3. Structural Calculation of Building

3.1 General

The major design criteria applied in this calculations 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".

3.2 Design Criteria

3.2.1 Loading Conditions

In this 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 design stress are determined from temporary stresses and permanent stresses for main structural parts of building by the above mentioned loads and external forces, according to table and the combination of the forces that make the structural member most disadvantageous are used in the design.

Table 1. Combination of Load

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

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

3.2.2 Seismic Force

The seismic coefficient shall be set down and applied to the building structure as follows;

Seismic coefficient	K = 0.05
Horizontal force to the building	H = 0.05 x W (Dead load of building plus adjusted live load)

3.3 Design of Members

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

Compressive strength of concrete at 28 days shall be 210 kg/cm^2 and more.

Reinforcement bar materials shall comply with deformed bar, "SD30". (JIS G 3112)

Weight of reinforced concrete shall be calculated as 2.4 t/m^3 and the "Young Ratio" 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 "SS41". (JIS G 3101)

3.4 Allowable Stress

3.4.1 Allowable Design Stress of Materials

Allowable design stresses of the structural materials will be as summarized below:

1) Concrete and Reinforcing Bar

Allowable Design Stress of Concrete and Reinforcing (kg/cm^2)

Type of stress / Materials	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
Rein. - bar (JIS G 3112)	1,800	1,800	1,000	2,700	2,700	1,500

Allowable Bond Stress per Unit Surfaces of Reinforcing Bar (kg/cm^2)

Type of stress / Materials	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

2) Structural Steel

(kg/cm^2)

Type of stress / Materials	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

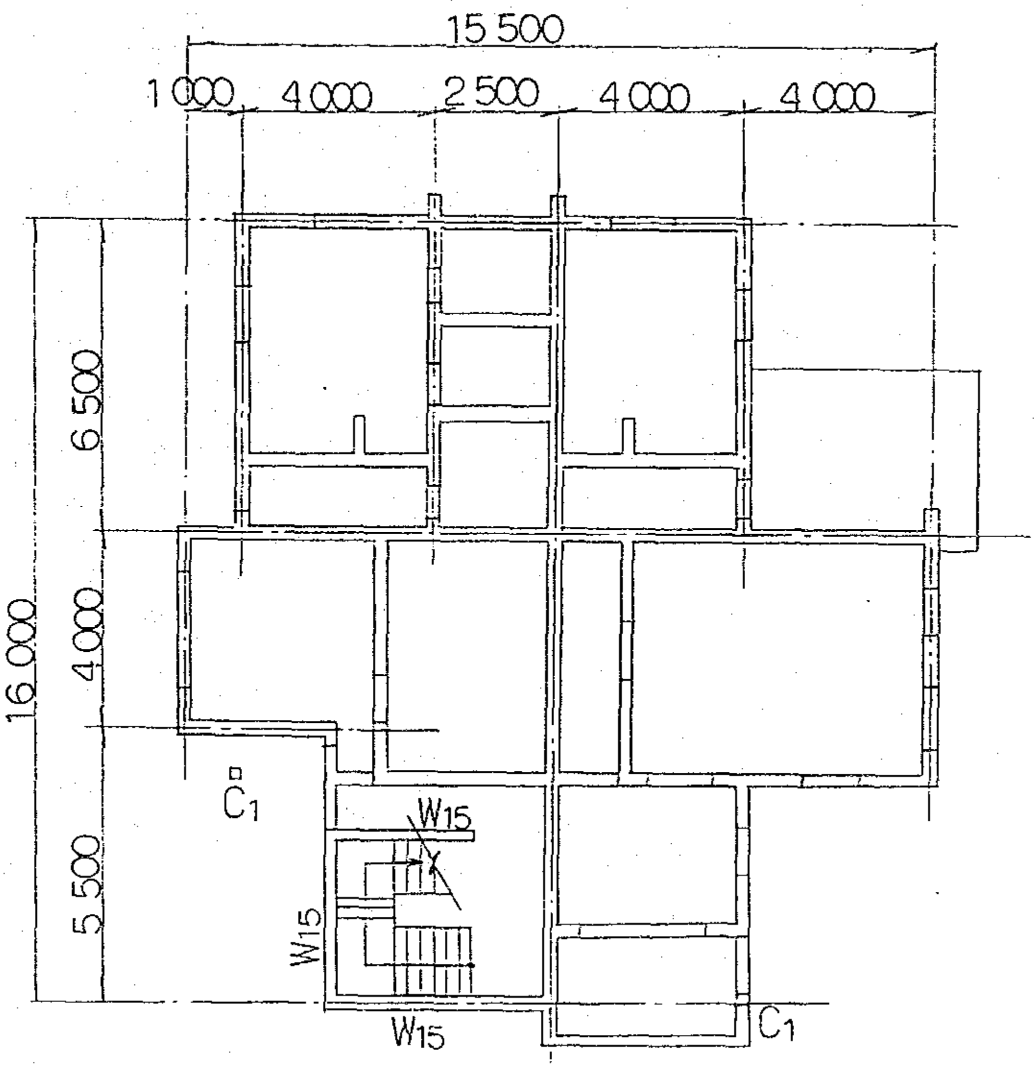
3.4.2 Allowable Bearing Capacity of Soil

The bearing capacity of soil is 30 t/m^2 for permanent load.

3.5 Structural Calculation

3.5.1 Utility Building A

Framing Plan



GROUND FLOOR PLAN

1). Assumed Load

A: To floor
B: To frame
C: To sesmic
D.L: Dead loa
T.L: Total load

1.1 Floor Load Table

Title	Material	Thick (cm)	Weight (kg/m2)		D.L (hg/m2)	L.L (kg/m2)	T.L (kg/m2)	Note
Roof	Concrete Water Proofing Cement Mortar Concrete Slab Ceiling	60 15 150	140 20 30 360 20	A	570	90	660	
				B		70	640	
				C		30	600	
1st Floor	Terrazzo Concrete Slab Ceiling	 150	80 360 20	A	460	180	640	
				B		130	590	
				C		60	520	

1.2 Dead Load of Girder and Wall

	Title	Size(cm)	Weight(kg/cm 2)
	Girder	15 x 60 15 x 40 15 x 85 15 x 45	162 + 42 → 210 90 + 26 → 120 252 + 62 → 320 108 + 30 → 140
	Column	15 x 15	54 + 24 → 80
	Wall	CB 15	200 + 80 → 280

2). Calculation of Axial Force of Columns

No.	Floor	Title	Calculation					W	ΣW
			Load(t/m^2 & t•m)	Area (m2)	Length (m)	Length (m)	W' (t)	(t)	(t)
W1	1F	Roof	0.64	16.16			10.4		
		G	0.21		11.5		2.4		
		W	0.28		1.2	11.5	3.9	16.7	
	F	W	0.28		1.2	11.5	3.9	3.9	20.6
W2	1F	Roof	0.64	10.65			6.9		
		G	0.21		6.5		1.4		
		W	0.28		1.2	6.5	2.2	10.5	
	F	W	0.28		1.2	6.5	2.2	2.2	12.7
W3	1F	Roof	0.64	8.16			5.3		
		G	0.21		5.25		1.1		
		W	0.28		1.2	4.0	1.4	7.8	
	F	W	0.28		1.2	4.0	1.4	1.4	9.2
W4	1F	Roof	0.64	8.25			5.3		
		G	0.21		5.0		1.1		
		W	0.28		1.2	3.2	1.1	7.5	
	F	W	0.28		1.2	3.2	1.1	1.1	8.6
W5	1F	Roof	0.64	3.0			2.0		
		G	0.21		2.5		0.6		
		W	0.28		1.2	2.5	0.9	3.5	
	F	W	0.28		1.2	2.5	0.9	0.9	4.4
W6	2F	Roof	0.64	9.58			6.2		
		G	0.21		7.5		1.6		
		W	0.28		1.2	7.5	2.6		
		Parapet	0.67		6.6		4.4	14.8	
	1F	W	0.28		1.2	7.5	2.6	2.6	17.4
W7	2F	Parapet	0.67	4.6			3.1		
		Roof	0.64		6.58		4.2		
		G	0.21		4.0		0.9		
		W	0.28		1.2	4.0	1.4	9.6	
	1F	W	0.28		1.2	4.0	1.4	1.4	11.0

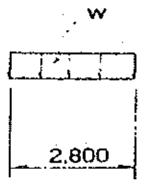
No.	Floor	Title	Calculation					W	ΣW
			Load(t/m^2 & t•m)	Area (m2)	Length (m)	Length (m)	W' (t)	(t)	(t)
W8	2F	Parapet	0.67	6.2			4.2		
		Roof	0.64	6.0			3.9		
		G	0.21		5.0		1.1		
		W	0.28		0.85	5.0	1.2	10.4	
	1F	W	0.28		0.85	5.0	1.2		
		G	0.32		5.0		1.6	2.8	13.2
W9	2F	Roof	0.64	8.56			5.8		
		G	0.21		5.0		1.1		
		W	0.28		1.2	3.2	1.1	8.0	
	1F	W	0.28		1.2	3.2	1.1	1.1	9.1
W10	2F	Roof	0.64	8.56			5.8		
		G	0.21		5.0		1.1		
		W	0.28		1.2	4.0	1.4	8.3	
	1F	1st Floor	0.59	7.88			4.7		
		G	0.21		5.0		1.1		
		W	0.28		1.2	4.0	1.4		
			0.28		1.2	5.0	1.7	8.9	17.2
	F	W	0.28		1.2	5.0	1.7	1.7	18.9
W11	2F	Parapet	0.67	4.5			3.0		
		Roof	0.64	7.77			5.0		
		G	0.21		4.5		1.0		
		W	0.28		1.2	4.5	1.5	10.5	
	1F	1st Floor	0.59	5.07			3.0		
		G	0.21	5.5			1.2		
		W	0.28		1.2	4.5	1.5		
			0.28		1.2	5.5	1.8	7.5	18.0
	F	W	0.28		1.2	5.5	1.8	1.8	19.8

No.	Floor	Title	Calculation					W	ΣW
			Load(t/m2 & t•m)	Area (m2)	Length (m)	Length (m)	W' (t)	(t)	(t)
W12	2F	Parapet	0.67	6.5			4.4		
		Roof	0.64	12.1			7.8		
		G	0.21		6.5		1.4		
			0.14		2.25		0.3		
		W	0.28		1.2	4.5	1.5	15.4	
	1F	1st Floor	0.59	3.38			2.0		
		G	0.21		6.5		1.4		
		W	0.28		2.4	4.5	3.1	6.5	21.9
	F	W	0.28		1.2	4.5	1.5	1.5	23.4
W13	2F	Parapet	0.67	3.95			2.7		
		Roof	0.64	2.28			1.5		
		G	0.21		2.75		0.6		
		W	0.28		1.2	2.75	0.9	5.7	
	1F	G	0.21		2.75		0.6		
		C	0.08		1.2		0.1		
		W	0.28		1.2	2.75	0.9	1.6	7.3
	F	C	0.08		1.2		0.1	0.1	7.4
W14	2F	Parapet	0.67	3.75			2.5		
		Roof	0.64	6.96			4.5		
		G	0.21		3.75		0.8		
		W	0.28		1.2	3.75	1.3	9.1	
	1F	1st Floor	0.59	1.33			0.8		
		G	0.21		3.75		0.8		
		W	0.28		1.2	3.75	1.3		
			0.28		1.2	3.0	1.0	3.9	13.0
	F	W	0.28		1.2	3.0	1.0	1.0	14.0
W15	1F	Parapet	0.34	4.0			1.4		
		Roof	0.64	1.75			1.2		
		G	0.21		4.0		0.9		
		W	0.28		1.2	4.0	1.4	4.9	
	F	W	0.28		1.2	4.0	1.4	1.4	6.3

No.	Floor	Title	Calculation					W	ΣW
			Load(t/m^2 & t•m)	Area (m2)	Length (m)	Length (m)	W' (t)	(t)	(t)
W16	1F	1st Floor	0.59	6.38			3.8		
		G	0.21		5.5		1.2		
		W	0.28		1.2	5.0	1.7	6.7	
	F	W	0.28		1.2	5.0	1.7	1.7	8.4
W17	1F	1st Floor	0.59	7.88			4.7		
		G	0.21		5.0		1.1		
		W	0.28		1.2	5.0	1.7	7.5	
	F	C	0.28		1.2	5.0	1.7	1.7	9.2
W18	1F	Roof	0.64	9.54			6.1		
		G	0.21		5.6		1.2		
		W	0.28		1.2	5.6	1.9	9.2	
	F	W	0.28		1.2	5.6	1.9	1.9	11.1
W19	1F	Roof	0.64	6.28			4.0		
		1st Floor	0.59	9.69			5.7		
		G	0.21		8.25		7.8		
		B	0.21		2.5		0.6		
		W	0.28		1.2	7.5	2.6	14.7	
	F	W	0.28		1.2	7.5	2.6	2.6	17.3
W20	1F	Roof	0.64	4.92			3.2		
		1st Floor	0.59	10.91			6.6		
		G	0.21		7.25		1.6		
		B	0.21		2.5		0.6		
		W	0.28		1.2	6.5	2.2	14.1	
	F	W	0.28		1.2	6.5	2.2	2.2	16.3
W21	1F	Parapet	0.34		1.0		0.4		
		Roof	0.64	1.13			0.8		
		1st Floor	0.59		5.13		3.0		
		G	0.21		4.0		0.9		
		B	0.21		2.5		0.6		
		W	0.28		1.2	3.0	1.0	6.7	
	F	W	0.28		1.2	3.0	1.0	1.0	7.7

No.	Floor	Title	Calculation					W	ΣW
			Load(t/m2 & t•m)	Area (m2)	Length (m)	Length (m)	W' (t)	(t)	(t)
W22	2F	Parapet	0.67		2.0		1.4		
		Roof	0.64	9.03			5.8		
		G	0.21		5.25		1.1		
		W	0.28		1.2	4.0	1.4	9.7	
	1F	1st Floor	0.59		8.72		5.2		
		G	0.21		5.95		1.3		
		B	0.21		2.5		0.6		
		W	0.28		1.2	4.0	1.4		
			0.28		1.2	3.5	1.2	9.7	19.4
	F	W	0.28		1.2	3.5	1.2	1.2	20.6
W23	2F	Roof	0.64	10.85			6.9		
		G	0.21		5.25		1.1		
		B	0.12		2.25		0.3		
		W	0.28		1.2	4.0	1.4	9.7	
	1F	1st Floor	0.59		5.75		3.4		
		Roof	0.64		11.8		7.6		
		G	0.21		7.25		1.6		
		B	0.21		2.5		0.6		
		W	0.28		1.2	4.0	1.4		
			0.28		1.2	6.5	2.2	16.8	26.5
	F	W	0.28		1.2	6.5	2.2	2.2	28.7

3). Design of Girder and Beam



W = 0.64 x 1.25 + 0.21 = 1.01 t/m

M = 1/12 x 1.01 x 2.8^2 = 0.66 t·m

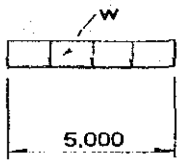
Q = 1/2 x 1.01 x 2.8 = 1.425

<G> B x D = 15 x 40 cm d = 35 cm j = 30.63 cm

At = 66/(1.8 x 30.63) = 1.20 cm^2 2-D13

φ = 1420/(14 x 30.63) = 3.31cm

τ = 1420/(15 x 30.63) = 3.1 < 4.25 kg/cm^2 O K



W = 9.1/5.0 + 0.64 x 1.39 + 0.21 = 2.92 t/m

M = 1/8 x 2.92 x 5.0^2 = 9.13 t·m

Q = 1/2 x 2.92 x 5.0 = 7.3 t

<B1> B x D = 30 x 60 d = 55 j = 48.13

End φ = 7300/(14 x 48.13) = 10.83 cm 3-D19

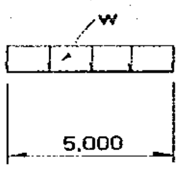
τ = 7300/(30 x 48.13) = 5.05 > 4.25 kg/cm^2 N G

DQ = 7.3 - 30 x 48.13 x 4.25 x 10^{-3} = 1.17t

DQ/bj = 0.9 Pw = 0.30

D10 x = 1.43/(30 x 0.003) = 15.8 cm ∴ D10 - @150

Center At = 913/(1.8 x 48.13) = 10.54 cm^2 5-D19



W = 13.2/5.0 + 0.64 x 2.14 + 0.38 = 4.39 t/m

M = 1/8 x 4.39 x 5.0^2 = 13.72 t·m

Q = 1/2 x 4.39 x 5.0 = 10.98 t

<B2> B x D = 35 x 60 d = 55 j = 48.13

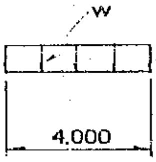
End φ = 10980/(14 x 48.13) = 16.30 cm 4-D19

τ = 10980/(35 x 48.13) = 6.52 > 4.25 kg/cm^2 N G

DQ = 10.98 - 35 x 48.13 x 4.25 x 10^{-3} = 3.83t

DQ/bj = 2.3 Pw = 0.46 D13 x = 15.7 cm D13-@150

Center At = 1372/(1.8 x 48.13) = 15.84 cm^2 6-D19

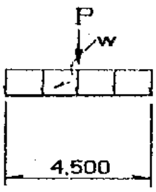


W = 13.2/5.0 + 0.64 x 1.38 + 0.38 = 3.91t/m
M = 1/8 x 3.91 x 4.0^2 = 7.82 t·m
Q = 1/2 x 3.91 x 4.0 = 7.82 t

<B1> B x D = 30 x 60 j = 48.13

End
φ = 7820/(14 x 48.13) = 11.61cm 3-D19
τ = 7820/(30 x 48.13) = 5.42 > 4.25 kg/cm^2 N G
DQ = 7.82 - 6.13 = 1.69t
DQ/bj = 1.2 Pw = 0.31
D13 x = 2.54/(30 x 0.0031) = 27.3 cm ∴D13 - @200

Center
At = 782/(1.8 x 48.13) = 9.03 cm^2 5-D19

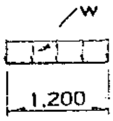


W = 0.21 + 0.64 x 1.12 = 0.93 t/m
P = 0.64 x 2.25 x 2.25 = 3.24 t
M = 1/8 x 0.93 x 4.5^2 + 1/4 x 3.24 x 4.5= 6.0 t·m
Q = 1/2 x 0.93 x 4.5 + 1/2 x 3.24 = 3.72 t

<B3> B x D = 18 x 60 d = 55 j = 48.13

End
φ = 3720/(14 x 48.13) = 5.52 cm 2-D16
τ = 3720/(75 x 48.13) = 5.15 > 4.25 kg/cm^2 N G
DQ = 3.72 - 15 x 48.13 x 4.25 x 10^{-3} = 0.65t
DQ/bj = 0.9 Pw = 0.32
D10 x = 1.43/(15 x 0.0032) = 29.7 cm ∴ D10 - @200

Center
At = 600/(1.8 x 48.13) = 6.92 cm^2 4-D16



W = 0.66 t/m/

M = 1/2 x 0.66 x 1.2^2 = 0.48 t·m

Q = 0.66 x 1.2 = 0.80 t

<CS1> D = 15 cm d = 12 cm j = 10.5 cm

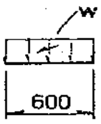
At = 48 x 1.5/(1.8 x 10.5) = 3.81 cm^2 D10&13

$$x = \frac{0.99x100}{3.81} = 25.9 \text{ cm}$$

φ = 800 x 1.5/(14 x 10.5) = 8.16 cm

$$x = \frac{3.5x100}{8.16} = 42.8 \text{ cm}$$

∴ D10&13-@200



W = 0.66 t/m

M = 1/2 x 0.66 x 0.6^2 = 0.12 t·m

Q = 0.66 x 0.6 = 0.40 t

<CS2> D = 15 cm d = 12 cm j = 10.5 cm

At = 12 x 1.5/(1.8 x 10.5) = 0.96 cm^2 D10

$$x = \frac{0.71x100}{0.96} = 73.9 \text{ cm}$$

φ = 400 x 1.5/(14 x 10.5) = 4.08 cm

$$x = \frac{3.0x100}{4.08} = 73.5 \text{ cm}$$

∴ D10-@200

4). Design of Slab

		Lx(m)	Ly(m)	t(Cm)	w(t/m2)
D10,D13	S01	4.0	5.0	15.0	0.660
	S02	4.5	4.5	15.0	0.660
	S03	4.0	5.0	15.0	0.870
	S04	4.0	4.0	15.0	0.760

D10,D13 S01 Lx(m) 4.0 Ly(m) 5.0 t(Cm) 15.0 w(t/m2) 0.660

LAMBDA= 1.25 wLx2(t*m)= 10.560 ft(kg/Cm2)=2000.0

S1

	ALPHA	M(t*m/m2)	at(Cm2/m)	D10	D10&D13	D13	
X-E	-0.059	-0.624	2.97	@23.9	@33.3	@42.7	) D10,D13-@200
X-C	0.039	0.416	1.98	@35.8	@50.0	@64.1	
Y-E	-0.042	-0.440	2.29	@31.1	@43.3	@55.6	) D10,D13-@200
Y-C	0.028	0.293	1.52	@46.6	@65.0	@83.3	

S02 Lx(m) 4.5 Ly(m) 4.5 t(Cm) 15.0 w(t/m2) 0.660

LAMBDA= 1.00 wLx2(t*m)= 13.365 ft(kg/Cm2)=2000.0

S1

	ALPHA	M(t*m/m2)	at(Cm2/m)	D10	D10&D13	D13	
X-E	-0.042	-0.557	2.65	@26.8	@37.3	@47.9	) D10,D13-@200
X-C	0.028	0.371	1.77	@40.2	@56.0	@71.8	
Y-E	-0.042	-0.557	2.89	@24.5	@34.2	@43.9	) D10,D13-@200
Y-C	0.028	0.371	1.93	@36.8	@51.3	@65.9	

S03 Lx(m) 4.0 Ly(m) 5.0 t(Cm) 15.0 w(t/m2) 0.870

LAMBDA= 1.25 wLx2(t*m)= 13.920 ft(kg/Cm2)=2000.0

S1

	ALPHA	M(t*m/m2)	at(Cm2/m)	D10	D10&D13	D13	
X-E	-0.059	-0.823	3.92	@18.1	@25.3	@32.4	) D10,D13-@200
X-C	0.039	0.549	2.61	@27.2	@37.9	@48.6	
Y-E	-0.042	-0.580	3.01	@23.6	@32.9	@42.2	) D10,D13-@200
Y-C	0.028	0.387	2.01	@35.3	@49.3	@63.2	

S04 Lx(m) 4.0 Ly(m) 4.0 t(Cm) 15.0 w(t/m2) 0.760

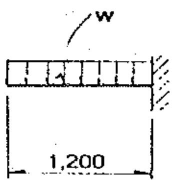
LAMBDA= 1.00 wLx2(t*m)= 12.160 ft(kg/Cm2)=2000.0

S1

	ALPHA	M(t*m/m2)	at(Cm2/m)	D10	D10&D13	D13	
X-E	-0.042	-0.507	2.41	@29.4	@41.0	@52.6	) D10,D13-@200
X-C	0.028	0.338	1.61	@44.1	@61.5	@79.0	
Y-E	-0.042	-0.507	2.63	@27.0	@37.6	@48.3	) D10,D13-@200
Y-C	0.028	0.338	1.75	@40.5	@56.4	@72.4	

5). Design of Stair

Floor load	D.L		L.L	T.L
			300	960
Terrazzo	60			
		660	180	840
Concrete slab	600			
			80	740



$W = 0.25 \times 0.96 = 0.24$

$M = 1/2 \times 0.24 \times 1.2^2 = 0.18$ t·m

$Q = 0.24 \times 1.2 = 0.29$

D = 25cm d = 20cm j = 17.5cm

$At = \frac{18 \times 1.5}{1.8 \times 17.5} = 0.86 \text{ cm}^2$ 1-D13

$\varphi = \frac{290 \times 1.5}{21 \times 17.5} = 1.18$ cm

6). Design of Foundation

Allowable bearing capacity $fe = 30\ t/m^2$ (permanent)

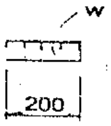
Dead load 2.4 x 0.19 x 0.75 = 0.35 t/m

2.0 x (1.0 - 0.19) x 0.6 = 0.98 t/m

Total=1.33 t/m

No.	LF (m)	N (t)	P' = N/LF (t/m)	P (t/m)
W1	10.5	20.6	1.96	3.29
W2	6.0	12.7	2.12	3.45
W3	4.75	9.2	1.94	3.27
W4	4.5	8.6	1.92	3.25
W5	2.0	4.4	2.2	3.53
W10	4.0	18.9	4.73	6.06
W11	5.0	19.8	3.96	5.29
W12	4.5	23.4	5.2	6.53
W14	2.5	14.0	5.6	6.93
W15	4.0	6.3	1.58	2.91
W16	4.0	8.4	2.1	3.43
W17	4.0	9.2	2.3	3.63
W18	5.0	11.1	2.22	3.55
W19	8.25	45.85	5.56	6.89
W20	7.25	33.9	4.68	6.01
W21	3.5	14.3	4.09	5.42
W22	4.75	25.15	5.30	6.63
W23	7.25	35.3	4.87	6.20

No.	L' (m)	L (m)	σ_c	P" (t/m)	σ_c' (t/m^2)
W1	0.11	0.40			
W2	0.12	"			
W3	0.11	"			
W4	0.11	"			
W5	0.12	"			
W10	0.21	"			
W11	0.18	"			
W12	0.22	"			
W14	0.23	"	17.4t/m^2 < 30t/m^2	5.95	14.9
W15	0.10	"			
W16	0.12	"			
W17	0.13	"			
W18	0.12	"			
W19	0.23	"			
W20	0.20	"			
W21	0.18	"			
W22	0.22	"			
W23	0.21	"			



$W = 14.9$ t/m

$M = 1/2 \times 14.9 \times 0.2^2 = 0.30$ t·m

$Q = 14.9 \times 0.2 = 2.98$ t

<F1> D = 18 cm d = 12 cm j = 10.5 cm

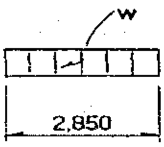
$At = 30/1.8 \times 10.5 = 1.59\ cm^2$ D10

$$x = \frac{0.71 \times 100}{1.59} = 44.6\ cm$$

$\varphi = 2980/21 \times 10.5 = 13.5$ ∴ D10-@200

$$x = \frac{3.0 \times 100}{13.5} = 22.2\ cm$$

$\tau = 2980/100 \times 10.5 = 2.9\ kg/cm^2 < 4.25\ kg/cm^2$ OK



$W = 5.6$ t/m

$M = 1/2 \times 5.6 \times 2.85^2 = 3.80$ t·m

$Q = 1/2 \times 5.6 \times 2.85 = 7.98$ t

<FG1> B x D = 19 x 75 cm d = 67 cm j = 58.63 cm

$At = 380/1.8 \times 58.63 = 3.60\ cm^2$

2-D16

$\varphi = 7980/21 \times 58.63 = 6.48$ cm

$\tau = 7980/19 \times 58.63 = 7.16 > 4.25\ kg/cm^2$ NG

$DQ = 7.98 - 19 \times 58.63 \times 4.25 \times 10^{-3} = 3.25t$

$DQ/bj = 2.92$ $Pw = 0.49$

D10 $x = 1.43/19 \times 0.0049 = 15.3$ cm ∴ D10 - @150

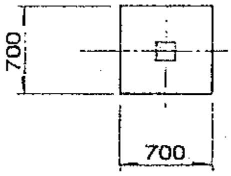
<W13>

N' = 7.4t

$A = 7.4/28.5 = 0.26\ m^2$ 　　 $l \times l' = 0.7 \times 0.7$

N = 7.4 x 2.0 x 0.7 x 0.7 x 0.75 = 8.2 t

$\sigma_c = 8.2/0.7 \times 0.7 = 16.8 < 30.0\ t/m^2$ 　　 O K



l/a = 4.7

M = 0.37 x 0.15 = 0.06 t·m

Q = 0.39 x 7.4 = 2.89 t

<F2>

D = 25 cm 　　 d = 17 cm 　　 j = 14.88 cm

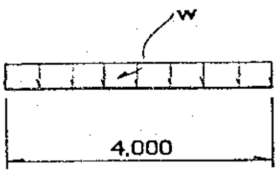
$At = 6/1.8 \times 14.88 = 0.22\ cm^2$ 　　 4-D10

$\varphi = 2890/21 \times 14.88 = 9.25$ cm

$\tau = 2890/65 \times 14.88 = 3.0 < 4.25\ kg/cm^2$

7). Design of Steel Roof

Asbestos cement board	30			
Purline	10	60		
Ceiling	20		70	
Beam	10			90
Girder	20			



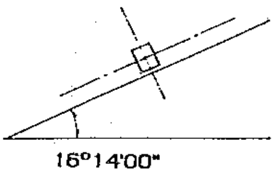
(G) W = 0.06 t/m

90 cm interval

W = 0.06 x 0.9 = 0.054

Wx = 0.054 x cos q = 0.052

Wy = 0.054 x sin q = 0.016



$Mx = 0.052 \times 4.0^2 \times 1/8 = 0.104$ tm

$My = 0.016 \times 4.0^2 \times 1/8 = 0.032$ tm

use C - 100 x 50 x 20 x 1.6

Zx = 11.6 (16.1)

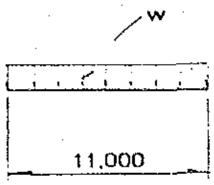
Zy = 4.30 (6.06)

$$\frac{\sigma x + \sigma y}{f_b} = 10.4/11.6 \times 1.4 + 3.2/4.3 \times 1.4 = 0.84 < 1.0 \quad \text{OK}$$

$$\delta_x = \frac{5 \times 0.52 \times 4.0^4 \times 10^8}{384 \times 2.1 \times 10^6 \times 80.7} = 1.01 \text{ cm}$$

$\delta = 1.63$ cm (1/245)

$$\delta y = \frac{5 \times 0.16 \times 4.0^4 \times 10^8}{384 \times 2.1 \times 10^6 \times 19.0} = 1.29 \text{ cm}$$



$W = 0.09 \times 4.0 = 0.36$ t/m

$M = 1/8 \times 0.36 \times 11.0^2 = 5.46$ t·m

$Q = 1/2 \times 0.36 \times 11.0 = 1.98$ t

<SB1> use H - 400 x 200 x 8 x 13

I=23700 z=1190

$l_b = 367$

$f_b = 900 \times 20 \times 1.3/40 \times 367 = 1.59$ $\therefore f_b = 1.4$

$\sigma_b/f_b = 546/1190 \times 1.4 = 0.33 < 1.0$ OK

$$\delta = \frac{5 \times 3.6 \times 11.0^4 \times 10^8}{384 \times 2.1 \times 10^6 \times 23700} = 1.38 \text{ cm}$$

(l/797)

8). Design of Foundation (for F2)

(a)	Parapet	0.34 x 4.0 =	1.4	
	Roof	0.64 x 1.8 x 4.0=	4.6	6.3 t
	C	0.08 x 3.0 =	0.3	
(b)	Roof	0.09 x 4.0 x 6.0=	2.2	
	"	0.64 x 1.5 x 4.0=	3.9	8.6
	G	0.53 x 4.0 =	2.2	
	C	0.08 x 3.0 =	0.3	

