THE GOVERNMENT OF MAURITIUS
MINISTRY OF ENERGY, WATER RESOURCES AND POSTAL SERVICES
CENTRAL WATER AUTHORITY

THE DETAILED DESIGN ON THE PORT LOUIS WATER SUPPLY PROJECT IN MAURITIUS

FINAL REPORT (2)

DATA BOOK

FOR

LOT II : CIVIL WORKS(DAM AND APPURTENANT STRUCTURES INCLUDING CLOSURES OF DIVERSION TUNNEL)

MARCH 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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PART I HYDRAULIC DESIGN CALCULATION

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1. Spillway

1.1 Hydraulic Design Value

An energy coefficient "a" in the following equation is assumed to be 1.0 in this design calculation:

$$Hv = aV^2/(2g) \quad \text{(Eq. 1)}$$

where,
- hv : velocity head in m
- h : mean velocity in m/s
- g : acceleration of gravity (= 9.8 m/s^2)

Manning's coefficient of roughness is assumed as shown in the below:

1)	Approach channel	—	friction loss in neglected
2)	Side channel trough	—	friction loss in neglected
3)	Transition channel	0.014	
4)	Chuteway	0.018	for assessment of water level
		0.008	for assessment of specific energy of flow to be dissipated

1.2 General Layout

General layout of the spillway is as shown in Fig. 1.1. Basic condition for design of the spillway are determined by the basic design as summarized below:

(1) Discharge

(a) Probable maximum flood — 1,890 m3/s

(2) Reservoir water level

(a) Normal high water level (= crest elevation of uncontrolled overflow weir) — EL. 189.0 m

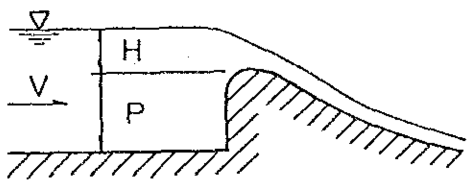
(b) Design flood water level — EL. 193.5 m

1.3 Hydraulic Design of Approach Channel

Approach channel has such a hydraulic function as to guide water from the reservoir to the overflow crest under stable and low velocity flow condition without causing excessive turbulence and abrupt changes in velocity of approach. For attaining this function there are the following design criteria:

(1a)	$P/H \geq 0.2$	(To restrict decrease of discharge coefficient due to downstream apron effect within 10 per cent)
(1b)	$P/H \geq 0.7$	(To eliminate downstream apron effect on discharge coefficient of overflow crest)
(2)	$V \leq 4.0$ m/s	(For approach channel protection)
(3)	$Fr \leq 0.4$	(For stable subcritical flow)

where,
- P : overflow crest height measured from approach channel floor, in m
- H : overflow head above overflow crest apex, in m
- V : Velocity of approach, in m/s
- Fr : Froude number of approaching flow



For above condition of (1a) is normally adopted to minimize downstream apron effect on discharge coefficient. However, the severer condition of (1b) is herein adopted so as to ensure design discharge capacity independently from the downstream apron elevation in the side channel trough. When bottom elevation of the approach channel is set at EL. 185.0 m being 4.0 m lower than the overflow crest elevation, all the above conditions are satisfied as shown below:

<u>For Spillway Design Discharge</u>

(1b) $P = 4.0$ m

$H = 193.5 - 189.0 = 4.5$ m

Then, $P/H = 0.889 > 0.7$

(2) $Q = 1{,}890\ m^3/s$

$q = Q/B$

$= 1{,}890/90 = 21.0\ m^3/s/m$

$V = q/(H + P)$
$= 21.0/(4.5 + 4.0)$
$= 2.47$ m/s < 4.0 m/s

(3) $Fr = q/[g(H + P)^3]^{1/2}$
$= 21.0/[9.8\ (4.5 + 4.0)^3]^{1/2}$
$= 0.271 < 0.4$

It is then concluded from a hydraulic point of view that the bottom elevation of approach channel is to be set at or below EL. 185.0 m that is 4.0 m below the uncontrolled overflow crest. Actural bottom elevation of the approach channel is determined at EL. 185.0 m through the layout design taking into account the topographic and geologic conditions of the site as well as arrangement with the other structures.

1.4 Hydraulic Design of Uncontrolled Overflow Crest

An uncontrolled overflow crest is provided so as to make spillway discharge only dependent on the reservoir water level and not to be affected by the downstream flow condition.

1.4.1 Profile of uncontrolled overflow crest

The profile consists of the following 4 parts (refer to Fig. 1.2).

(1) Upstream vertical face
(2) Compound circular curve upstream from the cest apex
(3) Semi-nappe curve from the crest apex to the point P where the curve has a slope of l=0.8
(4) Straight line having a slope of l=0.8

The downstream slope of l=0.8 is determined from a viewpoint of the stability of the overflow weir.

Semi-nappe curve of the overflow crest are designed by the following equation:

$$Y/Ho = -K\ (X/Ho)^n \quad \text{......................................} \quad \text{(Eq. 2)}$$

where, Ho : design head of overflow weir
= 4.5 m
K,n : constants depending on slope of upstream face of the weir and velocity of approach. To be read from Fig. 1.3.

Discharge per meter of overflow crest is obtained below for the spillway design discharge:

$$q = Q/B$$
$$= 1{,}890/90$$
$$= 21.0\ m^3/s/m$$

Velocity of approach Va and its velocity head ha are expressed by the equations:

$$Va = q/(P + ho) \quad \text{..} \quad \text{(Eq. 3)}$$
$$ha = Va^2/(2g)$$

where, ho = Ho - ha = 4.5 - ha

Eq. (3) is solved to obtain Va = 2.57 m/s and ha = 0.34 m as shown below:

$$ho = 4.5 - 0.34$$
$$= 4.16\ m$$
$$Va = 21.0/(4.0 + 4.16)$$
$$= 2.57\ m/s$$
$$ha = 2.57^2/(2 \times 9.8)$$
$$= 0.34\ m$$

A parameter ha/Ho will then be:

$$ha/Ho = 0.34/4.5$$
$$= 0.076\ m$$

With this parameter, the constants K and n are read from Fig. 1.3 as follows:

$K = 0.511, n = 1.842$

Then, the curve from apex of the crest (origin of coordinates X and Y) to a point P shown in Fig. 1.2 is given by the following equation:

$Y/4.5 = -0.511\ (X/4.5)^{1.842}$ .... (Eq. 4)

or

$Y = -0.144X^{1.842}$

Coordinates of the point P is given with a condition that the curve has a slope of l=0.8 at this point P as follows:

$Y' = -0.144 \times 1.842X^{0.842} = -1/0.8$

Then, coordinates X and Y of the point P will be:

$X = [1/(0.8 \times 0.144 \times 1.842)]^{1/0.842} = 6.305$ m

$Y = -0.144 \times 6.305^{1.842} = -4.279$ m

Parameters for a compound circular curve that is adapted as an upstream profile from the crest apex are also read from Fig. 1.3. They are:

$Xc/Ho = 0.248$	$Yc/Ho = 0.099$
$R_1/Ho = 0.492$	$R_2/Ho = 0.205$

Substituting the design head Ho=4.5 m to the above equations, coordinates (Xc, Yc) of the upstream end point of the compound circular curvature and their radii R_1 and R_2 are obtained as follows:

$Xc = -1.116$ m	$Yc = -0.437$ m
$R_1 = 2.214$ m	$R_2 = 0.923$ m

Profile of the uncontrolled overflow crest are thus determined as shown in Fig. 1.2.

1.4.2 Discharge coefficient

The discharge over an ogee crest is given by the formula:

$$Q = CBH^{1.5} \quad \text{...} \quad \text{(Eq. 5)}$$

where,
- Q : discharge in m^3/s
- C : a variable coefficient of discharge
- B : effective length of crest, in m
- H : total head on the crest, in m, including velocity of approach head, ha

The discharge coefficient C in the above formula usually varies from 2.0 to 2.2 for the design head of the overflow crest depending on the bottom elevation of approach channel, shape of crest profile, downstream apron effect and tailwater effect.

Bottom elevation of the approach channel and shape of the uncontrolled overflow crest profiles have been determined. The side channel trough will be designed so that the downstream water level will not affect coefficient of discharge of the overflow crest as a free overflow.

The discharge coefficient for the design head of Ho=4.5m is checked in accordance with the Iwasaki's formula as follows:

$$Cd = 2.200 - 0.0416(H/P)^{0.990} \quad \text{.........................} \quad \text{(Eq. 6)}$$

$$C = 1.60\,[1 + 2a(H/Hd)]/[1 + a(H/Hd)]$$

where,
- Cd : coefficient of discharge at H=Hd
- C : coefficient of discharge at an operating head of H
- Hd : design head (=4.5 m)
- H : total head on the crest, in m, including velocity of approach head ha
- P : crest height measured from approach channel floor (=4.0 m)
- a : constant, to be solved from equation
  C = Cd at H = Hd

Substituting H=4.5 m and P=4.0 m to Eq. 6 discharge coefficient is estimates to be 2.153 as follows:

$$C = 1.60\,[1 + 2a(H/Hd)]/[1 + a(H/Hd)]$$

$$= 1.60\,(1 + 2a)/(1 + a) = 2.153$$

Solving the above equation for "a"

$$a = 0.5281$$

Then, discharge coefficient for operating heads other than the discharge head are given by the equation:

$$C = 1.60\,[1 + 1.0562\,(H/Hd)]/[1 + 0.5281\,(H/Hd)]$$
$$= 1.60\;(1 + 0.2347H)/(0.1173H) \quad \text{.................. (Eq. 7)}$$

Estimated Discharge Coefficient and Discharge Capacity
of Uncontrolled Overflow Crest

R.W.L. (EL. m)	H (m)	C	Q (m^3/s)
189.0	0	-	0
189.5	0.5	1.689	54
190.0	1.0	1.768	159
190.5	1.5	1.839	304
191.0	2.0	1.904	485
191.5	2.5	1.963	698
192.0	3.0	2.017	943
192.5	3.5	2.066	1,218
193.0	4.0	2.111	1,520
193.5	4.5	2.153	1,890

Note: $Q = 90CH^{1.5}$

The estimated discharge rating curve of the controlled overflow crest is shown in Fig. 1.4. These discharge coefficients and discharge capacities are, however, subject to modification based on the results of hydraulic model test.

1.5 Hydraulic Design of Side Channel Trough and Transitional Channel

Water spilt from the uncontrolled overflow crest is collected in the side channel trough and is guided to the chuteway through by the transitional channel.

1.5.1 Section and profile of side channel trough

1) Cross section

Cross section of the side channel trough consists of 2 side walls and 1 floor slab. The uncontrolled overflow weir forms a wall in the reservoir side having a slope of 1=0.8. The mountain side wall is designed to be 1=0.15. Bottom width of the side channel trough is determined through trial designs to be 25.0 m at its downstream end and 12.5 m at its upstream end respectively.

2) Profile

The side channel trough has a length of 90 m being equal to the crest length of the overflow weir. Bottom slope of the side channel trough is 1=45. Bottom elevation at the downstream end of the side channel trough is EL. 176.0 m and one at the upstream end is EL. 178.0 m respectively.

1.5.2 Flow condition in side channel

There are the following criteria for hydraulic design of side channel trough:

i) Flow in a channel trough is to be subcritical to attain large water depth and low flow velocity in the trough for good diffusion of incoming water from overflow crest with water bulk in the trough.

ii) Water level in side channel trough at its upstream end is to be set below such level as not to cause downstream submergence of overflow or:

$$D \leq (2/3)\,H \quad \text{(Eq. 8)}$$

where, D : water depth in the side channel trough at its upstream end measured from the overflow crest, in m

H : operating head of flow over the overflow crest, in m

The second condition will be checked in paragraph 1.5 based on the water surface profile calculation.

For attaining subcritical flow in the side channel trough and transitional channel as well as to keep certain water depth in the trough for discharge less than the spillway design discharge, a control sill is provided at the downstream end of the transitional channel. However, for securing subcritical flow in the trough under the spillway design discharge, bottom slope of the side channel trough is designed at a gentler slope than the critical slope ic for the spillway design discharge.

The critical slope ic is checked below for the downstream 9.0 m reaches of the side channel trough. This section interval is taken as 10 per cent of the trough length 90 m.

1) Design conditions and critical flow

				Section 1 at 9.0 m upstream	Section 2 at downstream end
a)	Design discharge	Q	(m^3/s)	1,701	1,890
b)	Bottom width	B	(m)	23.75	25.0
c)	Critical depth	D	(m)	7.55	7.75
d)	Critical flow area	A	(m2)	206.39	222.28
e)	Critical flow velocity	V	(m/s)	8.24	8.50
f)	Hydraulic radius at critical flow	R		5.03	5.10

The above values are obtained by the following equation where subscript 1 denotes values of the upstream section "1" of the reaches and subscript 2 denotes ones of the downstream end section "2":

(a) Q2 = 1,890 m^3/s (spillway design discharge)

Q1 = (1,890/90) x 81

= 1,701 m^3/s

(b) B2 = 25.0 m

B1 = 12.5 + (12.5/90) x 81

= 23.75 m

(c) Critical depth, area, velocity and hydraulic radius of each section are obtained by solving the following equation for critical flow in an open channel by trial and method:

$$[(1Q2)/(gA3)]\ \frac{dA}{dD} = 1 \ \ldots\ldots\ldots\ldots \quad \text{(Eq. 9)}$$

$$\frac{dA'}{dD} = Bs$$

where, a : energy coefficient (=1.0)

g : acceleration of gravity (9.8 m/s2)

Q : discharge in m3/s

A : (2B + 0.95D) D/2

B : bottom width of channel, in m

Bs : channel width of water surface, in m
= B + 0.95D

D : water depth in m

R : A/(B + 2.29D)

2) Critical slope ic

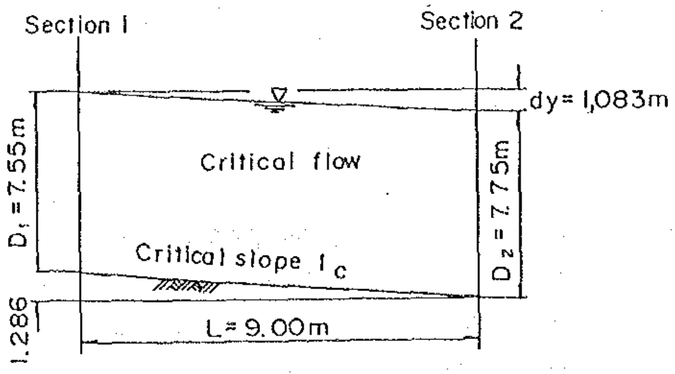
A channel having the same section and discharge with the designed side channel trough but having the critical channel slope ic for the spillway design discharge is first assumed. In this case, flow will be critical throughout the channel reaches of 9 m.

Water level rise "dy" in this assumed channel reaches from the downstream end section "2" to the upstream section "1" is estimated by the Hinds formula as shown below:

$$dy = (Q_1/g)\,[(V_1 + V_2)/(Q_1 + Q_2)]\,[(V_2 - V_1) + V_2\,(Q_2 - Q_1)/Q_1] \ \ldots\ldots \quad \text{(Eq. 10)}$$

$$= (1{,}890/9.8) \times [(8.50 + 8.24)/(1{,}890 + 1{,}701)]$$
$$\times [(8.50 - 8.24) + 8.50 \times (1{,}890 - 1{,}701)/1{,}701]$$
$$= 1.083$$

Accordingly, profile of this channel reaches will be as shown below:



From the above figure, the critical slope ic is obtained as follows:

$$ic = [(D2 + dy) - D1] / L \quad \text{(Eq. 11)}$$
$$= [(7.75 + 1.083) - 7.55] / 9.0$$
$$= 1/7.0$$

The design channel slope of 1/45 is gentler than the critical slope of 1/7.0 resulting subcritical flow in the side channel trough under the spillway design discharge even without the control sill at the end of the transitional channel.

1.5.3 Section and profile of transition channel

The transitional channel conveys water collected in the side channel trough to the chuteway under subcritical flow. The transitional channel is designed as shown below:

(1) Cross section

(a)	Type	Rectangular
(b)	Width	25.0 m

(2) Profile

(a)	Channel length	50.0 m
(b)	Channel slope	1 = 1,000
(c)	Bottom elevation at the upstream end	EL. 176.0 m
(d)	Bottom elevation at the downstream end	EL. 175.950 m

(3) Plan — Straight axis

(4) Control sill at the downstream end

(a) Height above channel floor 1.042 m

(b) Slope of upstream face vertical

Width of the transitional channel is determined to be the same with that of the side channel trough at its downstream end in view of stable flow. A control sill is provided at the downstream end of the transitional channel to realize subcritical flow in the upstream transitional channel and the side channel trough even for discharge less than the spillway design discharge as well as smooth flow transition from subcritical in the upstream channels to supercritical in the downstream chuteway. Height of the control sill is assumed to be 1.0 m referring to other spillways, and is subject to modification by a hydraulic model test.

1.5.4 Flow condition in transitional channel

For securing subcritical flow in the transitional channel the channel slope needs to be gentler than the critical slope ic for the spillway design discharge. The critical slope ic is obtained below:

(1) Critical depth

Critical depth Dc in a rectangular section is given by:

$$Dc = [(aQ^2) / (gB^2)]^{1/3} \quad \text{(Eq. 12)}$$

where, Dc : critical depth in m

a : energy coefficient (=1.0)

g : acceleration of gravity (=9.8 m/s^2)

Q : discharge (=1,890 m^3/s)

B : channel width (=25 m)

Substituting respective values to Eq. 11, the critical depth is obtained as follows:

$$Dc = 1{,}890^2 / (9.8 \times 25^2)]^{1/3}$$
$$= 8.35 \text{ m}$$

(2) Critical slope

Critical slope ic is equal to a friction loss slope of the critical flow, or:

$ic = (n^2Q^2) / (Rc^{4/3}Ac^2)$ .... (Eq. 13)

where, ic : critical slope for Q

n : Manning's coefficient of roughness (=0.014)

Q : discharge (=1,890 m^3/s)

Rc : critical hydraulic radius in m

Ac : critical flow area in m^2

Based on the critical depth of Dc = 8.35 m, the critical slope ic is obtained by Eq. 12 below:

$$
\begin{aligned}
Ac &= BDc \\
&= 25 \times 8.35 \\
&= 208.75 \text{ m}^2
\end{aligned}
$$

$$
\begin{aligned}
Rc &= Ac/(B + 2Dc) \\
&= 208.75/(25 + 2 \times 8.35) \\
&= 5.01 \text{ m}
\end{aligned}
$$

Hence, the critical slope is:

$$
\begin{aligned}
ic &= (0.014^2 \times 1{,}890^2) / (5.01^{4/3} \times 208.75^2) \\
&= 0.00187 \\
&= 1/535
\end{aligned}
$$

The design channel slope of i = 1/1,000 is gentler than the above critical slope of ic = 1/535. Therefore, flow in the transitional channel at the spillway design discharge will be subcritical even without the control sill at its downstream end.

1.5.5 Water surface profile in side channel trough and transitional channel

Water surface profile in the transitional channel is first checked in accordance with the following equation for non-uniform flow in an open channel:

$$\frac{dh}{dX} = \frac{i - \frac{n^2}{R^{4/3}} \left(\frac{Q}{A}\right)^2 + \frac{aQ^2}{gA^3} \frac{\partial A}{\partial X}}{1 - \frac{aQ^2 B}{gA^3}} \quad \text{.............................} \quad \text{(Eq. 14)}$$

where,
h : water depth in m
X : coordinate along channel, in m
i : channel slope (= 1/1000)
n : Manning's coefficient of roughness (=0.014)
Q : discharge in m^3/s
R : hydraulic radius in m
A : flow area in m^2
a : energy coefficient (= 1.0)
g : acceleration of gravity (= 9.8 m/s^2)
B : channel width (= 25 m)

Boundary condition of Eq. 13 is given as a critical depth on the control sill provided at the downstream end of the transitional channel. The critical depth is given by Eq. 11. The non-uniform flow calculation is made from this downstream end toward upstream end of the transitional channel for the design discharge.

