) Shearing area of concrete section

$A = 14.1 \times 300 \times 2 = 8460\ (cm^2)$

(b) Shearing stress of concrete

$\tau = (Wf + Ws \times \sin 37.5686) / A$

$= (18000 + 1800 \times \sin 37.5686) / 8460 = 2.3\ (kgf/cm^2) < 7\ (kgf/cm^2)$

where,

Wf = Load due to water $0.2 \times 300 \times 300 = 18000$ (kgf)

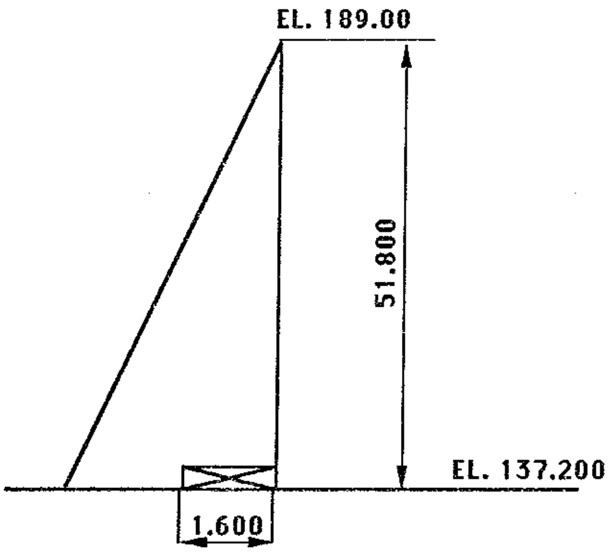
Ws = Trash rack weight 1800 (kgf)

5.3.4.3 River Outlet Inlet Bulkhead Gate

(1) Design Conditions

Type	:	Horizontally pull type sluice gate with by-pass valve
Quantity	:	1 set
Opening	:	1.5 m square
Design head	:	51.80 m
Max. deflection	:	1/800 of clear span
Sealing method	:	4 edges rubber seal at down stream face of gate
Corrosion allowance	:	Not considered
Opening operation	:	Handled by temporarily installed winch

(2) Total Hydraulic Load

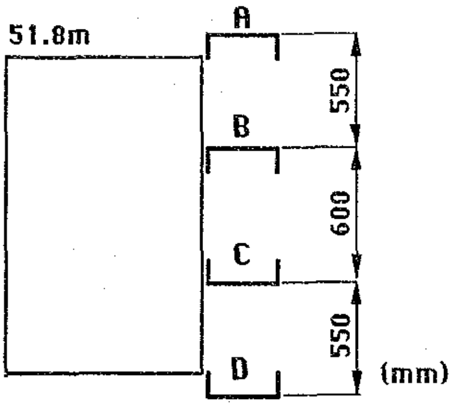


Sealing : 1.6 m square

Pt = 1.6 x 1.6 x 52 = 132.608 (ton)

(3) Main Horizontal Beams

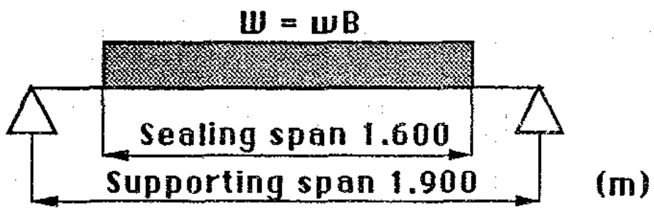
(a) Arrangement and reaction force (w) of main horizontal beams



A-beam	0.25 x 51.8 = 12.95 (t/m)
B-beam	(0.25 + 0.30) x 51.8 = 28.49 (t/m)
C-beam	(0.25 + 0.30) x 51.8 = 28.49 (t/m)
D-beam	0.25 x 51.8 = 12.95 (t/m)

The strength calculation has to be made for B-beam which is taken maximum load.