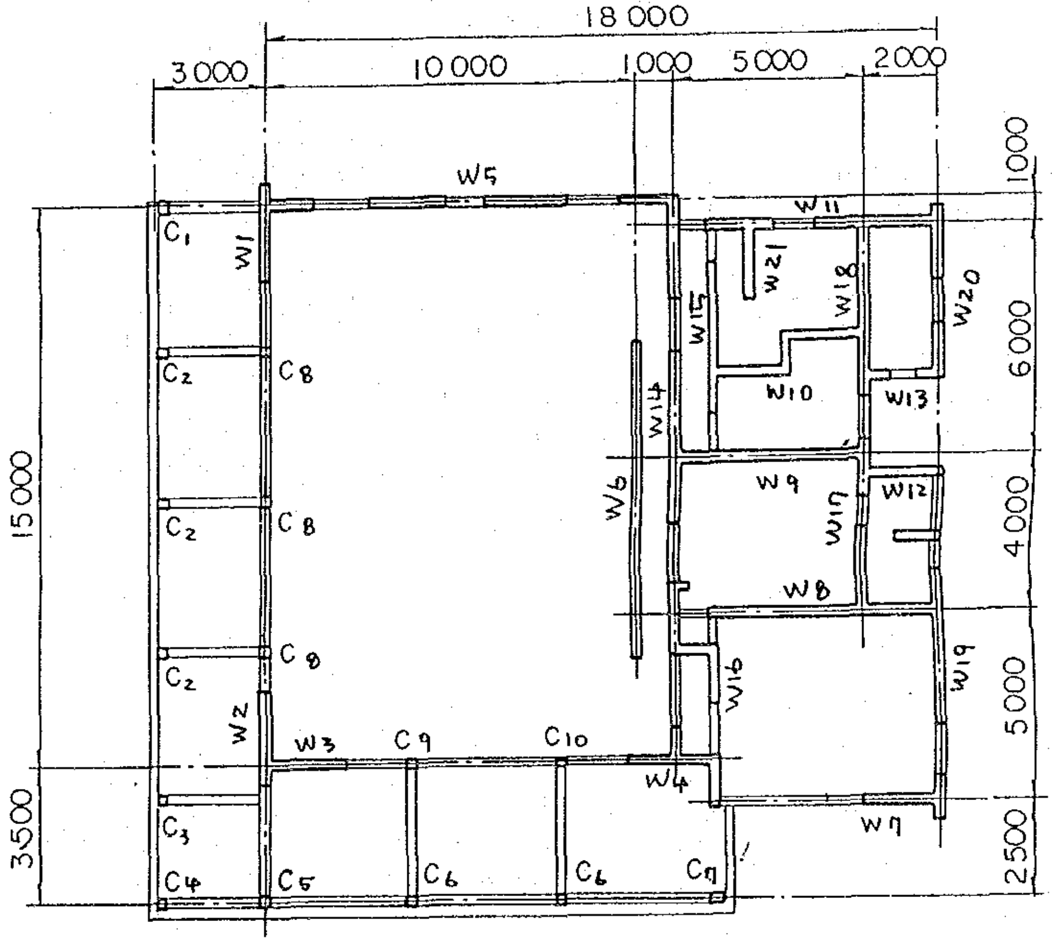
$A = 8.6/28.5 = 0.302$ $\rightarrow l \times l' = 0.7 \times 0.7$

<F2> $N = 8.6 + 2.0 \times 0.7 \times 0.7 \times 0.75 = 9.4$ t

$\sigma = 9.4/0.7 \times 0.7 = 19.1 < f_e = 30.0$ t/m^2 OK

3.5.2 Utility Building B

Framing Plan



GROUND FL PLAN

1). Assumed Load

A : To floor
B : To frame
C : To seismic

1-1 Floor Load Table

D.L : Dead load
L.L : Live load
T.L : Total load

Title	Material	Thick (cm)	Weight (kg/m^2)		D.L (kg/m^2)	L.L (kg/m^2)	T.L (kg/m^2)	Note
	Concrete	60	140	A		90	660	
	Water Proofing		20					
Roof (1)	Cement Mortar	15	30	B	570	70	640	
(concrete)	Concrete Slab	150	360					
	Ceiling		20	C		30	600	
	Asbestos Cement Board		30	A	60	-	60	
	Puline		10					
Roof (2)	Ceiling		20	B	90	-	90	
(steel)	Beam		10					
	Girder		20	C	90	-	90	

1-2 Dead Load of Girder and Wall

	Title	Size (cm)	Weight (kg/cm^2)
	Girder	15 x 60	162 + 42 → 210
		15 x 40	90 + 26 → 120
		15 x 85	252 + 62 → 320
		15 x 45	108 + 30 → 140
	Beam	25 x 60	270 + 46 → 320
	Column	15 x 15	54 + 24 → 80
	Wall	W15	360 + 80 → 440
		CB15	200 + 80 → 280

2). Calculation of Axial Force of Columns

G : Girder
W : Wall
C : Column
B : Beam

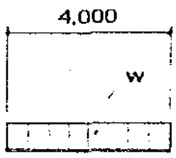
No.	Floor	Title	Calculation					W (t)	ΣW (t)
			Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)		
C1	1F	Roof(1)	0.64	3.27			2.1		
		G	0.21		3.5		0.8		
		C	0.08		1.4		0.2	3.1	
	F	C	0.08		1.4		0.2	0.2	3.3
C2	1F	Roof(1)	0.64	6.3			4.1		
		G	0.21		5.5		1.2		
		C	0.08		1.4		0.2	5.5	
	F	C	0.08		1.4		0.2	0.2	5.7
C3	1F	Roof(1)	0.64	5.12			3.3		
		G	0.21		4.75		1.0		
		C	0.08		1.4		0.2	4.5	
	F	C	0.08		1.4		0.2	0.2	4.7
C4	1F	Roof(1)	0.64	2.09			1.4		
		G	0.21		2.75		0.6		
		C	0.08		1.4		0.2	2.2	
	F	C	0.08		1.4		0.2	0.2	2.4
C5	1F	Roof(1)	0.64	6.39			4.1		
		G	0.21		5.25		1.1		
		C	0.08		1.4		0.2	5.4	
	F	C	0.08		1.4		0.2	0.2	5.6
C6	1F	Roof(1)	0.64	7.3			4.7		
		G	0.21		5.75		1.2		
		C	0.08		1.4		0.2	6.1	
	F	C	0.08		1.4		0.2	0.2	6.3
C7	1F	Roof(1)	0.64	3.0			2.0		
		G	0.21		3.25		0.7		
		C	0.08		1.4		0.2	2.9	
	F	C	0.08		1.4		0.2		3.1
C8	1F	Roof(4)	0.64	6.0			3.9		
		Roof(2)	0.09	22.8			2.1		
		G	0.21		5.5		1.2		
		W(W15)	0.44		1.25	4.0	2.2		
		C	0.08		1.4		0.2	9.6	
	F	C	0.08		1.4		0.2	0.2	9.8

No.	Floor	Title	Calculation					W (t)	ΣW (t)
			Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)		
C9	1F	Roof(1)	0.64	4.53			2.9		
		Roof(2)	0.09	6.0			0.6		
		G	0.21		5.75		1.2		
		W(W15)	0.44		1.65	3.0	2.2		
		C	0.08		1.4		0.2	7.1	
	F	C	0.08		1.4		0.2	0.2	7.3
C10	1F	Roof(1)	0.64	4.53			2.9		
		Roof(2)	0.09	6.0			0.6		
		G	0.21		5.75		1.2		
		W(W15)	0.44		1.95	3.0	2.6		
		C	0.08		1.4		0.2	7.5	
	F	C	0.08		1.4		0.2	0.2	7.7
W1	1F	Roof(1)	0.64	4.5			2.9		
		G	0.21		4.5		1.0		
		W(W15)	0.44		1.2	3.0	1.6		
		W(CB15)	0.28		1.2	3.0	1.0	6.5	
	F	WC(B15)	0.28		1.2	3.0	1.0	1.0	7.5
W2	1F	Roof	0.64	6.0			2.9		
		G	0.21		5.5		1.2		
		W(W15)	0.44		1.2	2.0	1.1		
		W(CB15)	0.28		1.2	1.7	0.6	6.8	
	F	W(CB15)	0.28		1.2	1.7	0.6	0.6	7.4
W3 · W4	1F	Roof	0.64	4.97			3.2		
		G	0.21		3.0		0.7		
		W(W15)	0.44		1.35	3.0	1.8		
		W(CB15)	0.28		1.2	2.0	0.7	6.4	
	F	W(CB15)	0.28		1.2	2.0	0.7	0.7	7.1
W5	1F	Roof(2)	0.09	29.64			2.7		
		W(W15)	0.44		2.05	11.0	10.0		
		G	0.21		11.0		2.4		
		WC(B15)	0.28		1.2	11.0	3.7	18.8	
	F	W(CB15)	0.28		1.2	11.0	3.7	3.7	22.5
W6	1F	Roof(1)	0.64	4.25			2.8		
		G	0.21		8.5		1.8		
		W(CB15)	0.28		1.2	8.5	2.9	7.5	
	F	W(CB15)	0.28		1.2	8.5	2.9	2.9	10.4

No.	Floor	Title	Calculation					W (t)	ΣW (t)
			Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)		
W7	1F	Roof(1)	0.64	9.75			6.3		
		W(W15)	0.44		1.5	6.0	4.0		
		G	0.21		6.0		1.3		
		B	0.32		2.5		0.8		
		W(CB15)	0.28		1.2	6.0	2.0	14.4	
	F	W(CB15)	0.28		1.2	6.0	2.0	2.0	16.4
W8	1F	Roof(1)	0.64	17.25			11.1		
		W(W15)	0.44		1.5	6.5	4.3		
		G	0.21		6.5		1.4		
		B	0.32		2.5		0.8		
		W(CB15)	0.28		1.2	6.0	2.0	19.6	
	F	W(CB15)	0.28		1.2	6.0	2.0	2.0	21.6
W9	1F	Roof(1)	0.64	9.5			6.1		
		W(W15)	0.44		1.9	2.0	1.7		
		"	0.44		1.0	4.0	1.8		
		G	0.21		5.0		1.1		
		W(CB15)	0.28		1.2	5.0	1.7	12.4	
	F	W(CB15)	0.28		1.2	5.0	1.7	1.7	14.1
W10	1F	Roof(1)	0.64	7.69			5.0		
		W(W15)	0.44		1.1	5.0	2.5		
		G	0.21		5.0		1.1		
		W(CB15)	0.28		1.2	5.0	1.7	10.3	
	F	W(CB15)	0.28		1.2	5.0	1.7	1.7	12.0
W11	1F	Roof(1)	0.64	4.0			2.6		
		W(W15)	0.44		2.25	2.0	2.0		
		"	0.44		1.45	5.0	3.2		
		G	0.21		7.0		1.5		
		W(CB15)	0.28		1.2	7.0	2.4	11.7	
	F	W(CB15)	0.28		1.2	7.0	2.4	2.4	14.1
W12 · W13	1F	Roof(1)	0.64	2.0			1.3		
		W(W15)	0.44		0.65	2.0	0.6		
		G	0.21		2.0		0.5		
		W(CB15)	0.28		1.2	2.0	0.7	3.1	
	F	W(CB15)	0.28		1.2	2.0	0.7	0.7	3.8
W14	1F	Roof(2)	0.99	85.5			7.7		
		W(W15)	0.44		2.7	15.0	17.9		
		Roof(1)	0.64	12.75			8.2		
		G	0.21		15.0		3.2		
		W(CB15)	0.28		1.2	15.0	5.1	42.1	
	F	W(CB15)	0.28		1.2	15.0	5.1	5.1	47.2

No.	Floor	Title	Calculation: Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)	W (t)	ΣW (t)
W15	1F	Roof(1)	0.64	5.01			3.2		
		W(W15)	0.44		1.8	5.0	4.0		
		G	0.21		5.0		1.1		
		W(CB15)	0.28		1.2	4.0	1.4	9.7	
	F	W(CB15)	0.28		1.2	4.0	1.4	1.4	11.1
W16	1F	Roof(1)	0.64	9.28			6.0		
		W(W15)	0.44		1.8	4.0	3.2		
		G	0.21		4.0		0.9		
		W(CB15)	0.28		1.2	4.0	1.4	11.5	
	F	W(CB15)	0.28		1.2	4.0	1.4	1.4	12.9
W17	1F	Roof(1)	0.64	7.53			4.9		
		W(W15)	0.44		0.8	4.0	1.4		
		G	0.21		4.75		1.0		
		W(CB15)	0.28		1.2	4.0	1.4	8.7	
	F	W(CB15)	0.28		1.2	4.0	1.4	1.4	10.1
W18	1F	Roof(1)	0.64	7.97			5.1		
		W(W15)	0.44		0.8	5.5	2.0		
		G	0.21		5.5		1.2		
		W(CB15)	0.28		1.2	4.5	1.6	9.9	
	F	W(CB15)	0.28		1.2	4.0	1.6	1.6	11.5
W19	1F	Roof(1)	0.64	8.5			5.5		
		W(W15)	0.44		1.0	9.75	4.3		
		G	0.21		9.75		2.1		
		W(CB15)	0.28		1.2	7.0	2.4	14.3	
	F	W(CB15)	0.28		1.2	7.0	2.4	2.4	16.7
W20	1F	Roof(1)	0.64	3.75			2.4		
		W(W15)	0.44		1.0	5.25	2.4		
		G	0.21		5.25		1.1		
		W(CB15)	0.28		1.2	4.5	1.6	7.5	
	F	W(CB15)	0.28		1.2	4.5	1.6	1.6	9.1
W21	1F	Roof(1)	0.64	3.75			2.4		
		W(W15)	0.44		2.1	2.0	1.9		
		G	0.21		2.0		0.5		
		W(CB15)	0.28		1.2	2.0	0.7	5.5	
	F	W(CB15)	0.28		1.2	2.0	0.7	0.7	6.2

3). Design of Girder and Beam

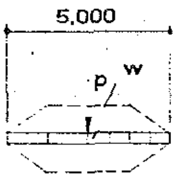


$W = 0.64\ t/m^2 \times 0.95\ m + 0.21\ t/m = 0.82\ t/m$

$C = 1/12 \times 0.82 \times 4.0^2 = 1.10\ t{\cdot}m$
$Mo = 1/8 \times 0.82 \times 4.0^2 = 1.65\ t{\cdot}m$
$Q = 1/2 \times 0.82 \times 4.0 = 1.65\ t$

< G1 >　　B x D = 15 cm x 60 cm　d = 55 cm　j = 48.13 cm

$At = 165\ t{\cdot}cm / 1.8 \times 48.13 = 1.91\ cm^2$　2 - D13
$\varphi = 1650 / 14 \times 48.13 = 2.45\ cm$
$\tau = 1650 / 15 \times 48.13 = 2.3\ kg/cm^2 < 4.25\ kg/cm^2$ O.K

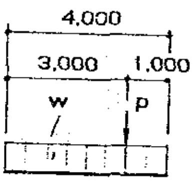


$W = 0.32\ t/m$
$P = 0.64 \times 5.25 \times 2 = 6.72$

$Mo = 1/8 \times 0.32 \times 5.0^2 + 1/4 \times 6.72 \times 5.0 = 9.4\ tm$
$Q = 1/2 \times 0.32 \times 5.0 + 1/2 \times 6.72 = 4.16\ t$

< B1 >　　B x D = 30 x 60　d = 55　j - 48.13

End　$\varphi = 4160 / 14 \times 48.13 = 6.17\ cm^2$　3-D19
$\tau = 4160 / 30 \times 48.13 = 3.46\ kg/cm^2 < 4.25\ kg/cm^2$ O.K
Center　$At = 940 / 1.8 \times 48.13 = 10.85\ cm^2$　5-D19



$W = 0.32\ t/m$
$P = 4.16\ t$

$$Qa = 1/2 \times 0.32 \times 4.0 + \frac{4.16 \times 1.0}{4.0} = 1.68\ t$$
$$Qb = 1/2 \times 0.32 \times 4.0 + \frac{4.16 \times 3.0}{4.0} = 3.76\ t$$
$$M = 1/8 \times 0.32 \times 4.0^2 + 1.04 \times 2.0 = 2.72\ t{\cdot}m$$

< G2 >　　B x D = 25 x 60　d = 55　j = 48.13

End　$\varphi = 3760 / 14 \times 48.13 = 5.58\ cm^2$　2-D16
$\tau = 3760 / 25 \times 48.13 = 3.13\ kg/cm^2 < 4.25$ O.K
Center　$At = 272 / 1.8 \times 48.13 = 2.83\ cm^2$　2-D16

4). Design of Slab

		Lx(m)	Ly(m)	t(cm)	w(t/m2)
D10,D13]	S01	3.0	4.0	15.0	0.660
	S02	3.0	5.0	15.0	0.660
	S03	3.5	4.0	15.0	0.660

		Lx(m)	Ly(m)	t(cm)	w(t/m2)
D10,D13]	S01	3.0	4.0	15.0	0.660

LAMBDA= 1.33 wLx2(t*m)= 5.940 ft(kg/cm2)=2000.0

S1

	ALPHA	M(t*m/m2)	at(cm2/m)	D10	D10&D13	D13	
X-E	-0.063	-0.376	1.79	@39.7	@55.3	@70.9	) D10,13-@200
X-C	0.042	0.251	1.19	@59.5	@82.9	@##.#	
Y-E	-0.042	-0.247	1.29	@55.2	@77.0	@98.8	) D10,13-@200
Y-C	0.028	0.165	0.86	@82.8	@##.#	@##.#	

	Lx(m)	Ly(m)	t(cm)	w(t/m2)
S02	3.0	5.0	15.0	0.660

LAMBDA= 1.67 wLx2(t*m)= 5.940 ft(kg/cm2)=2000.0

S1

	ALPHA	M(t*m/m2)	at(cm2/m)	D10	D10&D13	D13	
X-E	-0.074	-0.438	2.09	@34.0	@47.4	@60.9	) D10,13-@200
X-C	0.049	0.292	1.39	@51.0	@71.2	@91.3	
Y-E	-0.042	-0.247	1.29	@55.2	@77.0	@98.8	) D10,13-@200
Y-C	0.028	0.165	0.86	@82.8	@##.#	@##.#	

	Lx(m)	Ly(m)	t(cm)	w(t/m2)
S03	3.5	4.0	15.0	0.660

LAMBDA= 1.14 wLx2(t*m)= 8.085 ft(kg/cm2)=2000.0

S1

	ALPHA	M(t*m/m2)	at(cm2/m)	D10	D10&D13	D13	
X-E	-0.053	-0.425	2.02	@35.1	@48.9	@62.8	) D10,13-@200
X-C	0.035	0.283	1.35	@52.7	@73.4	@94.2	
Y-E	-0.042	-0.337	1.75	@40.6	@56.6	@72.6	) D10,13-@200
Y-C	0.028	0.225	1.17	@60.9	@84.9	@##.#	

5). Design of Foundation

Allowable bearing capacity fe = 30 t/m^2 (Permanent)

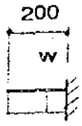
Dead load 2.4 t/m^3 x 0.19 m x 0.75 m = 0.35 t/m
2.0 t/m^3 x (1.0 - 0.91 m) x 0.6 m = 0.98 t/m] 1.33 t/m

W : Wall C : Column

No.	LF (m)	N (t)	P'=N/LF (t/m)	P (t/m)
W1	2.4	7.5	3.13	4.46
W2	2.4	7.4	3.09	4.42
W3 (W4)	2.0	7.1	3.55	4.88
W5	11.0	22.5	2.05	3.38
W6	8.5	10.4	1.23	2.56
W7	6.0	16.4	2.74	4.07
W8	6.6	21.6	3.28	4.61
W9	4.6	14.1	3.07	4.40
W10	4.6	12.0	2.61	3.94
W11	6.6	14.1	2.14	3.47
W12 W13	1.6	3.8	2.38	3.71
W14	15.0	47.2	3.15	4.48
W15	6.0	11.1	1.85	3.18
W16	5.0	12.9	2.58	3.91
W17	4.0	10.1	2.53	3.86
W18	6.5	11.5	1.77	3.10
W19	8.5	16.7	1.97	3.30
W20	4.0	9.1	2.28	3.61
W21	2.0	6.2	3.1	4.43

No.	$L' = \frac{P}{fc}$ (m)	L (t)	$\sigma_c = \frac{P}{L}$ (t/m)	P"(t/m) (P'+0.35)	$\sigma c' = \frac{P''}{L}$
W1	0.15	0.40			
W2	0.15	"			
W3 (W4)	0.17	"	12.2 t/m^2 < 30	3.9	9.75
W5	0.12	"			
W6	0.09	"			
W7	0.14	"			
W8	0.16	"			
W9	0.15	"			
W10	0.14	"			
W11	0.12	"			
W12 W13	0.13	"			
W14	0.15	"			
W15	0.11	"			
W16	0.13	"			
W17	0.13	"			
W18	0.11	"			
W19	0.11	"			
W20	0.12	"			
W21	0.15	0.40			

< F1 >

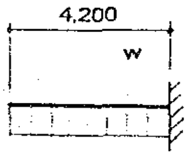


W = 9.75 t/m

[M = 1/2 x 9.75 x 0.2^2 = 0.20 t·m
Q = 9.75 x 0.12 = 1.95 t

D = 18 cm d = 12 cm j = 10.5 cm

At = 20/1.8 x 10.5 = 1.06 cm^2 $x = \frac{0.71 \times 100}{1.06} = 66.9$ cm] D10-@200
φ = 1950/21.0 x 10.5 = 8.85 cm $x = \frac{3.0 \times 100}{8.85} = 33.8$ cm
τ = 1950/100 x 10.5 = 1.9 kg/cm^2 < 4.25 kg/cm^2 O.K



W = 2.74 t/m

[M = 1/12 x 2.74 x 4.2^2 = 4.03 t·m
Q = 1/2 x 2.74 x 4.2 = 5.76 t

<FG1> B x D = 19 x 75 d - 67 j = 58.63

At = 403/1.8 x 58.63 = 3.82 cm^2] 2-D16
φ = 5760/21 x 58.63 = 4.68 cm
τ = 5760/19 x 58.63 = 5.17 > 4.25 NG

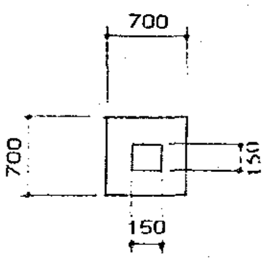
ΔQ = 5.76 - 19 x 58.63 x 4.25 x 10^{-3} = 1.03 t
ΔQ/bj = 0.92 Pw = 0.31

D10 x = 1.43/194 x 0.0031 = 24.2 cm

∴ D10-@150

< F2 >

(C8)



N' = 9.8 t
A = 9.8/28.5 = 0.34 m^2 l x l' = 0.7 m x 0.7 m
N = 9.8 + 2.0 x 0.7 x 0.7 x 0.75 = 10.54 t
σ_c = 10.54 t /0.7 m x 0.7 m = 21.6 t/m^2 < 30.0 t/m^2

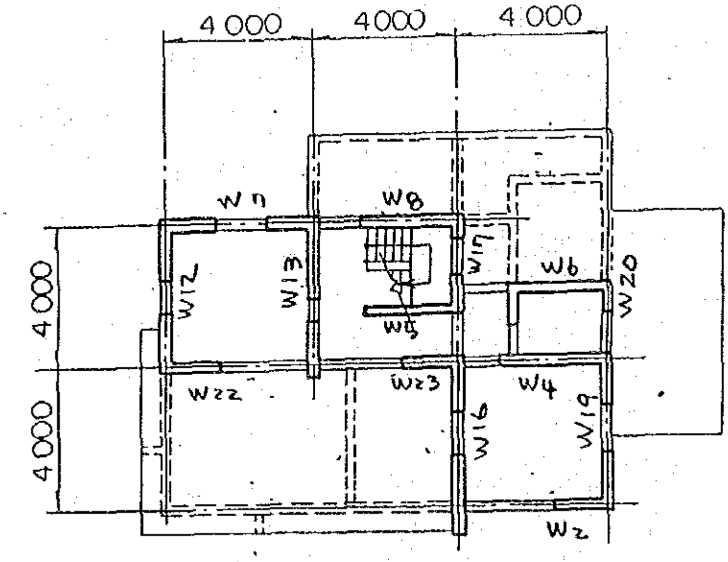
l/a = 4.7
M = 0.37 x 0.15 x 9.8 = 0.55 t·m
Q = 0.39 x 9.8 = 3.83 t

D = 25 cm d = 18 cm j = 15.75 cm

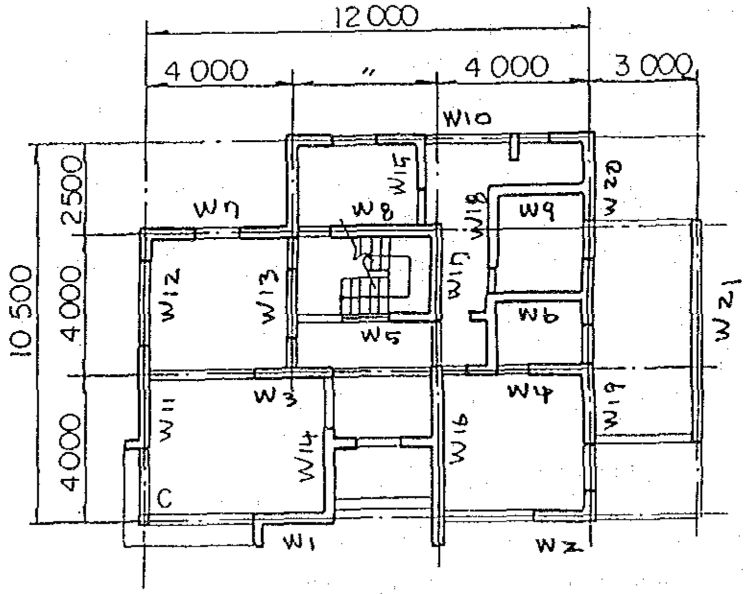
At = 55 / 1.8 x 15.75 = 1.94 cm^2] 4-D10
φ = 3830 / 21 x 15.75 = 11.58 cm
τ = 3830 / 65 x 15.75 = 3.75 kg/cm^2 < 4.25 kg/cm^2 O.K

3.5.3 Residence Type A

Framing Plan



1st FL PLAN



GROUND FL PLAN

1). Assumed Load

A : To floor
B : To frame
C : To seismic
D.L : Dead load
L.L : Live load
T.L : Total load

1-1 Floor Load Table

Title	Material	Thick (cm)	Weight (kg/m²)		D.L (kg/m²)	L.L (kg/m²)	T.L (kg/m²)	Note
Roof	Concrete Water Proofing Cement Mortar Concrete Slab Ceiling	60 15 150 	140 20 30 360 20	A	570	90 (180)	660 (750)	() Balcony
				B		70 (130)	640 (700)	
				C		30 (60)	600 (630)	
1st Floor	Terrazzo Concrete Slab Ceiling	150	80 360 20	A	460	180	640	
				B		130	590	
				C		60	520	
Stair	Terazzo Concrete Slab	250	60 600	A	660	180	840	
				B		130	790	
				C		60	720	

1-2 Dead Load of Girder and Wall

	Title	Size (cm)	Weight (kg/cm²)
	Girder	15 x 60	162 + 42 → 210
		15 x 40	90 + 26 → 120
		15 x 85	252 + 62 → 320
		15 x 45	108 + 30 → 140
		25 x 60	270 + 46 → 320
	Column	15 x 15	54 + 24 → 80
	Wall	W25	360 + 80 → 440
		CB15	200 + 80 → 280

2). Calculation of Axial Force of Columns

G : Girder
W : Wall
C : Column
B : Beam

No.	Floor	Title	Calculation					W (t)	ΣW (t)
			Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)		
C1	1F	Roof	0.70	3.82			2.7		
		W(W15)	0.44		1.05	3.85	1.8		
		G	0.32		2.5		0.8		
		C	0.08		1.4		0.2	5.3	
	F	C	0.08		1.4		0.2		
		W	0.44		1.3	2.5	1.5	1.7	7.0
W1	1F	Roof	0.70	10.14			7.1		
		W(W15)	0.44		1.05	5.0	2.4		
		G	0.32		5.0		1.6		
		W(CB15)	0.28		1.1	2.0	0.7	11.8	
	F	W(CB15)	0.28		1.1	2.0	0.7	0.7	12.5
W2	2F	Roof	0.64	5.71			3.7		
		W(W15)	0.44		0.75	3.28	1.1		
		G	0.21		2.75		0.6		
		W(CB15)	0.28		1.4	1.5	0.6	6.0	
	1F	1st Floor	0.59	3.22			1.9		
		W(CB15)	0.28		1.4	1.5	0.6		
		G	0.21		2.75		0.6		
		W(CB15)	0.28		1.4	1.5	0.6	3.7	9.7
	F	W(CB15)	0.28		1.4	1.5	0.6	0.6	10.3
W3	1F	1st Floor	0.59	5.59			3.4		
		Roof	0.70	7.62			5.4		
		G	0.21		6.5		1.4		
		W(CB15)	0.28		1.4	2.0	0.8	11.0	
	F	W(CB15)	0.28		1.4	2.0	0.8	0.8	11.8
W4	2F	Roof	0.64	5.9			3.8		
		G	0.21		4.0		0.9		
		W(CB15)	0.28		1.4	3.2	1.3	6.0	
	1F	1st Floor	0.59	5.9			3.5		
		W(CB15)	0.28		1.4	3.2	1.3		
		G	0.32		5.5		1.8		
		W(CB15)	0.28		1.4	2.5	1.0	7.6	13.6
	F	W(CB15)	0.28		1.4	2.5	1.0	1.0	14.6
W5	1F	1st Floor	0.59	2.92			1.8		
		G	0.21		3.3		0.7		
		W(W15)	0.44		1.4	2.5	1.6	4.1	
	F	W(W15)	0.44		1.4	2.5	1.6	1.6	5.7

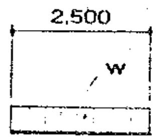
No.	Floor	Title	Calculation					W (t)	ΣW (t)
			Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)		
W6	2F	Roof	0.64	3.82			2.5		
		W(W15)	0.44		4.0		1.8		
		G	0.21		3.25		0.7		
		W(CB15)	0.28		1.4	2.5	1.0	6.0	
	1F	Roof	0.64	1.57			1.0		
		1st Floor	0.59	1.50			0.9		
		G	0.21		2.5		0.6		
		W(CB15)	0.28		2.8	2.5	2.0	4.5	10.5
	F	W(CB15)	0.28		1.4	2.5	1.0	1.0	11.5
W7	2F	Roof	0.64	6.24			4.0		
		W(W15)	0.44		0.75	4.53	1.5		
		G	0.21		4.0		0.9		
		W(CB15)	0.28		1.4	4.0	1.6	8.0	
	1F	1st Floor	0.59	4.0			2.4		
		G	0.21		4.0		0.9		
		W(CB15)	0.28		2.8	4.0	3.2	6.5	14.5
	F	W(CB15)	0.28		1.4	4.0	1.6	1.6	16.1
W8	2F	Roof	0.64	6.24			4.0		
		W(W15)	0.44		0.75	4.53	1.5		
		G	0.21		4.0		0.9		
		W(CB15)	0.28		1.4	4.0	1.6	8.0	
	1F	Roof	0.64	2:82			1.8		
		Stair	0.79	3.44			2.7		
		G	0.21		4.0		0.9		
		W(CB15)	0.28		1.4	4.0	1.6		
		W(W15)	0.44		1.4	3.15	2.0	9.0	17.0
	F	W(W15)	0.44		1.4	3.15	2.0	2.0	19.0
W9	1F	Roof	0.64	3.44			2.2		
		G	0.21		2.5		0.6		
		W(CB15)	0.28		1.4	2.5	1.0	3.8	
	F	W(CB15)	0.28		1.4	2.5	1.0	1.0	4.8
W10	1F	Roof	0.64	5.64			3.6		
		W(W15)	0.44		0.2	8.0	0.7		
		G	0.21		8.0		1.7		
		W(CB15)	0.28		1.4	8.0	3.2	9.2	
	F	W(CB15)	0.28		1.4	8.0	3.2	3.2	12.4
W11	1F	Roof	0.70	5.98			4.2		
		W(W15)	0.44		1.05	3.0	1.4		
		G	0.32		3.0		1.0		
		W(CB15)	0.28		1.4	2.0	0.8	7.4	
	F	W(CB15)	0.28		1.4	2.0	0.8	0.8	8..2