Calculation results for the transitional channel are summarized below:

Discharge (m^3/s)	Water level at (in m)		
	Control weir	Upstream end (1)	Upstream end (2)
1,890	184.3	185.15	187.6/1

/1 with loss of head due to the gradual contraction from the trapezoidal section to the rectangular section

In between the transitional channel and the side channel is a loss of head due to the gradual contraction from the trapezoidal section to the rectangular section. This gradual contraction is not yet taken into account in the water level that are obtained by the non-uniform flow analyses. The loss of head h1 and the depth D1 at the entrance to the gradual contraction are given by:

$$h_1 = 0.2\ (V_2^2 - V_1^2)\ /\ (2g) \quad \text{..............................} \quad \text{(Eq. 15)}$$

$$D_1 = D_2 + h_1 + (V_2^2 - V_1^2)\ /\ (2g) \quad \text{....................} \quad \text{(Eq. 16)}$$

where,
V1 : velocity before the contraction, in m/s
V2 : velocity after the contraction, in m/s

D1	:	depth before the contraction, in m
D2	:	depth after the contractor, in m
h1	:	loss of head due to the gradual contraction in m
g	:	acceleration of gravity (= 9.8 m/s^2)

The loss is obtained as follows:

$$V2 = 1{,}890/(25.0 \times 9.15) = 8.26 \text{ m/s}$$
$$A1 = (25 \times 2 + 0.95 \times 11.6) \times 11.6/2 = 353.9 \text{ m}^2$$
$$V1 = 1{,}890/353.9 = 5.34 \text{ m/s}$$
$$h1 = 0.2\,(8.26^2 - 5.34^2) / (2 \times 9.8)$$
$$= 0.405$$
$$D1 = 9.15 + 0.405 + (8.26^2 - 5.34^2) / (2 \times 9.8)$$

With this depth at the downstream end for the discharge, water surface profile in the side channel trough are obtained by the Hinds equation (E1. 10).

Water level and depth at the upstream end, and velocity and Froude number at the downstream end of the side channel trough are summarized below:

	at upstream end		at downstream end			
Discharge (m^3/s)	Water level (El. m)	Depth/1 (m)	Velocity (m/s)	Depth (m)	Area (m^2)	Fr. No./2
1,890	190.93	+1.93	5.00	12.0	368.4	0.5

/1: Measured from the overflow crest EL. 189.0 m
/2: $Fr = V/(gD)^{1/2}$, D = A/T

where,	Fr	:	Froude number
	V	:	velocity in m/s
	A	:	flow area in m^2
	T	:	channel width at water surface, in m = B + 0.95D
	D	:	depth, in m, measured from the channel floor
	B	:	bottom width (+ 25 m at the downstream end)

Water level at the upstream end will be EL. 190.93 m exceeding the overflow crest elevation by 1.93 m. As shown below, this depth in the side channel trough measured from the overflow crest satisfies the criterion set forth by Eq. 8:

$$D/H_{max} = 1.93/4.5$$
$$= 0.429 < 2/3$$

1.5.6 Freeboard of transitional channel

Wall around the side channel trough are raised up to EL. 196.0 m being equal to the dam crest elevation. This wall height around the side channel trough high enough in view of the specific energy of the incoming water that will be EL. 193.5 m at the maximum flood.

Due to such layout of the transitional channel as across the dam axis and spillway bridge, the side walls along the transitional channel are also raised up to the dam crest elevation at EL. 196.0 m except downstream 15 m reaches where the wall height is gradually reduced.

Freeboard for each point are as shown below:

Point	Water level (EL. m)	Wall elevation (EL. m)	Freeboard (m)
Upstream end	187.6	196.0	8.4
Control weir	184.3	186.0	1.7

As shown in the above figure, the design wall is higher enough for the design flood discharge.

1.6 Hydraulic Design of Chuteway

Chuteway has such a hydraulic function as safely to convey high velocity flow from the control sill provided at the upstream end of the chuteway to the energy dissipator at the downstream end.

1.6.1 Section and profiles of chuteway

The chuteway is designed as straight reaches in plan and profile joined by vertical curves. Its dimensions are determined as described below:

(1) Cross section

(a) Type — Rectangular

(b) Channel width — 30 m

(2) Profile

(a)	Channel slope	1 : 2.0
(b)	Horizontal length of channel	131.0 m
(c)	Bottom elevation at BP of the chuteway	EL. 177.0 m
(d)	Bottom elevation at EP of the chuteway	EL. 112.0 m

1.6.2 Water surface profile in chuteway

Water surface profiles in the chuteway are obtained by Eq. 14 for non-uniform flow. Since the flow is supercritical the calculation is made from the upstream end, for which a boundary condition is given as a critical depth on the control sill, toward the downstream end.

As the required adjustment factor of depth due to the channel slope of l=1.6875 is in the order of $\cos\theta = 0.86$, the steep slope effect on the channel flow is neglected in the non-uniform analysis.

Manning's coefficient of roughness is assumed at n=0.018 to be conservative in checking water surface profile in and freeboards of the chuteway in accordance with the criteria set forth in the design criteria report.

Result is presented in Table-1.1.

Another non-uniform flow calculation is made for the spillway design discharge with Manning's n=0.008 to be conservative in estimating energy of the incoming flow to the stilling basin. Result is presented in Table 1.2.

1.6.3 Freeboard of chuteway

There is an empirical formula which gives a resalable indication of desirable freeboard values. The formula is expressed in the form of:

$$\text{Freeboard (m)} = 0.6 + 0.037VD^{1/3} \quad \text{.................... (Eq. 17)}$$

where, V : velocity, in m/s
D : depth of flow, in m

Substituting velocity and depth of flow that are presented in 1.6.2 to the above formula, the minimum freeboard required against the spillway design discharge (Q=1,890 m^3/s) at representative sections are obtained as follows:

Required Minimum Wall Height of Chuteway

STA.	Depth (m)	Velocity (m/s)	Freeboard (m)	D + Fb (m)
0	7.399	8.515	1.21	8.61
0+50	2.631	23.95	1.82	4.45
0+100	2.071	30.42	2.03	4.10
0+145.34	1.835	34.33	2.16	4.00

As shown in the above table, the design wall is higher than the required minimum against the spillway design discharge.

1.7 Hydraulic Design of Stilling Basin

Energy of the flow in the chuteway will be dissipated in the stilling basin before returning to the downstream river channel.

1.7.1 Section and profiles of stilling basin

The energy dissipator is determined to be a stilling basin type having a horizontal apron with end sill. The basin has a rectangular cross section. Design condition of the stilling basin are as follows:

(1)	Design discharge	1,040 m^3/s
(2)	Tailwater level at the design discharge (assumed)	EL. 126.0
(3)	Depth of incoming flow from the chuteway	0.968 m
(4)	Froude number of incoming flow the chuteway	11.63

The above depth and Froude number of the incoming flow are obtained by the non-uniform flow analysis for the chuteway, of which results are presented in 1.6.2.

Based on the above design conditions, the stilling basin is designed as summarized below:

(1)	Floor elevation of the stilling basin	EL. 112.0
(2)	Top elevation of the end sill	EL. 121.0

(3)	Water level after hydraulic jump without backwater effect of tailwater level	EL. 125.97
(4)	Tailwater level (assumed)	EL. 126.0
(5)	Top elevation of the protection wall	EL. 130.0
(6)	Length of the stilling basin	80.0 m
(7)	Width of the stilling basin	30.0 m
(8)	Height of the end sill measured from apron surface	1.0 m
(9)	Height of the protection wall measured from apron surface	18.0 m

1.7.2 Hydraulic jump

Based on the design conditions, hydraulic jump in the stilling basin is checked as follows:

(1) Hydraulic jump

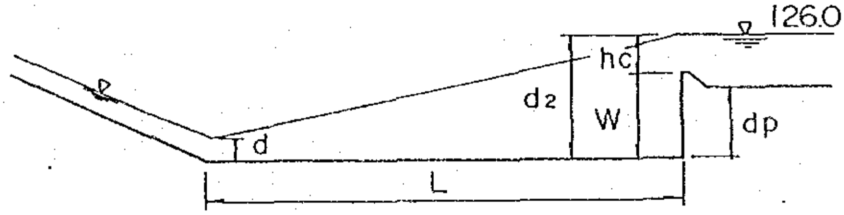
Since the Froude number of the incoming flow of 11.63 is higher than 4.5, a true hydraulic jump will form in the stilling basin. A conjugate depth and length of the hydraulic jump in a horizontal channel is given by the equations:

$$\frac{W}{d} = \frac{(1 + 2Fr^2)\sqrt{1 + 8Fr^2} - 1 - 5Fr^2}{1 + 4Fr^2 - \sqrt{1 + 8Fr^2}} - \frac{3}{2}Fr^{2/3} \quad \text{(Eq. 18)}$$

$$L = 6d_2 \quad \text{(Eq. 19)}$$

where,

W	:	height of end sill
Fr	:	Froude number before jump = $V/\sqrt{gd}$
d	:	depth before jump
V	:	velocity before jump



Substituting the respective values to the above equations, the conjugate depth and length of the hydraulic jump are:

$d = 0.968$ m	$v = 35.81$ m/s	$Fr = 11.63$
$\frac{W}{d} = 8.521$	$W = 8.248$	$hc = 4.968$

$d2 = W + hc = 13.22$ m $dp = 13.22 - 6.0 = 7.22$ m

$L = 6 \times 13.22 = 79.3$ m

Bottom EL. 120.0 - 7.22 = 112.78 m

Based on the above length (79.3 m) of hydraulic jump in a horizontal channel, length of the stilling basin L is determined to be 80 m in the conservative side. The floor elevation of the stilling basin will then to be EL. 112.0 m.

Table 1.1 WATER SURFACE PROFILE IN CHUTEWAY (n=0.018, Q=1,890m3/s)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
STA.	Water depth	Area	Velocity	(V^2)/2g	Water surface width	Hydraulic depth	R^(4/3)	Surface slope	Mean surface slope	Friction loss head	Bottom elevation	Total energy	
		A	V		P	R		SF	MSF	HF	BM	EG.H	EG.H'
	(m)	(m2)	(m/s)		(m)	(m)				(m)	(El.m)	(El.m)	(El.m)
0	7.399	221.97	8.515	3.699	44.8	4.954	8.447	0.00028	-	-	177.00	188.10	-
0+50	2.631	78.93	23.95	29.25	35.26	2.238	2.928	0.0634	0.0318	1.593	154.64	186.52	186.51
0+100	2.071	62.13	30.42	47.21	34.14	1.82	2.222	0.135	0.0992	4.959	132.28	181.56	181.56
0+145.34	1.835	55.05	34.33	60.14	33.67	1.635	1.926	0.198	0.1665	7.555	112.00	173.98	174.00

Note :

(4) = 1,890 / (3) (6) = 2 x (2) + 30.0 (7) = (3) / (6) (9) = 0.018^2 * (4)^2 / (8)

(11) = (10) * L (13) = (12) + (2) + (5) (14) = EG.H(n-i) - (11)

Table 1.2 **WATER SURFACE PROFILE IN CHUTEWAY** (n=0.008, Q=1,040m3/s)

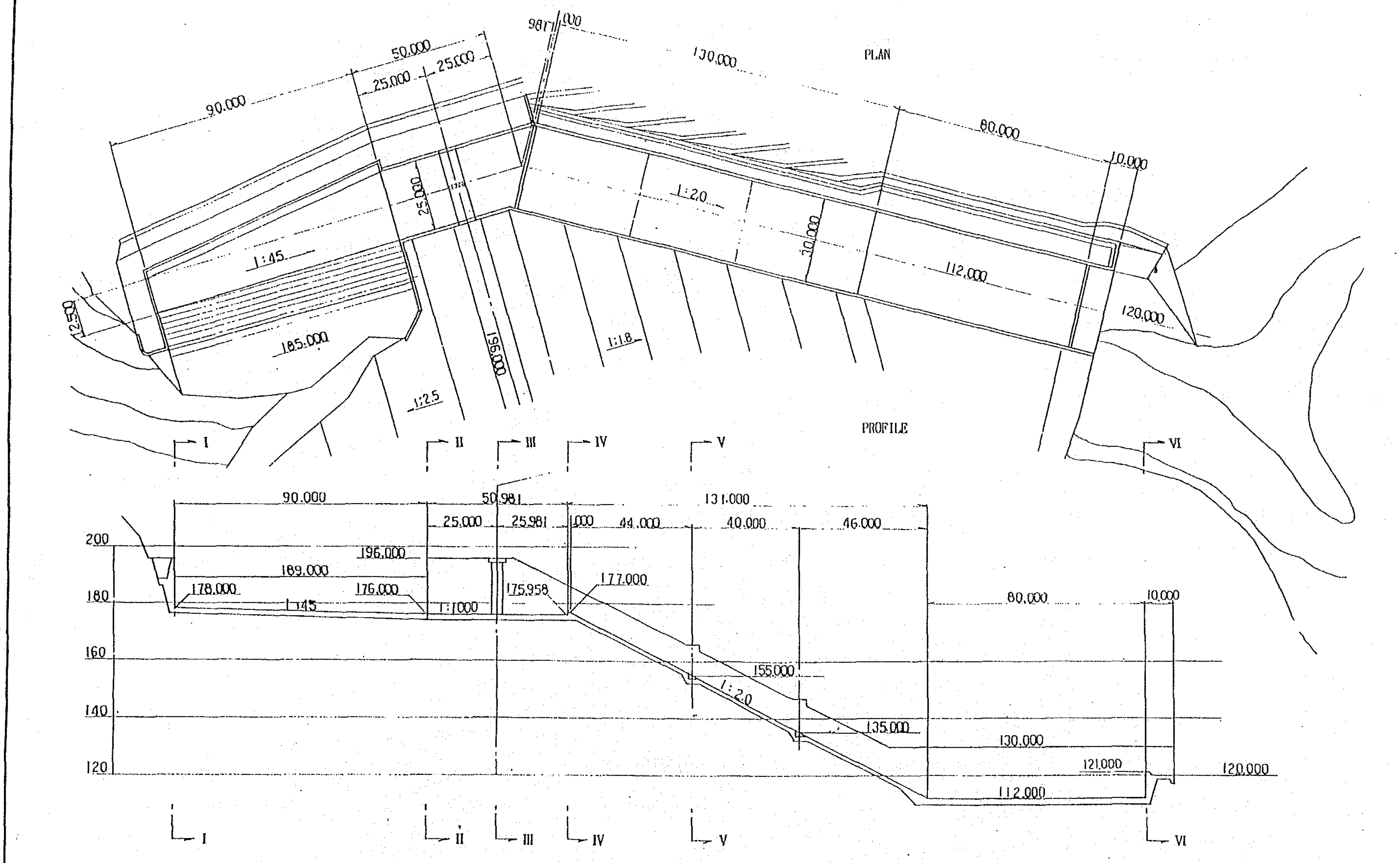
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
STA.	Water depth	Area	Velocity	(V^2)/2g	Water surface width	Hydraulic depth	R^(4/3)	Surface slope	Mean surface slope	Friction loss head	Bottom elevation	Total energy	
		A	V		P	R		SF	MSF	HF	BM	EG.H	EG.H'
	(m)	(m2)	(m/s)		(m)	(m)				(m)	(El.m)	(El.m)	(El.m)
0	4.968	149.04	6.978	2.484	39.94	3.732	5.789	0.00054	-	-	177.00	184.45	-
0+50	1.487	44.61	23.31	27.73	32.97	1.353	1.496	0.0232	0.0119	0.593	154.64	183.86	183.86
0+100	1.125	33.75	30.81	48.45	32.25	1.047	1.062	0.057	0.0401	2.005	132.28	181.85	181.86
0+145.34	0.968	29.04	35.81	65.44	31.94	0.909	0.881	0.0928	0.0749	3.397	112.00	178.41	178.45

Note :

(4) = 1,040 / (3) (6) = 2 x (2) + 30.0 (7) = (3) / (6) (9) = 0.008^2 * (4)^2 / (8)

(11) = (10) * L (13) = (12) + (2) + (5) (14) = EG.H(n-i) - (11)

Fig. 1.1



ORIGINAL DESIGN OF SPILLWAY

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PORT LOUIS WATER SUPPLY PROJECT

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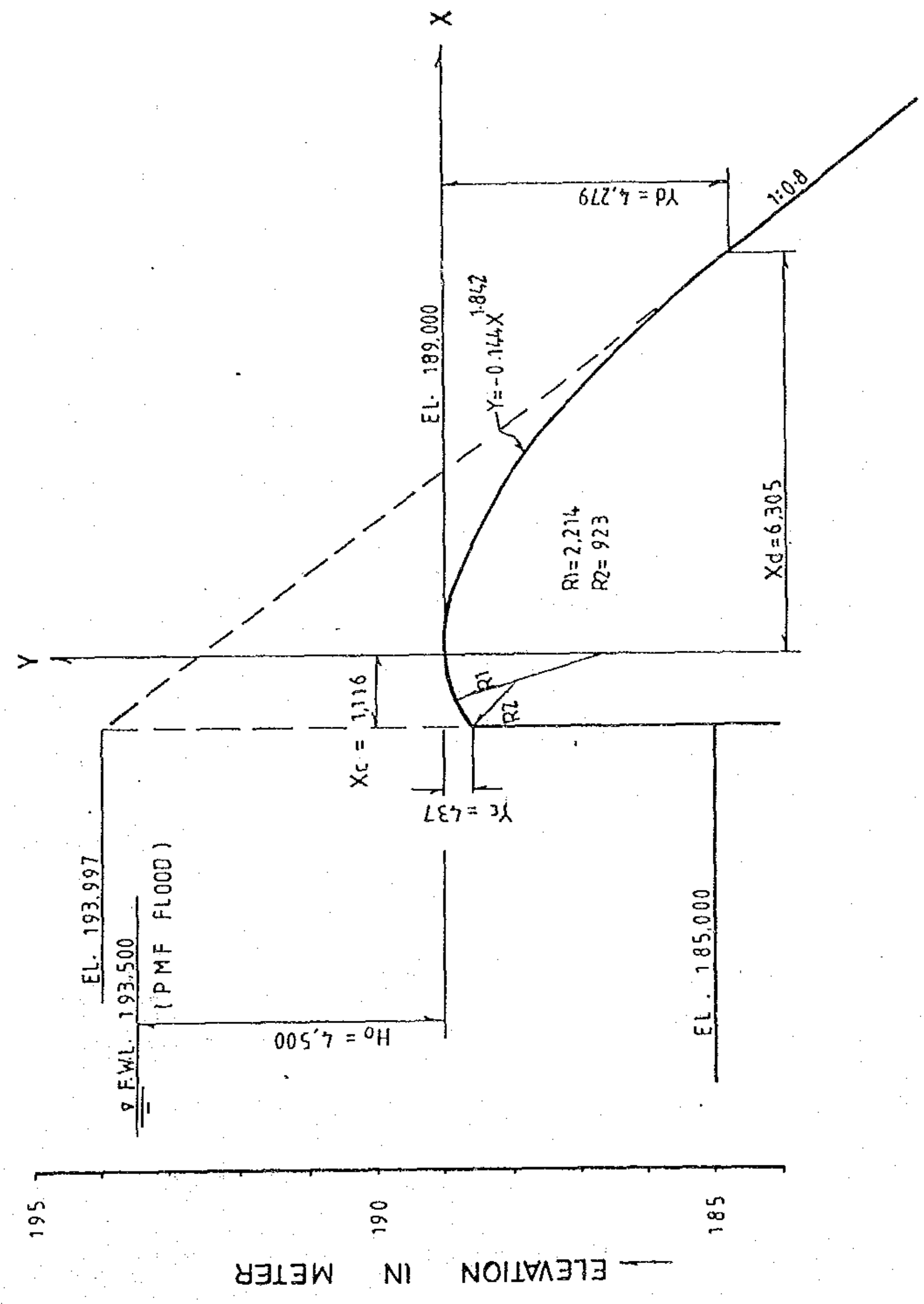
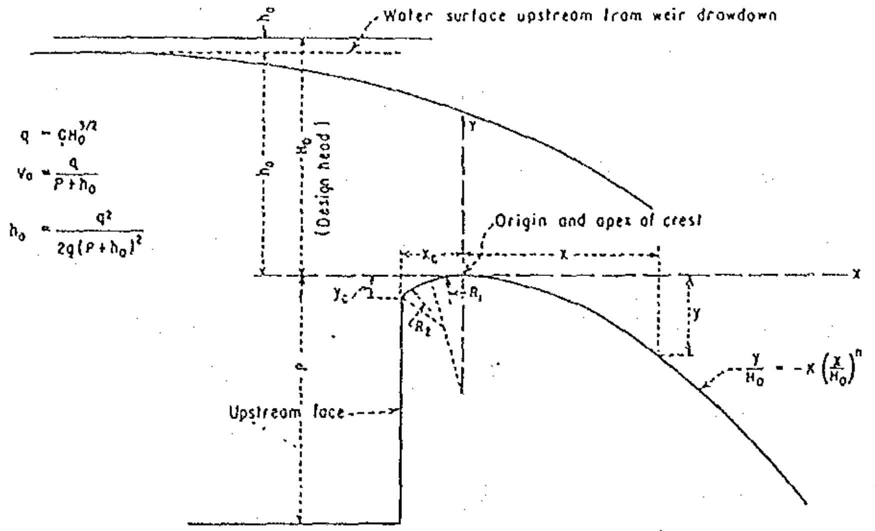
Fig. 1.2