(b) Bending moment and shearing force



$Mm = W \times (2 \times L - B) / 8$

$Sm = W / 2$

where,

Mm	=	Max bending moment	
Sm	=	Max. shearing force	
W	=	Water pressure load on each beams (ton)	
B	=	Sealing span	1.600 (m)
L	=	Supporting span	1.900 (m)

B-beam

$W = 28.49 \times 1.600 = 45.584$ (ton)

$Mm = 45.584 \times (2 \times 1.900 - 1.600) / 8 = 12.536$ (ton-m)

$= 1253600$ (kg-cm)

$Sm = 45.584 / 2 = 22.792$ (ton)

$= 227920$ (kg)

(c) Bending stress and shearing stress

$\sigma m = Mm / Z$

$\tau m = Sm / Aw$

where,

σm = Max bending stress

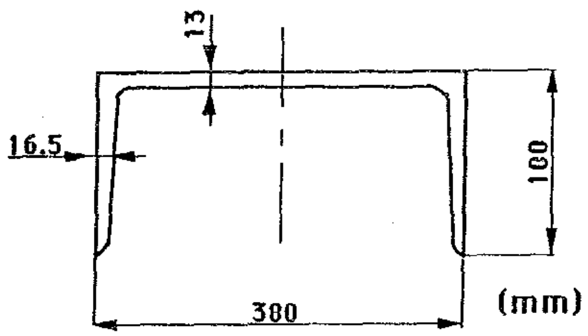
τm = Max. shearing stress

I = Moment of ineatia (cm^4)

Z = Modulus of section (cm^3)

Aw = Area of web (cm^2)

B-beam



$I = 15600$ (cm^4)

$Z = 823$ (cm^3)

$Aw = 45.11$ (cm^2)

$\sigma m = 1253600 / 823 = 1523$ (kg/cm^2) < 1800 (kg/cm^2)

$\tau m = 22792 / 45.11 = 505$ (kg/cm^2) < 1050 (kg/cm^2)

(d) Deflection

$$\delta m = W \times (L^3 - L \times B^2/2 + B^3/8) / (48 \times E \times I)$$

where,

δm = Max deflection

W = Water pressure load on each beams (kg)

E = Young's modulus (kg/cm^2)

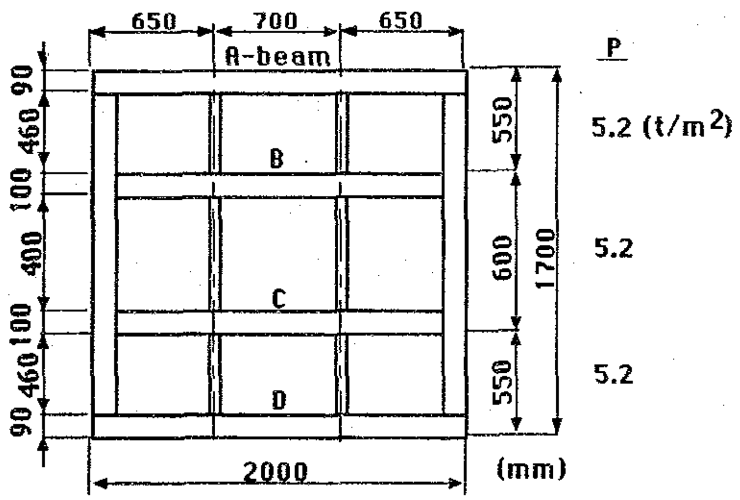
B-beam

$$\delta m = \frac{45584 \times (190^3 - 190 \times 160^2/2 + 160^3/8)}{(48 \times 2.1 \times 10^6 \times 15600)} = 0.143 \text{ (cm)}$$

$\delta m/L = 0.143 / 190 = 1/1329 \quad < 1/800$

(4) Vertical Girders

(a) Bending moment and shearing force

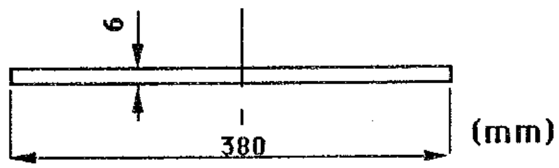


Mm = Max bending moment

Sm = Max. shearing force

No.	P(kg/cm2)	a(cm)	b(cm)	Mm(kg-cm)	Sm(kg)
1	5.18	70	55	91405	4986
2	5.18	70	60	108780	5439
3	5.18	70	55	91405	4986

(b) Bending stress and shearing stress



Z = Modulus of section 144.40 (cm^3)
Aw = Area of web 22.80 (cm^2)

No.	Bending stress (kg/cm^2)	Shearing stress (kg/cm^2)
1	633	219
2	753	239
3	633	219

Allowable bending stress : 1800 (kg/cm^2)
Allowable shearing stress : 1050 (kg/cm^2)

(5) Skin Plate

$$\sigma = (k \times a^2 \times p / t^2) / 100$$

where,

- σ = Bending stress (kg/cm^2)
- k = Coefficient by "b/a"
- a = Short span of plate (cm)
- b = Long span of plate (cm)
- p = Water pressure (kg/cm^2)
- t = Thickness of skin plate (cm)