No.	Floor	Title	Calculation					W (t)	ΣW (t)
			Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)		
W12	2F	Roof	0.64	6.38			4.4		
		W(W15)	0.44		0.75	5.05	1.7		
		G	0.21		4.0		0.9		
		W(CB15)	0.28		1.4	4.0	1.6	8.6	
	1F	1st Floor	0.59	4.0			2.4		
		Roof	0.70	0.83			0.6		
		W(W15)	0.44		1.05	1.83	0.9		
		G	0.21		4.0		0.9		
		W(CB15)	0.28		2.8	4.0	3.2	8.0	16.6
	F	W(CB15)	0.28		1.4	4.0	1.6	1.6	18.2
W13	2F	Roof	0.64	8.0			5.2		
		G	0.21		4.0		0.9		
		W(CB15)	0.28		1.4	4.0	1.6	7.7	
	1F	1st Floor	0.59	6.61			3.9		
		Roof	0.64	1.57			1.0		
		W(W15)	0.44		0.2	2.5	0.3		
		G	0.21		7.2		1.6		
		W(CB15)	0.28		1.4	4.0	1.6		
		"	0.28		1.4	4.5	1.8	10.2	17.9
	F	W(CB15)	0.28		1.4	4.5	1.8	1.8	19.7
W14	1F	Roof	0.70	7.75			5.5		
		G	0.21		4.0		0.9		
		W(CB15)	0.28		1.4	2.5	1.0	7.4	
	F	W(CB15)	0.28		1.4	2.5	1.0	1.0	8.4
W15	1F	Roof	0.64	3.13			2.0		
		G	0.21		2.5		0.6		
		W(CB15)	0.28		1.4	2.5	1.0	3.6	
	F	W(CB15)	0.28		1.4	2.5	1.0	1.0	4.6
W16	2F	Roof	0.64	5.82			3.8		
		W(W15)	0.44		0.4	4.9	0.9		
		G	0.21		4.9		1.1		
		W(CB15)	0.28		1.2	4.9	1.7	7.5	
	1F	Roof	0.70	4.99			3.5		
		1st Floor	0.59	4.72			2.8		
		G	0.21		4.9		1.1		
		W(CB15)	0.28		2.4	4.9	3.3	10.7	18.2
	F	W(CB15)	0.28		1.2	4.9	1.7	1.7	19.9

No.	Floor	Title	Calculation					W (t)	ΣW (t)
			Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)		
W17	2F	Roof	0.64	4.94			3.2		
		W(W15)	0.44		2.1	4.0	3.7		
		G	0.21		4.0		0.9		
		W(CB15)	0.28		1.2	2.5	0.9	8.7	
	1F	Roof	0.64	5.41			3.5		
		1st Floor	0.59	3.35			2.0		
		G	0.21		6.5		1.4		
		W(CB15)	0.28		2.4	2.5	1.7	8.6	17.3
	F	W(CB15)	0.28		1.2	2.5	0.9	0.9	18.2
W18	2F	Roof	0.64	1.94			1.3		
		G	0.21		2.0		0.5		
		W(CB15)	0.28		1.2	2.0	0.7	2.5	
	1F	Roof	0.64	5.16			3.3		
		1st Floor	0.59	2.22			1.3		
		G	0.21		5.0		1.1		
		W(CB15)	0.28		1.2	2.0	0.7	8.1	10.6
		W(CB15)	0.28		1.2	5.0	1.7		
	F	W(CB15)	0.28		1.2	5.0	1.7	1.7	12.3
W19	2F	Roof	0.64	6.32			4.1		
		W(W15)	0.44		0.75	4.83	1.6		
		G	0.21		4.0		0.9		
		W(CB15)	0.28		1.2	4.0	1.4	8.0	
	1F	1st Floor	0.59	4.0			2.4		
		Roof	0.64	3.0			2.0		
		G	0.21		4.0		0.9		
		W(CB15)	0.28		2.4	4.0	2.7	8.0	16.0
	F	W(CB15)	0.28		1.2	4.0	1.4	1.4	17.4
W20	2F	Roof	0.64	2.19			1.4		
		W(W15)	0.44		0.75	2.53	0.9		
		G	0.21		2.0		0.5		
		W(CB15)	0.28		1.2	2.0	0.7	3.5	
	1F	1st Floor	0.59	1.0			0.6		
		Roof	0.64	8.75			5.6		
		W(W15)	0.44		0.2	4.5	0.4		
		G	0.21		6.5		1.4		
		W(CB15)	0.28		1.2	2.0	0.7		
		W(CB15)	0.28		1.2	6.5	2.2	10.9	14.4
	F	W(CB15)	0.28		1.2	6.5	2.2	2.2	16.6

No.	Floor	Title	Calculation					W (t)	ΣW (t)
			Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)		
W21	1F	Roof	0.64	9.0			5.8		
		W(W15)	0.44		0.2	9.0	0.8		
		G	0.21		6.0		1.9		
		W(CB15)	0.28		1.2	6.0	2.0	10.5	
	F	W(CB15)	0.28		1.2	6.0	2.0	2.0	12.5
W22	2F	Roof	0.64	6.24			4.0		
		W(W15)	0.44		0.75	4.53	1.5		
		G	0.21		4.0		0.9		
		W(W15)	0.44		0.9	4.0	1.6		
		W(CB15)	0.28		2.4	1.5	1.0	9.0	9.0
W23	2F	Roof	0.64	6.1			3.9		
		W(W15)	0.44		0.75	4.0	1.4		
		G	0.21		4.0		0.9		
		W(W15)	0.44		1.5	4.0	2.7		
		W(CB15)	0.28		2.4	1.5	1.0	9.9	9.9

3). Design of Girder and Beam

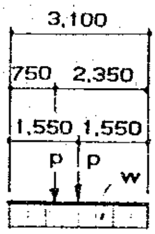


W = 0.21 t/m + 0.64 t/m^2 x 2.88 m^2/2.5 m + 0.64 t/m^2 x 5.25 m + 0.44 t/m^2 x 0.75 m = 1.61 t/m

[C = 1/12 x 1.61 x 2.5^2 = 0.84 t·m
Q = 1/2 x 1.61 x 2.5 = 2.02 t

<G1> B x D = 15 x 60 d = 55 j = 48.13

At = 84/1.8 x 48.13 = 0.97 cm^2
φ = 2020/14 x 48.13 = 3.00 cm
τ = 2020/15 x 48.13 = 2.8 kg/cm^2 < 4.25 kg/cm^2 O.K



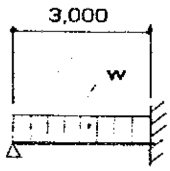
W = 0.32 t/m
P1 = 9.0 t
P2 = 0.59 t/m^2 x 3.59 m^2 + 0.70 t/m^2 x 4.19 m^2 = 5.05 t

$Qa = 1/2 \times 0.32 \times 3.1 + \frac{9.0 \times 2.35}{3.1} + 1/2 \times 5.05 = 9.84$ t
$Qb = 1/2 \times 0.32 \times 3.1 + \frac{9.0 \times 0.75}{3.1} + 1/2 \times 5.05 = 5.20$ t
M = 1/8 x 0.32 x 3.1^2 + 2.18 x 1.55 + 1/4 x 5.05 x 3.1
= 7.68 t·m

< B2B > B x D = 30 x 60 d = 55 j - 48.13

End
φ = 9840/14 x 48.13 = 14.60 3-D19
τ = 9840/30 x 48.13 = 6.81 > 4.25 NG
ΔQ = 9.84 t - 6.14 t = 3.7 t
ΔQ/bj = 3700/30 x 48.13 = 2.6 Pw = 0.50
D13 x = 2.54/30 x 0.0050 = 16.9 cm D13-@150

Center At = 768/1.8 x 48.13 = 8.86 4-D19

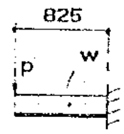


W = 0.32 t/m^2 + 0.70 t/m^2 x 0.525 m + 0.44 t/m^2 x 1.05 m + 0.70 t/m^2 x 1.0 m = 1.85 t/m

[M = 1/8 x 1.85 x 3.0^2 = 2.09 t·m
Q = 5/8 x 1.85 x 3.0 = 3.47 t

< G2 > B x D = 25 x 60 d = 55 j = 48.13

At = 209/1.8 x 48.13 = 2.41 cm^2] 2-D16
φ = 3470/14 x 48.13 = 5.15 cm
τ = 3470 / 25 x 48.13 = 2.88 kg/cm^2) < 4.25 kg/cm^2



W = 0.75 t/m
P = 0.44 x 1.05 = 0.46 t

[M = 1/2 x 0.75 x 0.825^2 + 0.46 x 0.825 = 0.64 t·m
Q = 0.75 x 0.825 + 0.46 = 1.08 t

CS1

D = 15 cm d = 12 cm j = 10.5 cm

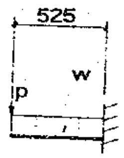
At = 64 t·cm/1.8 x 10.5 = 3.39 cm^2

$$x = \frac{0.99 \times 100}{3.39} = 29.2\text{cm}$$

φ = 1080/21.0 x 10.5 = 7.35 cm

$$x = \frac{3.5 \times 100}{7.35} = 47.6\text{cm}$$

∴D10 & 13-@200



W = 0.66 t/m
P = 0.44 x 0.75 = 0.33 t

CS2

[M = 1/2 x 0.66 x 0.525^2 + 0.33 x 0.525 = 0.27 t·m
Q = 0.66 x 0.525 + 0.33 = 0.68 t

D = 15 cm d = 12 cm j = 10.5 cm

At = 27/1.8 x 10.5 = 1.43 cm^2

$$x = \frac{0.71 \times 100}{1.43} = 49.6\text{cm}$$

φ = 680/21.0 x 10.5 = 4.63 cm

$$x = \frac{3.0 \times 100}{4.63} = 64.7\text{ cm}$$

∴D10-@200

4). Design of Slab

		Lx(m)	Ly(m)	t(Cm)	w(t/m2)
D10,D13]	S01	4.0	4.0	15.0	0.660
	S02	4.0	5.0	15.0	0.750
	S03	4.0	4.0	15.0	0.640

		Lx(m)	Ly(m)	t(Cm)	w(t/m2)
D10,D13]	S01	4.0	4.0	15.0	0.660

LAMBDA= 1.00 wLx2(t*m)= 10.560 ft(Kg/Cm2)=2000.0

S1

	ALPHA	M(t*m/m2)	at(Cm2/m)	D10	D10&D13	D13	
X-E	-0.042	-0.440	2.10	@33.9	@47.3	@60.6	) D10.13-@200
X-C	0.028	0.293	1.40	@50.8	@70.9	@90.9	
Y-E	-0.042	-0.440	2.29	@31.1	@43.3	@55.6	) D10.13-@200
Y-C	0.028	0.293	1.52	@46.6	@65.0	@83.3	

	Lx(m)	Ly(m)	t(Cm)	w(t/m2)
S02	4.0	5.0	15.0	0.750

LAMBDA= 1.25 wLx2(t*m)= 12.000 ft(Kg/Cm2)=2000.0

S1

	ALPHA	M(t*m/m2)	at(Cm2/m)	D10	D10&D13	D13	
X-E	-0.059	-0.709	3.38	@21.0	@29.3	@37.6	) D10.13-@200
X-C	0.039	0.473	2.25	@31.5	@44.0	@56.4	
Y-E	-0.042	-0.500	2.60	@27.3	@38.1	@48.9	) D10.13-@200
Y-C	0.028	0.333	1.73	@41.0	@57.2	@73.3	

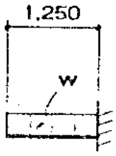
	Lx(m)	Ly(m)	t(Cm)	w(t/m2)
S03	4.0	4.0	15.0	0.640

LAMBDA= 1.00 wLx2(t*m)= 10.240 ft(Kg/Cm2)=2000.0

S1

	ALPHA	M(t*m/m2)	at(Cm2/m)	D10	D10&D13	D13	
X-E	-0.042	-0.427	2.03	@34.9	@48.7	@62.5	) D10.13-@200
X-C	0.028	0.284	1.35	@52.4	@73.1	@93.8	
Y-E	-0.042	-0.427	2.22	@32.0	@44.7	@57.3	) D10.13-@200
Y-C	0.028	0.284	1.48	@48.0	@67.0	@85.9	

5). Design of Stair



$W = 0.84\ t/m^2 \times 0.25\ m = 0.21\ t/m$

$$\left[\begin{array}{lll} M & = & 1/2 \times 0.21 \times 1.25^2 = 0.17\ t\cdot m \\ Q & = & 0.21 \times 1.25 = 0.27\ t \end{array}\right.$$

$D = 25\ cm \quad d = 20\ cm \quad j = 17.5\ cm$

$$\left.\begin{array}{lll} At & = & \frac{17}{1.8 \times 17.5} = 0.54\ cm^2 \\ \varphi & = & \frac{270}{21.0 \times 17.5} = 0.74\ cm \end{array}\right] \text{1-D13}$$

6). Design of Foundation

Allowable bearing capacity fe = 30 t/m^2 (Permanent)

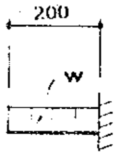
Dead load 2.4 t/m^3 x 0.19 m x 0.75 m = 0.35 t/m
2.0 t/m^3 x (1.0 - 0.19 m) x 0.6 m = 0.98 t/m] 1.33 t/m

W : Wall C : Column

No.	LF (m)	N (t)	P'=N/LF (t/m)	P (t/m)	No.	LF (m)	N (t)	P'=N/LF (t/m)	P (t/m)
W1	3.5	12.5	3.58	4.91	C1	2.5	7.0	2.8	4.13
W2	2.75	10.3	3.75	5.08					
W3	5.0	11.8	2.36	3.69					
W4	5.5	14.6	2.66	3.99					
W5	3.6	5.7	1.59	2.92					
W6	2.1	11.5	5.48	6.81					
W7	3.6	16.1	4.47	5.80					
W8	3.6	19.0	5.28	6.61					
W9	2.1	4.8	2.29	3.62					
W10	7.6	12.4	1.63	2.96					
W11+ W12+ W22	7.10	8.2+18.2 +9.0= 35.4	5.06	6.39					
W13	5.7	19.7	3.46	4.79					
W14	3.6	8.4	2.34	3.67					
W15	2.1	4.6	2.19	3.52					
W16+ W23	4.0	19.9+9.9 =29.8	7.45	8.78					
W17	3.6	18.2	5.06	6.39					
W18	4.6	12.3	2.68	4.01					
W19	4.0	17.4	4.35	5.68					
W20	5.6	16.6	2.97	4.30					
W21	5.5	12.5	2.28	3.61					

No.	$L'=\frac{P}{fe}$ (m)	L (t)	$\sigma_c=\frac{P}{L}$ (t/m)	P"(t/m) (P+0.35)	$\sigma_c'=\frac{P"}{L}$
W1	0.17	0.40			
W2	0.17	"			
W3	0.13	"			
W4	0.14	"			
W5	0.10	"			
W6	0.23	"			
W7	0.20	"			
W8	0.22	"			
W9	0.12	"			
W10	0.10	"			
W11+W12+ W22	0.22	"			
W13	0.16	"			
W14	0.13	"			
W15	0.12	"			
W16+W23	0.30	"	21.95 t/m^2 < 30 t/m^2	7.80	19.5
W17	0.22	"			
W18	0.14	"			
W19	0.19	"			
W20	0.14	"			
W21	0.12				
C1	0.14	0.40			

<F1A>



W = 19.5

$$\begin{cases} M = 1/2 \times 19.5 \times 0.2^2 = 0.39\ t\cdot m \\ Q = 19.5 \times 0.2 = 3.9\ t/m \end{cases}$$

D = 18 cm d = 12 cm j = 10.5 cm

At = 39/11.8 x 10.5 = 2.06 cm^2

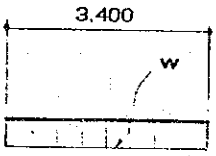
$$x = \frac{0.71\times100}{2.06} = 34.4\ cm$$

φ = 3900/21 x 10.5 = 17.69 cm

$$x = \frac{3.0\times100}{17.69} = 16.95$$

∴D10-@150

τ = 3900/100 x 10.5 = 3.7 kg/cm^2 < 4.25 kg/cm^2



W = 3.58

$$\begin{cases} M = 1/12 \times 3.58 \times 3.4^2 = 3.45\ t\cdot m \\ Q = 1/2 \times 3.58 \times 3.4 = 6.09\ t \end{cases}$$

<FG1>

B x D = 19 x 75 d - 67 j = 58.63

At = 345/1.8 x 58.63 = 3.27 cm^2

φ = 6090/21 x 58.63 = 4.95 cm

τ = 6090/19 x 58.63 = 5.47 kg/cm^2 > 4.25 kg/cm^2 NG

ΔQ = 6.09 t - 19 x 58.63 x 4.25 x 10^{-3} = 1.36 t

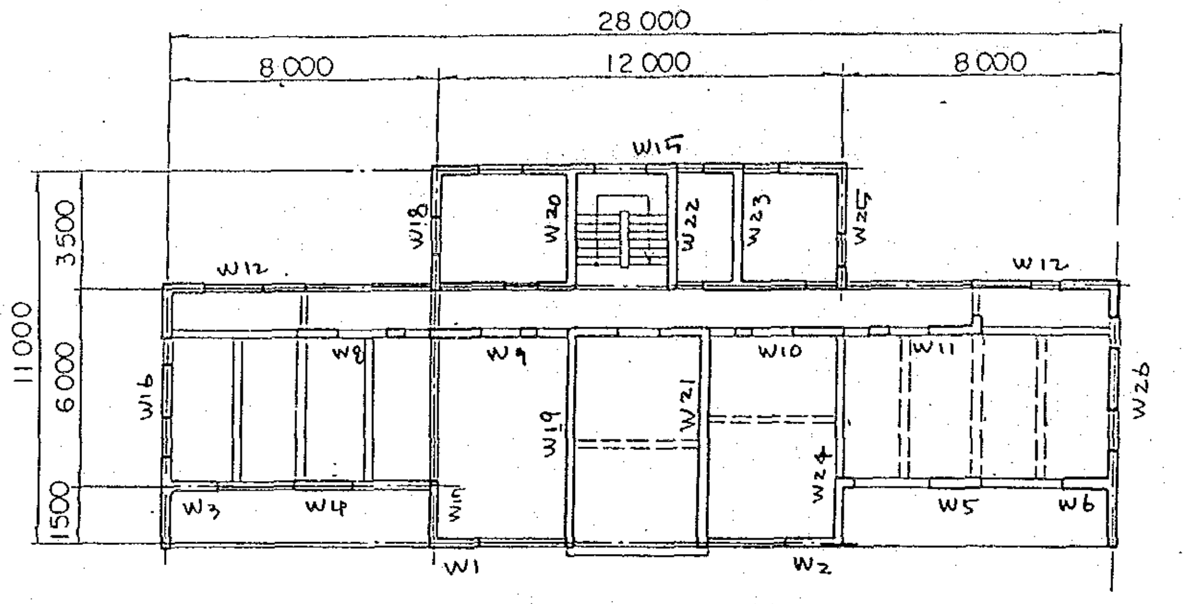
ΔQ/bj = 1.3 Pw = 0.35

D10 x = 1.43/19 x 0.0035 = 21.5 cm

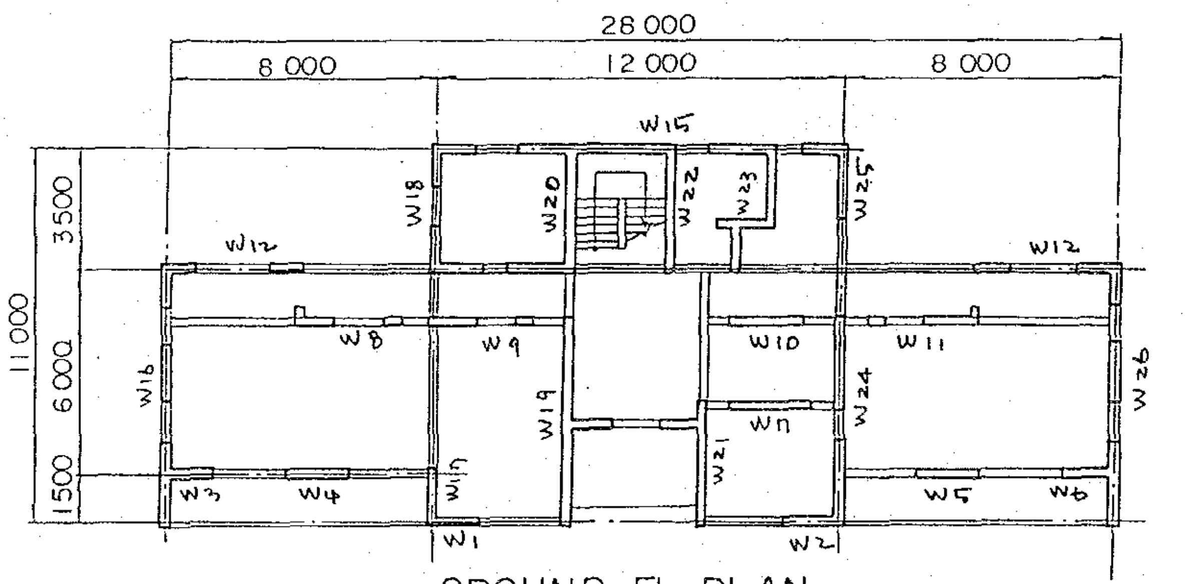
∴ D10-@150

3.5.4 Engineer's Office

Framing Plan



1st FL PLAN



GROUND FL PLAN

1). Assumed Load

A : To floor
B : To frame
C : To seismic
D.L : Dead load
L.L : Live load
T.L : Total load

1-1 Floor Load Table

Title	Material	Thick (cm)	Weight (kg/m^2)		D.L (kg/m^2)	L.L (kg/m^2)	T.L (kg/m^2)	Note
Roof	Concrete Water Proofing Cement Mortar Concrete Slab Ceiling	60 15 150	140 20 30 360 20	A	570	90	660	
				B		70	640	
				C		30	600	
1st Floor	Terrazzo Concrete Slab Ceiling	150	80 360 20	A	460	300	760	
				B		180	640	
				C		80	540	
Stair	Terazzo Concrete Slab	250	60 600	A	660	300	960	
				B		180	960	
				C		180	840	

1-2 Dead Load of Girder and Wall

	Title	Size (cm)	Weight (kg/cm^2)
	Girder	15 x 60	162 + 42 → 210
		15 x 40	90 + 26 → 120
		15 x 85	252 + 62 → 320
		15 x 45	108 + 30 → 140
		25 x 60	270 + 46 → 320
	Beam	30 x 60	324 + 48 → 370
	Column	15 x 15	54 + 24 → 80
	Wall	W25	360 + 80 → 440
		CB15	200 + 80 → 280

2). Calculation of Axial Force of Columns

G : Girder
W : Wall
C : Column
B : Beam

No.	Floor	Title	Calculation: Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)	W (t)	ΣW (t)
W1	2F	Roof	0.64	3.22			2.1		
		W(W15)	0.44		0.9	2.75	1.1		
		G	0.32		2.75		0.9		
		W(CB15)	0.28		1.2	1.5	0.5	4.6	
	1F	W(CB15)	0.28		0.9	1.25	0.4		
		1st Floor	0.64	3.22			2.1		
		G	0.32		2.75		0.9		
		W(CB15)	0.28		2.4	1.5	1.0	4.4	9.0
	F	W(CB15)	0.28		1.2	1.5	0.5		
		"	0.28		0.9	1.25	0.4	0.9	9.9
W2	2F	Roof	0.64	3.22			2.1		
		W(W15)	0.44		0.6	2.75	0.8		
		G	0.32		2.75		0.9		
		W(CB15)	0.28		1.2	1.5	0.5	4.3	
	1F	W(CB15)	0.28		0.9	1.25	0.4		
		1st Floor	0.64	3.94			2.6		
		G	0.32		2.75		0.9		
		W(CB15)	0.28		2.4	1.5	1.0	4.9	9.2
	F	W(CB15)	0.28		1.2	1.5	0.5		
		"	0.28		0.9	1.25	0.4	0.9	10.1
W3 · W6	2F	W(W15)	0.44		0.9	2.75	1.1		
		Roof	0.64	6.4			4.1		
		G	0.32		2.75		0.9		
		W(CB15)	0.28		1.2	1.5	0.5	6.6	
	1F	W(W15)	0.44		1.2	1.25	0.7		
		1st Floor	0.64	6.4			4.1		
		G	0.32		2.75		0.9		
		W(CB15)	0.28		2.4	1.5	1.0	6.7	13.3
	F	W(CB15)	0.28		1.2	1.5	0.5	0.5	13.8
W4 · W5	2F	W(W15)	0.44		0.9	4.0	1.6		
		Roof	0.64	13.72			8.8		
		G	0.32		4.0		1.3		
		B	0.37		4.5		1.7		
		W(CB15)	0.28		1.2	1.5	0.5	13.9	
	1F	W(W15)	0.44		1.2	4.0	2.2		
		1st Floor	0.64	13.72			8.8		
		G	0.32		4.0		1.3		
		B	0.37		4.5		1.7		
		W(CB15)	0.28		2.4	1.5	1.0	15.0	28.9
	F	W(CB15)	0.28		1.2	1.5	0.5	0.5	29.4

No.	Floor	Title	Calculation					W (t)	ΣW (t)
			Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)		
W7	1F	1st Floor	0.64	6.98			4.5		
		G	0.32		3.1		1.0		
		W(CB15)	0.28		1.2	2.1	0.7	6.2	
	F	W(CB15)	0.28		1.2	2.1	0.7	0.7	6.9
W8	2F	Roof	0.64	14.72			9.5		
		G	0.32		6.0		2.0		
		B	0.37		6.75		2.5		
		W(CB15)	0.28		1.2	2.4	0.8	14.8	
	1F	1st Floor	0.64	14.72			9.5		
		G	0.32		6.0		2.0		
		B	0.37		6.75		2.5		
		W(CB15)	0.28		2.4	2.4	1.6	15.6	30.4
	F	W(CB15)	0.28		1.2	2.4	0.8	0.8	31.2
W9	2F	Roof	0.64	11.28			7.3		
		G	0.32		7.0		2.3		
		W(CB15)	0.28		1.2	2.0	0.7	10.3	
	1F	1st Floor	0.64	11.28			7.3		
		G	0.32		7.0		2.3		
		W(CB15)	0.28		2.4	2.0	1.4	11.0	21.3
	F	W(CB15)	0.28		1.2	2.0	0.7	0.7	22.0
W10	2F	Roof	0.64	8.94			5.8		
		G	0.32		7.0		2.3		
		W(CB15)	0.28		1.2	2.0	0.7	8.8	
	1F	1st Floor	0.64	6.44			4.2		
		G	0.32		4.0		1.3		
		W(CB15)	0.28		1.2	2.0	0.7		
		"	0.28		1.2	2.2	0.8	7.0	15.8
	F	W(CB15)	0.28		1.2	2.2	0.8	0.8	16.6
W11	2F	Roof	0.64	16.5			10.6		
		G	0.32		6.0		2.0		
		B	0.37		6.38		2.4		
		W(CB15)	0.28		1.2	2.4	0.8	15.8	
	1F	1st Floor	0.64	16.5			10.6		
		G	0.32		6.0		2.0		
		B	0.37		6.38		2.4		
		W(CB15)	0.28		2.4	2.4	1.6	16.6	32.4
	F	W(CB15)	0.28		1.2	2.4	0.8	0.8	33.2

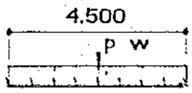
No.	Floor	Title	Calculation					W (t)	ΣW (t)
			Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)		
W12	2F	Roof	0.64	4.22			2.7		
		W(W15)	0.44		0.6	6.0	1.6		
		G	0.21		6.0		1.3		
		W(CB15)	0.28		1.2	1.7	0.6	6.2	
	1F	W(W15)	0.44		0.9	2.0	0.8		
		W(CB15)	0.28		0.9	2.4	0.6		
		1st Floor	0.64	4.22			2.7		
		G	0.21		6.0		1.3		
		W(CB15)	0.28		2.4	1.7	1.2	6.6	12.8
	F	W(W15)	0.44		0.9	2.0	0.8		
		W(CB15)	0.28		0.9	2.4	0.6		
		"	0.28		1.2	1.7	0.6	2.0	14.8
W13	2F	Roof	0.64	9.57			6.2		
		W(W15)	0.44		0.6	2.0	0.6		
		G	0.21		7.5		1.6		
		W(CB15)	0.28		1.2	3.2	1.1	9.5	
	1F	W(W15)	0.44		0.9	2.0	0.8		
		1st Floor	0.64	9.57			6.2		
		G	0.21		7.5		1.6		
		W(CB15)	0.28		2.4	3.2	2.2	10.8	20.3
	F	W(W15)	0.44		0.9	2.0	0.8		
		W(CB15)	0.28		1.2	3.2	1.1	1.9	22.2
W14	2F	Roof	0.64	9.63			6.2		
		W(W15)	0.44		0.6	2.0	0.6		
		G	0.21		8.5		1.8		
		W(CB15)	0.28		1.2	3.2	1.1	9.7	
	1F	W(W15)	0.44		0.9	2.0	0.8		
		1st Floor	0.64	9.63			6.2		
		G	0.21		8.5		1.8		
		W(CB15)	0.28		2.4	3.2	2.2	11.0	20.7
	F	W(W15)	0.44		0.9	2.0	0.8		
		W(CB15)	0.28		1.2	3.2	1.1	1.9	22.6
W15	2F	W(W15)	0.44		0.6	12.0	3.2		
		Roof	0.64	9.44			6.1		
		G	0.21		12.0		2.6		
		W(CB15)	0.28		1.2	12.0	4.1	16.0	
	1F	1st Floor	0.64	9.44			6.1		
		G	0.21		12.0		2.6		
		W(CB15)	0.28		2.4	12.0	8.2	16.9	32.9
	F	W(CB15)	0.28		1.2	12.0	4.1	4.1	37.0

No.	Floor	Title	Calculation: Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)	W (t)	ΣW (t)
W16	2F	W(W15)	0.44		0.6	9.0	5.4		
		Roof	0.64	5.19			3.4		
		G	0.32		7.5		2.4		
		W(CB15)	0.28		1.2	6.5	2.2	13.4	
	1F	W(W15)	0.44		0.9	1.5	0.6		
		1st Floor	0.64	5.19			3.4		
		G	0.32		7.5		2.4		
		W(CB15)	0.28		2.4	6.5	4.4	10.8	24.2
	F	W(CB15)	0.28		1.2	6.5	2.2	2.2	26.4
W17	2F	W(W15)	0.44		0.6	5.0	1.4		
		Roof	0.64	9.85			6.3		
		G	0.32		5.0		1.6		
		W(CB15)	0.28		1.2	1.5	0.5	9.8	
	1F	W(W15)	0.44		0.9	1.25	0.5		
		1st Floor	0.64	9.85			6.3		
		G	0.32		5.0		1.6		
		W(CB15)	0.28		2.4	1.5	1.0	9.4	19.2
	F	W(CB15)	0.28		1.2	1.5	0.5	0.5	19.7
W18	2F	W(W15)	0.44		0.6	3.5	1.0		
		Roof	0.64	3.06			2.0		
		G	0.32		3.5		0.8		
		W(CB15)	0.28		1.2	3.5	1.2	5.0	
	1F	1st Floor	0.64	3.06			2.0		
		G	0.21		3.5		0.8		
		W(CB15)	0.28		2.4	3.5	2.4	5.2	10.2
	F	W(CB15)	0.28		1.2	3.5	1.2	1.2	11.4
W19	2F	W(W15)	0.44		0.6	3.25	0.9		
		Roof	0.64	18.78			12.0		
		G	0.32		9.25	6.0	3.0		
		W(CB15)	0.28		1.2		2.0	17.9	
	1F	W(CB15)	0.28		0.9	3.25	0.9		
		1st Floor	0.64	20.58			13.2		
		G	0.32		9.25		3.0		
		W(CB15)	0.28		2.4	6.0	4.0	22.6	40.5
		W(W15)	0.44		1.2	2.9	1.5		
	F	W(CB15)	0.28		1.2	6.0	2.0		
		W(CB15)	0.28		0.9	1.25	0.4	2.4	42.9