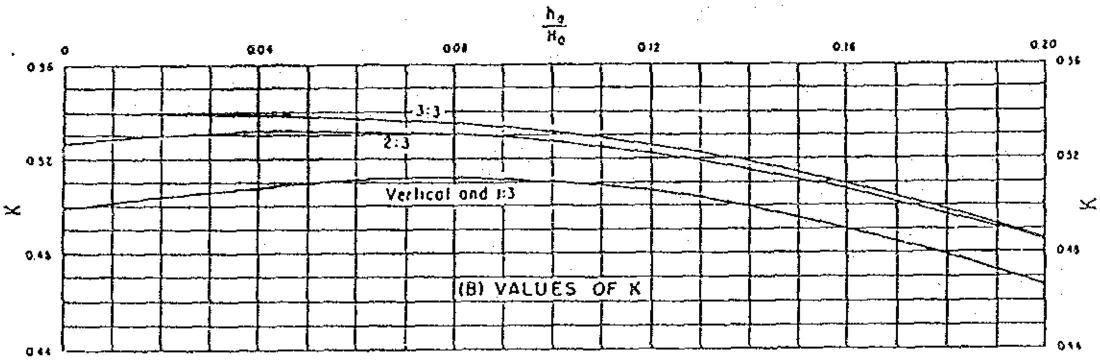


UNCONTROLED OVERFLOW WEIR	GOVERNMENT OF MAURITIUS PORT LOUIS WATER SUPPLY PROJECT
	JAPAN INTERNATIONAL COOPERATION AGENCY

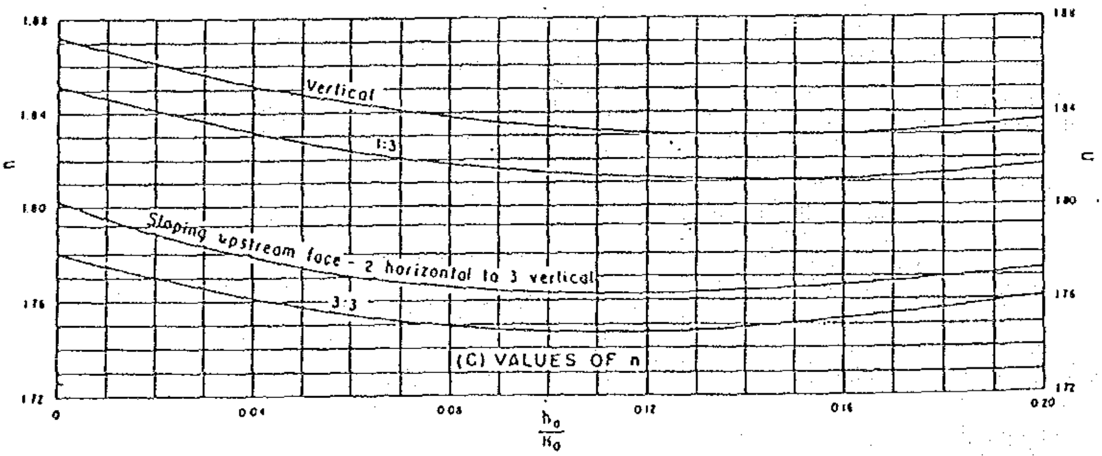
Fig. 1.3(1)



(A) ELEMENTS OF NAPPE-SHAPED CREST PROFILES



(B) VALUES OF K



(C) VALUES OF n

FACTORS OF DEFINITION OF NAPPE-SHAPED CREST PROFILE (1/2)

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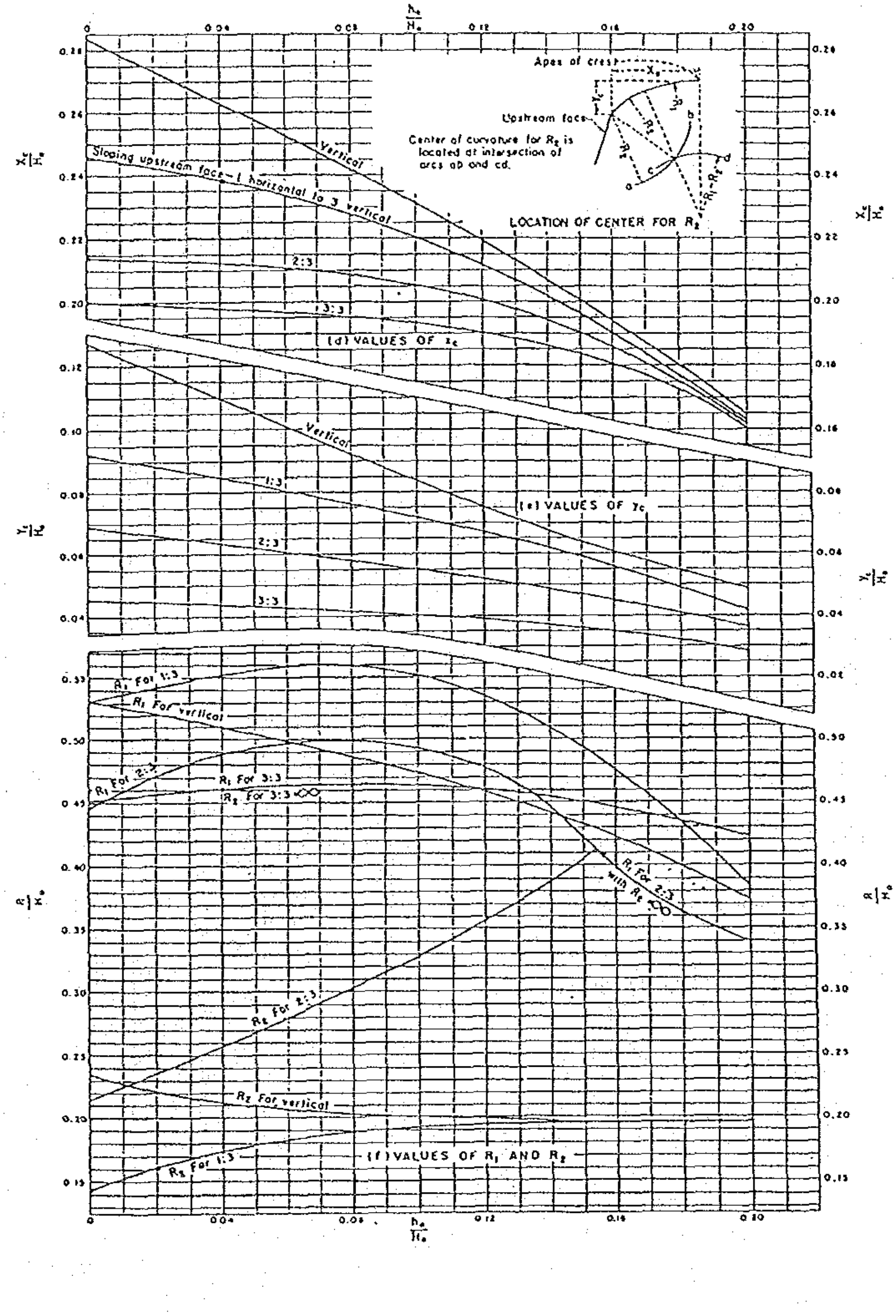
Fig. 1.3(2)



FACTORS OF DEFINITION OF NAPPE-SHAPED CREST PROFILE (2/2)

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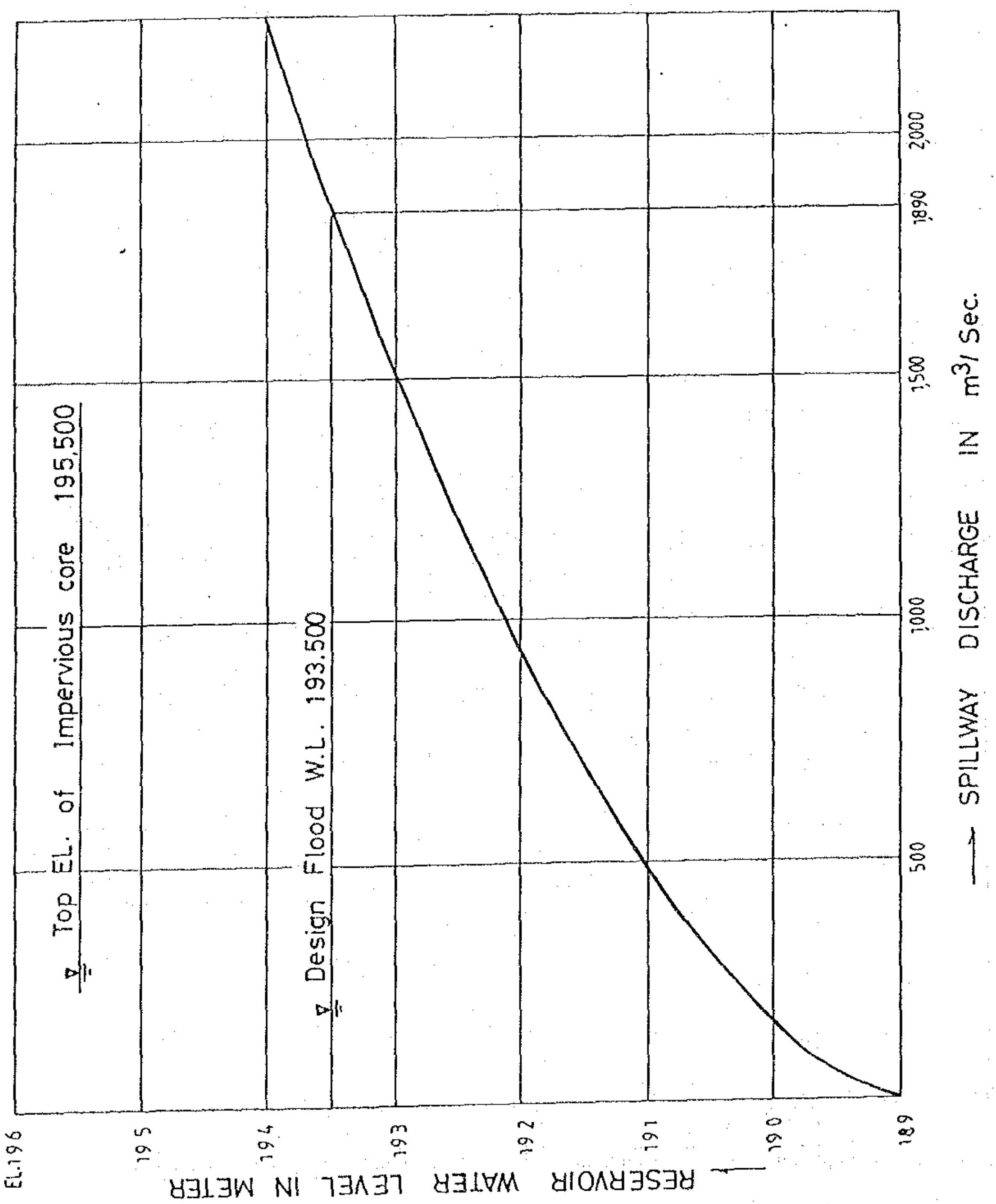
Fig. 1.4



RATING CURVE OF OVERFLOW WEIR

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

PART II STABILITY ANALYSIS

PART II STABILITY ANALYSIS

2.1 Main Dam and Cofferdam

2.1.1 Method of Dam Stability Analysis

The dam stability is analyzed by the slip circular method which examines trially the safety against slip along various assumed failure circles.

The factor of safety is given by the following equation:

$$Fs = \frac{\Sigma\{C \times L + (N - U - Ne) \times \tan \Phi\}}{\Sigma (T + Te)}$$

where,

Fs	:	Factor of safety
N	:	normal force acting on slip circle of each slice
T	:	tangential force acting on slip circle of each slice
U	:	pore pressure acting on slip circle of each slice
Ne	:	normal force of earthquake load acting on slip circle of each slice
Te	:	tangential force of earthquake load acting on slip circle of each slice
Φ	:	angle of internal friction of materials on slip circle of each slice
C	:	cohesion of materials on slip circle of each slice
L	:	arc length of slip circle of each slice
Σ	:	Summation for all slices

The factor of safety without earthquake force is obtained by substitution Ne = 0 and Te = 0 into the above equation. The normal force (N) and tangential force (T) are defined as:

$$N = W \cos \theta + Pn = W \cos \theta + P \sin \theta$$
$$T = W \sin \theta + Pt = W \sin \theta + P\cos \theta$$

where,

θ	:	angle between horizontal and the tangent of the arc at slice
W	:	total weight of slice (embankment and water)

$$W = (D1\ wet\ .h1 + D1\ sat\ .h2 + D2\ sat\ .h3)^* \Delta X$$

or $$W = (D2\ wet\ .h4 + D2\ sat\ .h5)^* \Delta X$$

in which

ΔX : width of a slice

Di wet	:	wet density of material (i)
Di sat	:	saturated density of material (i)
hi	:	height of a slice of material (i)
P	:	differential water pressure acting on both sides of a slice

$$P = Dw\ (h2 + h3 - \Delta X/2 \times \tan\theta) \times \Delta X \times \tan\theta$$
$$= (h2 + h3) \times \Delta X/2 \times \tan\theta \qquad (Dw = 1.0\ t/m^3)$$

The normal and tangential forces due to earthquake are defined as follows:

$$Ne = W \times k \times \sin\theta$$
$$Te = W \times k \times \cos\theta$$

where,

k : horizontal seismic coefficient

Besides the above, the safety should be checked for plane surface sliding of cohesionless materials.

The factor of safety against plane surface sliding of cohesionless materials is given by the following equations. These equations are derived from the slip circular equation assuming a radius of circle to be infinite; that is, infinite slope.

(a) Submerged slopes (upstream slopes)

$$Fs = \frac{m - k \times R}{1 + k \times R \times m} \times \tan\phi$$

(b) Dry slopes (downstream slopes)

$$Fs = \frac{m - k}{1 + k \times m} \times \tan\phi$$

where,

Fs	:	factor of safety
m	:	slope gradient (1 : m)
k	:	horizontal seismic coefficient
ϕ	:	internal friction angle
R	:	Dsat/Dsub
D_{sat}	:	saturated density of material
D_{sub}	:	submerged density of material (Dsat - 1.0)

2.1.2 Design Value

The design values for dam stability analysis are determined on the basis of the field investigation results on construction materials.

Although Section 3.5 in Design Report for Lot-I "Dam Materials" of this report presents explanations on determination of design values, those are reproduced below:

<u>Design Values of Dam Materials</u>

Item		Earth	Filter Fine	Filter Coarse	Rock
Specific gravity		2.88			
(Oven dry condition)			2.87	2.87	2.87
Natural moisture content	(%)	40.00			
Water absorption			1.50	1.50	1.50
Dry density	(tf/m^3)	1.23	1.90	2.00	2.10
Wet density	(tf/m^3)	1.72	1.93	2.03	2.13
Saturated density	(tf/m^3)	1.80	2.23	2.30	2.37
Submerged density	(tf/m^3)	0.80	1.23	1.30	1.37
Coefficient of permeability	(cm/sec)	1×10^{-5}	1×10^{-3}	1×10^{-2}	1×10^{-1}
Strength parameter (effective stress analysis)					
Cohesion c'	(tf/m^3)	0.00	0.00	0.00	0.00
Internal friction angle (ø)	(degree)	30.00	36.00	38.00	40.00

The dam design considers that some talus deposits be left unexcavated in the rock zone of dam on the basis of dam stability analysis results. Design values for the talus deposits are conservatively assumed to be same as those of the fine filter material. Further, design values for coarse filter are also assumed to be same as those of fine filter for a conservative sake.

As for the seismic coefficient, the seismic coefficient of k = 0.05 is taken into consideration in the analysis in accordance with the standard which states that k = 0.05 should be taken into consideration even in areas having no earthquakes.

The safety factor which the dam has to secure is more than 1.2 in accordance with the standard.

2.1.3 Examined Cases

(1) Present Scheme and Future Expansion Scheme

The present project design considers to make it possible to expand the dam height if required in future.

Thus, the dam stability and dam slope should be examined in due consideration of both the present and expanded schemes. Further, the safety of the main cofferdam should be confirmed.

Hence, the dam stability is examined for the following three (3) cases:

(a):	Present scheme	(Dam crest	EL. 196.0 m)
(b):	Expanded scheme	(Dam crest	EL. 215.0 m)
(c):	Main cofferdam	(Dam crest	EL. 155.5 m)

(2) Loading Conditions

The dam will be subject to various loading conditions for which the safety of dam should be ensured.

In accordance with the standard, the dam stability is examined for the following loading conditions:

(a) Reservoir normal high water level with the full seismic load.
(b) Rapid drawdown of water level with the full seismic load.
(c) Immediately after completion with a half of seismic load.
(d) Design flood water level without seismic load.

(3) Dam Sections

Talus deposits will remain in the upstream rock zone foundation of left bank and in the downstream rock zone foundation of right bank where the critical sliding failure circles appear.

Therefore, the following two dam sections are taken into consideration in the analysis:

(a) Left bank dam section which include talus deposits for determination of upstream dam slope.

(b) Right bank dam section which include talus deposits for determination of downstream dam slope.

2.1.4 Results of Stability Analysis

The computer program calculated the factor of safety for various assumed failure circles in respective cases and indicated the minimum value of the factor of safety in respective cases, which are summarized in Table 2.1.1 to Table 2.1.4. The failure circle along which the minimum value of safety factor appeared is shown in Fig. 2.1.1 to Fig. 2.1.5.

As seen, the factor of safety more than 1.2 is surely secured in the upstream dam slope of 1 to 2.3 and downstream dam slope of 1 to 1.8.

Under the above slope of dam, the safety for plane surface sliding is also secured as follows:

<u>Submerged slope (upstream slope)</u>

$$Fs = \frac{m - k \cdot R}{1 + k \cdot R \cdot m} \times \tan \phi$$

$$= \frac{2.3 - 0.05 \times \frac{2.37}{1.37}}{1 + 0.05 \times \frac{2.37}{1.37} \times 2.3} \times \tan 40^\circ$$

$$= \frac{2.213}{1.199} \times 0.839 = 1.548 > 1.2$$

<u>Dry slope (downstream slope)</u>

$$Fs = \frac{m - k}{1 + k \cdot m} \times \tan \phi$$

$$= \frac{2.3 - 0.05}{1 + 0.05 \times 2.3} \times \tan 40^\circ$$

$$= 1.693 > 1.2$$

2.2 Examination on Soft Layers in Dam Foundation

2.2.1 General

The geology of both abutments of the dam site consists of alternate layers of hard basalt layer and weathered soft layer.

Fig. 2.2.1 shows situations of hard basalt layers,weathered soft layers, and talus deposits to be removed. The impervious core to be embanked on such alternate layers may cause differential settlements, resulting in occurrence of cracks in the impervious core.

Such being the case, analyses of deformation and stress by the Finite Element Method(F.E.M.) are made to provide countermeasures if necessary.

The analyses are made with a model as shown in Fig. 2.2.2. Elastic moduli used in the analyses are assumed on the basis of the in-situ rock tests carried out in the test adits as follows:

	Elastic Modulus (kg/cm^2)
Hard basalt	55,000
Soft layer	2,000
Core material	500

The unit weight of 1.8 t/m^3 which is the saturated density of core material is assumed for the impervious core material and core material depth of about 80 m is considered as loading on the foundation, taking the future expansion of dam into consideration. The unit weight of the hard basalt and soft layer is disregarded with consideration that it provides negligibly small effect on the result of analysis.

2.2.2 Analyses of Deformation and Stress

In order to clarify the effect due to the soft layer, the analyses of deformation and stress are made for the following two cases:

CASE (i): Case that the foundation consists only of the hard basalt; that is, the foundation is wholly provided with elastic modulus of $E = 55,000\ kg/cm^2$.

CASE (ii): Case that the foundation is intercalated with the soft layer as shown in Fig. 2.2.2.

The analysis by F.E.M. are made with the following model.

1) Number of nodal point : 84

2) Number of element : 72

Fig. 2.2.3 and Fig. 2.2.4 show stress distributions for CASE (i) and CASE (ii), respectively.

Deformations are calculated as tabulated in Table 2.2.1 and Table 2.2.2 and as shown below:

Point No.	Deformation (m) CASE (i)	CASE (ii)
34	-2.188×10^{-4}	-2.09×10^{-4}
40	-4.873×10^{-4}	-5.50×10^{-3}
46	-7.466×10^{-4}	-1.03×10^{-2}
52	-9.746×10^{-4}	-1.06×10^{-2}
58	-1.166×10^{-3}	-7.05×10^{-3}
64	-1.321×10^{-3}	-4.21×10^{-3}

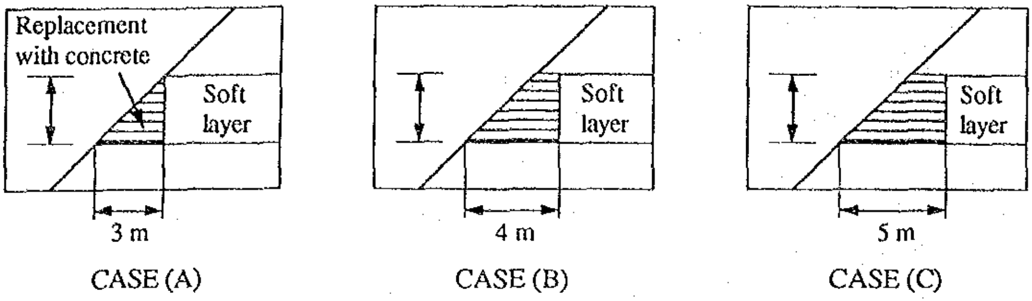
As seen in the above, a remarkable effect on deformations due to the intercalated soft layer is recognized.