No.	a	b	b/a	k	p	t	σ
1	46	70	1.52	45.8	5.18	1.8	1549
2	40	70	1.75	48.5	5.18	1.8	1241
3	46	70	1.52	45.8	5.18	1.8	1549

Allowable bending stress : 1800 (kg/cm^2)

(6) Weight of the Gate Leaf

(a) Main horizontal beams

	unit weight	Q'ty	weight
380 x 100 x 13 x 16.5 x 2000	124.00 (kg)	4	496.00 (kg)

(b) Skin plate

	unit weight	Q'ty	weight
1700 x 2000 x 18	480.42 (kg)	1	480.42 (kg)

(c) Vertical beams

	unit weight	Q'ty	weight
380 x 6 x 1700	30.43 (kg)	2	60.86 (kg)

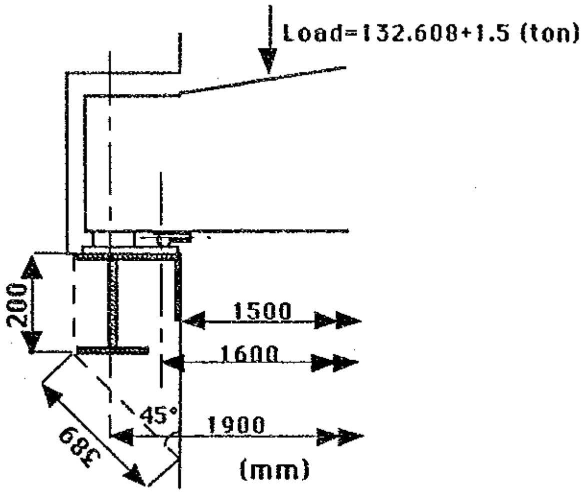
(d) Side beams

	unit weight	Q'ty	weight
380 x 100 x 13 x 16.5 x 1700	105.40 (kg)	2	210.80 (kg)

Total 1248.08 (kg)

x 1.2 ≒ 1.5 (ton)

(7) Guide Frame



(a) Shearing area of concrete section

$$A = (20.0 + 38.9) \times 170.0 = 10013\ (cm^2)$$

(b) Shearing stress of concrete

$$\tau = load / 2A$$
$$= (132608 + 1500) / (2 \times 10013) = 6.70\ (kg/cm^2) \quad < 10.5\ (kg/cm^2)$$

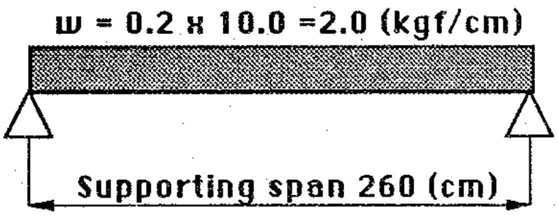
5.3.4.4 River Outlet Trash Racks

(1) Design Conditions

Type		:	Cage type fixed trash rack
Quantity		:	1 set
Dimension	Plan	:	2.6 m square
	Height	:	2.5 m
Design head		:	2.0 m
Steel bar		:	F.B. 12 mm thick by 100 mm wide
Bar pitch		:	100 mm
Corrosion Allowance		:	2 mm

(2) Screen Bar

(a) Bending Moment and Shearing Force



$M = w \times l^2 / 8 =$ 16900 (kgf-cm)

$S = w \times l / 2 =$ 260 (kgf)

where,

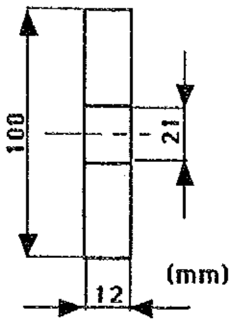
M = Max. bending moment (kgf-cm)

S = Max. shearing force (kgf)

w = Water pressure 0.2 x 10.0 = 2.0 (kgf/cm)

l = Supporting span 2.6 (m)

(b) Bending Stress and Shearing Stress



Corrosion Allowance = 2 (mm)

$Z =$ 16.01 (cm^3)
$A =$ 9.8 (cm^2)

$\sigma = M / Z =$ 1056 (kgf/cm^2) ($< \sigma_a$)
$\tau = S / A =$ 27 (kgf/cm^2) ($<$ 700 kgf/cm^2)