No.	Floor	Title	Calculation					W (t)	ΣW (t)
			Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)		
	2F	Roof	0.64	7.19			4.6		
		G	0.21		3.5		0.8		
		W(W15)	0.44		1.2	3.5	1.9	7.3	
W20	1F	1st Floor	0.64	3.06			2.0		
		Stair	0.84	4.13			3.5		
		G	0.21		3.5		0.8		
		W(W15)	0.44		2.4	3.5	3.8	10.1	17.4
	F	W(W15)	0.44		1.2	3.5	1.9	1.9	19.3
	2F	Roof	0.64	18.78			12.0		
		W(W15)	0.44		0.6	3.25	0.9		
		G	0.32		9.25		3.0		
		W(CB15)	0.28		1.2	6.0	2.0	17.9	
	1F	W(CB15)	0.28		0.9	1.25	0.4		
W21		1st Floor	0.64	17.4			11.2		
		G	0.32		9.7		3.1		
		W(CB15)	0.28		1.2	6.0	2.0		
		W(W15)	0.44		1.2	2.9	1.5	19.5	37.4
		W(CB15)	0.28		1.2	3.75	1.3		
	F	W(CB15)	0.28		1.2	3.75	1.3		
		"	0.28		0.9	1.25	0.4	1.7	39.1
	2F	Roof	0.64	6.63			4.3		
		G	0.21		3.5		0.8		
		W(CB15)	0.28		1.2	3.5	1.2	6.3	
W22	1F	1st Floor	0.64	2.5			1.6		
		Stair	0.84	4.13			3.5		
		G	0.21		3.5		0.8		
		W(CB15)	0.28		1.2	3.5	1.2		
		W(W15)	0.44		1.2	3.5	1.9	9.0	15.3
	F	W(W15)	0.44		1.2	3.5	1.9	1.9	17.2
	2F	Roof	0.64	5.5			3.6		
		G	0.21		3.5		0.8		
		W(CB15)	0.28		1.2	3.5	1.2	5.6	
W23	1F	1st Floor	0.64	5.5			3.6		
		G	0.21		3.5		0.8		
		W(CB15)	0.28		1.2	3.5	1.2		
		"	0.28		1.2	5.0	1.7	7.3	12.9
	F	W(CB15)	0.28		1.2	5.0	1.7	1.7	14.6

No.	Floor	Title	Calculation					W (t)	ΣW (t)
			Load (t/m^2 & t·m)	Area (m^2)	Length (m)	Length (m)	W' (t)		
W24	2F	W(W15)	0.44		0.6	3.75	1.0		
		Roof	0.64	7.72			5.0		
		G	0.32		5.0		1.6		
		W(CB15)	0.28		1.2	1.6	0.6	8.2	
	1F	1st Floor	0.64	9.04			5.8		
		G	0.32		8.15		2.6		
		W(CB15)	0.28		1.2	1.6	0.6		
		"	0.28		1.2	5.0	1.7	10.7	18.9
	F	W(CB15)	0.28		1.2	5.0	1.7	1.7	20.6
W25	2F	W(W15)	0.44		0.6	3.5	1.0		
		Roof	0.64	3.0			2.0		
		G	0.21		3.5		0.8		
		W(CB15)	0.28		1.2	3.5	1.2	5.0	
	1F	1st Floor	0.64	3.0			2.0		
		G	0.21		3.5		0.8		
		W(CB15)	0.28		2.4	3.5	2.4	5.2	10.2
	F	W(CB15)	0.28		1.2	3.5	1.2	1.2	11.4
W26	2F	W(W15)	0.44		0.6	9.0	2.4		
		Roof	0.64	9.16			5.9		
		G	0.32		9.5		3.1		
		B	0.37		1.13		0.5		
		W(CB15)	0.28		1.2	7.5	2.6	14.5	
	1F	W(W15)	0.44		0.9	1.5	0.6		
		1st Floor	0.64	9.16			5.9		
		G	0.32		9.5		3.1		
		B	0.37		1.13		0.5		
		W(CB15)	0.28		2.4	7.5	5.2	15.3	29.8
	F	W(CB15)	0.28		1.2	7.5	2.6	2.6	32.4

3). **Design of Girder and Beam**



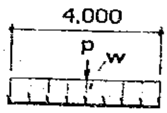
W = 0.37 t/m
P = 0.64 x 3.5 x 2 = 4.48 t

Mo = 1/8 x 0.37 x 4.5^2 x 1/4 x 4.48 x 4.5 = 5.98 t·m
Q = 1/2 x 0.37 x 4.5 + 1/2 x 4.48 = 3.08 t

<B1> B x D = 30 cm x 60 cm d = 55 cm j = 48.13 cm

End φ = 3080/14 x 48.13 = 4.57 cm 3-D19
τ = 3080/30 x 48.13 = 2.14 kg/cm² <4.25kg/cm² O.K.

Center At = 598/1.8 x 48.13 = 6.91 cm² 5-D19



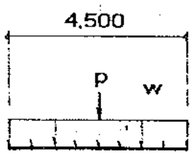
W = 0.32 + 0.64 x 0.75 = 0.80 t/m
P = 3.08 t

Mo = 1/8 x 0.80 x 4.0^2 + 1/4 x 3.08 x 4.0 = 4.68 t·m
Q = 1/2 x 0.80 x 4.0 + 1/2 x 3.08 = 3.14t

<G2A> B x D = 25 cm x 60 cm d = 55 cm j = 48.13 cm

End φ = 3140/14 x 48.13 = 4.66 cm 3-D16
τ = 3140/25 x 48.13 = 2.6 kg/cm² <4.25 kg/cm² O.K.

Center At = 468/1.8 x 48.13 = 5,140 cm² 3-D16



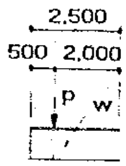
W = 0.32 t/m
P = 0.64 t/m² x 10.37 m² = 6.64 t

C = 1/12 x 0.32 x 4.5^2 + 1/8 x 6.64 x 4.5 = 4.28 t·m
Mo = 1/8 x 0.32 x 4.5^2 + 1/4 x 6.64 x 4.5 = 8.28 t·m
Q = 1/2 x 0.32 x 4.5 + 1/2 x 6.64 = 4.04 t

<G2A> B x D = 25 cm x 60 cm d = 55 cm j = 48.13 cm

End φ = 4040/14 x 48.13 = 6.0 cm 3-D16
τ = 4040/25 x 48.13 = 3.4 kg/cm² <4.25 kg/cm² O.K.
At = 428/1.8 x 48.13 = 4.94

Center M = 8.28 - 4.28 = 4.0 t·m
At = 400/1.8 x 48.13 = 4.62 3-D16



$W = 0.32 \text{ t/m} + 0.64 \text{ t/m}^2 \times 1.5 \text{ m} + 0.44 \text{ t/m}^2 \times 1.2 \text{ m}$
$= 1.81 \text{ t/m}$
$P = 3.08 \text{ t}$

$Qa = 1/2 \times 1.81 \times 2.5 + \dfrac{3.08 \times 2.0}{2.5} = 4.73 \text{ t}$

$Qb = 1/2 \times 1.81 \times 2.5 + \dfrac{3.08 \times 0.5}{2.5} = 2.88 \text{ t}$

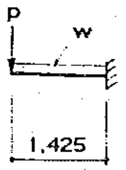
$M = 1/8 \times 1.81 \times 2.5^2 + 0.62 \times 1.25 = 2.19 \text{ t·m}$

<G2> B x D = 25 x 60 cm d = 55 cm j = 48.13 cm

End $\varphi = 4730/14 \times 48.13 = 7.02 \text{ cm}$ 2-D16

$\tau = 4730/25 \times 48.13 = 3.93 \text{ kg/cm}^2 < 4.25 \text{ kg/cm}^2$ O.K.

Center $At = 219/1.8 \times 48.13 = 2.53 \text{ cm}^2$ 2-D16



$W = 0.76 \text{ t/m}^2$
$P = 0.44 \text{ t/m}^2 \times 1.2 = 0.528 \text{ t/m}$

$M = 1/2 \times 176 \times 1.425^2 + 0.528 \times 1.425 = 1.524 \text{ t·m}$

$Q = 0.76 \times 1.425 + 0.528 = 1.611 \text{ t}$

CS3 D = 15 cm d = 12 cm j = 10.5 cm

$At = 152.4/1.8 \times 10.5 = 8.06 \text{ cm}^2$

D13 $x = \dfrac{1.27 \times 100}{8.06} = 15.7 \text{ cm}$

$\varphi = 1611/14 \times 10.5 = 10.96 \text{ cm}$

$x = \dfrac{4.0 \times 100}{10.96} = 36.14 \text{ cm}$

∴ D13 - @ 150

4). **Design of Slab**

```
              Lx(m)   Ly(m)   t(cm)   w(t/m2)
D10,D13 ] S01   3.5     4.0    15.0    0.660
          S02   4.0     6.0    15.0    0.660
          S03   3.5     4.0    15.0    0.760
          S04   4.0     6.0    15.0    0.760
```

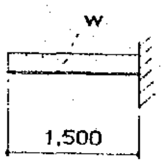
```
              Lx(m)   Ly(m)   t(cm)   w(t/m2)
D10,D13 ] S01   3.5     4.0    15.0    0.660
             LAMBDA= 1.14   wLx2(t*m)=   8.085   ft(kg/cm2)=2000.0
        S1
              ALPHA  M(t*m/m2) at(cm2/m)   D10    D10&D13   D13
          X-E  -0.053  -0.425     2.02    @35.1   @48.9   @62.8 ) D10,13-@200
          X-C   0.035   0.283     1.35    @52.7   @73.4   @94.2
          Y-E  -0.042  -0.337     1.75    @40.6   @56.6   @72.6 ) D10,13-@200
          Y-C   0.028   0.225     1.17    @60.9   @84.9   @##.#

              Lx(m)   Ly(m)   t(cm)   w(t/m2)
          S02   4.0     6.0    15.0    0.660
             LAMBDA= 1.50   wLx2(t*m)=  10.560   ft(kg/cm2)=2000.0
        S1
              ALPHA  M(t*m/m2) at(cm2/m)   D10    D10&D13   D13
          X-E  -0.070  -0.735     3.50    @20.3   @28.3   @36.3 ) D10,13-@200
          X-C   0.046   0.490     2.33    @30.4   @42.4   @54.4
          Y-E  -0.042  -0.440     2.29    @31.1   @43.3   @55.6 ) D10,13-@200
          Y-C   0.028   0.293     1.52    @46.6   @65.0   @83.3

              Lx(m)   Ly(m)   t(cm)   w(t/m2)
          S03   3.5     4.0    15.0    0.760
             LAMBDA= 1.14   wLx2(t*m)=   9.310   ft(kg/cm2)=2000.0
        S1
              ALPHA  M(t*m/m2) at(cm2/m)   D10    D10&D13   D13
          X-E  -0.053  -0.489     2.33    @30.5   @42.5   @54.5 ) D10,13-@200
          X-C   0.035   0.326     1.55    @45.7   @63.8   @81.8
          Y-E  -0.042  -0.388     2.02    @35.2   @49.1   @63.0 ) D10,13-@200
          Y-C   0.028   0.259     1.34    @52.8   @73.7   @94.5

              Lx(m)   Ly(m)   t(cm)   w(t/m2)
          S04   4.0     6.0    15.0    0.760
             LAMBDA= 1.50   wLx2(t*m)=  12.160   ft(kg/cm2)=2000.0
        S1
              ALPHA  M(t*m/m2) at(cm2/m)   D10    D10&D13   D13
          X-E  -0.070  -0.846     4.03    @17.6   @24.6   @31.5 ) D10,13-@200
          X-C   0.046   0.564     2.69    @26.4   @36.9   @47.3
          Y-E  -0.042  -0.507     2.63    @27.0   @37.6   @48.3 ) D10,13-@200
          Y-C   0.028   0.338     1.75    @40.5   @56.4   @72.4
```

5). **Design of Stair**



$W = 0.96\ t/m^2 \times 0.25\ m = 0.24\ t/m$
$M = 1/2 \times 0.24 \times 1.5^2 = 0.27\ t{\cdot}m$
$Q = 0.24 \times 1.5 = 0.36\ t$

D = 25 cm   d = 20 cm   j = 17.5 cm

$$At = \frac{27}{1.8 \times 17.5} = 0.86\ cm^2$$

$$\varphi = \frac{360}{21 \times 17.5} = 0.98\ cm \qquad \text{1-D13}$$

6). **Design of Foundation**

Allowable bearing capacity   fe = 30 t/m2 (Permanent)

Dead load   2.4 t/m3 x 0.19 m x 0.75 m = 0.35 t/m
2.0 t/m3 x (1.0 - 0.19) m x 0.6 m = 0.98 t/m   1.33 t/m

W: wall   C: column

NO	LF (m)	N (t)	P'=N/LF (t/m)	P (t/m)	NO	LF (m)	N (t)	P'=N/LF (t/m)	P (t/m)
W1	3.6	9.9	2.75	4.08	W21	4.75	39.1	8.23	9.56
W2	3.6	10.1	2.81	4.14	W22	3.5	17.2	4.92	6.25
W3•W6	2.55	13.8	5.42	6.75	W23	4.0	14.6	3.65	4.98
W4•W5	5.2	28.9	5.56	6.89	W24	6.0	20.6	3.44	4.77
W7	3.6	6.9	1.92	3.25	W25	3.5	11.4	3.26	4.59
W8	4.0	31.2	7.80	9.13	W26	6.0	32.4	5.4	6.73
W9	3.8	22.0	5.79	7.12					
W10	3.6	16.6	4.61	5.94					
W11	4.0	33.2	8.3	9.63					
W12	4.0	14.8	3.7	5.03					
W13	3.6	22.2	6.17	7.50					
W14	4.6	22.6	4.92	6.25					
W15	11.6	37.0	3.19	4.52					
W16	7.5	26.4	3.52	4.85					
W17	3.75	19.7	5.25	6.58					
W18	3.5	11.4	3.26	4.59					
W19	7.5	42.9	5.72	7.05					
W20	3.5	19.3	5.52	6.85					

NO	$L' = \frac{P}{fe}$ (m)	L (m)	$\sigma_c = \frac{P}{L}$	P" (t/m) (P + 0.35)	$\sigma_c' = \frac{P"}{L}$
W1	0.14	0.40			
W2	0.14	"			
W3•W6	0.23	"			
W4•W5	0.29	"			
W7	0.11	"			
W8	0.31	"			
W9	0.24	"			
W10	0.20	"			
W11	0.32	"	24.08 t/m2 <30 t/m2	8.65	21.63
W12	0.11	"			
W13	0.25	"			
W14	0.21	"			
W15	0.15	"			
W16	0.17	"			
W17	0.22	"			
W18	0.16	"			
W19	0.24	"			
W20	0.23	"			
W21	0.32	"			
W22	0.21	"			
W23	0.17	"			
W24	0.16	"			
W25	0.16	"			
W26	0.23	"			

<F1A>

W = 21.63

M = 1/2 x 21.63 x 0.2^2 = 0.44 t·m

Q = 21.63 x 0.2 = 4.33 t

D = 18 cm d = 12 cm j = 10.5 cm

At = 44/1.8 x 10.5 = 2.33 cm^2

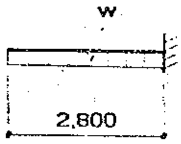
$$D10 \quad x = \frac{0.71 \times 100}{2.33} = 30.4\ cm^2$$

$\varphi = 4330/21 \times 10.5 = 19.64cm$

$$x = \frac{3.0 \times 100}{19.64} = 15.2\ cm$$

D10 - @150

$\tau = 4330/100 \times 10.5 = 4.12\ kg/cm^2 < 4.25\ kg/cm^2$ O.K.



$W = 5.56\ t/m$

$M = 1/12 \times 5.56 \times 2.8^2 = 3.63\ t\cdot m$

$Q = 1/2 \times 5.56 \times 2.8 = 7.78\ t$

<FG1A> B x D = 19 cm x 75 cm d = 67 cm j = 58.63 cm

$At = 373/1.8 \times 58.63 = 3.44\ cm^2$

$\varphi = 7780/21 \times 58.63 = 6.32cm$ 2-D16

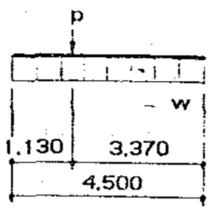
$\tau = 7780/19 \times 58.63 = 6.98\ kg/cm^2 > 4.25\ kg/cm^2$ NG

$\Delta Q = 7.78 - 19 \times 58.63 \times 4.25 \times 10^{-3} = 3.05\ t$

$\Delta Q/bj = 2.8$ PW = 0.50

D10 $x = 1.43/19 \times 0.005 = 15.1cm^2$

∴D10 - @150



$P = 5.25 \times 2.25 = 11.82\ t$

$Qa = 11.82 \times 3.37/4.5 = 8.85\ t$

$Qb = 11.82 \times 1.13/4.5 = 2.97\ t$

$$Ca = \frac{11.82 \times 3.37^2 \times 1.13}{4.5^2} = 7.49\ t\cdot m$$

$$Cb = \frac{11.82 \times 3.37 \times 1.13^2}{4.52} = 2.52\ t\cdot m$$

$Mo = 2.97 \times 2.25 = 6.69\ t\cdot m$

<FG1A> B x D = 25 cm x 75 cm d = 67 cm j = 58.6 cm

$At = 749/1.8 \times 58.63 = 7.10\ cm^2$

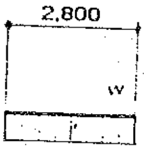
$\varphi = 8850/21 \times 58.63 = 7.19\ cm$ 4-D16

$\tau = 8850/25 \times 58.63 = 6.04\ kg/cm^2 > 4.25\ kg/cm^2$ NG

$\Delta Q = 8.85 - 25 \times 58.63 \times 4.25 \times 10^{-3} = 2.62\ t$

$\Delta Q/bj = 1.8$ PW = 0.40 %

D10 $x = 1.43/25 \times 0.0040 = 14.3\ cm$ ∴D10 - @100



W = 3.7 t/m

M = 1/12 x 3.7 x 2.8^2 = 2.42 t·m
Q = 1/2 x 3.7 x 2.8 = 5.18 t

B x D = 19 cm x 75 cm d = 67 cm j = 58.63 cm

At = 242/1.8 x 58.63 = 2.29 cm^2
φ = 5180/21.0 x 58.63 = 4.21 cm 2-D16

τ = 5180/19 x 58.63 = 4.65 kg/cm^2 >4.25 kg/cm^2 NG
ΔQ = 5.18 - 19 x 58.63 x 4.25 x 10^{-3} = 0.45t
ΔQ/bj = 0.4 PW = 0.25 %
D10 x = 1.43/19 x 0.0025 = 30.1 cm ∴D10 - @150

Table 1.1.1 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 1.1.2 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 1.1.3 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 1.1.4 RESULTS OF STRUCTURAL ANALYSES FOR DIVERSION TUNNEL

Item		Type I	Type II	
			U/S	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 1.1.5(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 1.1.5(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 1.1.5(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 1.1.5(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 1.1.6(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 (kg/cm2)
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 1.1.6(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
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 1.1.6(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 1.1.7(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·m)

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 1.1.7(2) STRUCTURAL ANALYSIS OF INLET PORTAL (SECTION A-A)

NOTES: x 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)	x					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)	x					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)	x	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)						266.0	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	x					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)	x					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						63.3	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)	x					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)	x					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	x					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)	x	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 1.1.8(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 1.1.8(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	38.4	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	26.4	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)						265.6	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	265.6	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 1.1.9(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 1.1.9(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 1.1.10 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	46.1	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						39.6	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	13.0
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 1.1.11 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 1.1.12 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 1.1.13 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 1.1.14 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 $\alpha_i \leq \phi = 25°$)

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

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

Table 1.1.15 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 $(\theta_{i+1}\alpha_i)$	$\overline{T}_i$ (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 $\alpha_i \leqq \phi = 25°$)

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

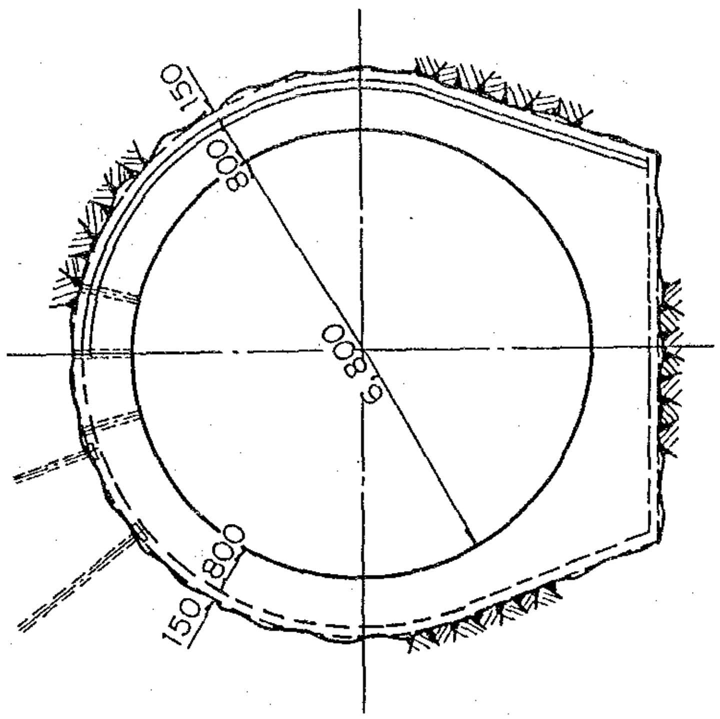
$\overline{T}_{i+1}$ = $\overline{T}_i \cdot \text{COS}(\theta_i - \alpha_i) / \text{COS}(\theta_{i+1} - \alpha_i)$

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

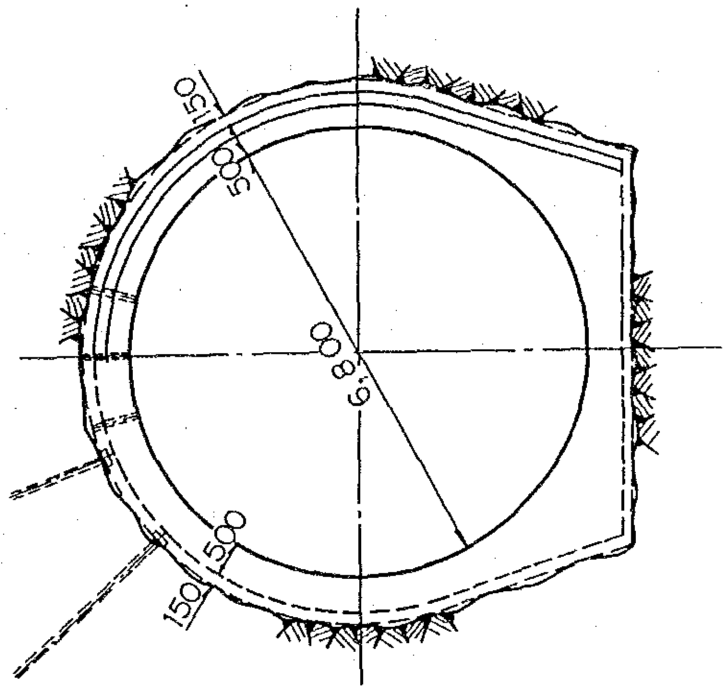
$\overline{T}_i$ = $\overline{T}_i \cdot (A_i / \overline{F}_i)\text{max}$

Tmax = 50.98 (ton)

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



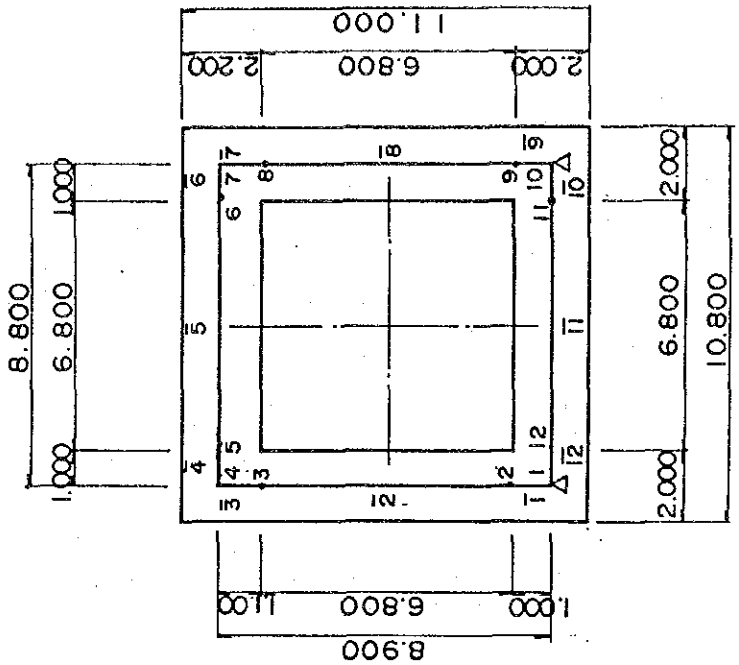
TYPE — II



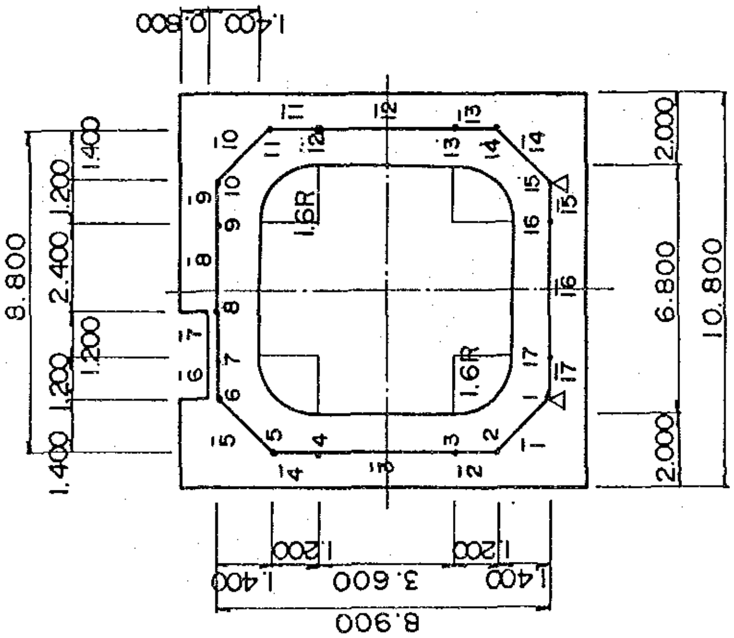
TYPE — I

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

Fig. 1.1.2



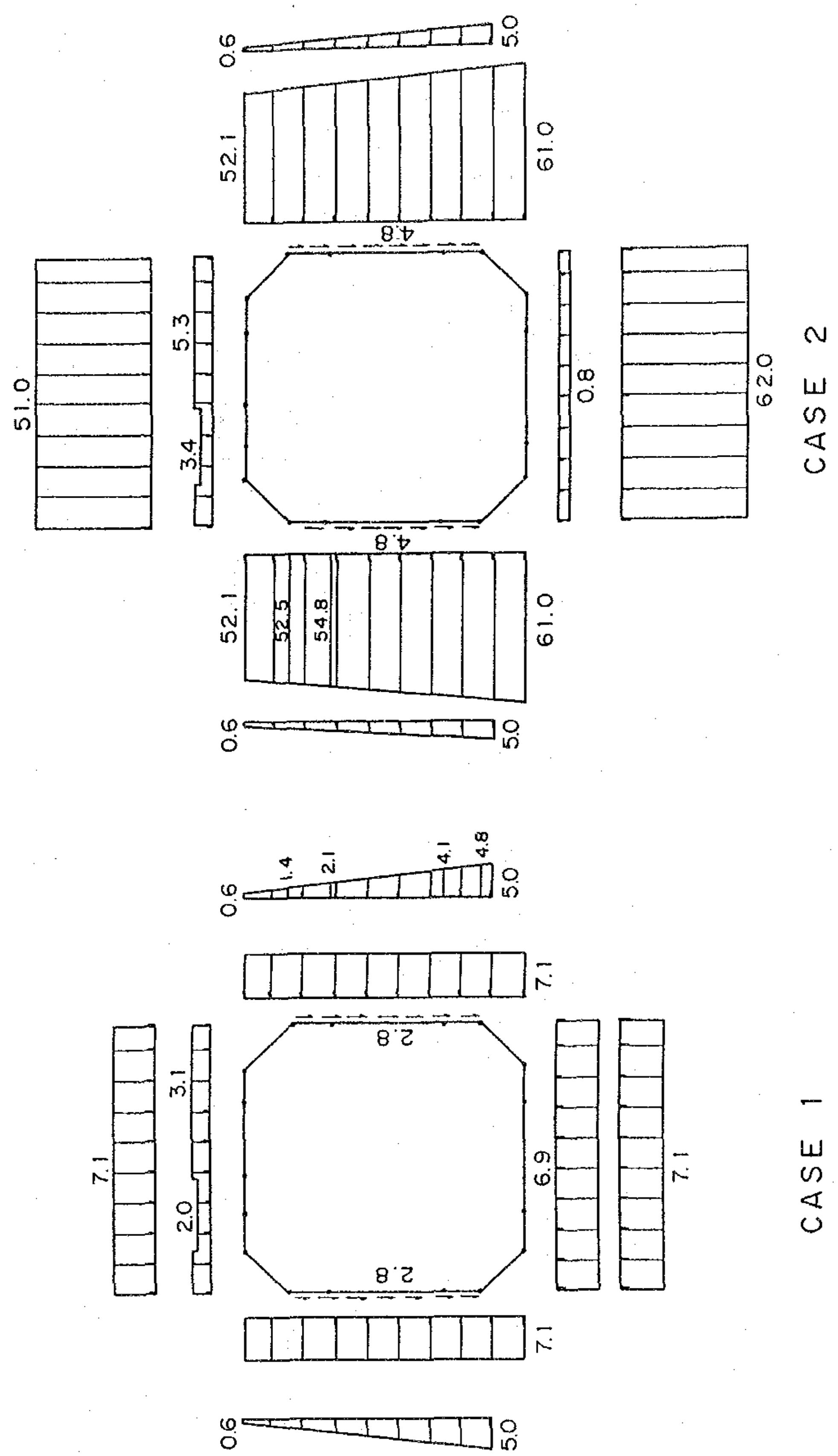
SECTION B - B



SECTION A - A

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

Fig. 1.1.3

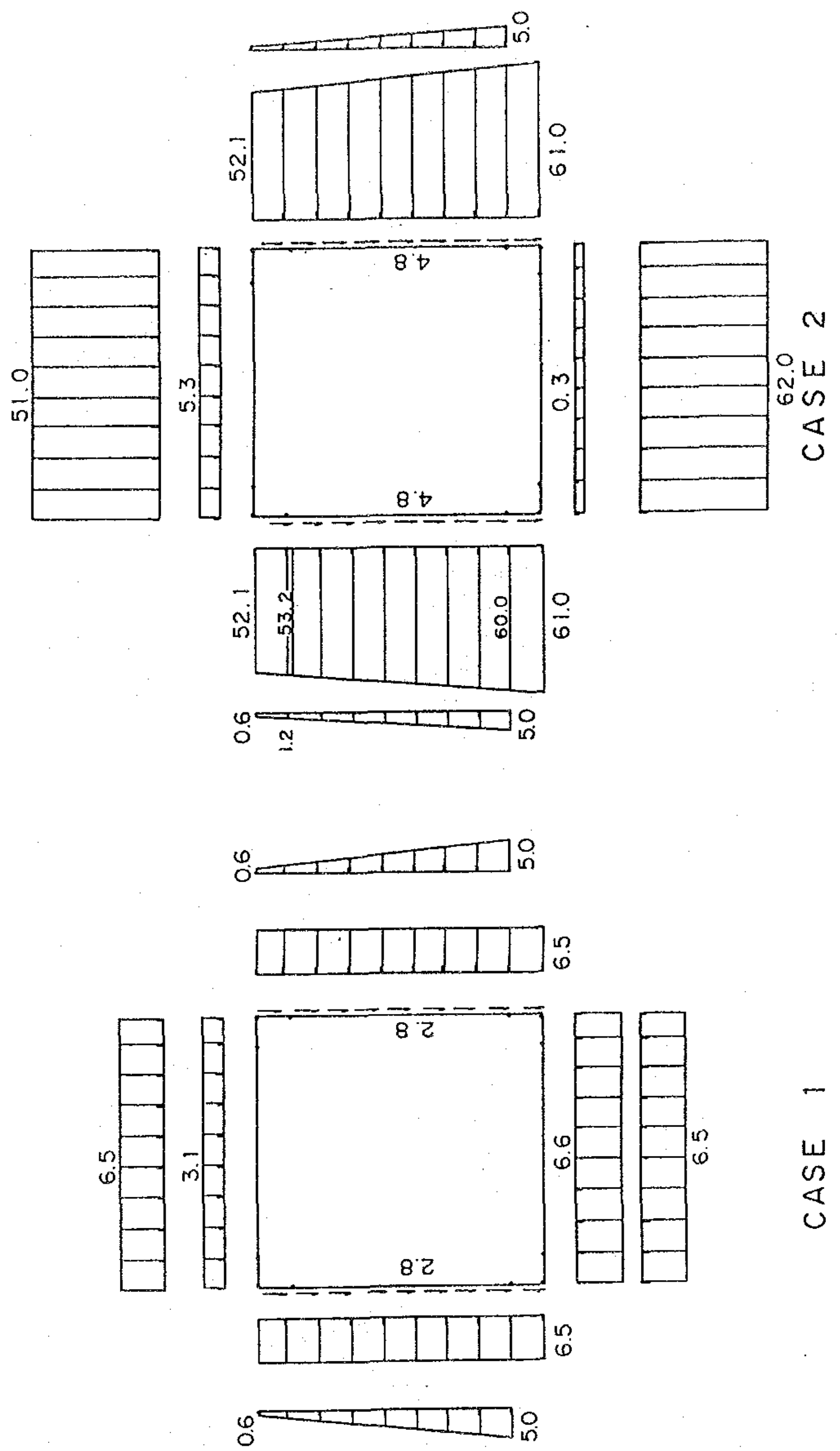


Loading diagram of inlet portal (section A-A)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 1.1.4(1)