2.2.3 Results of Analyses

As seen in Fig. 2.2.3 which shows the case that the foundation is assumed to consist wholly of the hard basalt, no tensions arise in the impervious core and foundation. However, in the case that the foundation is intercalated with the soft layer as shown in Fig. 2.2.4, tensions occur in the core and upper hard basalt layer due to deformations of the soft layer, suggesting that there is possibility of damage on the hard basalt layer and serious occurrence of cracks in the impervious core and that some countermeasure is required.

2.2.4 Examination on Dam Foundation Treatment

Therefore, examinations are made to find a suitable and effective countermeasure; that is, the following three (3) cases of replacement with concrete are examined with stress analyses by the Finite Element Method.



Results of stress analyses for the above three (3) cases are given in Fig. 2.2.5, Fig.2.2.6 and Fig. 2.2.7, respectively.

As seen in the above figures, tensions still occur in the upper hard layer in CASE (A) and CASE (B). The tension disappears in CASE (C).

The above analyses reveal that the replacement with concrete up to a depth of about 1.7 times thickness of the soft layer will be the efficient countermeasure to ensure the safety. Based on the above, the design of dam foundation treatment considers to replace with concrete up to the depth of 2.0 times soft layer thickness for the soft layers of core zone. The replacement will be made with lean concrete.

Table 2.1.1 RESULTS OF DAM STABILITY ANALYSIS
(Dam Scheme: Present Scheme (Dam Crest EL. 196.0 m),
Dam Section: Left Bank Dam Section)

MF-01: Case Name
SFN : Safety Factor in Normal Condition
SFE : Safety Factor in Seismic Condition

Case	Water Level	Seismic Coefficient	Upstream 1:2.3	Downstream 1:1.8
Reservoir Full	189.00	0.05	MO-01 SFN = 1.926 SFE = 1.568	MO-01 SFN = 1.533 SFE = 1.367
Rapid Drawdown (1)	155.50	0.05	MO-02 SFN = 1.979 SFE = 1.722	MO-02 SFN = 1.533 SFE = 1.367
Rapid Drawdown (2)	164.00	0.05	MO-03 SFN = 1.883 SFE = 1.594	MO-03 SFN = 1.533 SFE = 1.367
After Completion	—	0.025	MO-04 SFN = 1.979 SFE = 1.849	MO-04 SFN = 1.533 SFE = 1.446
Design Flood	193.50	—	MO-05 SFN = 1.979 SFE = —	MO-05 SFN = 1.533 SFE = —

Table 2.1.2 RESULTS OF DAM STABILITY ANALYSIS
(Dam Scheme: Expanded Scheme (Dam Crest EL. 215.0 m),
Dam Section: Left Bank Dam Section)

MF-01: Case Name
SFN : Safety Factor in Normal Condition
SFE : Safety Factor in Seismic Condition

Case	Water Level	Seismic Coefficient	Upstream		Downstream
			1:2.3	1:2.5	1:1.8
Reservoir Full	209.00	0.05	MF-01 SFN = 1.711 SFE = 1.387	MF-02 SFN = 1.881 SFE = 1.509	MF-01 SFN = 1.533 SFE = 1.366
Rapid Drawdown (1)	155.50	0.05	MF-03 SFN = 1.506 SFE = 1.294	MF-04 SFN = 1.620 SFE = 1.386	MF-03 SFN = 1.533 SFE = 1.366
Rapid Drawdown (2)	174.00	0.05	MF-05 SFN = 1.523 SFE = 1.289	MF-06 SFN = 1.620 SFE = 1.378	MF-05 SFN = 1.533 SFE = 1.366
After Completion	—	0.025	MF-07 SFN = 1.543 SFE = 1.435	MF-08 SFN = 1.597 SFE = 1.469	MF-07 SFN = 1.533 SFE = 1.446
Design Flood	212.50	—	MF-09 SFN = 1.831 SFE = —	MF-10 SFN = 1.982 SFE = —	MF-09 SFN = 1.533 SFE = —

Table 2.1.3 RESULTS OF DAM STABILITY ANALYSIS
(Dam Scheme: Expanded Scheme (Dam Crest EL. 215.0 m),
Dam Section: Right Bank Dam Section)

MF-01: Case Name
SFN : Safety Factor in Normal Condition
SFE : Safety Factor in Seismic Condition

Case	Water Level	Seismic Coefficient	Upstream 1:2.3	Downstream 1:1.8
Reservoir Full	209.00	0.05	—	MFR-01 SFN = 1.464 SFE = 1.276

Table 2.1.4 RESULTS OF DAM STABILITY ANALYSIS
(Main Coffer Dam (Dam Crest EL. 155.5 m))

MF-01: Case Name
SFN : Safety Factor in Normal Condition
SFE : Safety Factor in Seismic Condition

Case	Water Level	Seismic Coefficient	Upstream 1:2.3	Downstream 1:1.8
Rapid Drawdown	138.00	0.05	C-01 SFN = 1.843 SFE = 1.546	C-01 SFN = 1.604 SFE = 1.426
After Completion	—	0.025	C-02 SFN = 1.998 SFE = 1.866	C-02 SFN = 1.604 SFE = 1.511
Design Flood	154.50	—	C-03 SFN = 1.997 SFE = —	C-03 SFN = 1.604 SFE = —

Table 2.2.1 DEFORMATION OF EACH POINT - CASE(i) (1/2)

```
****************************************************************************
*****         NODAL DISPLACEMENT AND TOTAL             STEP NO.=  1    *****
****************************************************************************
```

N.P. NUMBER	UX (m)	UY (m)	UR (m)
1	0.0000000E+00	-1.0271979E-01	0.0000000E+00
2	0.0000000E+00	-8.7651848E-02	0.0000000E+00
3	0.0000000E+00	-7.1400869E-02	0.0000000E+00
4	0.0000000E+00	-5.4330267E-02	0.0000000E+00
5	0.0000000E+00	-3.6681729E-02	0.0000000E+00
6	0.0000000E+00	-1.8510176E-02	0.0000000E+00
7	0.0000000E+00	0.0000000E+00	0.0000000E+00
8	-5.3622863E-03	-1.0142778E-01	0.0000000E+00
9	-3.0543975E-03	-8.6315933E-02	0.0000000E+00
10	-1.3293913E-03	-7.0080042E-02	0.0000000E+00
11	-5.5442548E-05	-5.3150016E-02	0.0000000E+00
12	9.1078696E-04	-3.5760388E-02	0.0000000E+00
13	1.5621862E-03	-1.8015834E-02	0.0000000E+00
14	1.7600523E-03	0.0000000E+00	0.0000000E+00
15	-1.0492305E-02	-9.7505337E-02	0.0000000E+00
16	-5.9102985E-03	-8.2228738E-02	0.0000000E+00
17	-2.6213990E-03	-6.5989502E-02	0.0000000E+00
18	-3.3467391E-04	-4.9360781E-02	0.0000000E+00
19	1.3445573E-03	-3.2774859E-02	0.0000000E+00
20	2.4997966E-03	-1.6286262E-02	0.0000000E+00
21	2.6590658E-03	0.0000000E+00	0.0000000E+00
22	-1.5061507E-02	-9.0863207E-02	0.0000000E+00
23	-8.2948293E-03	-7.5228989E-02	0.0000000E+00
24	-3.7243327E-03	-5.8821759E-02	0.0000000E+00
25	-8.0254267E-04	-4.2384292E-02	0.0000000E+00
26	9.3416249E-04	-2.6508352E-02	0.0000000E+00
27	2.0609085E-03	-1.2137157E-02	0.0000000E+00
28	8.0636964E-04	0.0000000E+00	0.0000000E+00
29	-1.8602162E-02	-8.1503671E-02	0.0000000E+00
30	-9.8446458E-03	-6.5240606E-02	0.0000000E+00
31	-4.2855649E-03	-4.8388512E-02	0.0000000E+00
32	-1.1335557E-03	-3.1653550E-02	0.0000000E+00
33	5.0584104E-04	-1.5617582E-02	0.0000000E+00
34	6.8566253E-04	-2.1876344E-04	0.0000000E+00
35	[illegible]	0.0000000E+00	0.0000000E+00
36	-2.0578023E-02	-6.9609894E-02	0.0000000E+00
37	-1.0116833E-02	-5.2456499E-02	0.0000000E+00
38	-3.9368980E-03	-3.4848809E-02	0.0000000E+00
39	-6.9984845E-04	-1.7531444E-02	0.0000000E+00
40	5.9079164E-04	-4.8734549E-04	0.0000000E+00
41	5.9076565E-04	-2.4266928E-04	0.0000000E+00
42	5.9157113E-04	0.0000000E+00	0.0000000E+00
43	-2.0400047E-02	-5.5616291E-02	0.0000000E+00
44	-8.7256976E-03	-3.7255475E-02	0.0000000E+00
45	-2.3163553E-03	-1.8883672E-02	0.0000000E+00
46	4.6382951E-04	-7.4663613E-04	0.0000000E+00
47	4.9133681E-04	-4.9313417E-04	0.0000000E+00
48	5.0040321E-04	-2.4553880E-04	0.0000000E+00
49	5.0201222E-04	0.0000000E+00	0.0000000E+00
50	-1.7656298E-02	-3.9753641E-02	0.0000000E+00

Table 2.2.1 DEFORMATION OF EACH POINT - CASE(i) (2/2)

****
***** NODAL DISPLACEMENT AND TOTAL STEP NO.= 1 *****
****

N.P. NUMBER	UX (m)	UY (m)	UR (m)
51	-5.2042155E-05	-2.0298235E-02	0.0000000E+00
52	3.0360208E-04	-9.7461326E-04	0.0000000E+00
53	3.6879222E-04	-7.2027881E-04	0.0000000E+00
54	3.9844347E-04	-4.7720049E-04	0.0000000E+00
55	4.0957991E-04	-2.3780886E-04	0.0000000E+00
56	4.1226687E-04	0.0000000E+00	0.0000000E+00
57	-1.0900992E-02	-2.2932983E-02	0.0000000E+00
58	1.1982905E-04	-1.1658737E-03	0.0000000E+00
59	2.2589947E-04	-9.1398270E-04	0.0000000E+00
60	2.7864119E-04	-6.7925334E-04	0.0000000E+00
61	3.0439300E-04	-4.5077321E-04	0.0000000E+00
62	3.1494330E-04	-2.2502874E-04	0.0000000E+00
63	3.1763571E-04	0.0000000E+00	0.0000000E+00
64	-6.1290546E-05	-1.3213185E-03	0.0000000E+00
65	5.0726078E-05	-1.0753676E-03	0.0000000E+00
66	1.4960878E-04	-8.5172885E-04	0.0000000E+00
67	1.8811465E-04	-6.3617489E-04	0.0000000E+00
68	2.0666591E-04	-4.2371469E-04	0.0000000E+00
69	2.1455985E-04	-2.1191330E-04	0.0000000E+00
70	2.1665527E-04	0.0000000E+00	0.0000000E+00
71	-1.8694568E-05	-1.2318442E-03	0.0000000E+00
72	3.6074870E-05	-1.0124245E-03	0.0000000E+00
73	7.5118589E-05	-8.0629122E-04	0.0000000E+00
74	9.4907087E-05	-6.0453645E-04	0.0000000E+00
75	1.0469276E-04	-4.0385358E-04	0.0000000E+00
76	1.0886077E-04	-2.0233751E-04	0.0000000E+00
77	1.0998298E-04	0.0000000E+00	0.0000000E+00
78	0.0000000E+00	-1.2154080E-03	0.0000000E+00
79	0.0000000E+00	-9.9395376E-04	0.0000000E+00
80	0.0000000E+00	-7.8980514E-04	0.0000000E+00
81	0.0000000E+00	-5.9306605E-04	0.0000000E+00
82	0.0000000E+00	-3.9659965E-04	0.0000000E+00
83	0.0000000E+00	-1.9884452E-04	0.0000000E+00
84	0.0000000E+00	0.0000000E+00	0.0000000E+00

Table 2.2.2 DEFORMATION OF EACH POINT - CASE(ii) (1/2)

```
***********************************************************************************
*****          NODAL DISPLACEMENT AND TOTAL          STEP NO.=  1            *****
***********************************************************************************
```

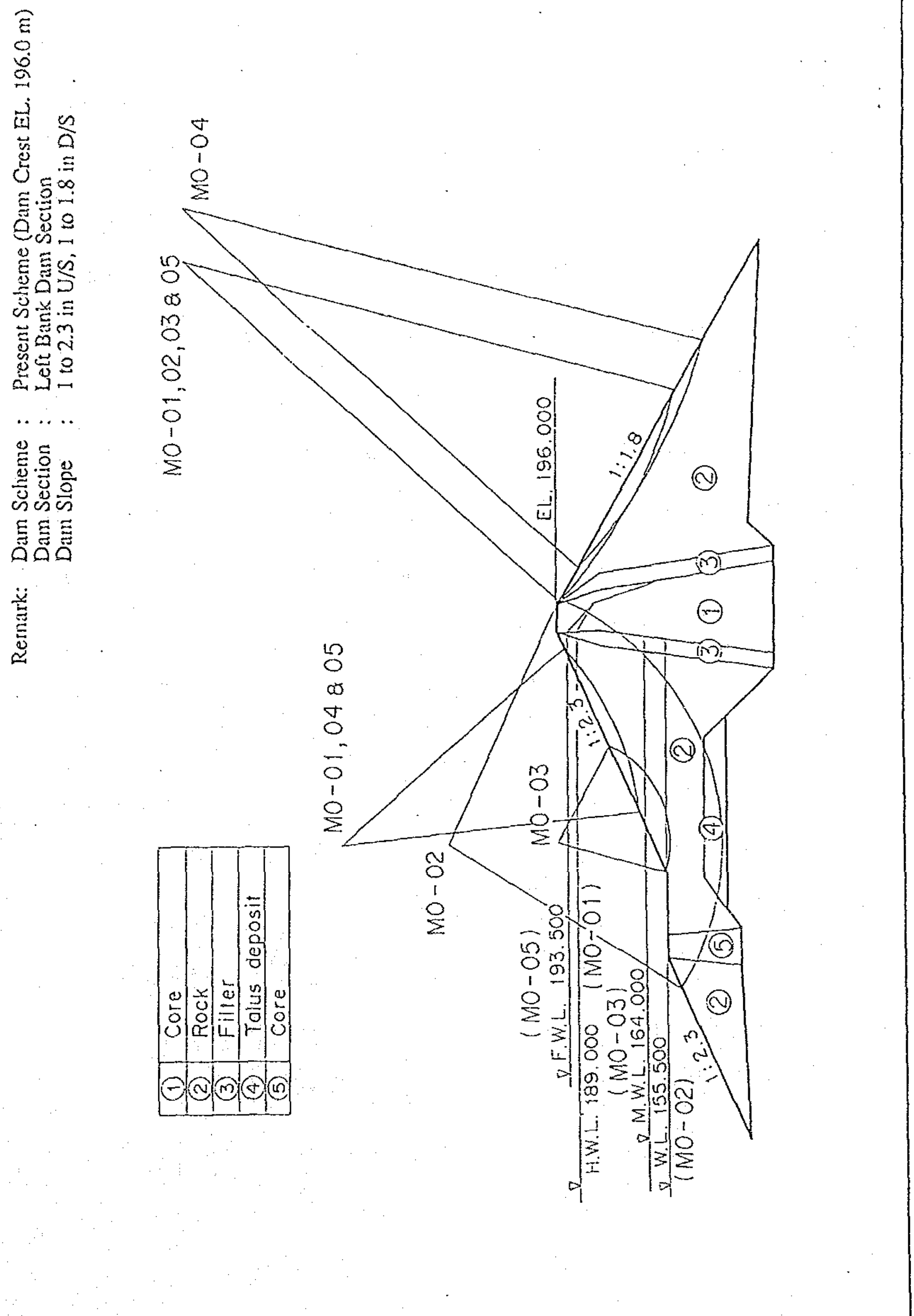
N.P. NUMBER	UX (m)	UY (m)	UR (m)
1	0.0000000E+00	-1.0480671E-01	0.0000000E+00
2	0.0000000E+00	-8.9241375E-02	0.0000000E+00
3	0.0000000E+00	-7.2609499E-02	0.0000000E+00
4	0.0000000E+00	-5.5210906E-02	0.0000000E+00
5	0.0000000E+00	-3.7243378E-02	0.0000000E+00
6	0.0000000E+00	-1.8803785E-02	0.0000000E+00
7	0.0000000E+00	0.0000000E+00	0.0000000E+00
8	-4.2976799E-03	-1.0371135E-01	0.0000000E+00
9	-2.3116684E-03	-8.8108352E-02	0.0000000E+00
10	-7.8187642E-04	-7.1470372E-02	0.0000000E+00
11	3.5652080E-04	-5.4167887E-02	0.0000000E+00
12	1.2218088E-03	-3.6431438E-02	0.0000000E+00
13	1.8311404E-03	-1.8357814E-02	0.0000000E+00
14	2.0353427E-03	0.0000000E+00	0.0000000E+00
15	-8.4295483E-03	-1.0039562E-01	0.0000000E+00
16	-4.4548733E-03	-8.4659798E-02	0.0000000E+00
17	-1.4748124E-03	-6.7957495E-02	0.0000000E+00
18	5.7517892E-04	-5.0793630E-02	0.0000000E+00
19	2.0184006E-03	-3.3700585E-02	0.0000000E+00
20	3.0785975E-03	-1.6767307E-02	0.0000000E+00
21	3.3083988E-03	0.0000000E+00	0.0000000E+00
22	-1.2192573E-02	-9.4795340E-02	0.0000000E+00
23	-6.2107953E-03	-7.8793686E-02	0.0000000E+00
24	-1.8805519E-03	-6.1860442E-02	0.0000000E+00
25	8.5966302E-04	-4.4605271E-02	0.0000000E+00
26	2.1355570E-03	-2.7766157E-02	0.0000000E+00
27	2.9334111E-03	-1.2753707E-02	0.0000000E+00
28	2.0752432E-03	0.0000000E+00	0.0000000E+00
29	-1.5349960E-02	-8.6840045E-02	0.0000000E+00
30	-7.3148335E-03	-7.0435460E-02	0.0000000E+00
31	-1.6677975E-03	-5.3078889E-02	0.0000000E+00
32	1.6387938E-03	-3.5357657E-02	0.0000000E+00
33	2.9145927E-03	-1.7696510E-02	0.0000000E+00
34	1.9804282E-03	-2.0925002E-04	0.0000000E+00
35	1.9635608E-03	0.0000000E+00	0.0000000E+00
36	-1.7625046E-02	-7.6424982E-02	0.0000000E+00
37	-7.5199608E-03	-5.9491701E-02	0.0000000E+00
38	-6.2158205E-04	-4.1768963E-02	0.0000000E+00
39	3.3300113E-03	-2.3624160E-02	0.0000000E+00
40	4.5629447E-03	-5.4982654E-03	0.0000000E+00
41	1.8633033E-03	-1.9637216E-04	0.0000000E+00
42	1.8256999E-03	0.0000000E+00	0.0000000E+00
43	-1.8622508E-02	-6.3354191E-02	0.0000000E+00
44	-6.5280987E-03	-4.5679214E-02	0.0000000E+00
45	1.0240967E-03	-2.7768074E-02	0.0000000E+00
46	5.6950535E-03	-1.0303684E-02	0.0000000E+00
47	4.4709826E-03	-5.0651368E-03	0.0000000E+00
48	1.6948313E-03	-1.6623805E-04	0.0000000E+00
49	1.6544053E-03	0.0000000E+00	0.0000000E+00
50	-1.7651723E-02	-4.7024637E-02	0.0000000E+00

Table 2.2.2 DEFORMATION OF EACH POINT - CASE(ii) (2/2)