Critical Stress

$\sigma_a = 0.6 \times s_y \times (1.23 - 0.0153 \times L / t) = 1156$ (kgf/cm^2)

where,

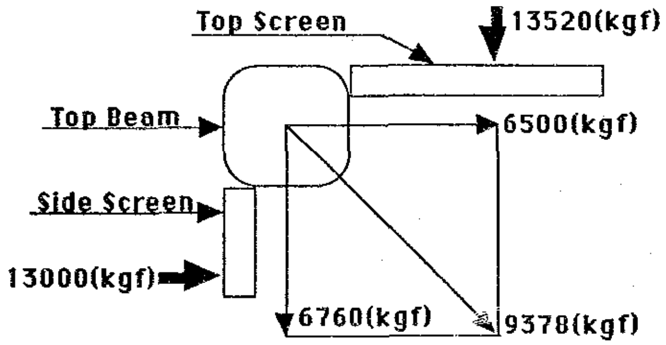
σ	=	Bending stress (kgf/cm^2)
τ	=	Shearing stress (kgf/cm^2)
L	=	Laterally unsupported length of screen bar 30 (cm)
t	=	Thickness of screen bar 1.2 - 0.2 = 1.0 (cm)
s_y	=	Yield strength of material 2500 (kgf/cm^2)

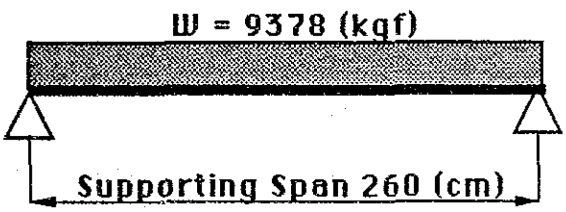
(3) Top Beam of Steel Frame

(a) Hydraulic Load

Top face	W = 0.2 x 260 x 260 = 13520 (kgf)
Side face	W = 0.2 x 250 x 260 = 13000 (kgf)

(b) Bending Moment and Shearing Force



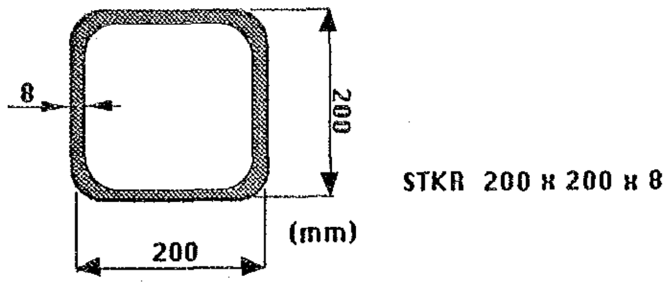


M = W x l / 8 = 304785 (kgf-cm)
S = W / 2 = 4689 (kgf)

where,

M	=	Max. bending moment (kgf-cm)
S	=	Max. shearing force (kgf)
W	=	Water pressure 9378 (kgf)
l	=	Height of steel post 260 (cm)

(c) Bending Stress and Shearing Stress



Corrosion Allowance = 2 (mm)

Z = 283 (cm^3)
A = 45.63 (cm^2)

$\sigma = M / Z =$ 1077 (kgf/cm^2) (< 1200 kgf/cm^2)
$\tau = S / A =$ 103 (kgf/cm^2) (< 700 kgf/cm^2)

where,

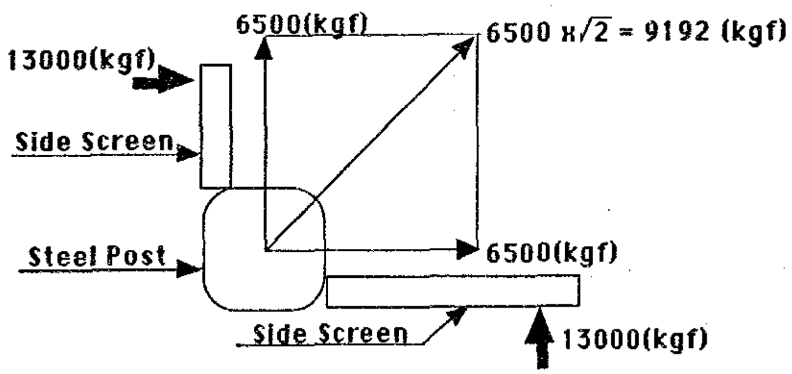
σ = Bending stress (kgf/cm^2)
τ = Shearing stress (kgf/cm^2)