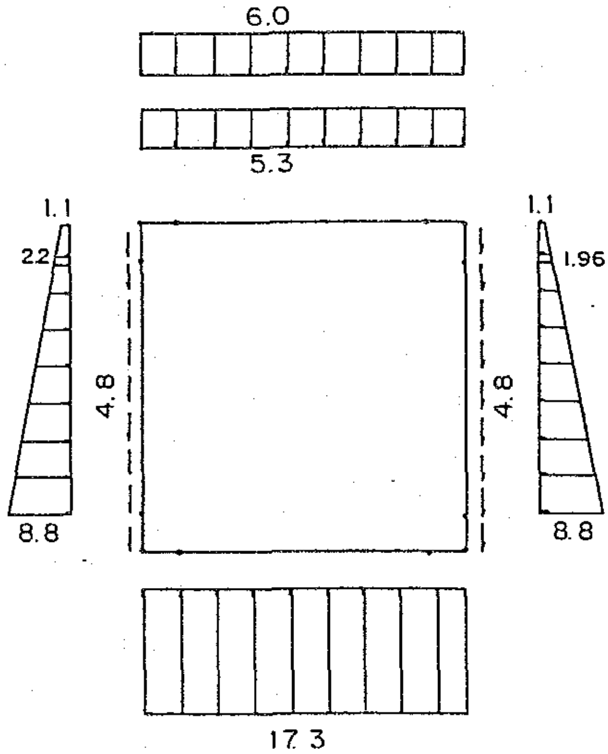


Loading diagram of inlet portal (section B-B)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 1.1.4(2)



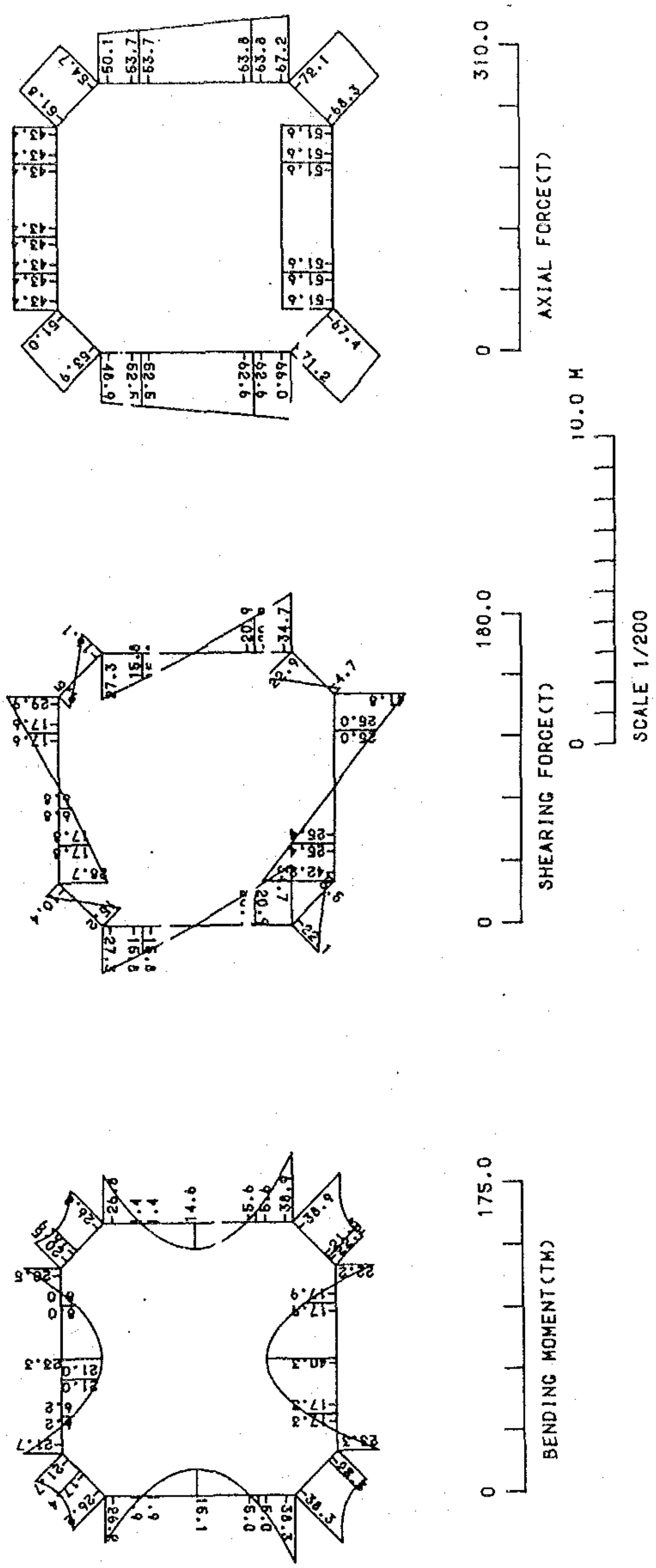
CASE 3

Loading diagram of inlet portal (section B-B)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 1.1.5

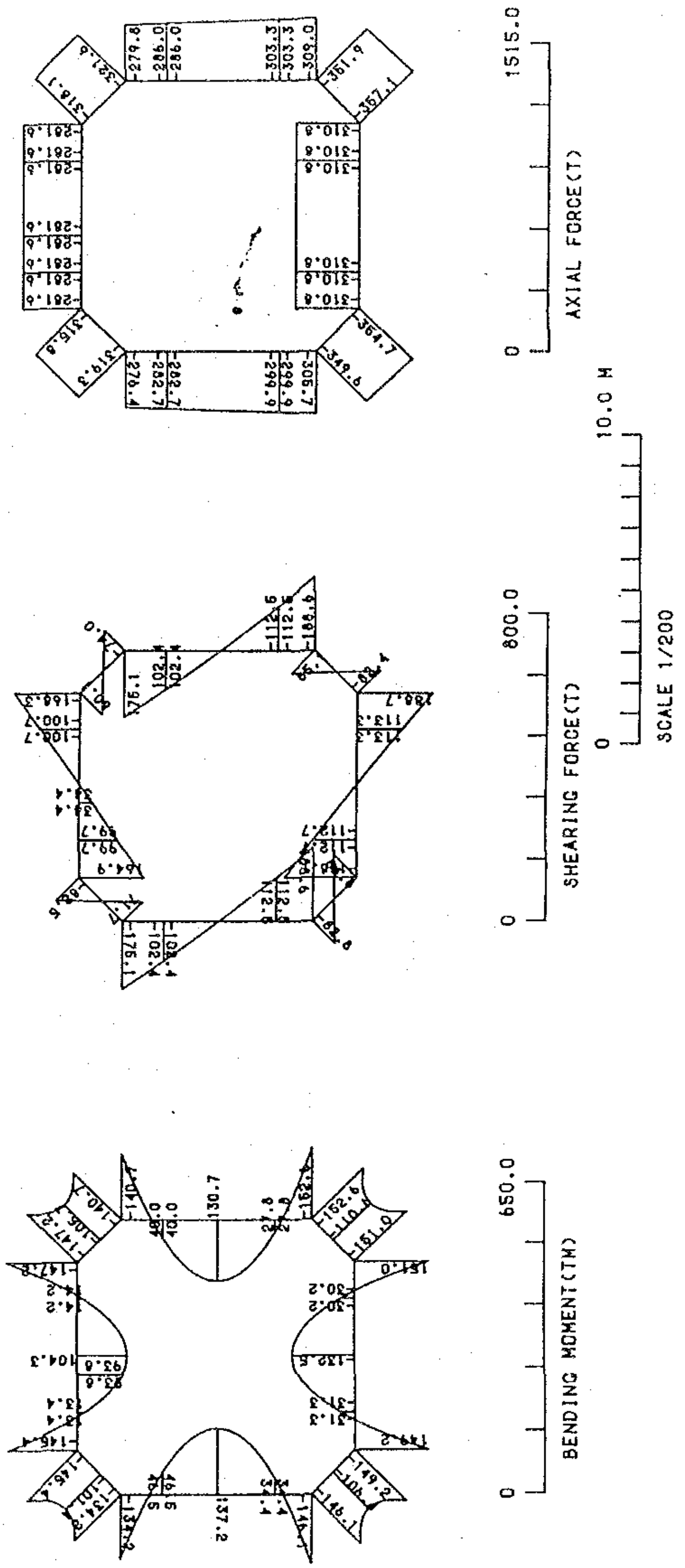


Bending moment shearing and axial force diagram
inlet portal section A-A (case -1)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 1.1.6

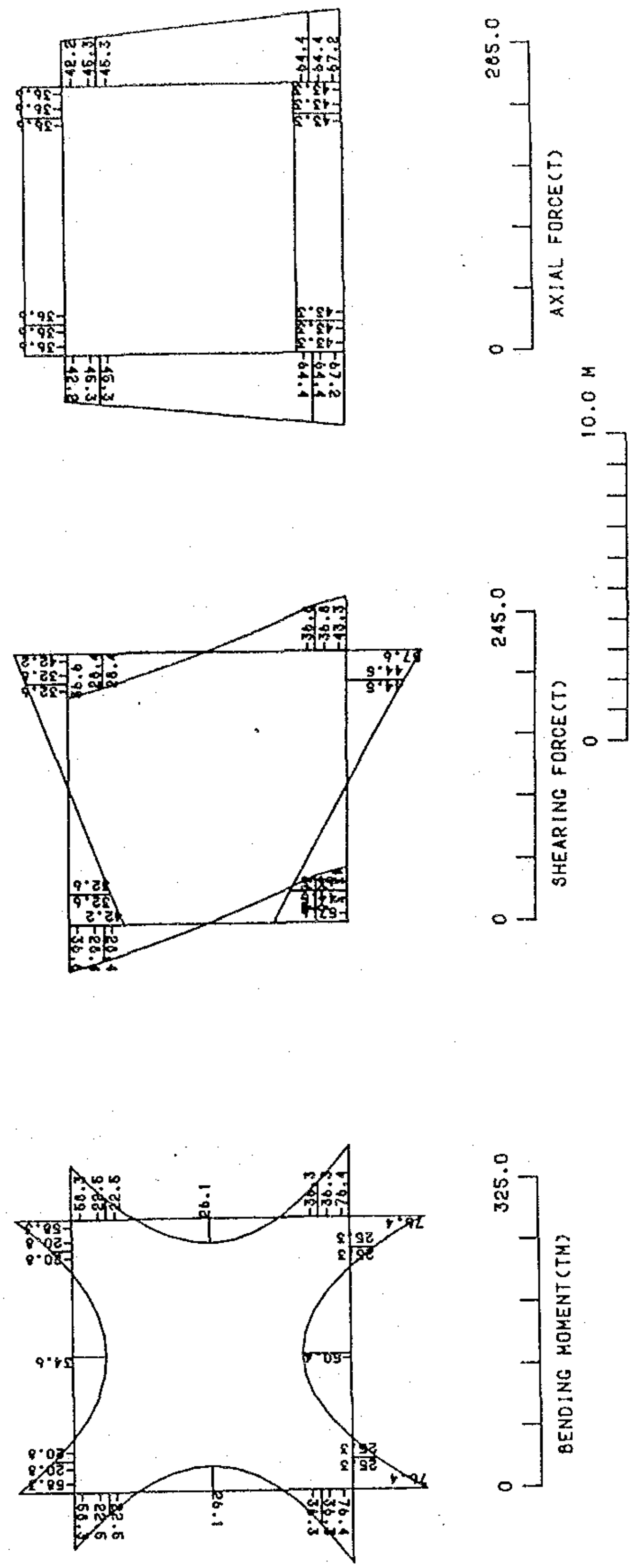


Bending moment shearing and axial force diagram
inlet portal section A-A (case -2)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

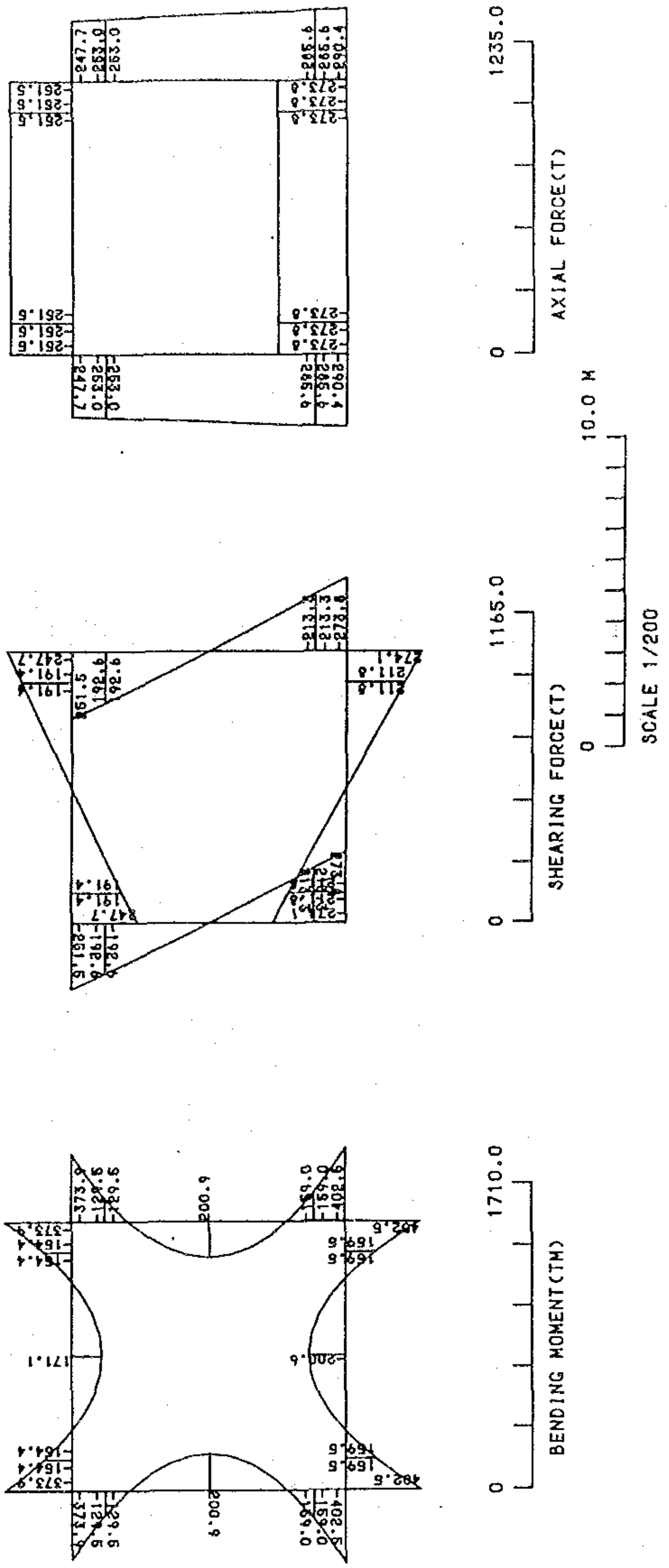
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 1.1.7



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. 1.1.8

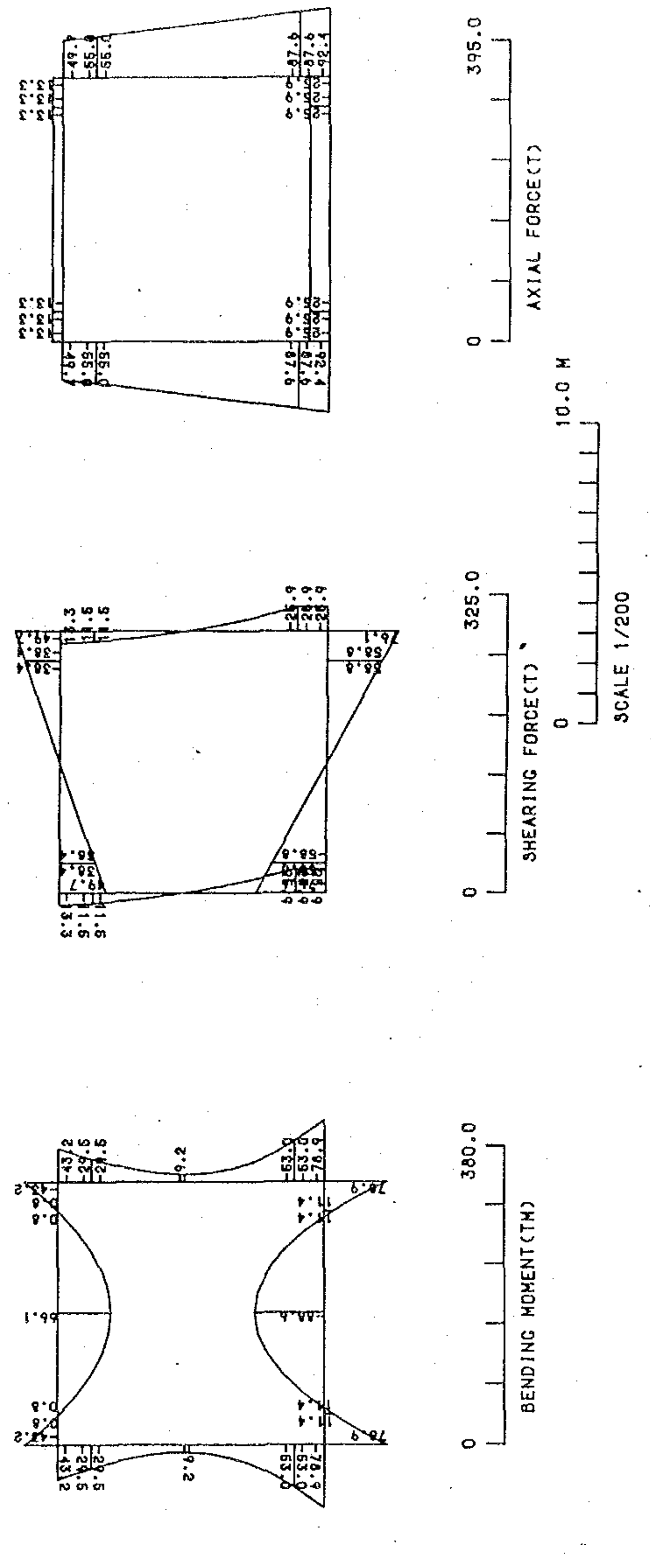


Bending moment shearing and axial force diagram
inlet portal section B-B (case -2)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 1.1.9

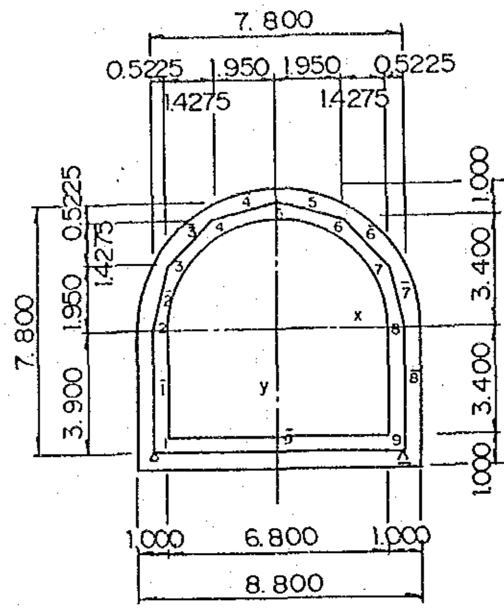


Bending moment shearing and axial force diagram inlet portal section B-B (case -3)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

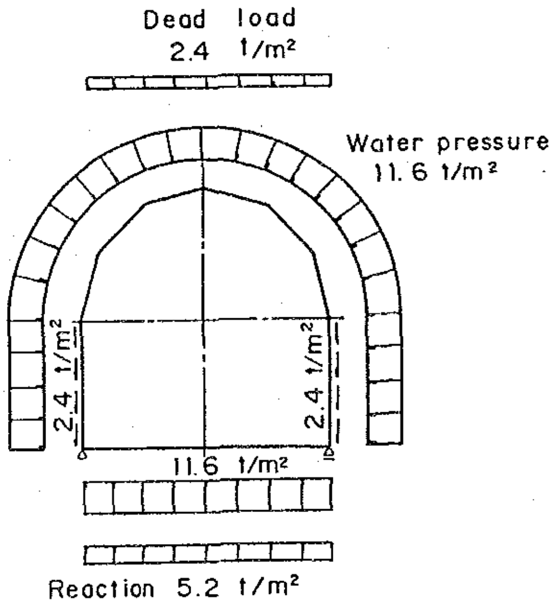
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 1.1.10

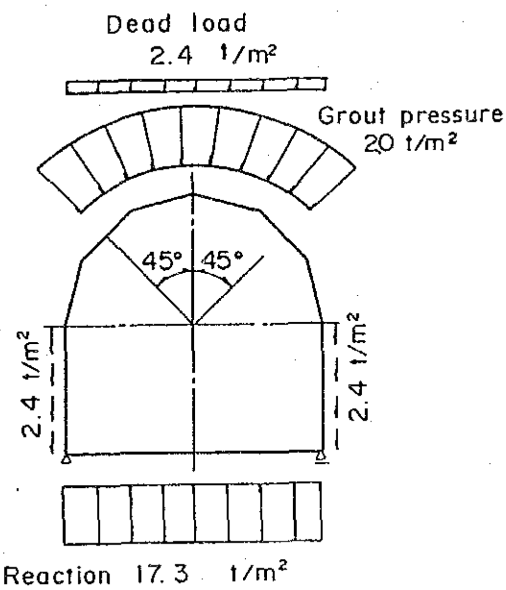


A = 1.0 m^2
I = 0.0833 m^2

	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



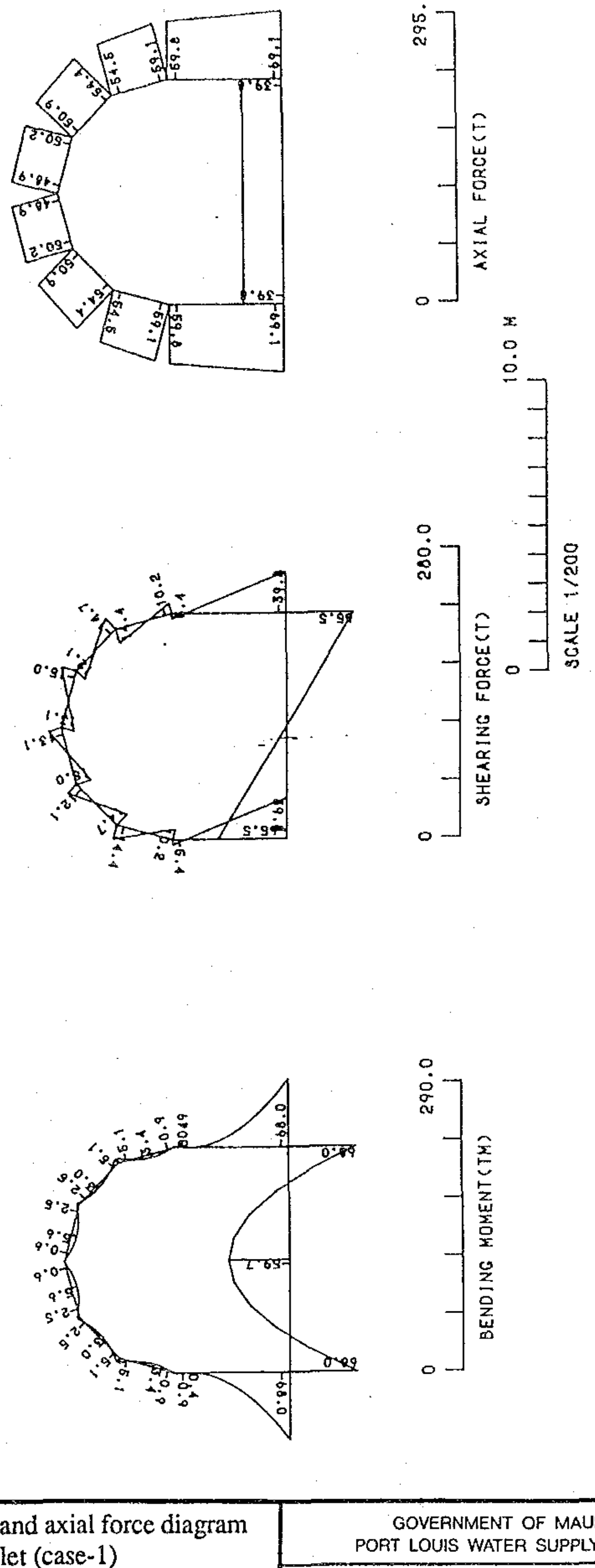
(2) Grouting condition

Load diagram outlet transition

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 1.1.11

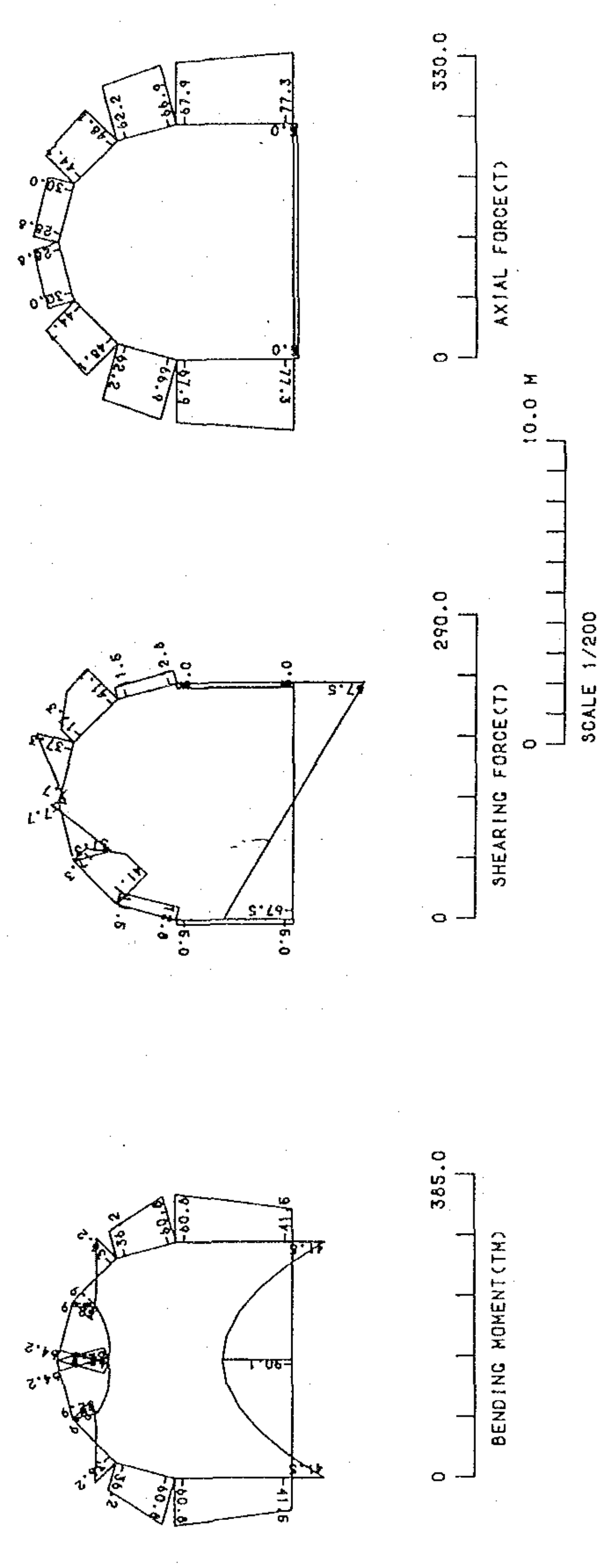


Bending moment shearing and axial force diagram transition of diversion outlet (case-1)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 1.1.12

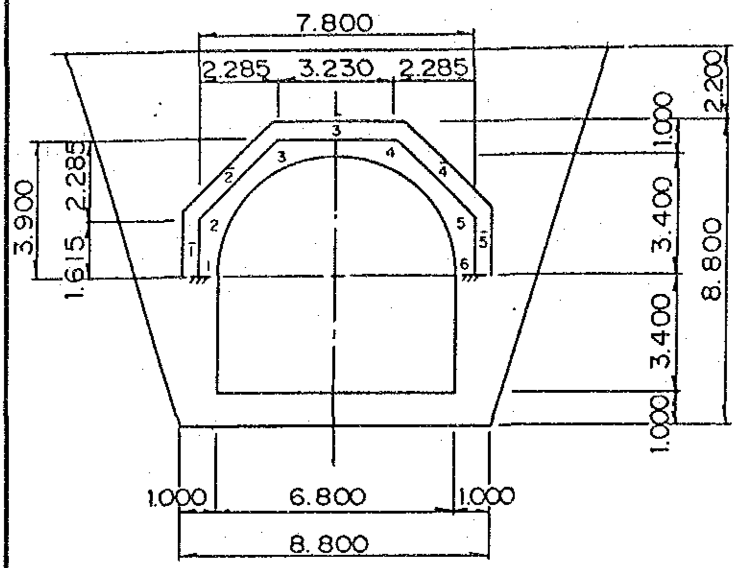


Bending moment shearing and axial force diagram transition of diversion outlet (case-2)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