****
***** NODAL DISPLACEMENT AND TOTAL STEP NO.= 1 *****
****

N.P. NUMBER	UX (m)	UY (m)	UR (m)
51	-4.0670235E-03	-2.8633144E-02	0.0000000E+00
52	3.2154680E-03	-1.0632131E-02	0.0000000E+00
53	5.0031740E-03	-7.1623705E-03	0.0000000E+00
54	4.3118545E-03	-3.8497939E-03	0.0000000E+00
55	1.4664738E-03	-1.1195683E-04	0.0000000E+00
56	1.4291067E-03	0.0000000E+00	0.0000000E+00
57	-1.2320660E-02	-2.8295682E-02	0.0000000E+00
58	-8.4380373E-05	-7.0454169E-03	0.0000000E+00
59	3.0595649E-03	-7.0275691E-03	0.0000000E+00
60	4.2085297E-03	-4.8415364E-03	0.0000000E+00
61	3.6204424E-03	-2.6101140E-03	0.0000000E+00
62	1.1739864E-03	-5.4170864E-05	0.0000000E+00
63	1.1416782E-03	0.0000000E+00	0.0000000E+00
64	-2.2111000E-03	-4.2126706E-03	0.0000000E+00
65	7.3467234E-05	-4.0339283E-03	0.0000000E+00
66	2.4677993E-03	-3.9668334E-03	0.0000000E+00
67	3.1425251E-03	-2.8628768E-03	0.0000000E+00
68	2.6726862E-03	-1.6627851E-03	0.0000000E+00
69	8.2140828E-04	-3.8948608E-06	0.0000000E+00
70	7.9801726E-04	0.0000000E+00	0.0000000E+00
71	-1.4726554E-03	-1.8353686E-03	0.0000000E+00
72	7.1800944E-05	-1.4496698E-03	0.0000000E+00
73	1.5374427E-03	-1.5733809E-03	0.0000000E+00
74	1.6762339E-03	-1.3229138E-03	0.0000000E+00
75	1.5086420E-03	-9.3399966E-04	0.0000000E+00
76	4.3043335E-04	3.5606852E-05	0.0000000E+00
77	4.0266353E-04	0.0000000E+00	0.0000000E+00
78	0.0000000E+00	0.0000000E+00	0.0000000E+00
79	0.0000000E+00	0.0000000E+00	0.0000000E+00
80	0.0000000E+00	0.0000000E+00	0.0000000E+00
81	0.0000000E+00	0.0000000E+00	0.0000000E+00
82	0.0000000E+00	0.0000000E+00	0.0000000E+00
83	0.0000000E+00	0.0000000E+00	0.0000000E+00
84	0.0000000E+00	0.0000000E+00	0.0000000E+00

Fig. 2.1.1

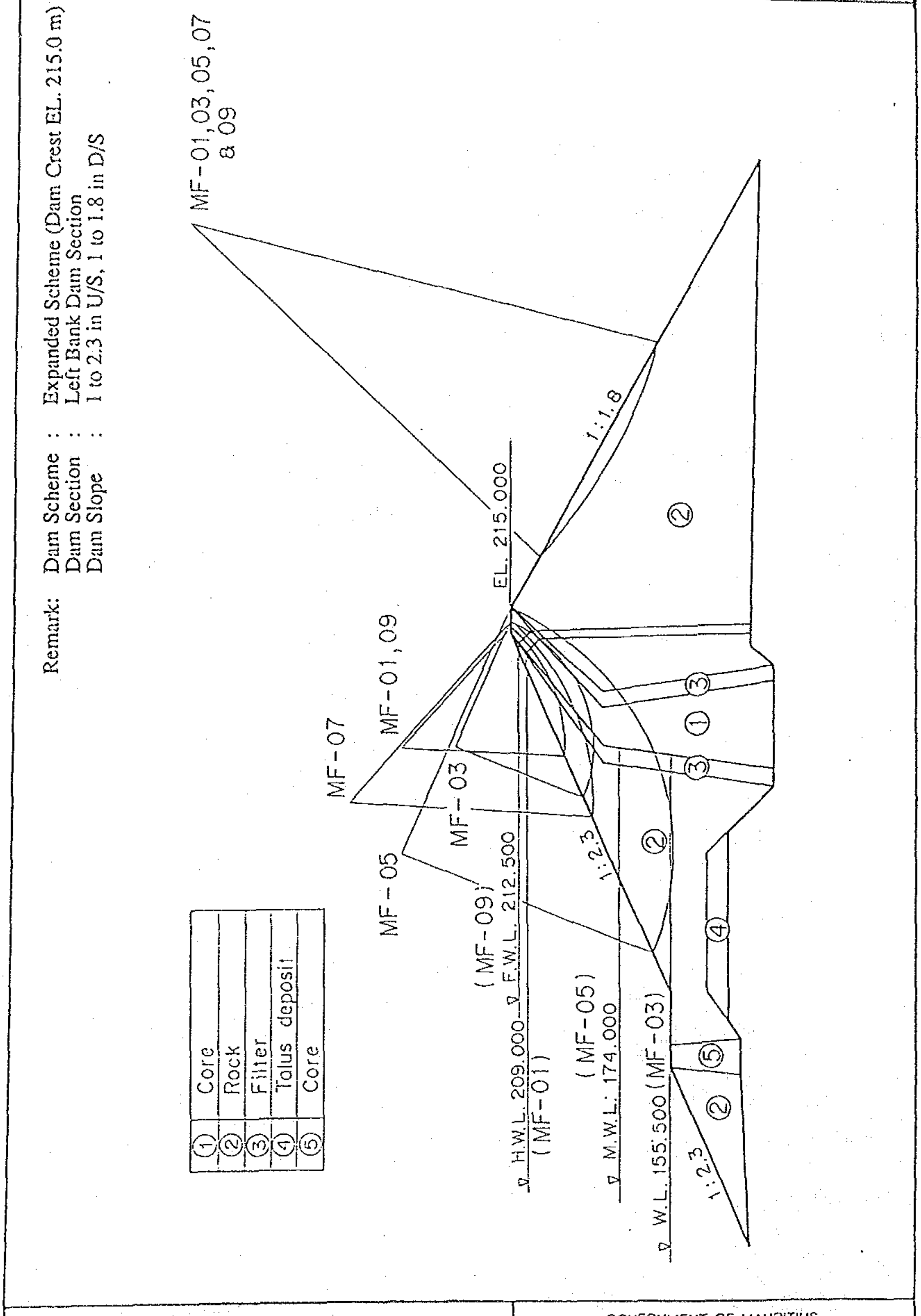


SLIDING CIRCLE WHICH PROVIDES MIN. SAFETY FACTOR

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.1.2



SLIDING CIRCLE WHICH PROVIDES MIN. SAFETY FACTOR

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

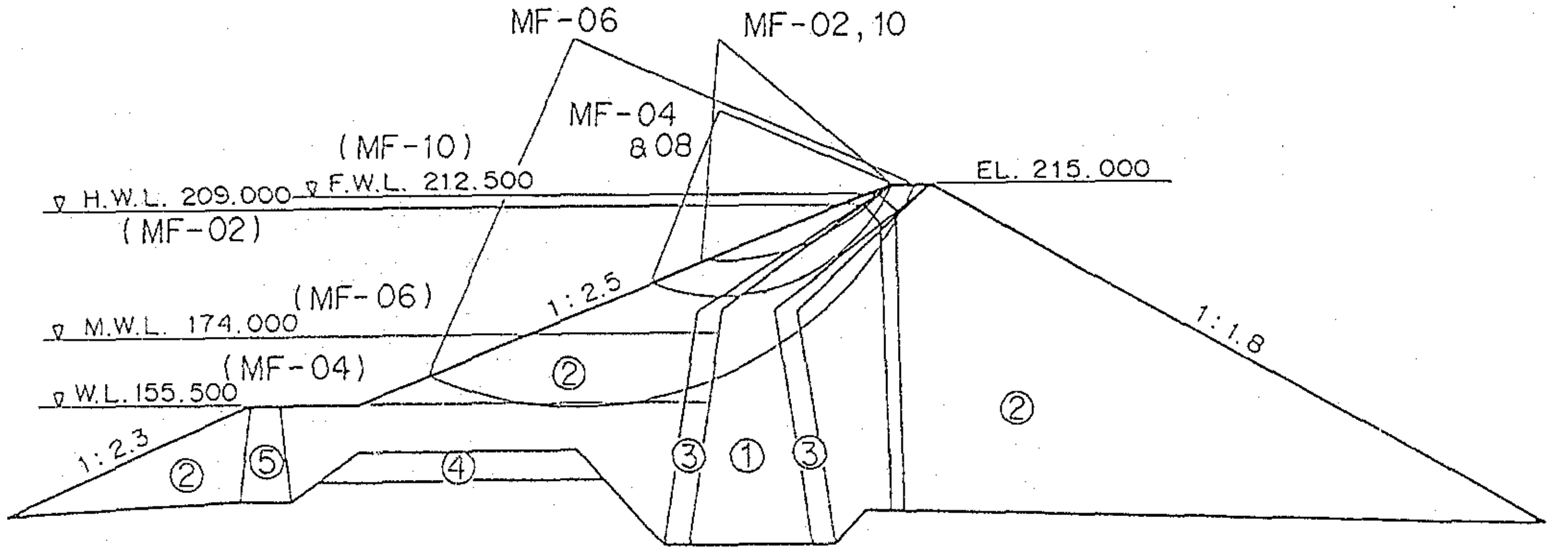
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.1.3

Remark:

Dam Scheme	:	Expanded Scheme (Dam Crest EL. 215.0 m)
Dam Section	:	Left Bank Dam Section
Dam Slope	:	1 to 2.5 in U/S, 1 to 1.8 in D/S

①	Core
②	Rock
③	Filter
④	Talus deposit
⑤	Core



SLIDING CIRCLE WHICH PROVIDES MIN.
SAFETY FACTOR

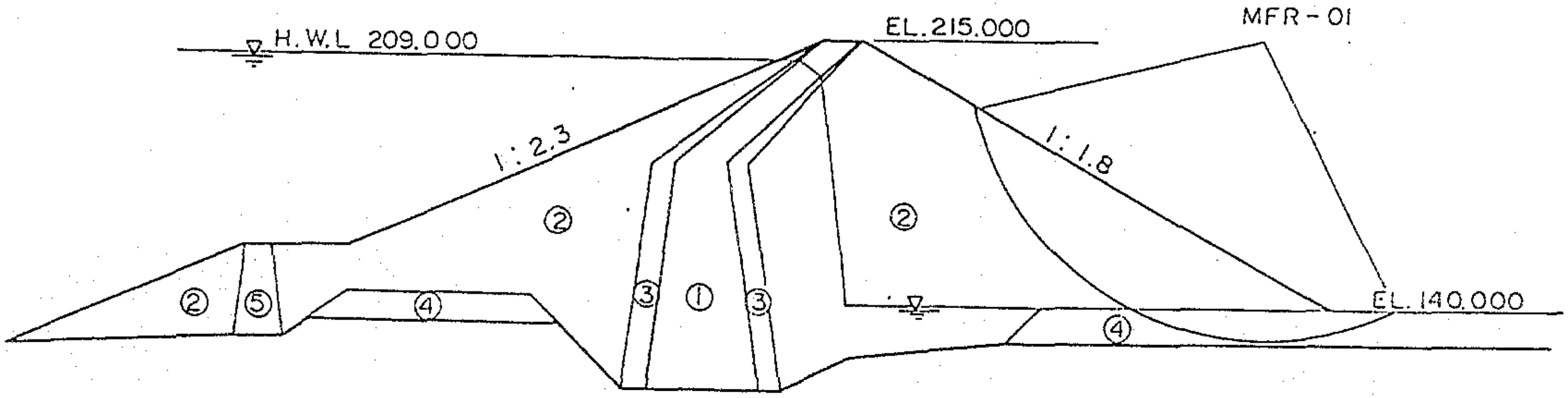
GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.1.4

Remark: Dam Scheme : Expanded Scheme (Dam Crest EL. 215.0 m)
Dam Section : Right Bank Dam Section
Dam Slope : 1 to 2.3 in U/S, 1 to 1.8 in D/S

①	Core
②	Rock
③	Filter
④	Talus deposit
⑤	Core

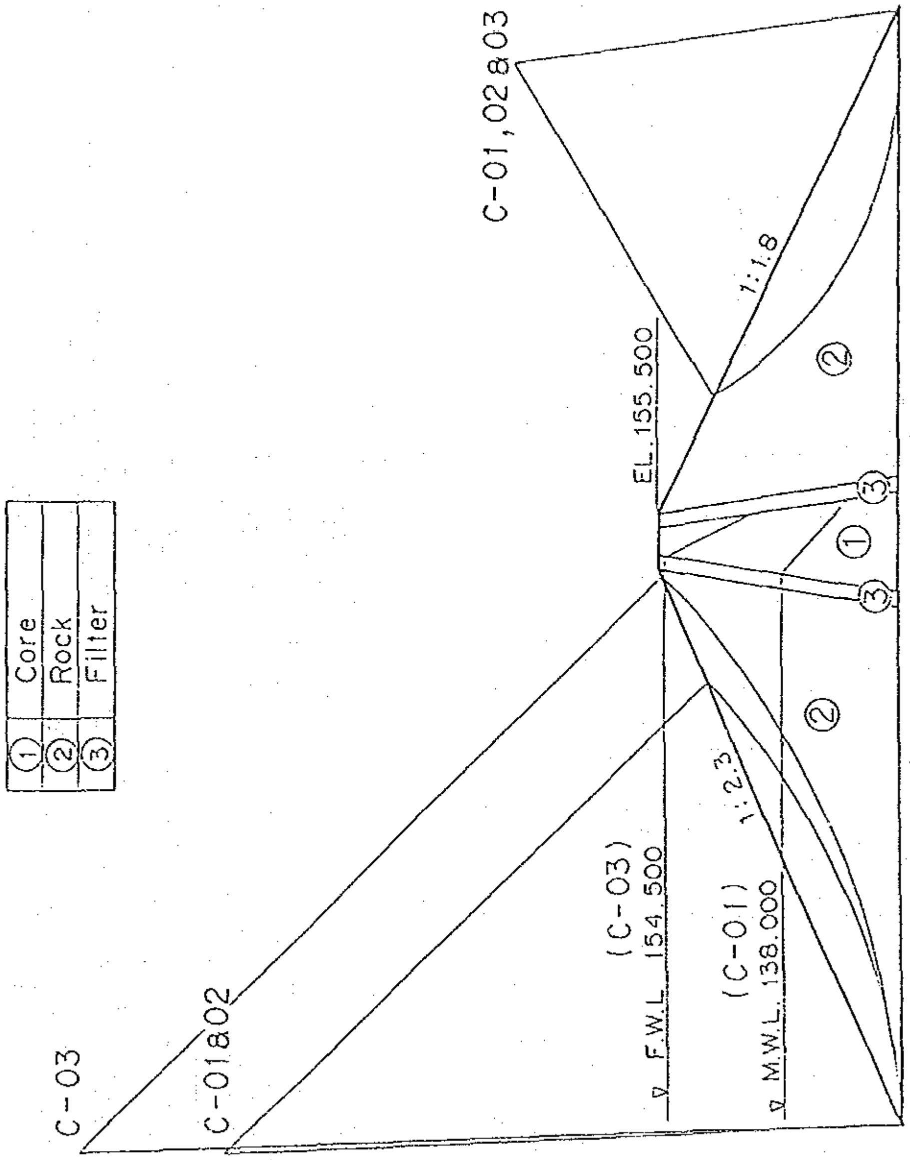


SLIDING CIRCLE WHICH PROVIDES MIN. SAFETY FACTOR

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.1.5

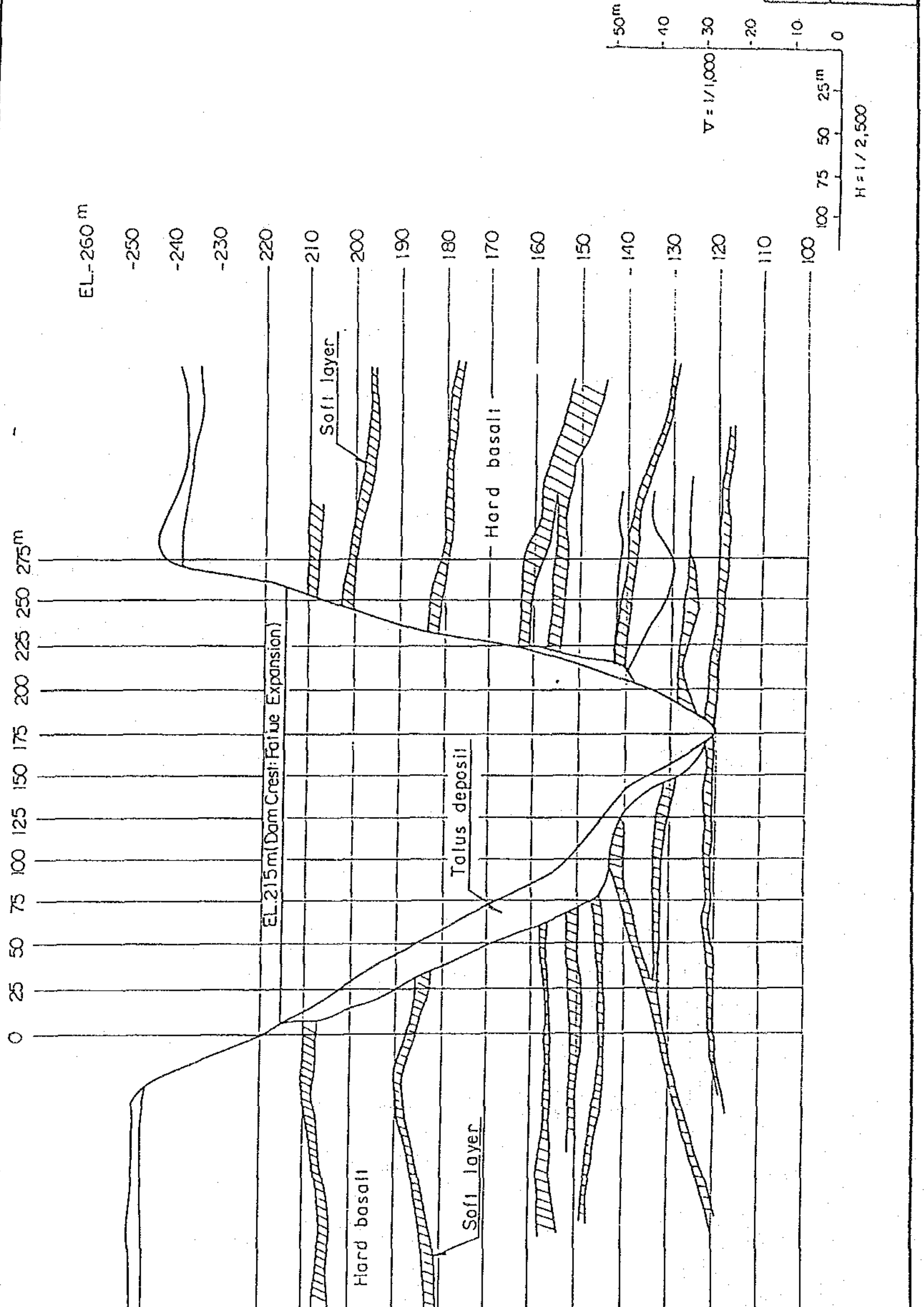


SLIDING CIRCLE WHICH PROVIDES MIN. SAFETY FACTOR (Main Cofferdam)