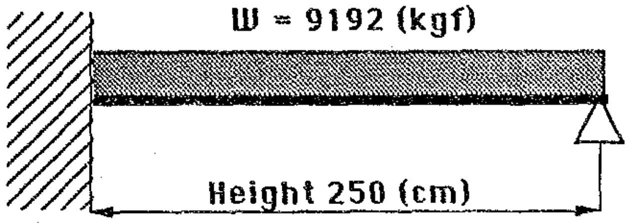
(4) Post of Steel Frame

(a) Hydraulic Load per each side Face

W = 0.2 x 250 x 260 = 13000 (kgf)

(b) Bending Moment and Shearing Force



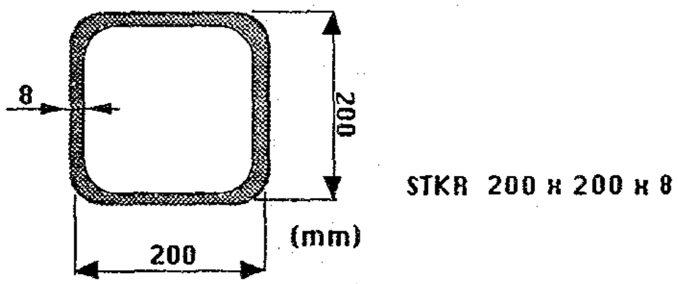


M = W x l / 8 = 287250 (kgf-cm)
S = 5 x W / 8 = 5745 (kgf)

where,

M = Max. bending moment (kgf-cm)
S = Max. shearing force (kgf)
W = Water pressure 9192 (kgf)
l = Height of steel post 250 (cm)

(c) Bending Stress and Shearing Stress



Corrosion Allowance = 2 (mm)

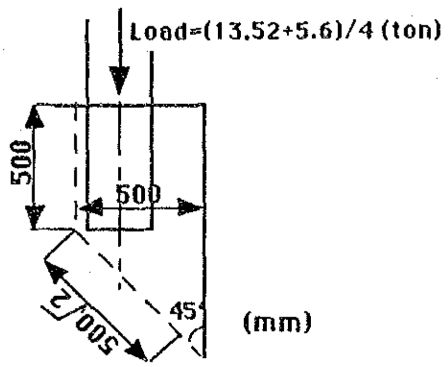
Z = 283 (cm^3)
A = 45.63 (cm^2)

$\sigma = M / Z =$ 1015 (kgf/cm^2) (< 1200 kgf/cm^2)
$\tau = S / A =$ 126 (kgf/cm^2) (< 700 kgf/cm^2)

where,

σ = Bending stress (kgf/cm^2)
τ = Shearing stress (kgf/cm^2)

(5) Shearing of Concrete



(a) Shearing area of concrete section

$$A = (50 \times 50 \times 2 + 50 \times 50\sqrt{2} / 2 \times 2) \times 4 = 34144 \ (cm^2)$$

(b) Shearing stress of concrete

$$\tau = (Wf + Ws) / A$$
$$= (13520 + 5600) / 34144 = 0.6 \ (kgf/cm^2) \quad < 7 \ (kgf/cm^2)$$

where,

Wf = Load due to water 0.2 x 260 x 260 = 13520 (kgf)

Ws = Trash rack weight 5600 (kgf)

5.3.4.5 Water Supply Conduit & River Outlet Conduit

(1) Design Condition

(a) Water Supply Conduit

Type	:	Embedded type welded steel conduit
Quantity	:	1 lane
Diameter	:	1.5 m to 0.4 m
Max. discharge	:	9 m^3/sec. (in stage of future electric power generation)
Total length	:	Approximate 210.207 m
Design pressure	:	
Internal pressure		9 kg/cm^2
External pressure		8 kg/cm^2
Corrosion allowance	:	2 mm

(b) River Outlet Conduit

Type	:	Embedded type welded steel conduit
Quantity	:	1 lane
Diameter	:	1.5 m to 1.0 m
Max. discharge	:	Approximate 25 m^3/sec.
Total length	:	Approximate 57.3 m
Design pressure	:	
Internal pressure		8 kg/cm^2
External pressure		8 kg/cm^2
Corrosion allowance	:	2 mm

(2) Minimum Thickness of Shell Plate

$$Tm = \frac{800 + D}{400}$$

where

Tm	:	Minimum thickness of shell plate (mm)
D	:	Inner diameter of pipe (mm)

$$Tm : \frac{800 + 1500}{400} = 5.75 \text{ (mm)}$$

(3) Tensile Stress due to Internal Pressure

To resist the internal pressure, maximum allowable head for the shell thickness of the pipe is calculated by the following formula.