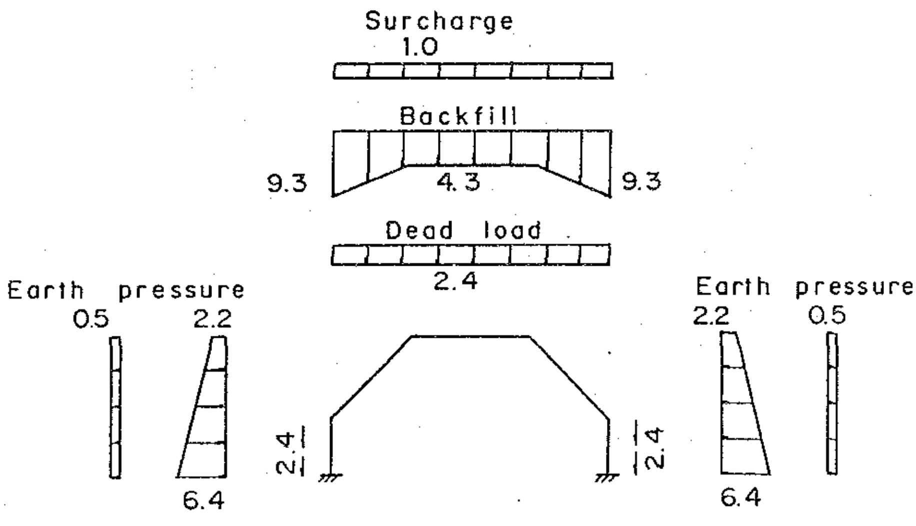
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 1.1.13



A = 1.0 m^2
I = 0.0833 m^4

	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

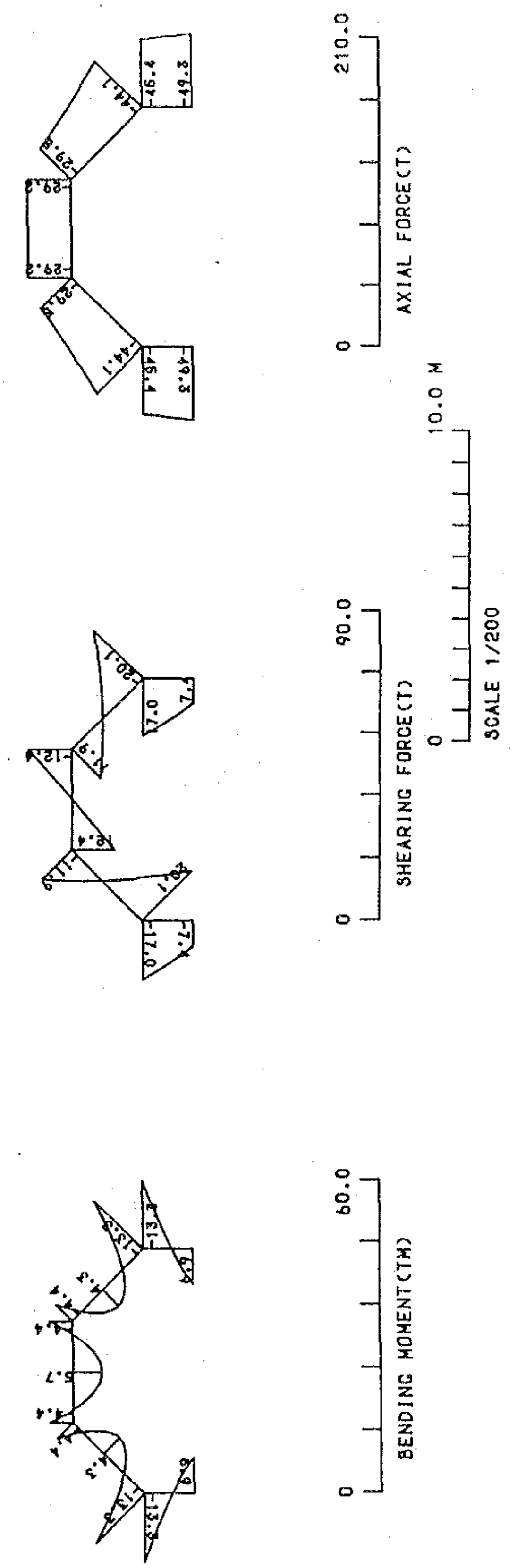


Load diagram of outlet portal

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 1.1.14

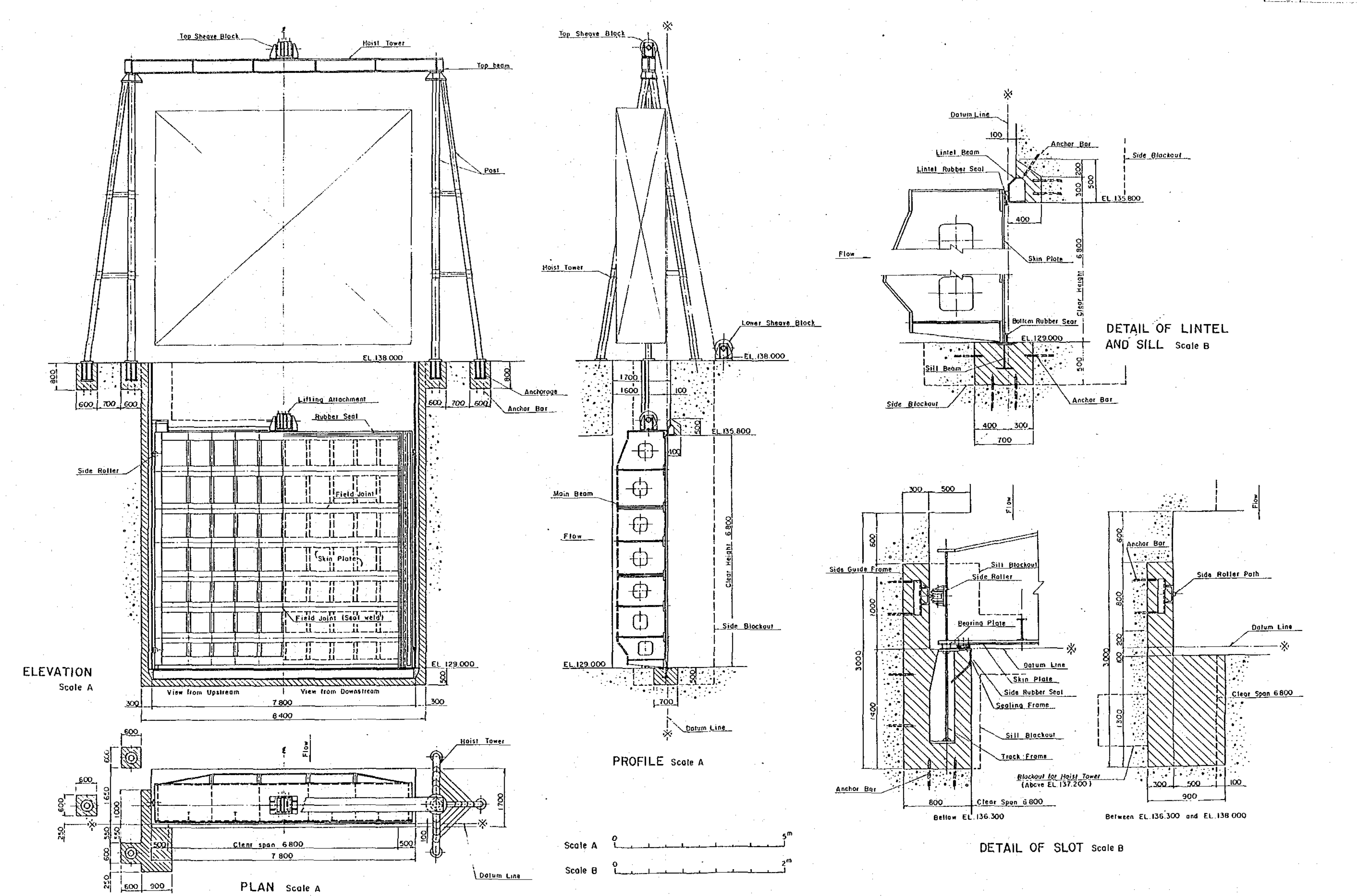


Bending moment shearing and axial force diagram,
Outlet portal

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 1.2.1

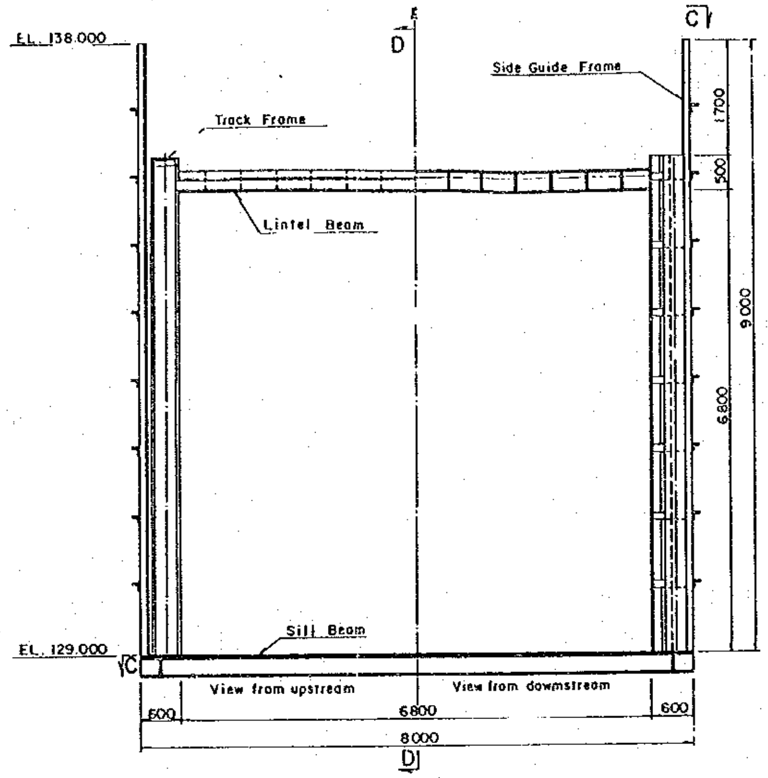


METAL WORK
DIVERSION GATE

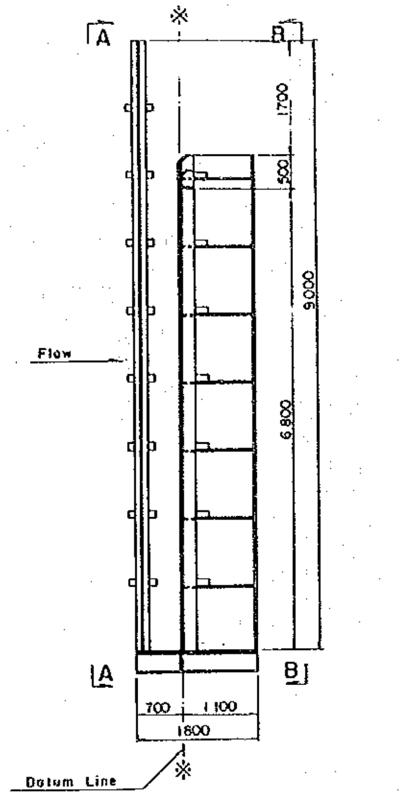
GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

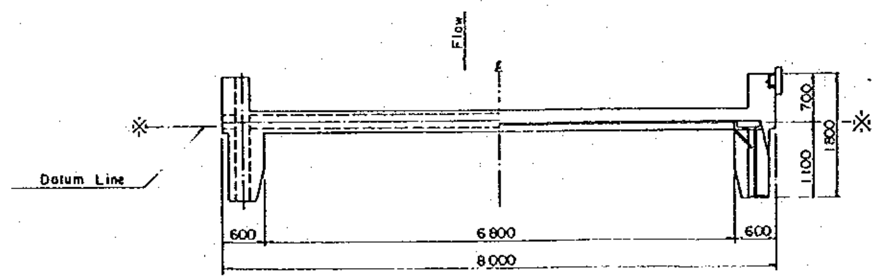
Fig. 1.2.2



VIEW A-A VIEW B-B
Scale A



SECTION D-D Scale A



SECTION C-C Scale A

Scale A 0 5m

METAL WORK
GUIDE FRAME OF DIVERSION GATE

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

PART II WATER PRESSURE TEST

RECORD OF WATER PRESSURE TEST HOLE NO. JD-3

DEPTH(m): 2-5

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
0.5	51.4	17.13	3.0	66.0	1.20	3.50	1.0	176.6	0.002113
1.0	65.4	21.80	3.0	66.0	1.20	3.50	1.5	148.3	0.001774
1.5	70.4	23.47	3.0	66.0	1.20	3.50	2.0	119.1	0.001425
2.0	76.6	25.53	3.0	66.0	1.20	3.50	2.5	103.4	0.001237
1.5	69.0	23.00	3.0	66.0	1.20	3.50	2.0	116.8	0.001397
1.0	51.0	17.00	3.0	66.0	1.20	3.50	1.5	115.6	0.001383
0.5	36.0	12.00	3.0	66.0	1.20	3.50	1.0	123.7	0.001480
AVERAGE								129.1	0.001544

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-3

DEPTH(m): 5-10

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
1.0	12.2	2.44	5.0	66.0	1.20	7.50	1.9	13.0	0.000174
2.0	29.2	5.84	5.0	66.0	1.20	7.50	2.9	20.3	0.000271
3.0	49.8	9.96	5.0	66.0	1.20	7.50	3.9	25.7	0.000343
4.0	41.6	8.32	5.0	66.0	1.20	7.50	4.9	17.1	0.000228
3.0	53.4	10.67	5.0	66.0	1.20	7.50	3.9	27.6	0.000367
2.0	36.0	7.20	5.0	66.0	1.20	7.50	2.9	25.1	0.000334
1.0	25.0	5.00	5.0	66.0	1.20	7.50	1.9	26.7	0.000356
AVERAGE								22.2	0.000296

k-VALUE: COEFFICIENT OF PERMEABILITY
k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-3

DEPTH(m): 10 - 15

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
1.0	42.4	8.48	5.0	66.0	1.20	12.50	2.4	35.8	0.000477
2.0	50.0	10.00	5.0	66.0	1.20	12.50	3.4	29.7	0.000395
4.0	73.4	14.68	5.0	66.0	1.20	12.50	5.4	27.3	0.000364
6.0	98.0	19.60	5.0	66.0	1.20	12.50	7.4	26.6	0.000354
4.0	76.0	15.20	5.0	66.0	1.20	12.50	5.4	28.3	0.000377
2.0	57.0	11.40	5.0	66.0	1.20	12.50	3.4	33.8	0.000451
1.0	45.0	9.00	5.0	66.0	1.20	12.50	2.4	38.0	0.000506
AVERAGE								31.4	0.000418

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-3

DEPTH(m): 15-20

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
2.0	44.4	8.88	5.0	66.0	1.20	16.45	3.8	23.6	0.000314
4.0	65.6	13.12	5.0	66.0	1.20	16.45	5.8	22.8	0.000303
6.0	82.2	16.44	5.0	66.0	1.20	16.45	7.8	21.2	0.000282
8.0	97.4	19.48	5.0	66.0	1.20	16.45	9.8	19.9	0.000266
6.0	84.0	16.80	5.0	66.0	1.20	16.45	7.8	21.6	0.000288
4.0	71.0	14.20	5.0	66.0	1.20	16.45	5.8	24.6	0.000328
2.0	55.5	11.10	5.0	66.0	1.20	16.45	3.8	29.5	0.000393
AVERAGE								23.3	0.000311

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-3
DEPTH(m): 20-25

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
2.0	0.9	0.18	5.0	66.0	1.20	19.42	4.1	0.4	0.000006
4.0	1.2	0.24	5.0	66.0	1.20	19.42	6.1	0.4	0.000005
7.0	41.2	8.24	5.0	66.0	1.20	19.42	9.1	9.1	0.000121
10.0	72.2	14.44	5.0	66.0	1.20	19.42	12.1	12.0	0.000159
7.0	59.0	11.80	5.0	66.0	1.20	19.42	9.1	13.0	0.000173
4.0	38.0	7.60	5.0	66.0	1.20	19.42	6.1	12.5	0.000167
2.0	24.0	4.80	5.0	66.0	1.20	19.42	4.1	11.8	0.000157
AVERAGE								8.5	0.000113

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-3
DEPTH(m): 25-30

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
2.0	47.8	9.56	5.0	66.0	1.20	19.41	4.1	23.5	0.000314
4.0	67.6	13.52	5.0	66.0	1.20	19.41	6.1	22.3	0.000297
7.0	89.2	17.84	5.0	66.0	1.20	19.41	9.1	19.7	0.000262
10.0	107.0	21.40	5.0	66.0	1.20	19.41	12.1	17.7	0.000236
7.0	88.0	17.60	5.0	66.0	1.20	19.41	9.1	19.4	0.000259
4.0	73.5	14.70	5.0	66.0	1.20	19.41	6.1	24.3	0.000323
2.0	56.5	11.30	5.0	66.0	1.20	19.41	4.1	27.8	0.000371
AVERAGE								22.1	0.000294

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-3
DEPTH(m): 30-35

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
2.0	52.2	10.44	5.0	66.0	1.20	19.66	4.1	25.6	0.000340
4.0	67.4	13.48	5.0	66.0	1.20	19.66	6.1	22.1	0.000295
7.0	90.2	18.04	5.0	66.0	1.20	19.66	9.1	19.9	0.000264
10.0	107.2	21.44	5.0	66.0	1.20	19.66	12.1	17.7	0.000236
7.0	86.0	17.20	5.0	66.0	1.20	19.66	9.1	18.9	0.000252
4.0	61.5	12.30	5.0	66.0	1.20	19.66	6.1	20.2	0.000269
2.0	46.0	9.20	5.0	66.0	1.20	19.66	4.1	22.5	0.000300
AVERAGE								21.0	0.000280

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-3
DEPTH(m): 35-40

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
2.0	49.8	9.96	5.0	66.0	1.20	28.02	4.9	20.2	0.000269
4.0	66.4	13.28	5.0	66.0	1.20	28.02	6.9	19.2	0.000256
7.0	88.4	17.68	5.0	66.0	1.20	28.02	9.9	17.8	0.000237
10.0	104.8	20.96	5.0	66.0	1.20	28.02	12.9	16.2	0.000216
7.0	84.0	16.80	5.0	66.0	1.20	28.02	9.9	16.9	0.000225
4.0	59.0	11.80	5.0	66.0	1.20	28.02	6.9	17.0	0.000227
2.0	43.5	8.70	5.0	66.0	1.20	28.02	4.9	17.7	0.000235
AVERAGE								17.9	0.000238

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-4
DEPTH(m): 6-10

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
0.5	18.6	4.65	4.0	66.0	0.80	2.57	0.8	55.6	0.000707
1.0	33.2	8.30	4.0	66.0	0.80	2.57	1.3	62.1	0.000790
1.5	41.8	10.45	4.0	66.0	0.80	2.57	1.8	56.9	0.000724
2.0	49.6	12.40	4.0	66.0	0.80	2.57	2.3	53.1	0.000675
1.5	33.0	8.25	4.0	66.0	0.80	2.57	1.8	44.9	0.000572
1.0	28.0	7.00	4.0	66.0	0.80	2.57	1.3	52.4	0.000666
0.5	11.5	2.88	4.0	66.0	0.80	2.57	0.8	34.3	0.000437
AVERAGE								51.3	0.000653

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-4
DEPTH(m): 10-15

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
1.0	34.0	6.80	5.0	66.0	0.80	12.80	2.4	28.8	0.000384
1.5	49.4	9.88	5.0	66.0	0.80	12.80	2.9	34.5	0.000460
2.0	56.6	11.32	5.0	66.0	0.80	12.80	3.4	33.7	0.000449
2.5	68.0	13.60	5.0	66.0	0.80	12.80	3.9	35.2	0.000469
2.0	57.0	11.40	5.0	66.0	0.80	12.80	3.4	33.9	0.000452
1.5	50.5	10.10	5.0	66.0	0.80	12.80	2.9	35.3	0.000470
1.0	33.0	6.60	5.0	66.0	0.80	12.80	2.4	28.0	0.000372
AVERAGE								32.8	0.000437

k-VALUE: COEFFICIENT OF PERMEABILITY
k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-4
DEPTH(m): 15-20

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
1.0	29.2	5.84	5.0	66.0	0.80	16.80	2.8	21.2	0.000282
2.0	43.6	8.72	5.0	66.0	0.80	16.80	3.8	23.2	0.000309
3.0	56.2	11.24	5.0	66.0	0.80	16.80	4.8	23.6	0.000314
4.0	68.6	13.72	5.0	66.0	0.80	16.80	5.8	23.8	0.000317
3.0	56.5	11.30	5.0	66.0	0.80	16.80	4.8	23.7	0.000316
2.0	45.0	9.00	5.0	66.0	0.80	16.80	3.8	23.9	0.000319
1.0	28.5	5.70	5.0	66.0	0.80	16.80	2.8	20.7	0.000275
AVERAGE								22.9	0.000305

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-4
DEPTH(m): 20-25

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
1.0	29.2	5.84	5.0	66.0	0.80	18.40	2.9	20.0	0.000266
2.0	56.8	11.36	5.0	66.0	0.80	18.40	3.9	29.0	0.000386
4.0	73.8	14.76	5.0	66.0	0.80	18.40	5.9	24.9	0.000332
5.0	89.6	17.92	5.0	66.0	0.80	18.40	6.9	25.9	0.000345
4.0	73.0	14.60	5.0	66.0	0.80	18.40	5.9	24.7	0.000328
2.0	56.0	11.20	5.0	66.0	0.80	18.40	3.9	28.6	0.000381
1.0	44.5	8.90	5.0	66.0	0.80	18.40	2.9	30.5	0.000406
AVERAGE								26.2	0.000349

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-4
DEPTH(m): 25-30

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
1.0	33.2	6.64	5.0	66.0	0.80	20.60	3.1	21.1	0.000282
2.0	41.0	8.20	5.0	66.0	0.80	20.60	4.1	19.8	0.000264
4.0	61.6	12.32	5.0	66.0	0.80	20.60	6.1	20.1	0.000267
5.0	76.0	15.20	5.0	66.0	0.80	20.60	7.1	21.3	0.000284
4.0	62.0	12.40	5.0	66.0	0.80	20.60	6.1	20.2	0.000269
2.0	40.5	8.10	5.0	66.0	0.80	20.60	4.1	19.6	0.000261
1.0	37.5	7.50	5.0	66.0	0.80	20.60	3.1	23.9	0.000318
AVERAGE								20.9	0.000278

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-4
DEPTH(m): 29-35

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
1.0	21.6	3.60	6.0	66.0	0.80	21.64	3.2	11.1	0.000153
2.0	26.6	4.43	6.0	66.0	0.80	21.64	4.2	10.4	0.000144
4.0	47.2	7.87	6.0	66.0	0.80	21.64	6.2	12.6	0.000174
6.0	67.2	11.20	6.0	66.0	0.80	21.64	8.2	13.6	0.000188
4.0	51.0	8.50	6.0	66.0	0.80	21.64	6.2	13.6	0.000188
2.0	37.0	6.17	6.0	66.0	0.80	21.64	4.2	14.5	0.000201
1.0	12.0	2.00	6.0	66.0	0.80	21.64	3.2	6.2	0.000085
AVERAGE								11.7	0.000162

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-4
DEPTH(m): 35-40

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
2.0	56.4	11.28	5.0	66.0	0.80	24.79	4.6	24.7	0.000330
4.0	75.8	15.16	5.0	66.0	0.80	24.79	6.6	23.1	0.000308
7.0	89.6	17.92	5.0	66.0	0.80	24.79	9.6	18.7	0.000250
9.0	101.4	20.28	5.0	66.0	0.80	24.79	11.6	17.5	0.000234
7.0	94.5	18.90	5.0	66.0	0.80	24.79	9.6	19.8	0.000263
4.0	76.0	15.20	5.0	66.0	0.80	24.79	6.6	23.2	0.000309
2.0	60.0	12.00	5.0	66.0	0.80	24.79	4.6	26.3	0.000351
AVERAGE								21.9	0.000292

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-4
DEPTH(m): 40-45

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
2.0	43.2	8.64	5.0	66.0	0.80	25.75	4.7	18.6	0.000247
4.0	56.4	11.28	5.0	66.0	0.80	25.75	6.7	16.9	0.000226
7.0	67.2	13.44	5.0	66.0	0.80	25.75	9.7	13.9	0.000185
9.0	75.6	15.12	5.0	66.0	0.80	25.75	11.7	13.0	0.000173
7.0	70.5	14.10	5.0	66.0	0.80	25.75	9.7	14.6	0.000194
4.0	57.0	11.40	5.0	66.0	0.80	25.75	6.7	17.1	0.000228
2.0	46.0	9.20	5.0	66.0	0.80	25.75	4.7	19.8	0.000263
AVERAGE								16.3	0.000217

k-VALUE: COEFFICIENT OF PERMEABILITY
k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-4

DEPTH(m): 45-50

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
2.0	38.4	7.68	5.0	66.0	0.80	26.80	4.8	16.1	0.000215
4.0	69.6	13.92	5.0	66.0	0.80	26.80	6.8	20.6	0.000274
7.0	94.6	18.92	5.0	66.0	0.80	26.80	9.8	19.4	0.000258
4.0	74.0	14.80	5.0	66.0	0.80	26.80	6.8	21.9	0.000292
2.0	55.5	11.10	5.0	66.0	0.80	26.80	4.8	23.3	0.000311
AVERAGE								20.3	0.000270

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-11
DEPTH(m): 15-20

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
1.0	35.2	7.04	5.0	66.0	0.83	14.31	2.5	28.0	0.000373
2.0	52.8	10.56	5.0	66.0	0.83	14.31	3.5	30.1	0.000400
3.0	61.4	12.28	5.0	66.0	0.83	14.31	4.5	27.2	0.000362
4.0	76.4	15.28	5.0	66.0	0.83	14.31	5.5	27.7	0.000369
3.0	71.0	14.20	5.0	66.0	0.83	14.31	4.5	31.5	0.000419
2.0	56.0	11.20	5.0	66.0	0.83	14.31	3.5	31.9	0.000424
1.0	41.0	8.20	5.0	66.0	0.83	14.31	2.5	32.6	0.000434
AVERAGE								29.8	0.000397

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-11
DEPTH(m): 20-25

GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
2.0	27.8	5.56	5.0	66.0	1.83	17.27	3.9	14.2	0.000189
4.0	54.4	10.88	5.0	66.0	1.83	17.27	5.9	18.4	0.000245
7.0	68.6	13.72	5.0	66.0	1.83	17.27	8.9	15.4	0.000205
10.0	85.6	17.12	5.0	66.0	1.83	17.27	11.9	14.4	0.000191
7.0	69.0	13.80	5.0	66.0	1.83	17.27	8.9	15.5	0.000206
4.0	51.5	10.30	5.0	66.0	1.83	17.27	5.9	17.4	0.000232
2.0	38.5	7.70	5.0	66.0	1.83	17.27	3.9	19.7	0.000262
AVERAGE								16.4	0.000219

k-VALUE: COEFFICIENT OF PERMEABILITY

RECORD OF WATER PRESSURE TEST HOLE NO. JD-11
DEPTH(m): 25-30

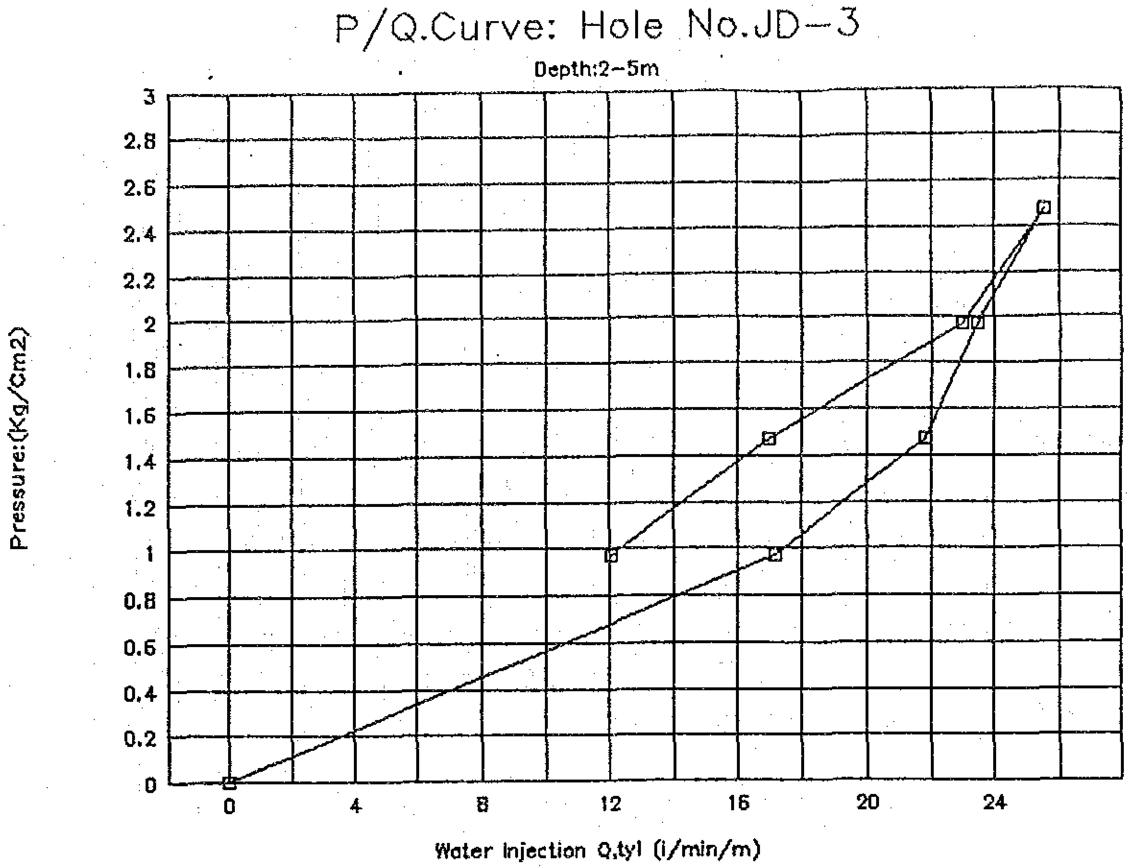
GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
2.0	34.4	6.88	5.0	66.0	1.33	21.82	4.3	15.9	0.000212
4.0	43.4	8.68	5.0	66.0	1.33	21.82	6.3	13.7	0.000183
7.0	63.8	12.76	5.0	66.0	1.33	21.82	9.3	13.7	0.000182
10.0	78.8	15.76	5.0	66.0	1.33	21.82	12.3	12.8	0.000170
7.0	65.5	13.10	5.0	66.0	1.33	21.82	9.3	14.1	0.000187
4.0	46.5	9.30	5.0	66.0	1.33	21.82	6.3	14.7	0.000196
2.0	35.0	7.00	5.0	66.0	1.33	21.82	4.3	16.2	0.000216
AVERAGE								14.5	0.000193