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.2.1

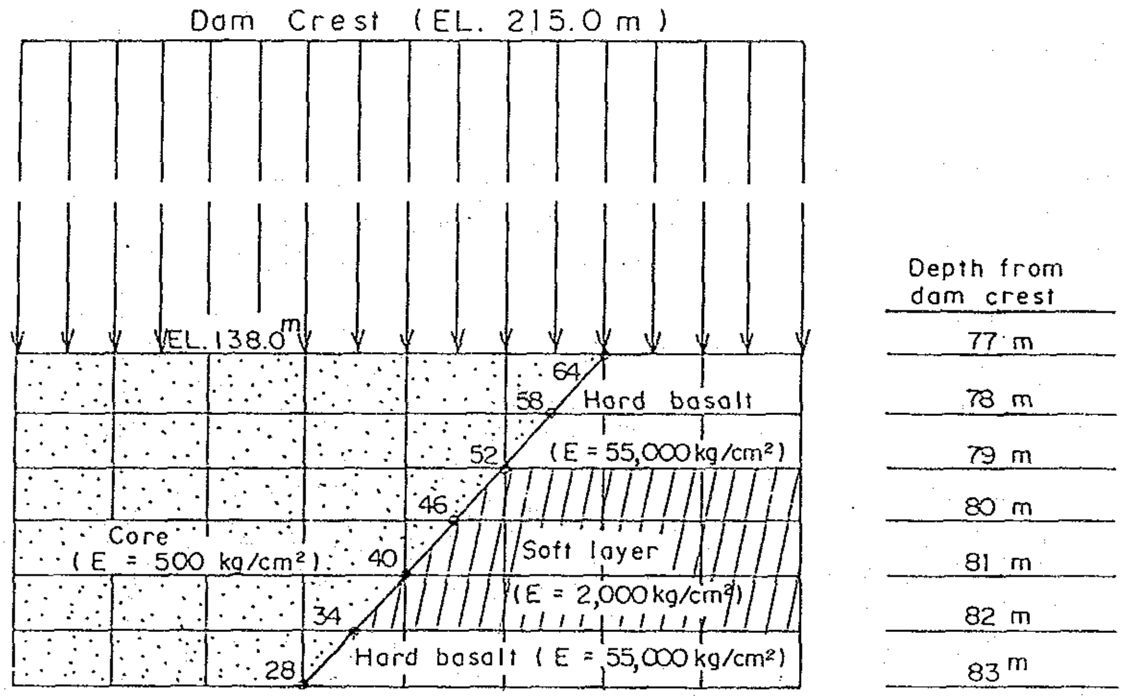


GEOLOGICAL SECTION AT DAM SITE

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

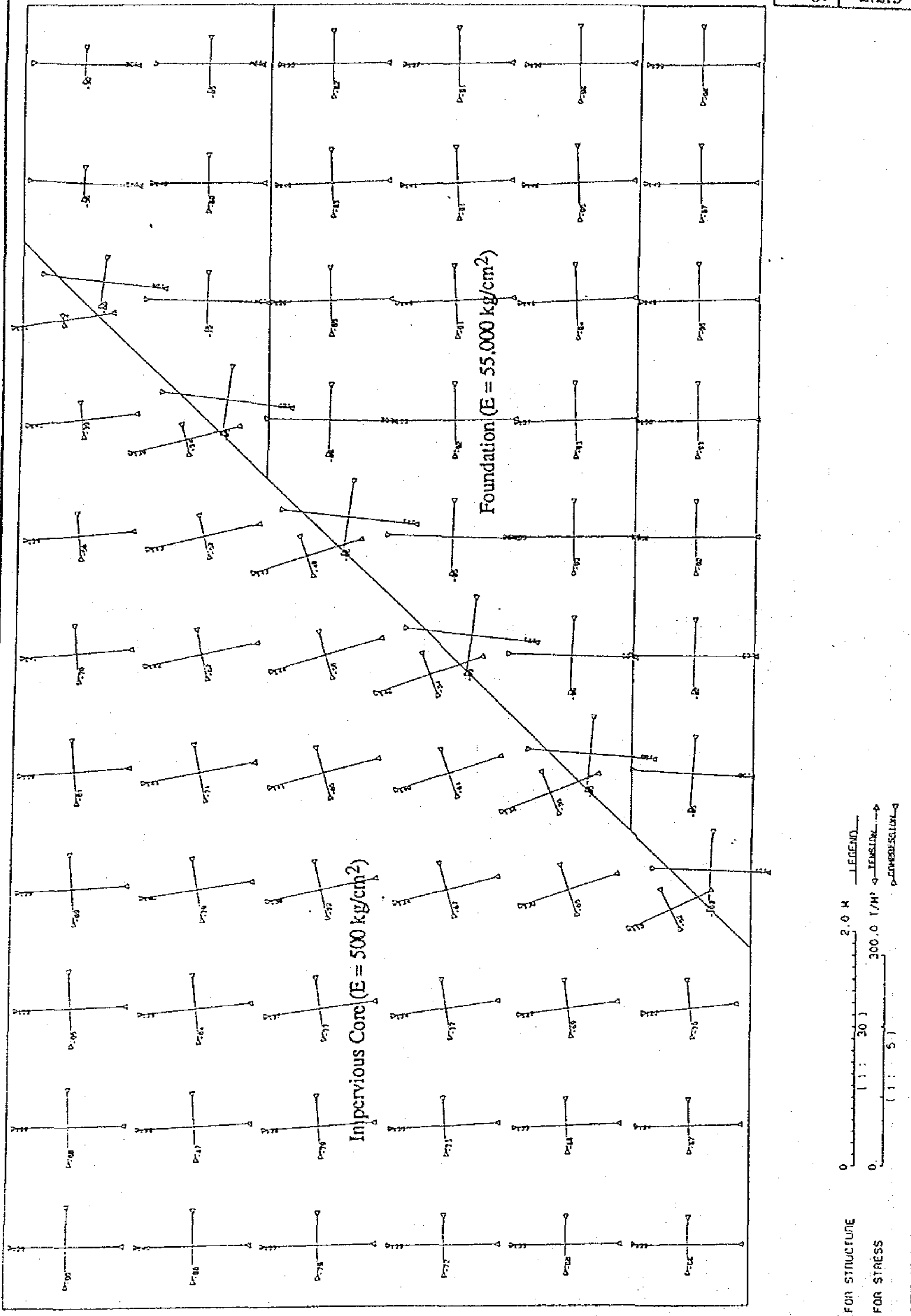
Fig. 2.2.2



MODEL FOR ANALYSIS

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

Fig. 2.2.3

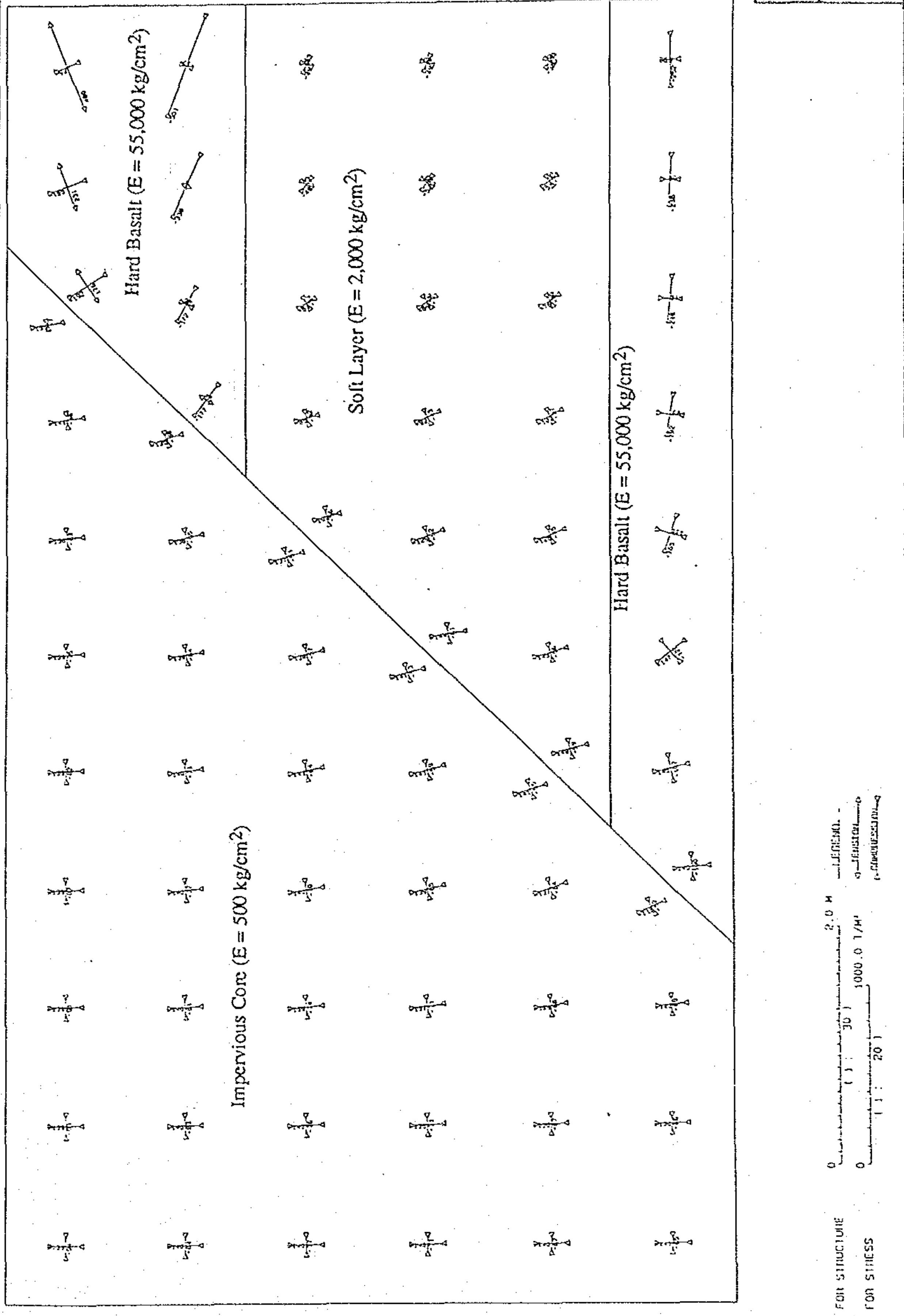


STRESS ANALYSIS RESULT (CASE (i))

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.2.4

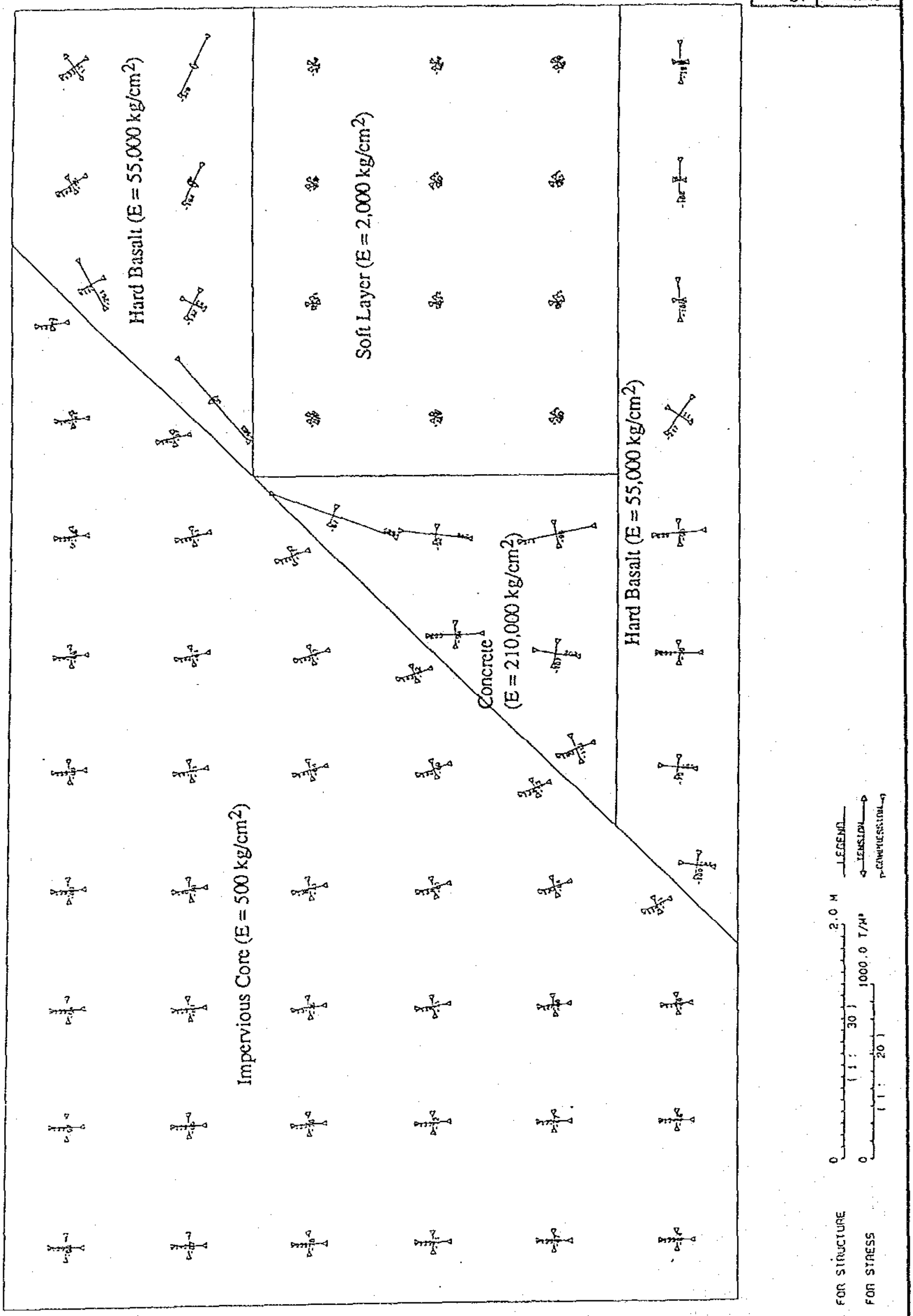


STRESS ANALYSIS RESULT (CASE (ii))

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.2.5

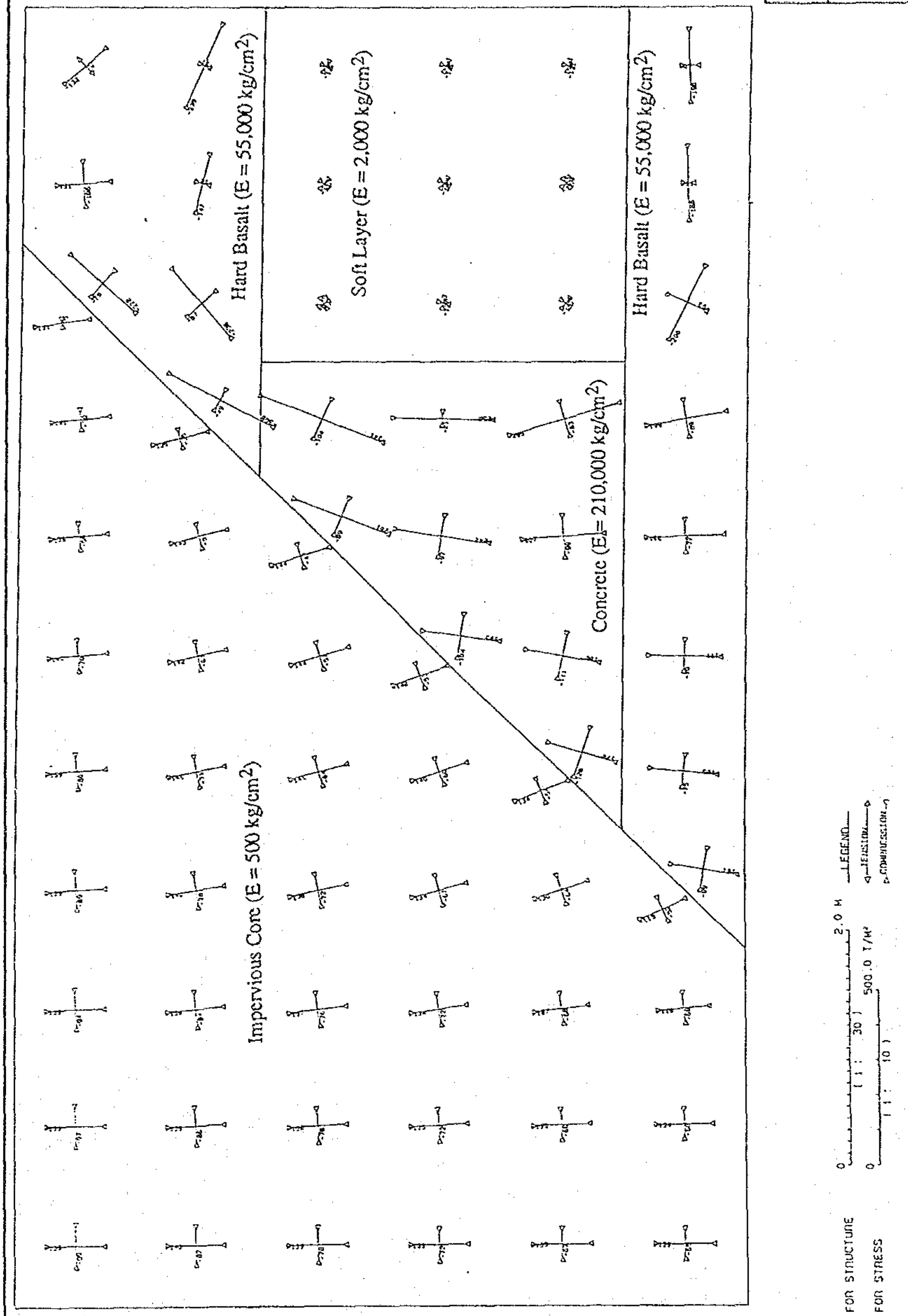


STRESS ANALYSIS RESULT (CASE (A))

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.2.6

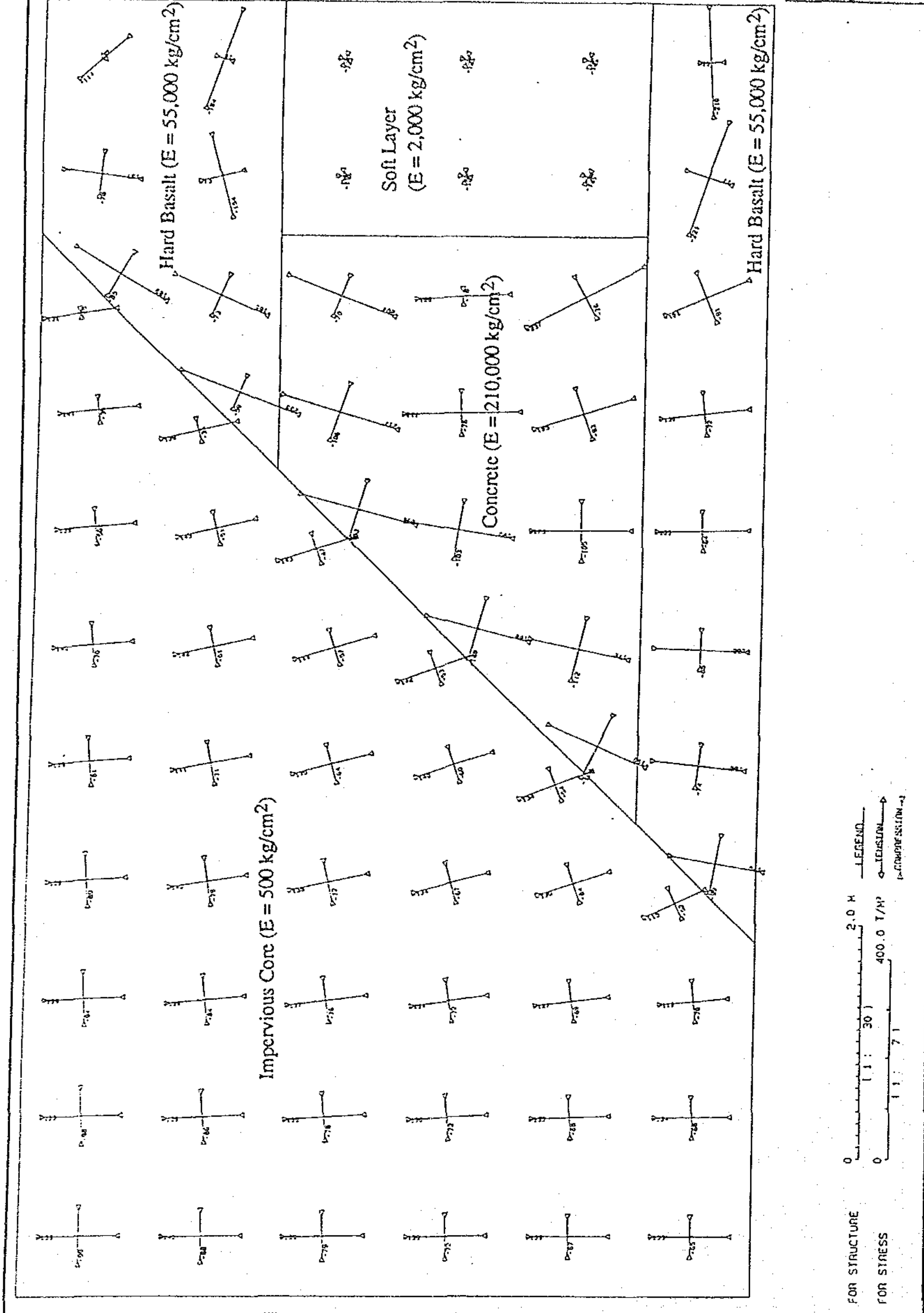


STRESS ANALYSIS RESULT (CASE (B))

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.2.7



STRESS ANALYSIS RESULT (CASE (C))

GOVERNMENT OF MAURITIUS
PORT LOUIS WATER SUPPLY PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

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****************************************************************************
*                     LIST OF INPUT DATA                                   *
****************************************************************************

TRO DAM ORIGINAL SCHEME RESERVOIR WL.189m 1:2.3 & 1:1.8 <MO-01>
----------------------------------------------------------------------------

NUMBER OF NODAL POINTS..................   26
NUMBER OF DIFFERENT MATERIALS...........    5
NUMBER OF ELEMENTS......................   16
NUMBER OF SURFACE LINES.................    7
NUMBER OF WATER POINTS..................    8
NUMBER OF PORE PRESSURE POINTS..........   26
ACCELERATION OF EARTHQUAKE..............    0.0500
UNITE WEIGHT OF WATER...................    1.0000
```

MATERIAL PROPATY

	TYPE	COHESION (T/M2)	FRICTION (DEGREE)	WEIGHT(WET) (T/M3)	WEIGHT(SAT) (T/M3)	ACC.FACTOR	PORE.FACTOR
1	0	0.0	30.0	1.72	1.80	1.000	0.000
2	0	0.0	40.0	2.13	2.37	1.000	0.000
3	0	0.0	36.0	1.93	2.23	1.000	0.000
4	0	0.0	36.0	1.93	2.23	1.000	0.000
5	0	0.0	30.0	1.72	1.80	1.000	0.000

DATA OF SLIPPE CIRCLE

OUTLINE OF GRID

NUMBER	GROUP (1)		GROUP (2)	
	X-COOR	Y-COOR	X-COOR	Y-COOR
1	-200.000	0.000	20.000	60.000
2	-40.000	0.000	160.000	60.000
3	-40.000	160.000	160.000	160.000
4	-200.000	160.000	20.000	160.000