$$Pa = \frac{2 \cdot \sigma a \cdot \eta \cdot (to\text{-}\varepsilon)}{Do + \varepsilon}$$

where,

Pa	:	Allowable internal pressure (kg/cm^2)		
σa	:	Allowable stress of material 40 kgf/mm2 class steel (JIS SM41B) 1,300 kg/cm2 (t ≤ 40 mm)		
η	:	Welding efficiency	0.9	(at site)
to	:	Thickness of shell plate		(mm)
ε	:	Corrosion allowance	2	(mm)
Do	:	Inner diameter of pipe		(mm)

The calculation result is shown on Table 5.3.1.

(4) Buckling of Pipe Shell and Stiffener Rings due to External Pressure

(a) Pipe shell without stiffener ring

The critical buckling pressure (Pk) for pipe shell without stiffener ring is calculated by the following formula as developed by E. AMSTUTZ.

$$\left(\frac{Ko}{rm} + \frac{\sigma N}{Es^*}\right) \cdot \left(1 + 12 \frac{rm^2}{t^2} \cdot \frac{\sigma N}{Ex^*}\right)^{1.5}$$

$$= 3.36 \cdot \frac{rm}{t} \cdot \frac{\sigma F^* - \sigma N}{Es^*} \cdot \left(1 - \frac{1}{2} \cdot \frac{rm}{t} \cdot \frac{\sigma F^* - \sigma N}{Es^*}\right)$$

where,

Ko : Gap between concrete and outer surface of pipe given by the following formula (cm)

$$Ko = \frac{\alpha s \cdot dT + \beta g \cdot \frac{\sigma a \cdot \eta}{Es} \cdot ro'}{1 + \beta g}$$

αs	:	Coefficient of liner expansion of steel	1.2×10^{-5}/°C
dT	:	Temperature variation	20°C
βg	:	Coefficient of plastic deformation of ground	0.5
σa	:	Allowable stress of material	(kgf/cm^2)
η	:	Welding efficiency	0.9
Es	:	Elastic modules of steel	2.1×10^6 kgf/cm^2
ro'	:	Outer radius of pipe	(cm)
rm	:	Radius to center of shell plate thickness	(cm)
t	:	Thickness of shell plate excluding corrosion allowance	(cm)
σN	:	Circumferential direct stress at deformed point	(kgf/cm^2)
Es*	:	Calculated by the following formula	

$$Es^* = \frac{Es}{1 - Vs^2}$$

Vs	:	Poisson's ratio of steel	0.3

σF^* : Calculated by the following formula

$$\sigma F^* = m \cdot \frac{\sigma F}{\sqrt{1 - Vs + Vs^2}}$$

σF = Yield point of material (kgf/cm²)

40 kgf/mm² class steel (JIS SM41B)

$t \leq 16$ mm 2500 kgf/cm²

$16 < t \leq 40$ mm 2400 kgf/cm²

$$\mu = 1.5 - 0.5 \cdot \frac{1}{(1 + 0.002 \cdot \frac{Es}{\sigma F})^2}$$

Thus, the critical buckling pressure (Pk) is

$$Pk = \frac{\sigma N}{\frac{rm}{t} \cdot (1 + 0.35 \cdot \frac{5\,m}{t} \cdot \frac{\sigma F^* - \sigma N}{Es^*})}$$

From circumferential direct stress (σN) at deformed point calculated by the above formula, then safety factor is:

$$Sf = \frac{Pk}{Po} \geq 1.5$$

where,

Sf	:	Safety factor	
Pk	:	Critical buckling pressure	(kgf/cm²)
Po	:	Design external pressure	(kgf/cm²)

(b) Result of calculation

The pipe shell shall be designed so as to have the safety factor more than 1.5 against the design external pressure in accordance with the formula give in Section 4.(1) in case of the pipe shell without stiffener ring.

The calculation result on the buckling pressure of pipe shell is shown on Table 5.3.2. As mentioned on Table 5.3.2, it is not required to provide the stiffener ring on any portion of pipe shell.

5.3.5 Dimension of Members

Dimensions and weight of each member determined on the basis of the design calculations carried out in the previous sections are summarized in Table 5.3.3 (1) to Table 5.3.3 (8)