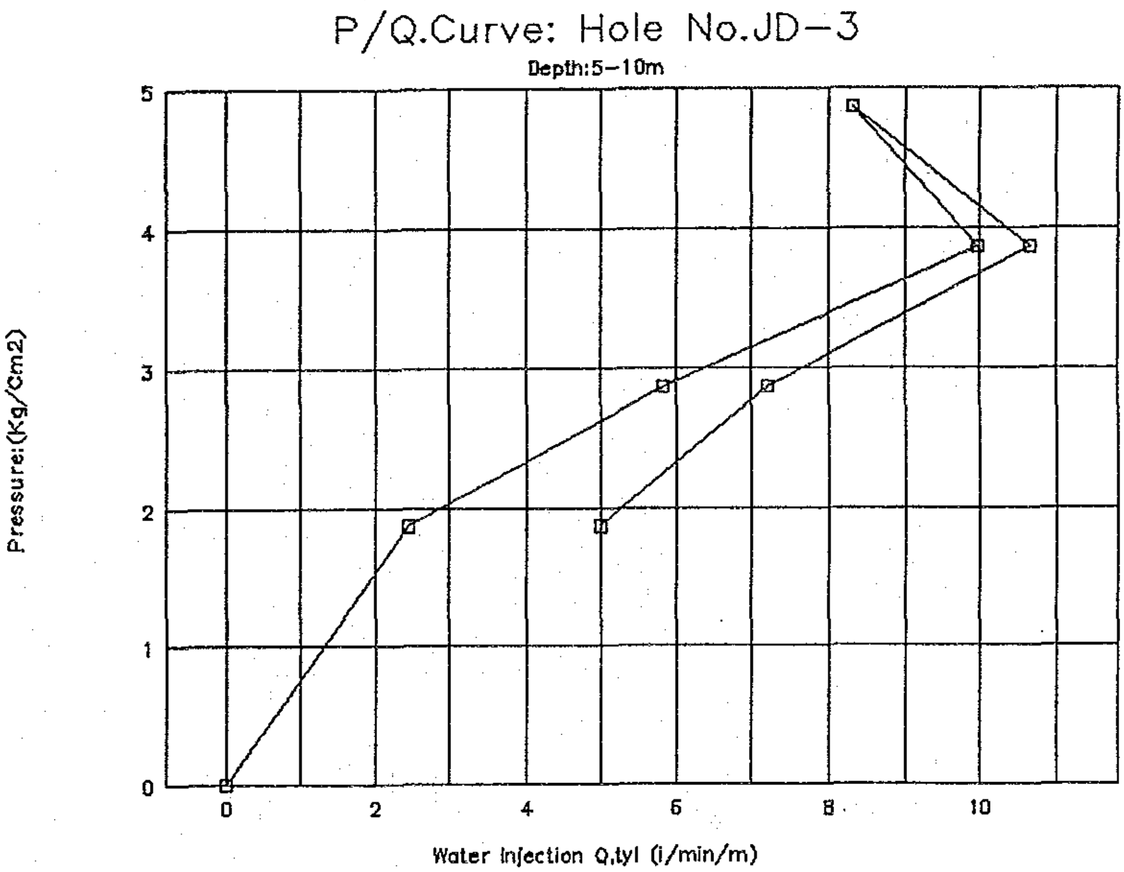
k-VALUE: COEFFICIENT OF PERMEABILITY

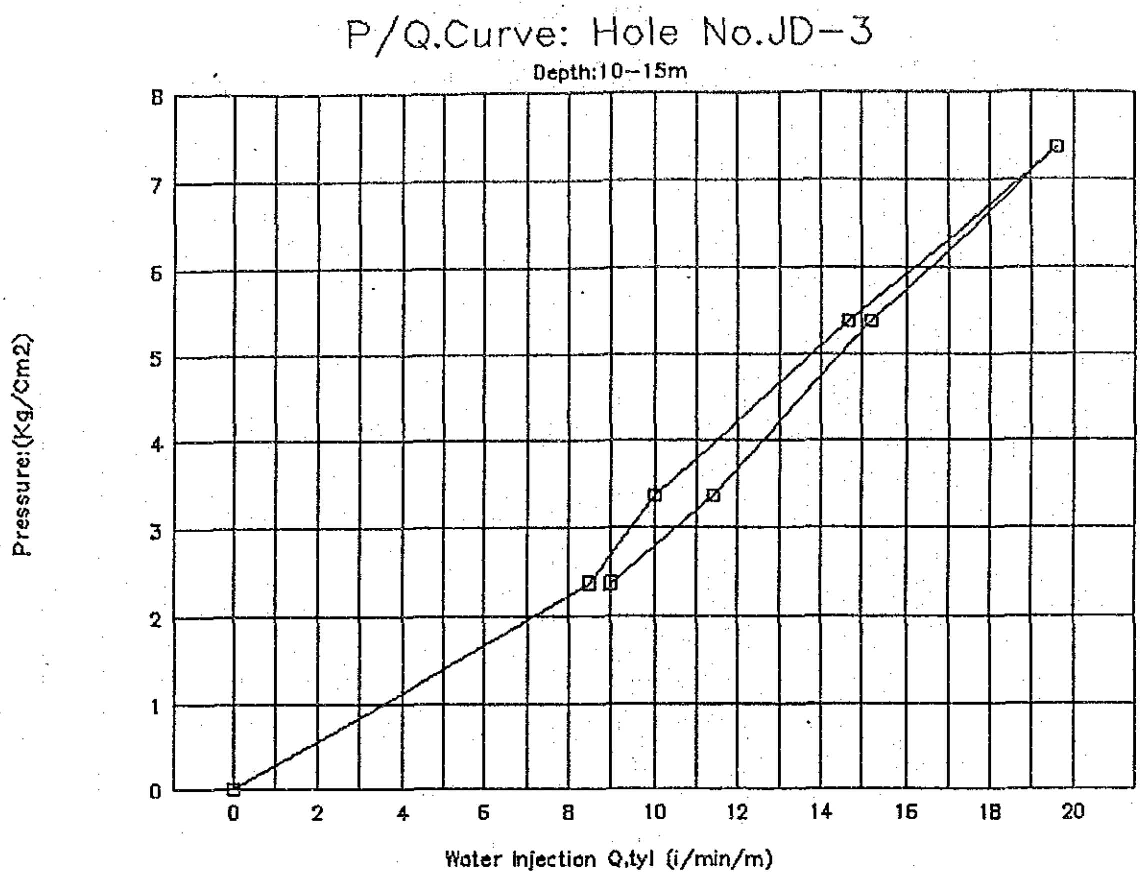
RECORD OF WATER PRESSURE TEST HOLE NO. JD-11
DEPTH(m): 30-35

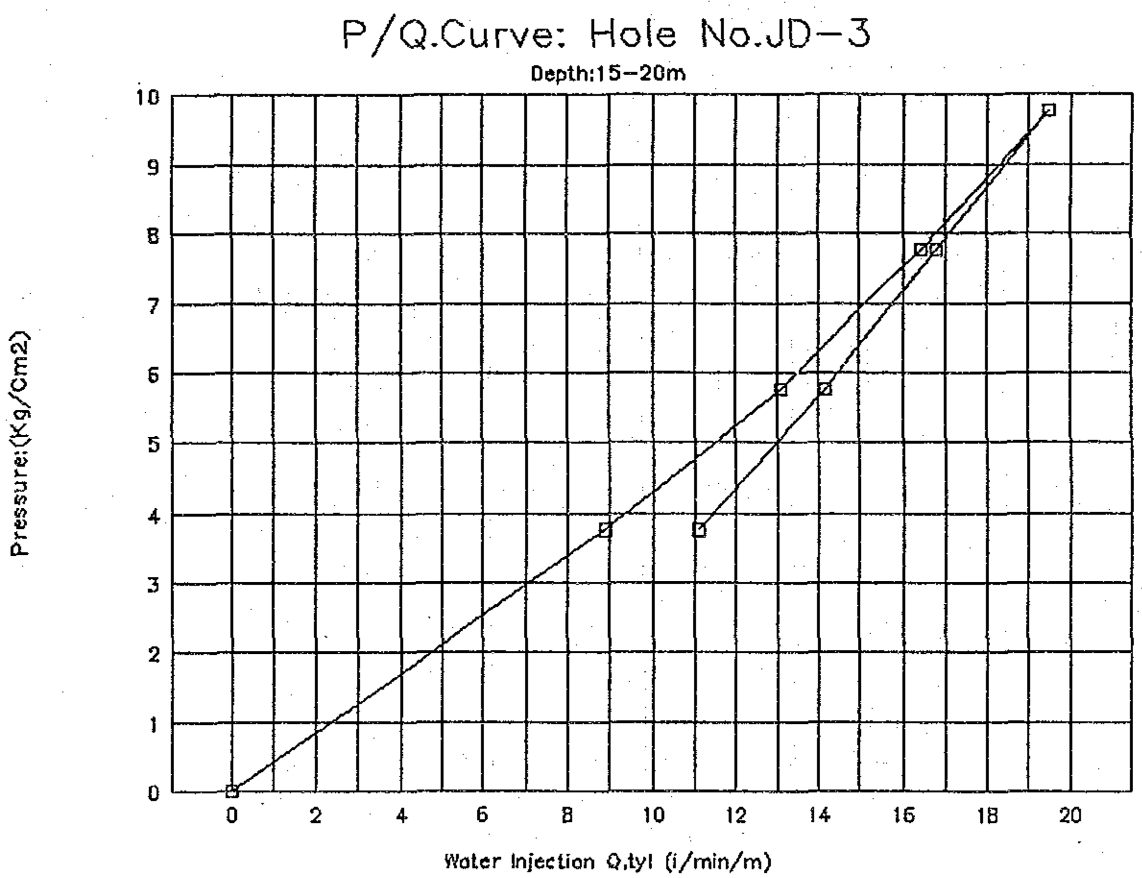
GAUGE PRESS. kg/cm2	INJECTION Q'ty lit/min	lit/min/m	TEST LENGTH m	HOLE DIA. mm	GAUGE HEIGHT m	WATER LEVEL m	TEST PRESS. kg/cm2	LUGEON VALUE	k-VALUE cm/sec
2.0	15.2	3.04	5.0	66.0	0.83	26.59	4.7	6.4	0.000085
4.0	22.2	4.44	5.0	66.0	0.83	26.59	6.7	6.6	0.000088
7.0	43.9	8.78	5.0	66.0	0.83	26.59	9.7	9.0	0.000120
10.0	59.4	11.88	5.0	66.0	0.83	26.59	12.7	9.3	0.000124
7.0	34.5	6.90	5.0	66.0	0.83	26.59	9.7	7.1	0.000094
4.0	27.0	5.40	5.0	66.0	0.83	26.59	6.7	8.0	0.000107
2.0	12.0	2.40	5.0	66.0	0.83	26.59	4.7	5.1	0.000067
AVERAGE								7.4	0.000098

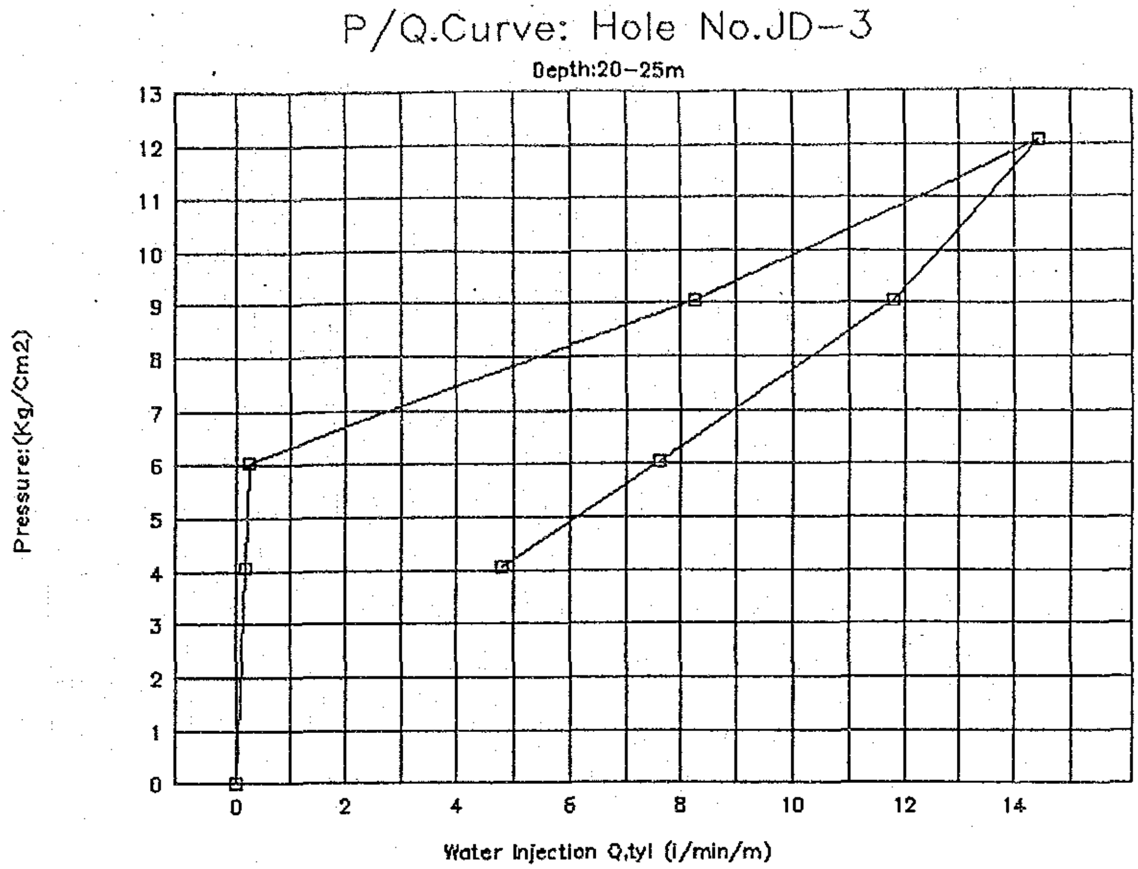
k-VALUE: COEFFICIENT OF PERMEABILITY

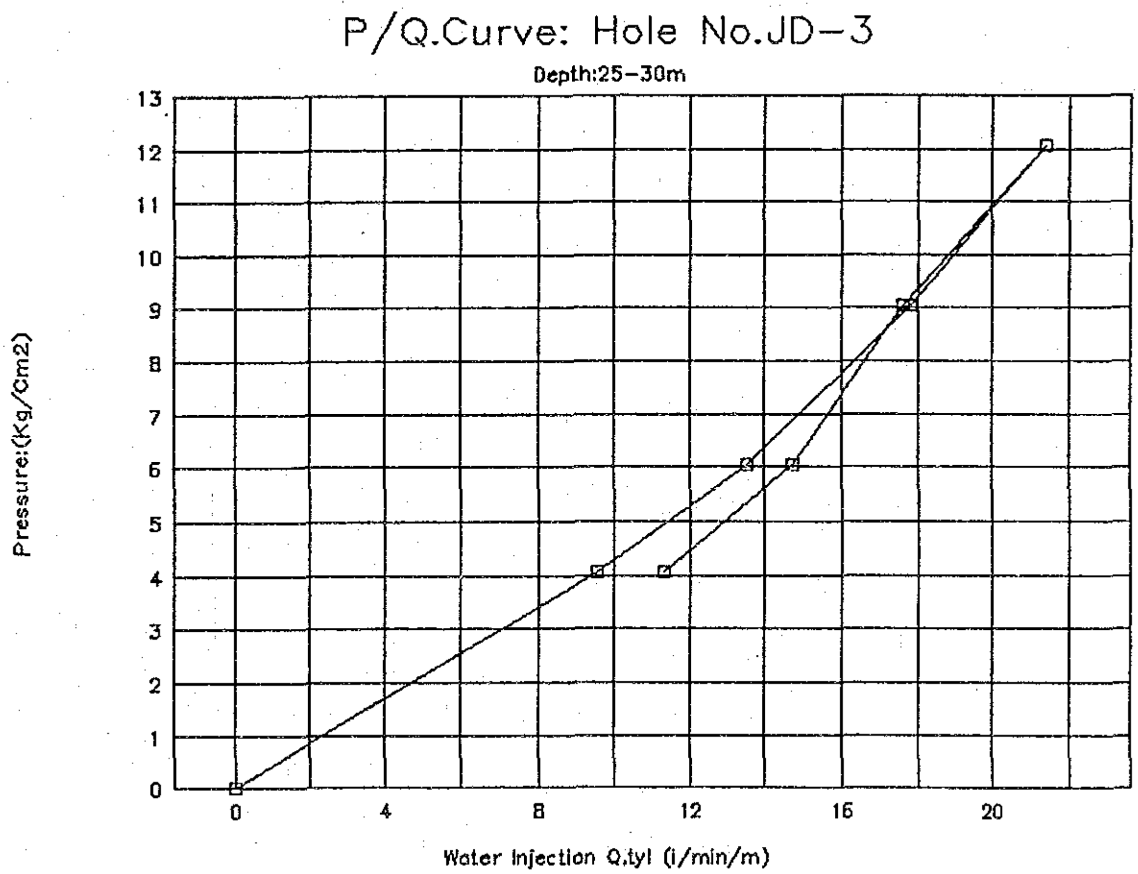

P/Q.Curve: Hole No.JD-3
Depth:2-5m
Pressure:(Kg/Cm2)
Water Injection Q.tyl (l/min/m)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
0
4
8
12
16
20
24

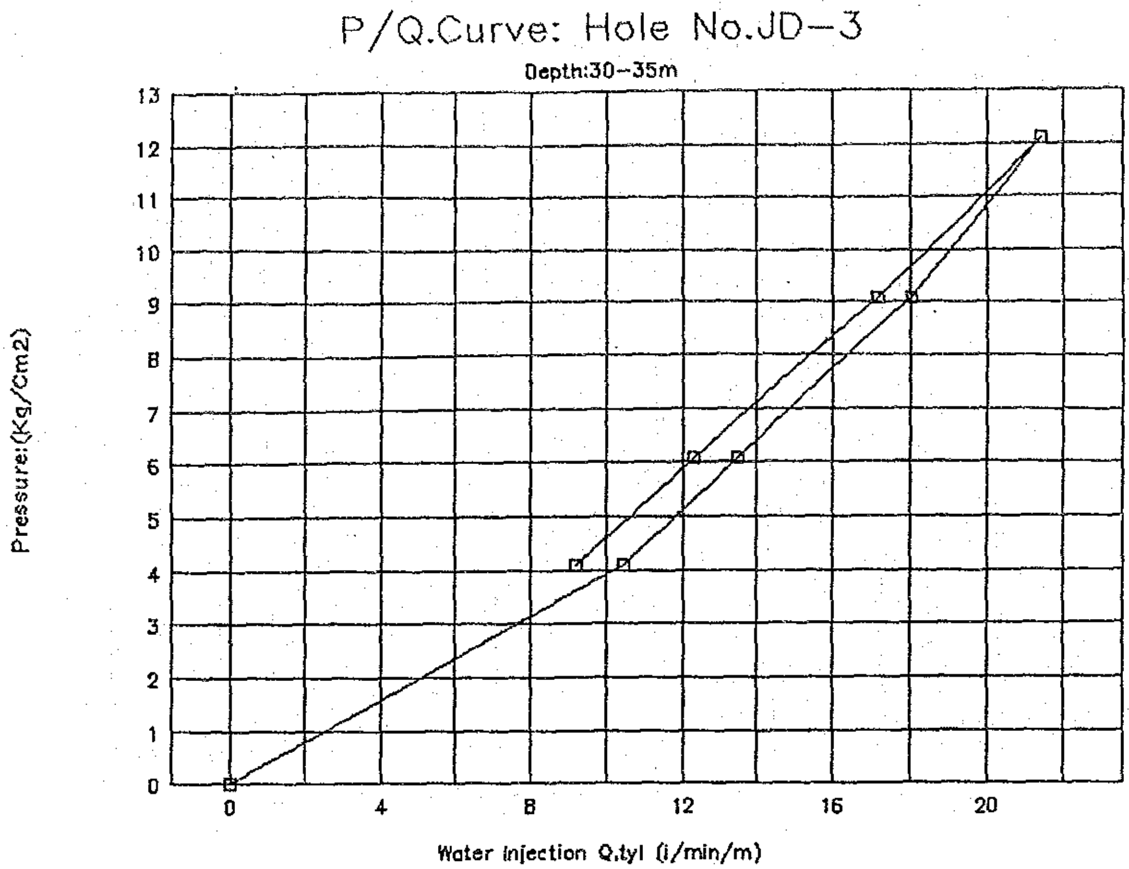

P/Q.Curve: Hole No.JD-3
Depth:5-10m
Pressure:(Kg/Cm2)
Water Injection Q.tyl (l/min/m)
0
1
2
3
4
5
0
2
4
6
8
10

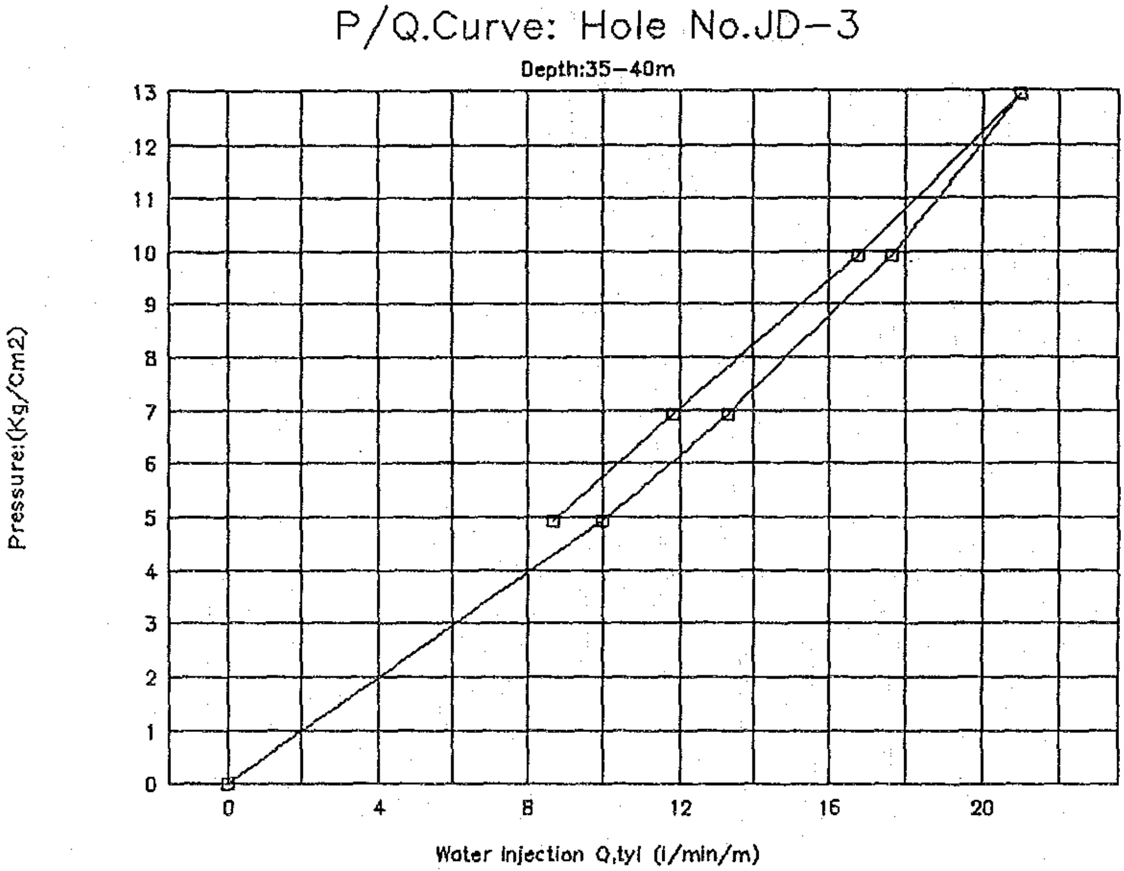

P/Q.Curve: Hole No.JD-3
Depth:10-15m
Pressure:(Kg/Cm2)
Water Injection Q.tyl (i/min/m)


P/Q.Curve: Hole No.JD-3
Depth:15-20m
Pressure:(Kg/Cm2)
Water Injection Q.tyl (i/min/m)


P/Q.Curve: Hole No.JD-3
Depth:20-25m
Pressure:(Kg/Cm2)
Water Injection Q.tyl (l/min/m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
0
2
4
6
8
10
12
14

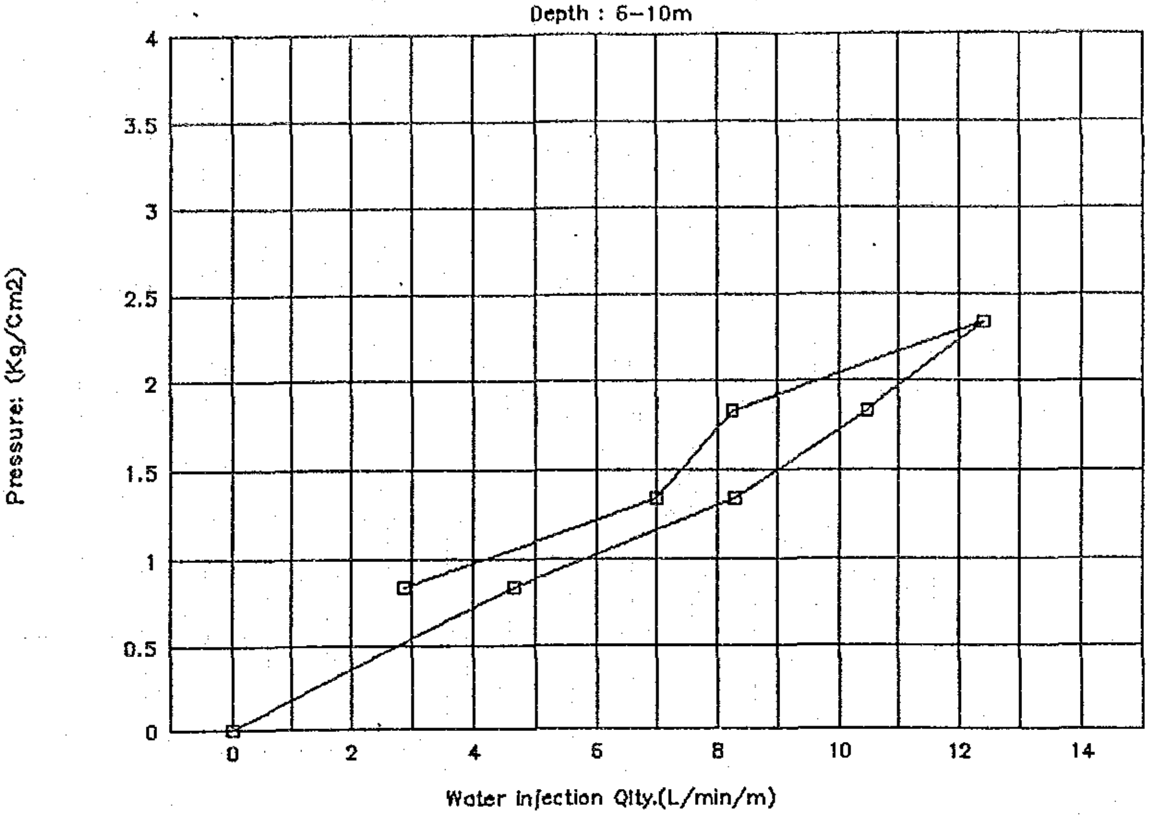

P/Q.Curve: Hole No.JD-3
Depth:25-30m
Pressure:(Kg/Cm2)
Water Injection Q.tyl (l/min/m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
0
4
8
12
16
20


P/Q.Curve: Hole No.JD-3
Depth:30-35m
Pressure:(Kg/Cm2)
Water Injection Q,tyl (l/min/m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
0
4
8
12
16
20


P/Q.Curve: Hole No.JD-3
Depth:35-40m
Pressure:(Kg/Cm2)
Water Injection Q,tyl (l/min/m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
0
4
8
12
16
20