```
THE INTERVAL(X)....................      20.0
THE INTERVAL(Y)....................      20.0
THE INTERVAL(R)....................      10.0
STOPPING HEIGHT FROM SURFACE.......       5.0
START LINE OF CIRCLE ..............  Y=( 0.000E-01)X+(-7.100E+01)
NUMBER OF LIMITTED CONDITIONS......        2
```

NUMBER	TYPE	**********	**********	**********	**********
1	-2	-105.0	-62.0	-33.0	-62.0
2	-2	-190.7	-70.0	-105.0	-62.0

COORDINATE OF NODAL POINT

POINT	X-COORDINATE (M)	Y-COORDINATE (M)
1	0.000	0.000
2	-93.150	-40.500
3	-114.900	-40.500
4	-122.900	-40.500
5	-190.750	-70.000
6	-125.900	-67.000
7	-111.900	-67.000
8	-15.525	-79.500
9	-9.525	-79.500
10	24.525	-79.500
11	30.525	-79.500
12	39.525	-71.000
13	-93.900	-54.000
14	-41.025	-54.000
15	-6.000	-16.000
16	-1.000	-16.000
17	15.000	-16.000
18	21.000	-16.000
19	145.000	-75.000
20	10.000	0.000
21	-104.977	-62.000
22	-33.025	-62.000
23	-200.000	-7.000

24	-0.438	-7.000
25	10.000	-13.500
26	18.300	-38.000

GROUND SURFACE DATA (NODAL NUMBER)

5	4	3	2	1	20	19

WATER LINE DATA (NODAL NUMBER)

23	24	25	26	10	11	12	19

ELEMENT DATA

ELEMENT	TYPE	I	J	K	L
1	2	4	5	6	4
2	5	4	6	7	3
3	2	3	7	21	13
4	2	3	13	2	3
5	4	21	22	14	13
6	2	2	13	14	15
7	2	1	2	15	1
8	2	15	14	22	8
9	3	15	8	9	16
10	3	1	15	16	1
11	1	16	9	10	17
12	1	1	16	17	20
13	3	20	17	18	20
14	3	17	10	11	18
15	2	18	11	12	18
16	2	20	18	12	19

DATA OF PORE PRESSURE IN NON-PERMEATION ZONE

NODAL POINT	X-COORDINATE	Y-COORDINATE	POTENTIAL
1	-9.525	-79.500	-72.500
2	-8.389	-70.437	-72.500
3	-7.253	-61.375	-72.500

4	-6.117	-52.312	-72.500
5	-4.982	-43.250	-72.500
6	-3.846	-34.187	-72.500
7	-2.710	-25.125	-72.500
8	-1.574	-16.062	-72.500
9	-0.438	-7.000	-72.500
10	0.475	-79.500	-55.500
11	1.812	-70.250	-55.500
12	3.150	-61.000	-55.500
13	4.488	-51.750	-55.500
14	5.825	-42.500	-55.500
15	7.163	-33.250	-55.500
16	8.500	-24.000	-55.500
17	10.475	-79.500	-41.500
18	12.040	-71.200	-41.500
19	13.605	-62.900	-41.500
20	15.170	-54.600	-41.500
21	16.735	-46.300	-41.500
22	18.300	-38.000	-41.500
23	20.475	-79.500	-19.500
24	21.737	-69.750	-19.500
25	23.000	-60.000	-19.500
26	24.525	-79.500	0.000

TRO DAM ORIGINAL SCHEME RESERVOIR WL.189m 1:2.3 & 1:1.8 <MO-01>

BLOCK	-- X-COORDINATE -- (START)	(PERIOD)	MAT	WATER	WEIGHT(SAT)	ACCEL	FRICTION	GRA. OF SLOPE	SAFETY FACTOR (NORMAL)	(SEISMIC)
1	-200.000	-190.750	0	-	-	-	-	-	-	-
2	-190.750	-125.900	2	-1	2.370	0.050	0.839	0.435	1.930	1.549
3	-125.900	-122.900	2	-1	2.370	0.050	0.839	0.435	1.930	1.549
4	-122.900	-114.900	5	-1	1.800	0.050	0.577	0.000	100.000	100.000
5	-114.900	-111.900	2	-1	2.370	0.050	0.839	0.000	100.000	100.000
6	-111.900	-104.977	2	-1	2.370	0.050	0.839	0.000	100.000	100.000
7	-104.977	-93.900	2	-1	2.370	0.050	0.839	0.000	100.000	100.000
8	-93.900	-93.150	2	-1	2.370	0.050	0.839	0.000	100.000	100.000
9	-93.150	-41.025	2	-1	2.370	0.050	0.839	0.435	1.930	1.549
10	-41.025	-33.025	2	-1	2.370	0.050	0.839	0.435	1.930	1.549
11	-33.025	-16.100	2	-1	2.370	0.050	0.839	0.435	1.930	1.549
12	-16.100	-15.525	2	1	2.370	0.050	0.839	0.435	1.930	1.693
13	-15.525	-9.525	2	1	2.370	0.050	0.839	0.435	1.930	1.693
14	-9.525	-6.000	2	1	2.370	0.050	0.839	0.435	1.930	1.693
15	-6.000	-2.625	2	1	2.370	0.050	0.839	0.435	1.930	1.693
16	-2.625	-1.000	2	1	2.370	0.050	0.839	0.435	1.930	1.693
17	-1.000	-0.438	2	1	2.370	0.050	0.839	0.435	1.930	1.693
18	-0.438	0.000	2	1	2.370	0.050	0.839	0.435	1.930	1.693
19	0.000	10.000	1	1	1.800	0.050	0.577	0.000	100.000	100.000
20	10.000	10.847	2	1	2.370	0.050	0.839	0.556	1.510	1.347
21	10.847	15.000	2	1	2.370	0.050	0.839	0.556	1.510	1.347
22	15.000	18.300	2	1	2.370	0.050	0.839	0.556	1.510	1.347
23	18.300	21.000	2	1	2.370	0.050	0.839	0.556	1.510	1.347
24	21.000	24.000	2	1	2.370	0.050	0.839	0.556	1.510	1.347
25	24.000	24.525	2	1	2.370	0.050	0.839	0.556	1.510	1.347
26	24.525	30.525	2	1	2.370	0.050	0.839	0.556	1.510	1.347
27	30.525	39.525	2	1	2.370	0.050	0.839	0.556	1.510	1.347
28	39.525	145.000	2	1	2.370	0.050	0.839	0.556	1.510	1.347

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*                         STABILITY ANALYSIS                               *
*              (MOST DANGEROUS SLIPPE CIRCLE)   (NORMAL)                   *
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TRO DAM ORIGINAL SCHEME RESERVOIR WL.189m 1:2.3 & 1:1.8 <MO-01>
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CALCULATION NUMBER...........................        95

SLIPPE CIRCLE(X-COORDINATE)..................     -80.000 (M)
     -DO-    (Y-COORDINATE)..................     100.000 (M)
     -DO-    (RADIUS)........................     131.000 (M)

SAFETY FACTOR(NORMAL  CONDITION).............       1.926
     -DO-    (SEISMIC CONDITION).............       1.571

RESISTANCE MOMENT(TOTAL:NORMAL ).............      60913. (TON*M)
     -DO-        ( -DO-:SEISMIC).............      58914. (TON*M)
RESISTANCE FORCE (COHESION)..................        0.00 (TON)
     -DO-        (FRICTION:BODY FORCE     )...    1273.10 (TON)
     -DO-        (  -DO-  :WATER PRESSURE)...      76.13 (TON)
     -DO-        (  -DO-  :PORE  PRESSURE)...    -884.25 (TON)
     -DO-        (  -DO-  :EARTHQUAKE     )...     -15.25 (TON)

SLIDING MOMENT(TOTAL:NORMAL )................      31634. (TON*M)
     -DO-     ( -DO-:SEISMIC)................      37511. (TON*M)
SLIDING FORCE (BODY FORCE)...................     503.70 (TON)
     -DO-     (WATER PRESSURE)...............    -262.22 (TON)
     -DO-     (EARTHQUAKE)...................      44.86 (TON)
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*                          STABILITY ANALYSIS                            *
*               (MOST DANGEROUS SLIPPE CIRCLE)  (SEISMIC)                *
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TRO DAM ORIGINAL SCHEME RESERVOIR WL.189m 1:2.3 & 1:1.8 <MO-01>
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CALCULATION NUMBER..........................        91

SLIPPE CIRCLE(X-COORDINATE)..................    -80.000 (M)
      -DO-    (Y-COORDINATE).................     80.000 (M)
      -DO-    (RADIUS).......................    111.000 (M)

SAFETY FACTOR(NORMAL  CONDITION).............      1.945
      -DO-    (SEISMIC CONDITION)............      1.568

RESISTANCE MOMENT(TOTAL:NORMAL )............     32133.  (TON*M)
      -DO-        ( -DO-:SEISMIC)............     30986.  (TON*M)
RESISTANCE FORCE (COHESION)..................      0.00  (TON)
      -DO-        (FRICTION:BODY FORCE    )...   1004.31 (TON)
      -DO-        (  -DO-  :WATER PRESSURE)...     82.27 (TON)
      -DO-        (  -DO-  :PORE  PRESSURE)...   -797.10 (TON)
      -DO-        (  -DO-  :EARTHQUAKE    )...    -10.33 (TON)

SLIDING MOMENT(TOTAL:NORMAL )................    16522.  (TON*M)
      -DO-     ( -DO-:SEISMIC)...............    19756.  (TON*M)
SLIDING FORCE (BODY FORCE)...................    406.07  (TON)
      -DO-     (WATER PRESSURE)..............   -257.22  (TON)
      -DO-     (EARTHQUAKE)..................     29.13  (TON)
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* MINMIM SAFETY FACTOR AT EACH GRID POINT (NORMAL) *

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TRO DAM ORIGINAL SCHEME RESERVOIR WL.189m 1:2.3 & 1:1.8 <MO-01>

NUMBER	SLIPPE CIRCLE COORDINATE X	Y	RADIUS	STATIC SAFETY FACTOR	STATIC MOMENT RESISTANCE	STATIC MOMENT SLIDING	DYNAMIC SAFETY FACTOR	DYNAMIC MOMENT RESISTANCE	DYNAMIC MOMENT SLIDING
1	-200.000	160.000	221.000	2.533	44979.	17758.	1.917	43720.	22801.
2	-180.000	60.000	121.000	2.257	30126.	13345.	1.756	29174.	16610.
3	-180.000	80.000	141.000	2.473	45158.	18262.	1.886	43864.	23254.
4	-180.000	100.000	161.000	2.681	62702.	23384.	2.010	61048.	30373.
5	-180.000	120.000	181.000	2.884	82621.	28643.	2.128	80596.	37881.
6	-180.000	140.000	201.000	3.063	105558.	34459.	2.229	103119.	46261.
7	-160.000	0.000	61.000	2.338	22318.	9547.	1.813	21639.	11933.
8	-160.000	20.000	81.000	2.616	37274.	14250.	1.975	36273.	18370.
9	-160.000	40.000	101.000	2.866	55621.	19407.	2.117	54258.	25624.
10	-160.000	60.000	121.000	3.109	77063.	24785.	2.254	75320.	33422.
11	-160.000	80.000	141.000	3.183	104865.	32942.	2.296	102537.	44657.
12	-160.000	100.000	161.000	3.077	143103.	46505.	2.241	139796.	62374.
14	-160.000	120.000	181.000	2.916	194017.	66541.	2.154	189260.	87871.
15	-160.000	140.000	201.000	2.761	259866.	94137.	2.067	253110.	122468.
16	-160.000	160.000	221.000	2.629	342916.	130423.	1.991	333532.	167524.
18	-140.000	0.000	51.000	3.111	7672.	2466.	2.230	7502.	3365.
20	-140.000	20.000	71.000	3.532	13475.	3815.	2.445	13210.	5403.
21	-140.000	40.000	101.000	3.379	101218.	29954.	2.400	99090.	41288.
23	-140.000	60.000	121.000	3.115	146803.	47125.	2.263	143431.	63374.
25	-140.000	80.000	141.000	2.898	205938.	71074.	2.145	200829.	93634.
26	-140.000	100.000	161.000	2.725	280372.	102897.	2.046	272967.	133394.
27	-140.000	120.000	181.000	2.573	372158.	144615.	1.957	361848.	184889.
29	-140.000	140.000	201.000	2.441	485357.	198836.	1.881	471642.	250742.
31	-140.000	160.000	221.000	2.410	604851.	250980.	1.863	588077.	315620.
33	-120.000	0.000	61.000	3.884	63562.	16364.	2.640	62408.	23642.
35	-120.000	20.000	81.000	3.260	107146.	32871.	2.327	104837.	45043.
37	-120.000	40.000	101.000	2.911	164940.	56654.	2.139	160945.	75230.
39	-120.000	60.000	121.000	2.693	239034.	88754.	2.016	232751.	115465.
41	-120.000	80.000	141.000	2.527	332518.	131593.	1.920	323284.	168375.
43	-120.000	100.000	161.000	2.402	445745.	185540.	1.849	433210.	234285.
46	-120.000	120.000	171.000	2.395	255857.	106825.	1.860	248436.	133557.

48	I	-120.000	140.000	191.000	I	2.344	339591.	144864.	I	1.832	329944.	180132.
50	I	-120.000	160.000	211.000	I	2.403	428239.	178233.	I	1.871	416651.	222653.
52	I	-100.000	0.000	61.000	I	3.099	90088.	29066.	I	2.228	88052.	39521.
54	I	-100.000	20.000	81.000	I	2.758	155878.	56512.	I	2.043	151895.	74364.
56	I	-100.000	40.000	101.000	I	2.554	241841.	94695.	I	1.927	235185.	122060.
60	I	-100.000	60.000	101.000	I	2.036	30637.	15049.	I	1.623	29545.	18207.
63	I	-100.000	80.000	121.000	I	2.024	57126.	28224.	I	1.615	55078.	34112.
66	I	-100.000	100.000	141.000	I	1.979	97404.	49215.	I	1.592	93990.	59035.
69	I	-100.000	120.000	161.000	I	1.980	148489.	75012.	I	1.599	143589.	89789.
72	I	-100.000	140.000	181.000	I	2.064	202823.	98248.	I	1.659	196649.	118532.
75	I	-100.000	160.000	201.000	I	2.218	260629.	117501.	I	1.764	253341.	143625.
78	I	-80.000	0.000	41.000	I	2.167	13489.	6224.	I	1.712	13037.	7615.
81	I	-80.000	20.000	61.000	I	2.112	31857.	15081.	I	1.675	30762.	18365.
84	I	-80.000	40.000	81.000	I	2.083	60861.	29225.	I	1.655	58746.	35493.
87	I	-80.000	60.000	101.000	I	2.008	104466.	52017.	I	1.613	100914.	62549.
91	I	-80.000	80.000	111.000	I	1.945	32133.	16522.	I	1.568	30986.	19756.
95	I	-80.000	100.000	131.000	I	1.926	60913.	31634.	I	1.571	58914.	37511.
99	I	-80.000	120.000	151.000	I	2.010	92596.	46074.	I	1.632	89852.	55064.
103	I	-80.000	140.000	171.000	I	2.174	126680.	58276.	I	1.745	123297.	70654.
107	I	-80.000	160.000	191.000	I	2.384	162671.	68228.	I	1.886	158734.	84179.
111	I	-60.000	0.000	31.000	I	2.175	6069.	2790.	I	1.717	5867.	3416.
115	I	-60.000	20.000	51.000	I	2.106	17837.	8468.	I	1.671	17222.	10307.
119	I	-60.000	40.000	71.000	I	2.002	39190.	19577.	I	1.611	37868.	23507.
123	I	-60.000	60.000	91.000	I	2.014	69269.	34394.	I	1.628	67170.	41256.
127	I	-60.000	80.000	111.000	I	2.207	102933.	46641.	I	1.762	100221.	56884.
132	I	-60.000	100.000	121.000	I	1.991	31382.	15762.	I	1.645	30533.	18557.
137	I	-60.000	120.000	141.000	I	2.156	48264.	22385.	I	1.760	47113.	26773.
142	I	-60.000	140.000	161.000	I	2.386	66314.	27795.	I	1.915	64906.	33897.
147	I	-60.000	160.000	181.000	I	2.650	85335.	32205.	I	2.087	83705.	40107.
152	I	-40.000	0.000	21.000	I	2.190	2034.	928.	I	1.728	1966.	1138.
157	I	-40.000	20.000	41.000	I	1.992	8961.	4498.	I	1.609	8665.	5387.
162	I	-40.000	40.000	61.000	I	1.970	22803.	11578.	I	1.614	22157.	13728.
167	I	-40.000	60.000	81.000	I	2.208	39442.	17862.	I	1.782	38526.	21623.
172	I	-40.000	80.000	101.000	I	2.581	57995.	22472.	I	2.030	56862.	28017.
177	I	-40.000	100.000	121.000	I	3.012	77836.	25839.	I	2.300	76523.	33277.
182	I	-40.000	120.000	141.000	I	3.485	98668.	28313.	I	2.577	97203.	37720.
188	I	-40.000	140.000	151.000	I	2.898	23004.	7938.	I	2.353	22701.	9650.
194	I	-40.000	160.000	171.000	I	3.207	30081.	9380.	I	2.549	29724.	11661.

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*                 MINMIM SAFETY FACTOR AT EACH GRID POINT  (SEISMIC)        *
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TRO DAM ORIGINAL SCHEME RESERVOIR WL.189m 1:2.3 & 1:1.8 <MO-01>

NUMBER	SLIPPE CIRCLE COORDINATE X	SLIPPE CIRCLE COORDINATE Y	RADIUS	STATIC SAFETY FACTOR	STATIC MOMENT RESISTANCE	STATIC MOMENT SLIDING	DYNAMIC SAFETY FACTOR	DYNAMIC MOMENT RESISTANCE	DYNAMIC MOMENT SLIDING
1	-200.000	160.000	221.000	2.533	44979.	17758.	1.917	43720.	22801.
2	-180.000	60.000	121.000	2.257	30126.	13345.	1.756	29174.	16610.
3	-180.000	80.000	141.000	2.473	45158.	18262.	1.886	43864.	23254.
4	-180.000	100.000	161.000	2.681	62702.	23384.	2.010	61048.	30373.
5	-180.000	120.000	181.000	2.884	82621.	28643.	2.128	80596.	37881.
6	-180.000	140.000	201.000	3.063	105558.	34459.	2.229	103119.	46261.
7	-160.000	0.000	61.000	2.338	22318.	9547.	1.813	21639.	11933.
8	-160.000	20.000	81.000	2.616	37274.	14250.	1.975	36273.	18370.
9	-160.000	40.000	101.000	2.866	55621.	19407.	2.117	54258.	25624.
10	-160.000	60.000	121.000	3.109	77063.	24785.	2.254	75320.	33422.
11	-160.000	80.000	141.000	3.183	104865.	32942.	2.296	102537.	44657.
12	-160.000	100.000	161.000	3.077	143103.	46505.	2.241	139796.	62374.
14	-160.000	120.000	181.000	2.916	194017.	66541.	2.154	189260.	87871.
15	-160.000	140.000	201.000	2.761	259866.	94137.	2.067	253110.	122468.
16	-160.000	160.000	221.000	2.629	342916.	130423.	1.991	333532.	167524.
18	-140.000	0.000	51.000	3.111	7672.	2466.	2.230	7502.	3365.
20	-140.000	20.000	71.000	3.532	13475.	3815.	2.445	13210.	5403.
21	-140.000	40.000	101.000	3.379	101218.	29954.	2.400	99090.	41288.
23	-140.000	60.000	121.000	3.115	146803.	47125.	2.263	143431.	63374.
25	-140.000	80.000	141.000	2.898	205938.	71074.	2.145	200829.	93634.
26	-140.000	100.000	161.000	2.725	280372.	102897.	2.046	272967.	133394.
27	-140.000	120.000	181.000	2.573	372158.	144615.	1.957	361848.	184889.
29	-140.000	140.000	201.000	2.441	485357.	198836.	1.881	471642.	250742.
31	-140.000	160.000	221.000	2.410	604851.	250980.	1.863	588077.	315620.
33	-120.000	0.000	61.000	3.884	63562.	16364.	2.640	62408.	23642.
35	-120.000	20.000	81.000	3.260	107146.	32871.	2.327	104837.	45043.
37	-120.000	40.000	101.000	2.911	164940.	56654.	2.139	160945.	75230.
39	-120.000	60.000	121.000	2.693	239034.	88754.	2.016	232751.	115465.
41	-120.000	80.000	141.000	2.527	332518.	131593.	1.920	323284.	168375.

43	I	-120.000	100.000	161.000	I	2.402	445745.	185540.	I	1.849	433210.	234285.
46	I	-120.000	120.000	171.000	I	2.395	255857.	106825.	I	1.860	248436.	133557.
48	I	-120.000	140.000	191.000	I	2.344	339591.	144864.	I	1.832	329944.	180132.
50	I	-120.000	160.000	211.000	I	2.403	428239.	178233.	I	1.871	416651.	222653.
52	I	-100.000	0.000	61.000	I	3.099	90088.	29066.	I	2.228	88052.	39521.
54	I	-100.000	20.000	81.000	I	2.758	155878.	56512.	I	2.043	151895.	74364.
56	I	-100.000	40.000	101.000	I	2.554	241841.	94695.	I	1.927	235185.	122060.
60	I	-100.000	60.000	101.000	I	2.036	30637.	15049.	I	1.623	29545.	18207.
63	I	-100.000	80.000	121.000	I	2.024	57126.	28224.	I	1.615	55078.	34112.
66	I	-100.000	100.000	141.000	I	1.979	97404.	49215.	I	1.592	93990.	59035.
69	I	-100.000	120.000	161.000	I	1.980	148489.	75012.	I	1.599	143589.	89789.
72	I	-100.000	140.000	181.000	I	2.064	202823.	98248.	I	1.659	196649.	118532.
75	I	-100.000	160.000	201.000	I	2.218	260629.	117501.	I	1.764	253341.	143625.
78	I	-80.000	0.000	41.000	I	2.167	13489.	6224.	I	1.712	13037.	7615.
81	I	-80.000	20.000	61.000	I	2.112	31857.	15081.	I	1.675	30762.	18365.
84	I	-80.000	40.000	81.000	I	2.083	60861.	29225.	I	1.655	58746.	35493.
87	I	-80.000	60.000	101.000	I	2.008	104466.	52017.	I	1.613	100914.	62549.
91	I	-80.000	80.000	111.000	I	1.945	32133.	16522.	I	1.568	30986.	19756.
95	I	-80.000	100.000	131.000	I	1.926	60913.	31634.	I	1.571	58914.	37511.
99	I	-80.000	120.000	151.000	I	2.010	92596.	46074.	I	1.632	89852.	55064.
103	I	-80.000	140.000	171.000	I	2.174	126680.	58276.	I	1.745	123297.	70654.
107	I	-80.000	160.000	191.000	I	2.384	162671.	68228.	I	1.886	158734.	84179.
111	I	-60.000	0.000	31.000	I	2.175	6069.	2790.	I	1.717	5867.	3416.
115	I	-60.000	20.000	51.000	I	2.106	17837.	8468.	I	1.671	17222.	10307.
119	I	-60.000	40.000	71.000	I	2.002	39190.	19577.	I	1.611	37868.	23507.
123	I	-60.000	60.000	91.000	I	2.014	69269.	34394.	I	1.628	67170.	41256.
127	I	-60.000	80.000	111.000	I	2.207	102933.	46641.	I	1.762	100221.	56884.
132	I	-60.000	100.000	121.000	I	1.991	31382.	15762.	I	1.645	30533.	18557.
137	I	-60.000	120.000	141.000	I	2.156	48264.	22385.	I	1.760	47113.	26773.
142	I	-60.000	140.000	161.000	I	2.386	66314.	27795.	I	1.915	64906.	33897.
147	I	-60.000	160.000	181.000	I	2.650	85335.	32205.	I	2.087	83705.	40107.
152	I	-40.000	0.000	21.000	I	2.190	2034.	928.	I	1.728	1966.	1138.
157	I	-40.000	20.000	41.000	I	1.992	8961.	4498.	I	1.609	8665.	5387.
162	I	-40.000	40.000	61.000	I	1.970	22803.	11578.	I	1.614	22157.	13728.
167	I	-40.000	60.000	81.000	I	2.208	39442.	17862.	I	1.782	38526.	21623.
172	I	-40.000	80.000	101.000	I	2.581	57995.	22472.	I	2.030	56862.	28017.
177	I	-40.000	100.000	121.000	I	3.012	77836.	25839.	I	2.300	76523.	33277.
182	I	-40.000	120.000	141.000	I	3.485	98668.	28313.	I	2.577	97203.	37720.
188	I	-40.000	140.000	151.000	I	2.898	23004.	7938.	I	2.353	22701.	9650.
194	I	-40.000	160.000	171.000	I	3.207	30081.	9380.	I	2.549	29724.	11661.

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*                            STABILITY ANALYSIS                               *
*                  (MOST DANGEROUS SLIPPE CIRCLE)   (NORMAL)                  *
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TRO DAM ORIGINAL SCHEME RESERVOIR WL.189m 1:2.3 & 1:1.8 <MO-01>
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CALCULATION NUMBER...........................        199

SLIPPE CIRCLE(X-COORDINATE)..................     140.000 (M)
      -DO-    (Y-COORDINATE)..................     140.000 (M)
      -DO-    (RADIUS)........................     191.000 (M)

SAFETY FACTOR(NORMAL  CONDITION).............       1.533
      -DO-    (SEISMIC CONDITION).............       1.367

RESISTANCE MOMENT(TOTAL:NORMAL )..............      99232. (TON*M)
      -DO-         ( -DO-:SEISMIC)............      96517. (TON*M)
RESISTANCE FORCE  (COHESION)..................        0.00 (TON)
      -DO-        (FRICTION:BODY FORCE     )...      519.54 (TON)
      -DO-        (   -DO-  :WATER PRESSURE)...        0.00 (TON)
      -DO-        (   -DO-  :PORE  PRESSURE)...        0.00 (TON)
      -DO-        (   -DO-  :EARTHQUAKE    )...      -14.21 (TON)

SLIDING MOMENT(TOTAL:NORMAL )..................    -64710. (TON*M)
      -DO-    ( -DO-:SEISMIC)..................    -70623. (TON*M)
SLIDING FORCE (BODY FORCE).....................    -338.80 (TON)
      -DO-    (WATER PRESSURE).................       0.00 (TON)
      -DO-    (EARTHQUAKE).....................     -30.96 (TON)
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* MINMIM SAFETY FACTOR AT EACH GRID POINT (NORMAL) *

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TRO DAM ORIGINAL SCHEME RESERVOIR WL.189m 1:2.3 & 1:1.8 <MO-01>

NUMBER	SLIPPE CIRCLE COORDINATE X	SLIPPE CIRCLE COORDINATE Y	RADIUS	STATIC SAFETY FACTOR	STATIC MOMENT RESISTANCE	STATIC MOMENT SLIDING	DYNAMIC SAFETY FACTOR	DYNAMIC MOMENT RESISTANCE	DYNAMIC MOMENT SLIDING
1	20.000	60.000	131.000	3.483	1058615.	-303961.	2.643	1051985.	-397993.
8	20.000	80.000	151.000	3.622	1279685.	-353343.	2.722	1272383.	-467373.
15	20.000	100.000	161.000	3.869	1088612.	-281382.	2.868	1082240.	-377390.
21	20.000	120.000	181.000	4.004	1267277.	-316483.	2.944	1260319.	-428146.
27	20.000	140.000	201.000	4.126	1448601.	-351113.	3.011	1441110.	-478668.
33	20.000	160.000	221.000	4.236	1632103.	-385332.	3.070	1624124.	-528973.
44	40.000	60.000	81.000	2.307	54690.	-23706.	1.950	53887.	-27631.
51	40.000	80.000	91.000	2.221	11939.	-5376.	1.888	11758.	-6227.
58	40.000	100.000	111.000	2.602	18505.	-7112.	2.163	18266.	-8446.
65	40.000	120.000	131.000	2.997	25675.	-8566.	2.435	25387.	-10424.
66	40.000	140.000	211.000	3.134	1947444.	-621442.	2.452	1931213.	-787765.
73	40.000	160.000	231.000	3.222	2180022.	-676502.	2.504	2162946.	-863650.
84	60.000	60.000	91.000	1.877	97416.	-51905.	1.637	95558.	-58378.
90	60.000	80.000	101.000	1.773	32666.	-18429.	1.554	31997.	-20591.
96	60.000	100.000	121.000	2.001	51376.	-25673.	1.730	50470.	-29175.
102	60.000	120.000	141.000	2.251	71992.	-31977.	1.918	70872.	-36951.
108	60.000	140.000	161.000	2.465	92820.	-37659.	2.069	91503.	-44223.
112	60.000	160.000	201.000	2.636	589518.	-223630.	2.146	582009.	-271147.
118	80.000	60.000	101.000	1.705	143968.	-84447.	1.506	140741.	-93436.
123	80.000	80.000	111.000	1.606	56126.	-34946.	1.425	54756.	-38436.
128	80.000	100.000	131.000	1.738	91304.	-52519.	1.529	89357.	-58446.
133	80.000	120.000	151.000	1.907	130202.	-68294.	1.660	127715.	-76951.
138	80.000	140.000	171.000	2.038	168905.	-82897.	1.755	165903.	-94547.
144	80.000	160.000	181.000	1.956	40653.	-20787.	1.694	39908.	-23562.
147	100.000	60.000	111.000	1.625	187656.	-115445.	1.443	182946.	-126759.
151	100.000	80.000	121.000	1.560	77056.	-49388.	1.389	74989.	-53985.
155	100.000	100.000	141.000	1.614	133041.	-82416.	1.431	129813.	-90684.
159	100.000	120.000	161.000	1.731	195440.	-112877.	1.525	191165.	-125342.

163	I	100.000	140.000	181.000	I	1.828	258060.	-141178.	I	1.597	252789.	-158277.
168	I	100.000	160.000	191.000	I	1.753	84715.	-48338.	I	1.539	82913.	-53885.
171	I	120.000	60.000	111.000	I	1.548	39613.	-25589.	I	1.379	38540.	-27950.
174	I	120.000	80.000	131.000	I	1.558	92179.	-59153.	I	1.388	89697.	-64645.
177	I	120.000	100.000	151.000	I	1.567	171639.	-109524.	I	1.395	167113.	-119834.
180	I	120.000	120.000	171.000	I	1.626	260155.	-160033.	I	1.441	253852.	-176131.
184	I	120.000	140.000	181.000	I	1.555	77767.	-50009.	I	1.384	75727.	-54735.
188	I	120.000	160.000	201.000	I	1.633	134295.	-82260.	I	1.445	131107.	-90746.
190	I	140.000	60.000	121.000	I	1.547	48939.	-31639.	I	1.378	47612.	-34555.
192	I	140.000	80.000	141.000	I	1.557	108835.	-69922.	I	1.386	105902.	-76407.
194	I	140.000	100.000	161.000	I	1.564	200367.	-128119.	I	1.392	194992.	-140058.
196	I	140.000	120.000	181.000	I	1.575	320162.	-203306.	I	1.401	311843.	-222641.
199	I	140.000	140.000	191.000	I	1.533	99232.	-64710.	I	1.367	96517.	-70623.
202	I	140.000	160.000	211.000	I	1.569	183725.	-117103.	I	1.395	179000.	-128342.
203	I	160.000	60.000	131.000	I	1.546	59587.	-38548.	I	1.377	57970.	-42099.
204	I	160.000	80.000	151.000	I	1.555	127276.	-81851.	I	1.385	123842.	-89435.
205	I	160.000	100.000	171.000	I	1.562	228533.	-146298.	I	1.391	222395.	-159916.
206	I	160.000	120.000	191.000	I	1.568	369436.	-235641.	I	1.395	359550.	-257654.
208	I	160.000	140.000	201.000	I	1.533	115650.	-75416.	I	1.367	112486.	-82307.
210	I	160.000	160.000	221.000	I	1.543	226773.	-147001.	I	1.374	220642.	-160561.

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*                     LIST OF INPUT DATA                                   *
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TRO DAM ORIGINAL SCHEME RAPID DRAWDOWN WL.155.5m 1:2.3 & 1:1.8 <MO-02>

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NUMBER OF NODAL POINTS...................     27
NUMBER OF DIFFERENT MATERIALS............      5
NUMBER OF ELEMENTS.......................     16
NUMBER OF SURFACE LINES..................      7
NUMBER OF WATER POINTS...................     13
NUMBER OF PORE PRESSURE POINTS...........     26
ACCELERATION OF EARTHQUAKE...............      0.0500
UNITE WEIGHT OF WATER....................      1.0000
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MATERIAL PROPATY

	TYPE	COHESION (T/M2)	FRICTION (DEGREE)	WEIGHT(WET) (T/M3)	WEIGHT(SAT) (T/M3)	ACC.FACTOR	PORE.FACTOR
1	0	0.0	30.0	1.72	1.80	1.000	0.000
2	0	0.0	40.0	2.13	2.37	1.000	0.000
3	0	0.0	36.0	1.93	2.23	1.000	0.000
4	0	0.0	36.0	1.93	2.23	1.000	0.000
5	0	0.0	30.0	1.72	1.80	1.000	0.000

DATA OF SLIPPE CIRCLE

OUTLINE OF GRID

....

NUMBER	GROUP(1) X-COOR	GROUP(1) Y-COOR	GROUP(2) X-COOR	GROUP(2) Y-COOR
1	-200.000	0.000	20.000	60.000
2	-40.000	0.000	160.000	60.000
3	-40.000	160.000	160.000	160.000
4	-200.000	160.000	20.000	160.000

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THE INTERVAL(X)...................      20.0
THE INTERVAL(Y)...................      20.0
THE INTERVAL(R)...................      10.0
STOPPING HEIGHT FROM SURFACE.......      5.0
START LINE OF CIRCLE ............. Y=( 0.000E-01)X+(-7.100E+01)
NUMBER OF LIMITTED CONDITIONS......      2
```