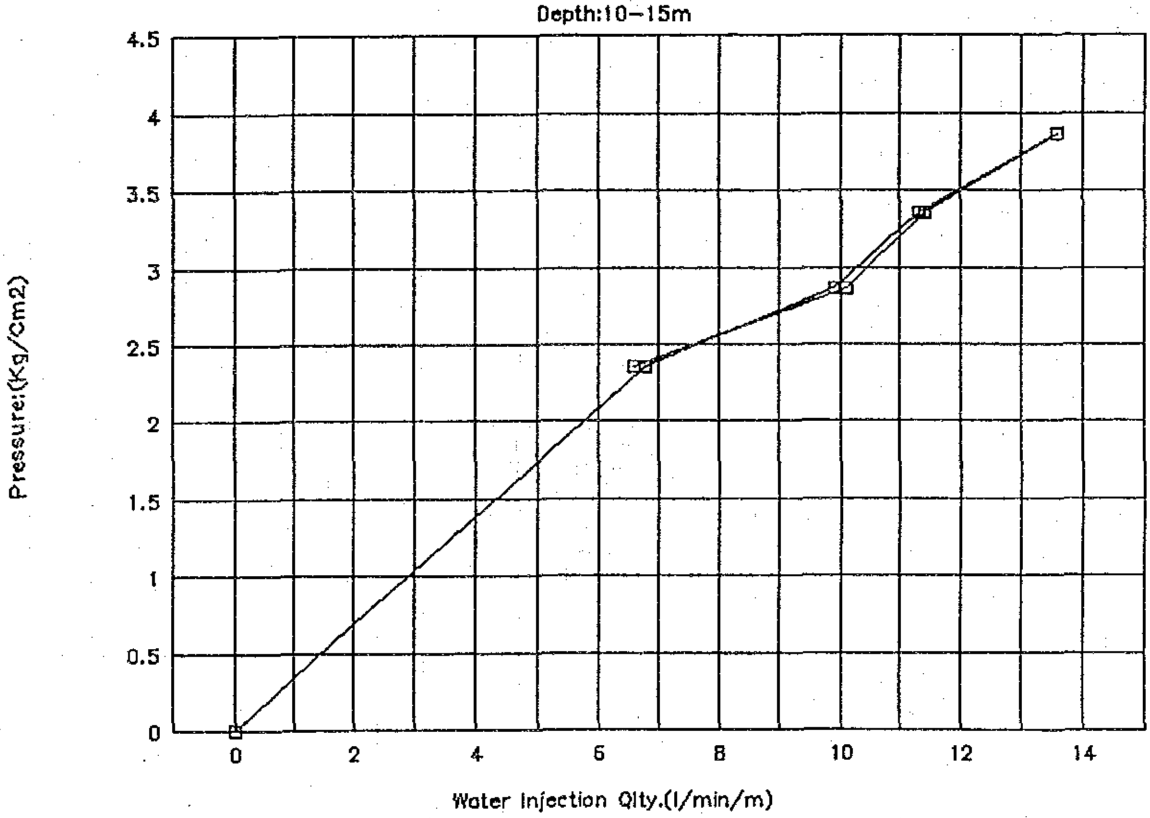
P/Q.Curve: Hole No.JD-4

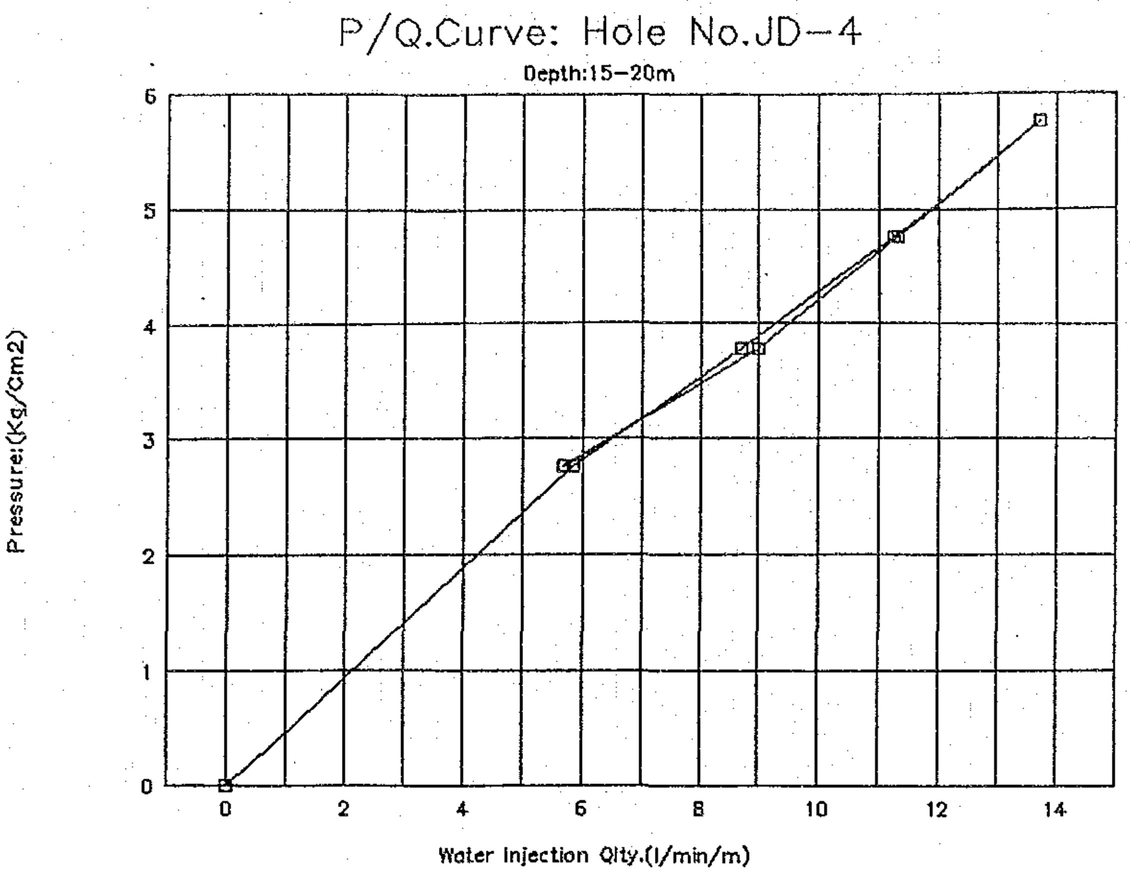
Depth : 6-10m

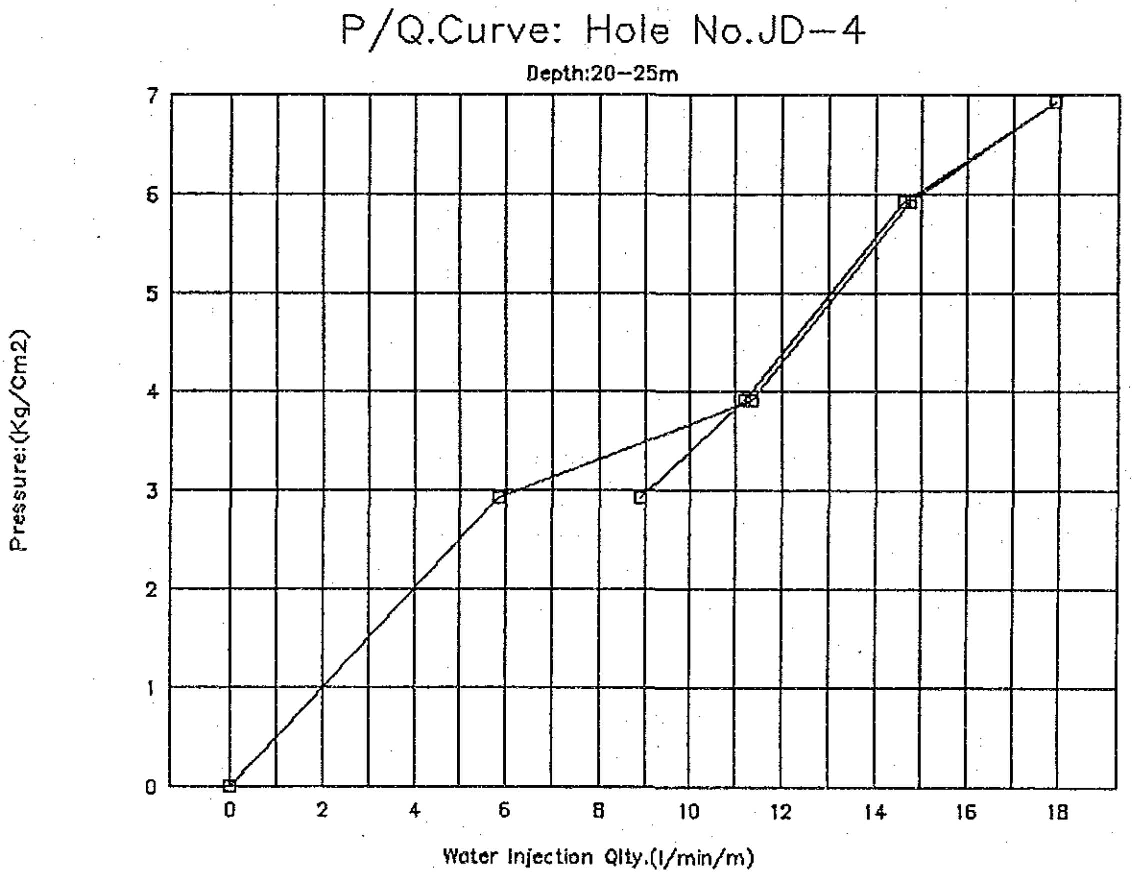


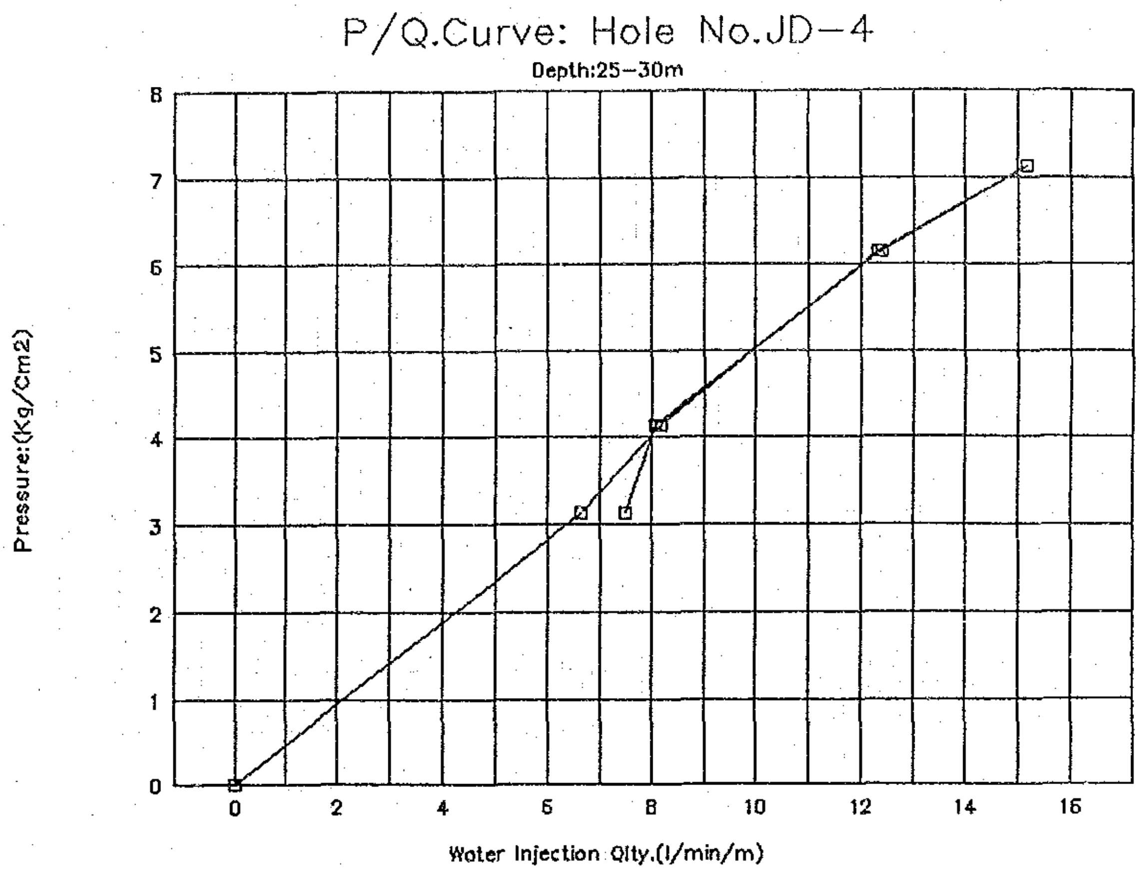
P/Q.Curve: Hole No.JD-4

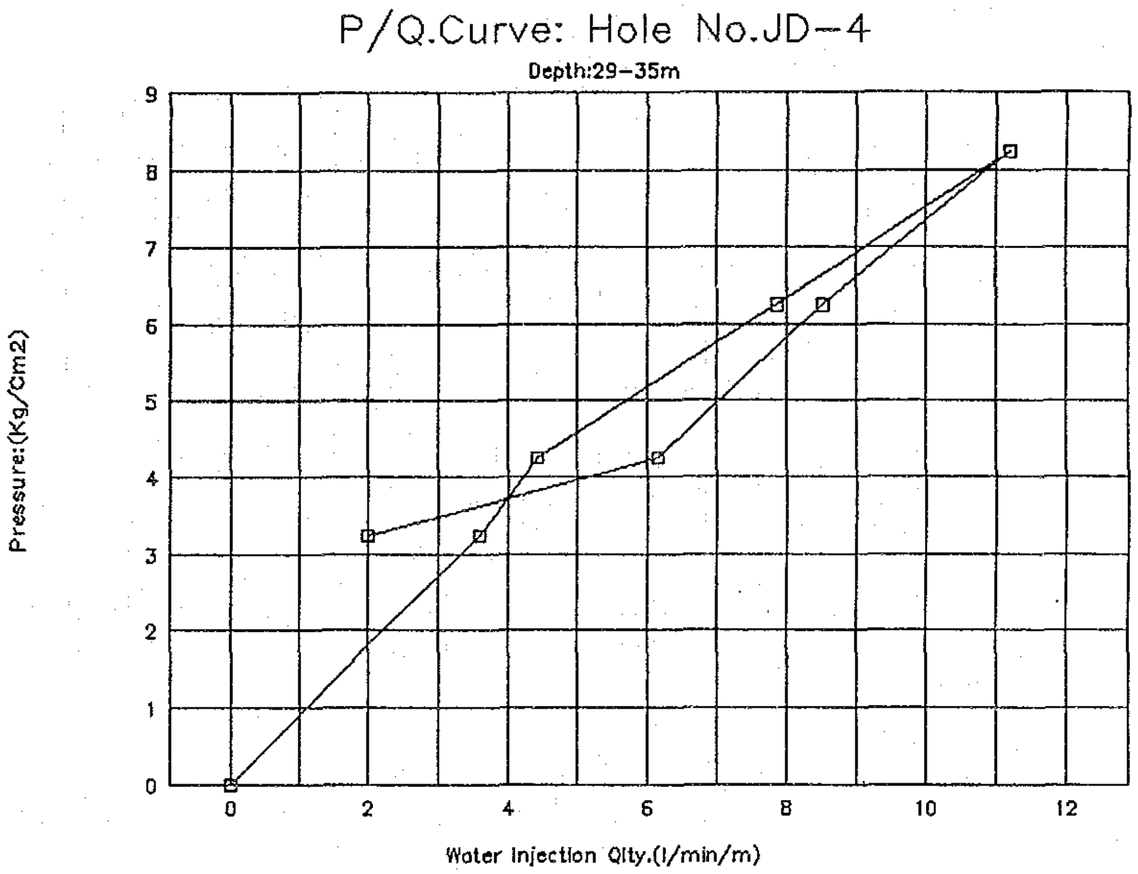
Depth:10-15m

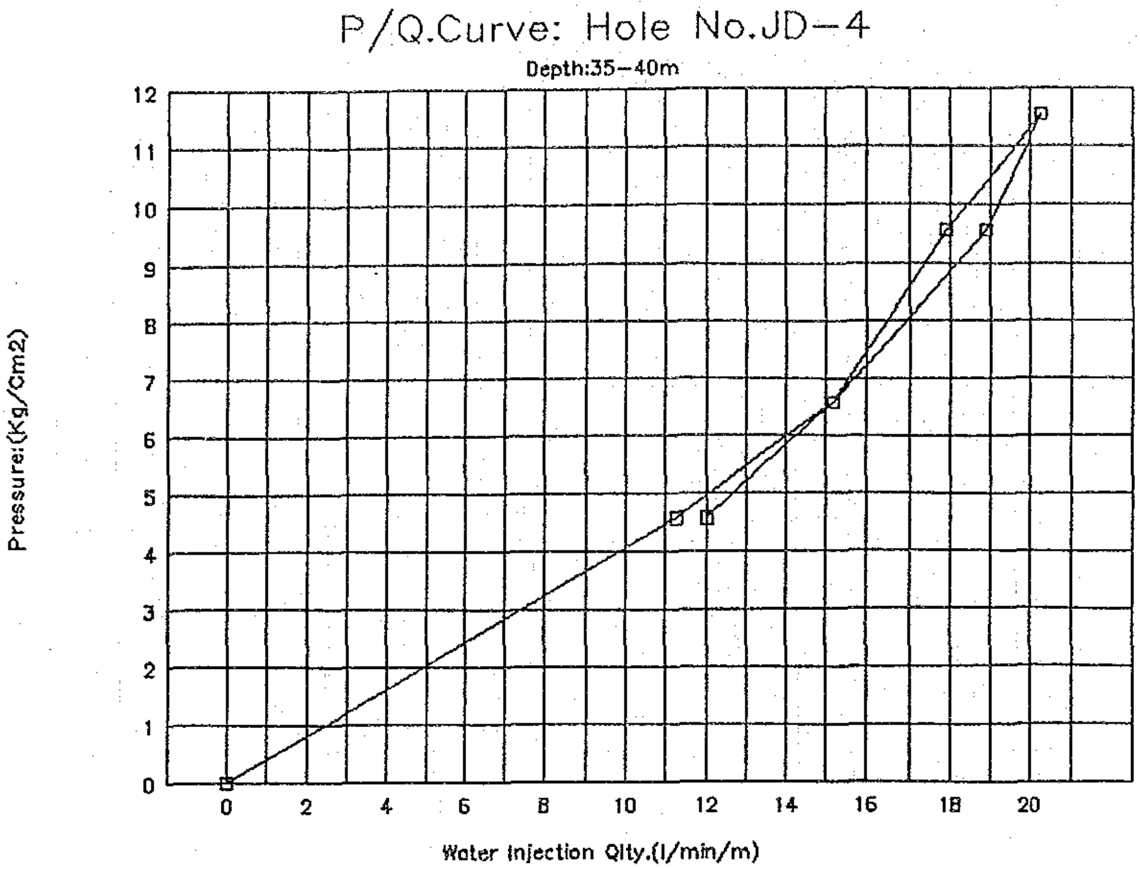


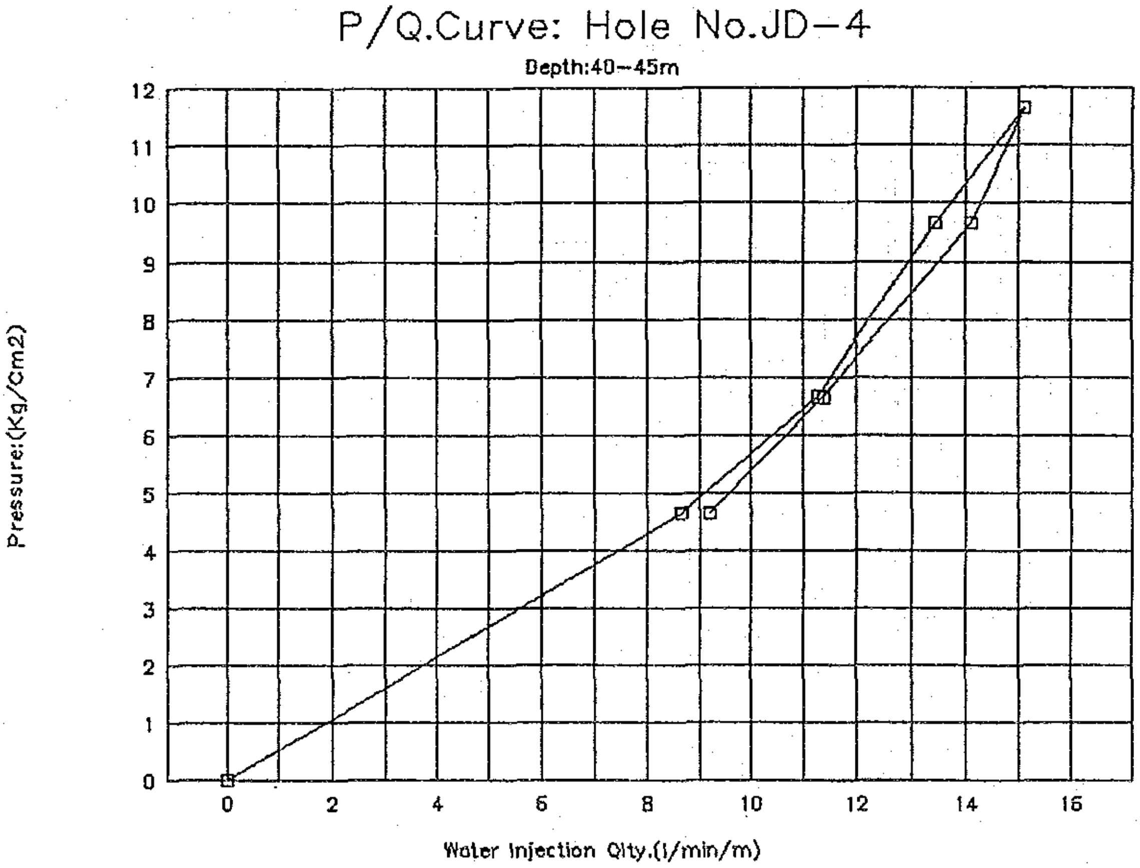

P/Q.Curve: Hole No.JD-4
Depth:15-20m
Pressure:(Kg/Cm2)
0
1
2
3
4
5
6
0
2
4
6
8
10
12
14
Water Injection Qlty.(l/min/m)

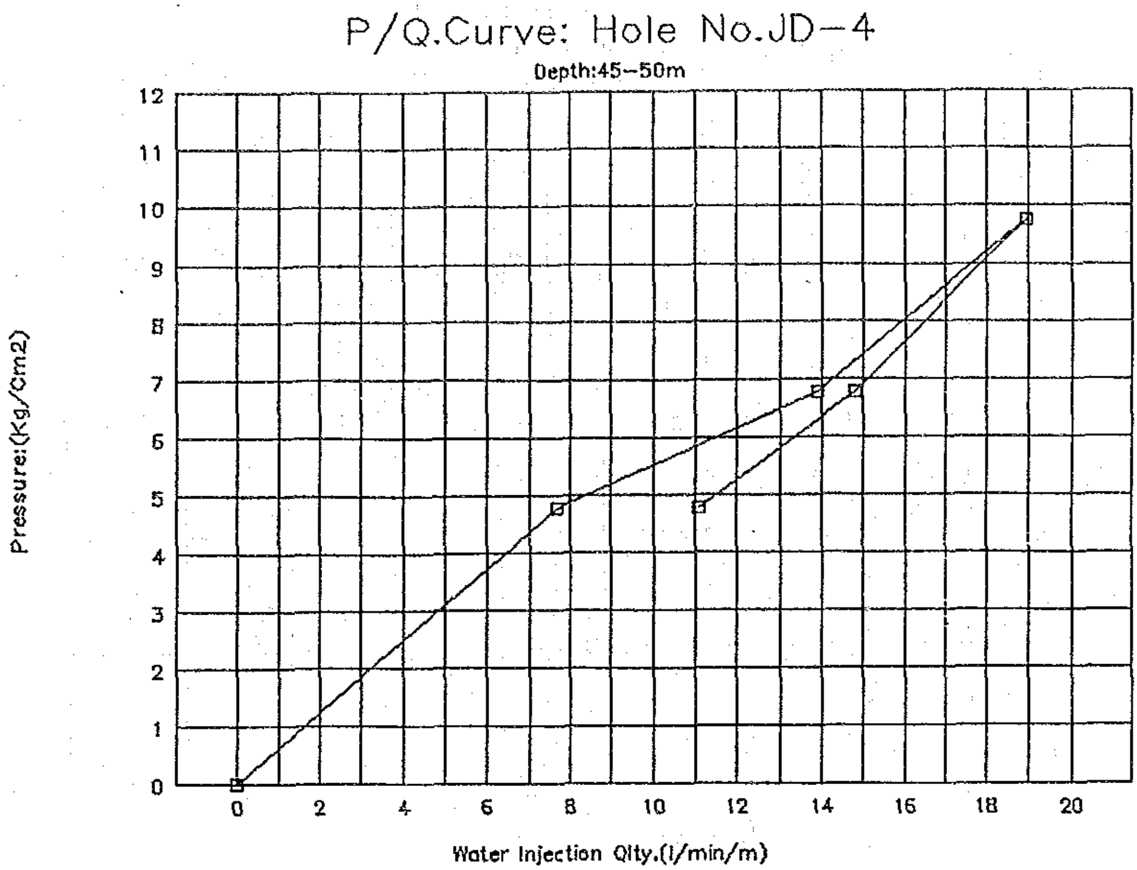

P/Q.Curve: Hole No.JD-4
Depth:20-25m
Pressure:(Kg/Cm2)
0
1
2
3
4
5
6
7
0
2
4
6
8
10
12
14
16
18
Water Injection Qlty.(l/min/m)


P/Q.Curve: Hole No.JD-4
Depth:25-30m
Pressure:(Kg/Cm2)
Water Injection Qlty.(l/min/m)

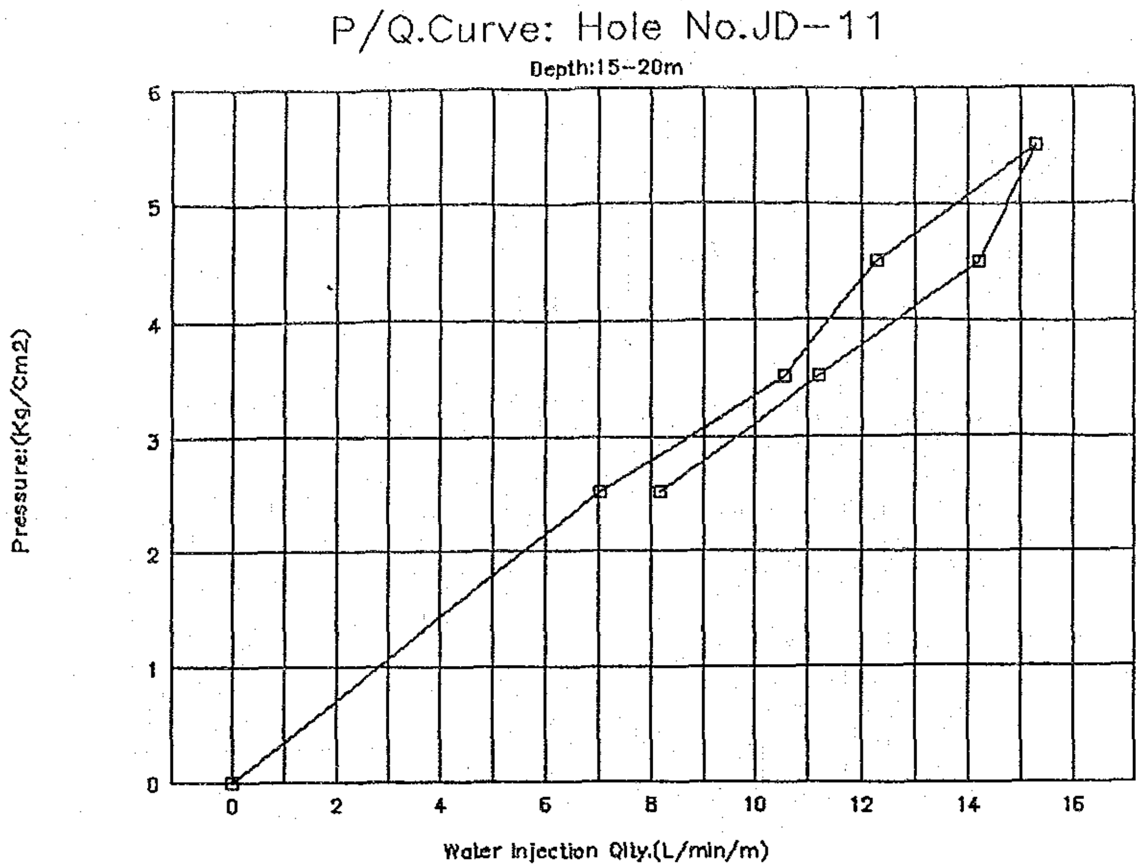

P/Q.Curve: Hole No.JD-4
Depth:29-35m
Pressure:(Kg/Cm2)
Water Injection Qlty.(l/min/m)


P/Q.Curve: Hole No.JD-4
Depth:35-40m
Pressure:(Kg/Cm2)
12
11
10
9
8
7
6
5
4
3
2
1
0
0
2
4
6
8
10
12
14
16
18
20
Water Injection Qlty.(l/min/m)

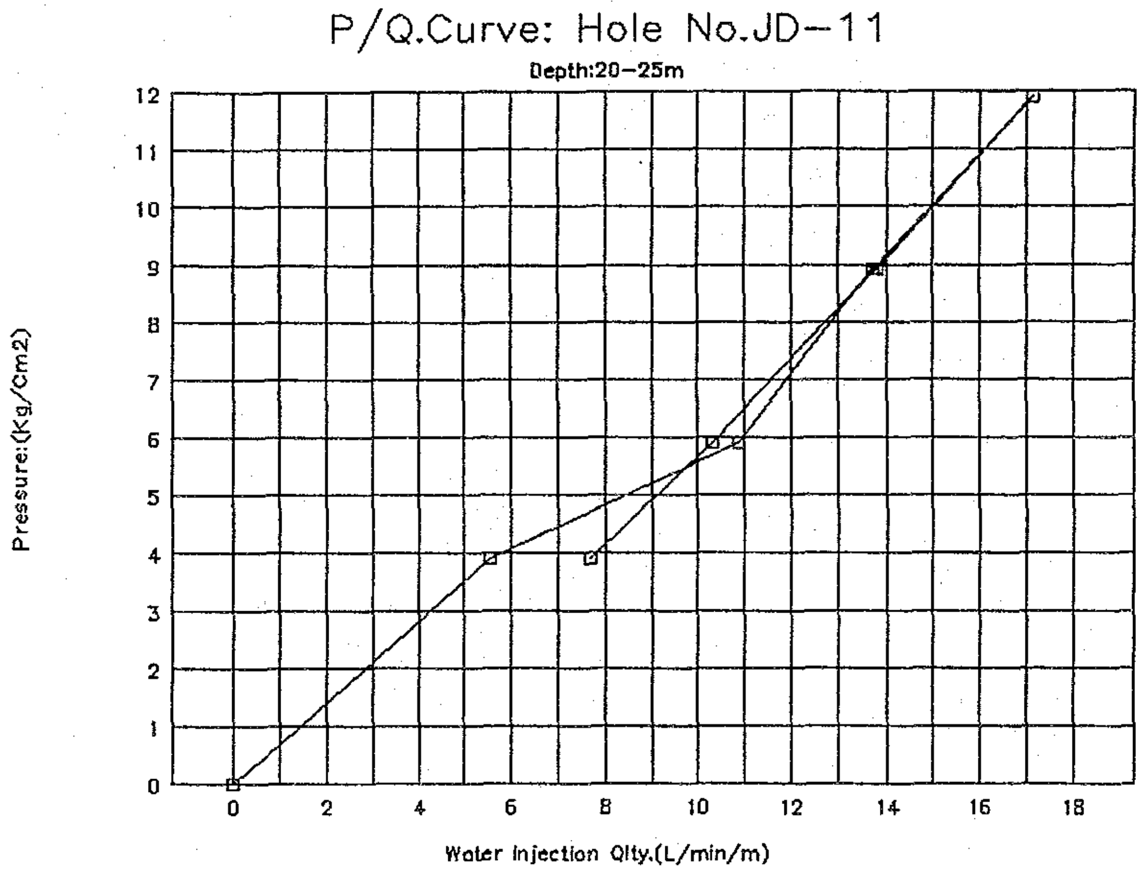

P/Q.Curve: Hole No.JD-4
Depth:40-45m
Pressure:(Kg/Cm2)
12
11
10
9
8
7
6
5
4
3
2
1
0
0
2
4
6
8
10
12
14
16
Water Injection Qlty.(l/min/m)



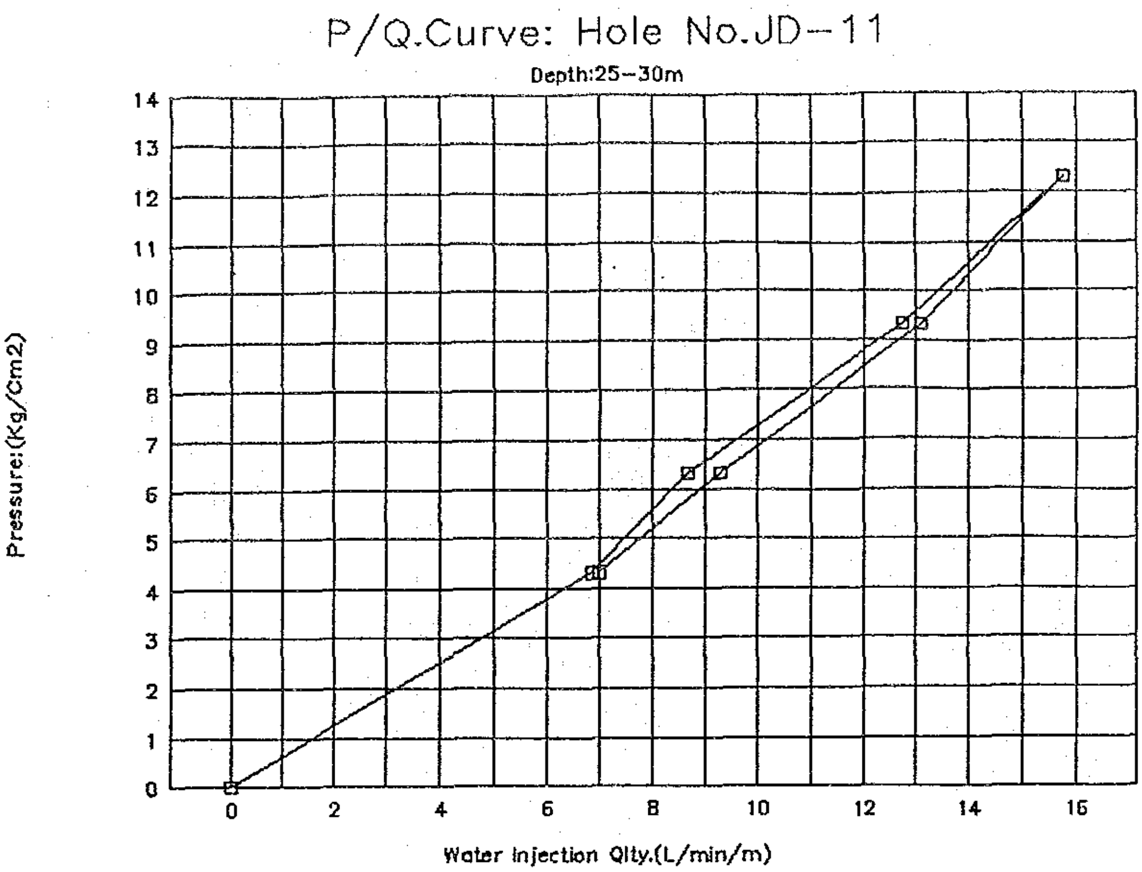
P/Q.Curve: Hole No.JD-4
Depth:45-50m
Pressure:(Kg/Cm2)
Water Injection Qlty.(l/min/m)
0
1
2
3
4
5
6
7
8
9
10
11
12
0
2
4
6
8
10
12
14
16
18
20



P/Q.Curve: Hole No.JD-11
Depth:15-20m
Pressure:(Kg/Cm2)
Water Injection Qlty.(L/min/m)
0
1
2
3
4
5
6
0
2
4
6
8
10
12
14
16



P/Q.Curve: Hole No.JD-11
Depth:20-25m
Pressure:(Kg/Cm2)
Water Injection Qlty.(L/min/m)
0
1
2
3
4
5
6
7
8
9
10
11
12
0
2
4
6
8
10
12
14
16
18


P/Q.Curve: Hole No.JD-11
Depth:25-30m
Pressure:(Kg/Cm2)
Water Injection Qlty.(L/min/m)