NUMBER	TYPE	**********	**********	**********	**********
1	-2	-190.7	-70.0	-105.0	-62.0
2	-2	-105.0	-62.0	-33.0	-62.0

COORDINATE OF NODAL POINT

POINT	X-COORDINATE (M)	Y-COORDINATE (M)
1	0.000	0.000
2	-93.150	-40.500
3	-114.900	-40.500
4	-122.900	-40.500
5	-190.750	-70.000
6	-125.900	-67.000
7	-111.900	-67.000
8	-15.525	-79.500
9	-9.525	-79.500
10	24.525	-79.500
11	30.525	-79.500
12	39.525	-71.000
13	-93.900	-54.000
14	-41.025	-54.000
15	-6.000	-16.000
16	-1.000	-16.000
17	15.000	-16.000
18	21.000	-16.000
19	145.000	-75.000
20	10.000	0.000
21	-104.977	-62.000
22	-33.025	-62.000
23	-200.000	-40.500

24	-3.500	-40.500
25	-0.438	-7.000
26	10.000	-13.500
27	18.300	-38.000

GROUND SURFACE DATA (NODAL NUMBER)

5	4	3	2	1	20	19

WATER LINE DATA (NODAL NUMBER)

23	4	3	2	24	16	25	26	27	10
11	12	19							

ELEMENT DATA

ELEMENT	TYPE	I	J	K	L
1	2	4	5	6	4
2	5	4	6	7	3
3	2	3	7	21	13
4	2	3	13	2	3
5	4	21	22	14	13
6	2	2	13	14	15
7	2	1	2	15	1
8	2	15	14	22	8
9	3	15	8	9	16
10	3	1	15	16	1
11	1	16	9	10	17
12	1	1	16	17	20
13	3	20	17	18	20
14	3	17	10	11	18
15	2	18	11	12	18
16	2	20	18	12	19

DATA OF PORE PRESSURE IN NON-PERMEATION ZONE

NODAL POINT	X-COORDINATE	Y-COORDINATE	POTENTIAL
1	-9.525	-79.500	-72.500
2	-8.389	-70.437	-72.500
3	-7.253	-61.375	-72.500
4	-6.117	-52.312	-72.500
5	-4.982	-43.250	-72.500
6	-3.846	-34.187	-72.500
7	-2.710	-25.125	-72.500
8	-1.574	-16.062	-72.500
9	-0.438	-7.000	-72.500
10	0.475	-79.500	-55.500
11	1.812	-70.250	-55.500
12	3.150	-61.000	-55.500
13	4.488	-51.750	-55.500
14	5.825	-42.500	-55.500
15	7.163	-33.250	-55.500
16	8.500	-24.000	-55.500
17	10.475	-79.500	-41.500
18	12.040	-71.200	-41.500
19	13.605	-62.900	-41.500
20	15.170	-54.600	-41.500
21	16.735	-46.300	-41.500
22	18.300	-38.000	-41.500
23	20.475	-79.500	-19.500
24	21.737	-69.750	-19.500
25	23.000	-60.000	-19.500
26	24.525	-79.500	0.000

TRO DAM ORIGINAL SCHEME RAPID DRAWDOWN WL.155.5m 1:2.3 & 1:1.8 <MO-02>

BLOCK	-- X-COORDINATE -- (START)	(PERIOD)	MAT	WATER	WEIGHT(SAT)	ACCEL	FRICTION	GRA. OF SLOPE	SAFETY FACTOR (NORMAL)	(SEISMIC)
1	-200.000	-190.750	0	-	-	-	-	-	-	-
2	-190.750	-125.900	2	-1	2.370	0.050	0.839	0.435	1.930	1.549
3	-125.900	-122.900	2	-1	2.370	0.050	0.839	0.435	1.930	1.549
4	-122.900	-114.900	5	-1	1.800	0.050	0.577	0.000	100.000	100.000
5	-114.900	-111.900	2	-1	2.370	0.050	0.839	0.000	100.000	100.000
6	-111.900	-104.977	2	-1	2.370	0.050	0.839	0.000	100.000	100.000
7	-104.977	-93.900	2	-1	2.370	0.050	0.839	0.000	100.000	100.000
8	-93.900	-93.150	2	-1	2.370	0.050	0.839	0.000	100.000	100.000
9	-93.150	-41.025	2	1	2.370	0.050	0.839	0.435	1.930	1.693
10	-41.025	-33.025	2	1	2.370	0.050	0.839	0.435	1.930	1.693
11	-33.025	-28.582	2	1	2.370	0.050	0.839	0.435	1.930	1.693
12	-28.582	-15.525	2	1	2.370	0.050	0.839	0.435	1.930	1.693
13	-15.525	-9.675	2	1	2.370	0.050	0.839	0.435	1.930	1.693
14	-9.675	-9.525	2	1	2.370	0.050	0.839	0.435	1.930	1.693
15	-9.525	-6.000	2	1	2.370	0.050	0.839	0.435	1.930	1.693
16	-6.000	-4.289	2	1	2.370	0.050	0.839	0.435	1.930	1.693
17	-4.289	-3.500	2	1	2.370	0.050	0.839	0.435	1.930	1.693
18	-3.500	-1.000	2	1	2.370	0.050	0.839	0.435	1.930	1.693
19	-1.000	-0.438	2	1	2.370	0.050	0.839	0.435	1.930	1.693
20	-0.438	0.000	2	1	2.370	0.050	0.839	0.435	1.930	1.693
21	0.000	10.000	1	1	1.800	0.050	0.577	0.000	100.000	100.000
22	10.000	10.847	2	1	2.370	0.050	0.839	0.556	1.510	1.347
23	10.847	15.000	2	1	2.370	0.050	0.839	0.556	1.510	1.347
24	15.000	18.300	2	1	2.370	0.050	0.839	0.556	1.510	1.347
25	18.300	21.000	2	1	2.370	0.050	0.839	0.556	1.510	1.347
26	21.000	24.000	2	1	2.370	0.050	0.839	0.556	1.510	1.347
27	24.000	24.525	2	1	2.370	0.050	0.839	0.556	1.510	1.347
28	24.525	30.525	2	1	2.370	0.050	0.839	0.556	1.510	1.347
29	30.525	39.525	2	1	2.370	0.050	0.839	0.556	1.510	1.347
30	39.525	145.000	2	1	2.370	0.050	0.839	0.556	1.510	1.347

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*                         STABILITY ANALYSIS                           *
*               (MOST DANGEROUS SLIPPE CIRCLE)   (NORMAL)              *
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TRO DAM ORIGINAL SCHEME RAPID DRAWDOWN WL.155.5m 1:2.3 & 1:1.8 <MO-02>
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CALCULATION NUMBER..........................        91

SLIPPE CIRCLE(X-COORDINATE)..................     -80.000 (M)
      -DO-    (Y-COORDINATE)..................     80.000 (M)
      -DO-    (RADIUS)........................    111.000 (M)

SAFETY FACTOR(NORMAL  CONDITION).............      1.979
      -DO-    (SEISMIC CONDITION).............      1.733

RESISTANCE MOMENT(TOTAL:NORMAL )..............     48959. (TON*M)
      -DO-         ( -DO-:SEISMIC)............     47921. (TON*M)
RESISTANCE FORCE  (COHESION)..................       0.00 (TON)
      -DO-        (FRICTION:BODY FORCE    )...     441.07 (TON)
      -DO-        (  -DO-  :WATER PRESSURE)...       0.00 (TON)
      -DO-        (  -DO-  :PORE  PRESSURE)...       0.00 (TON)
      -DO-        (  -DO-  :EARTHQUAKE    )...      -9.35 (TON)

SLIDING MOMENT(TOTAL:NORMAL )..................    24739. (TON*M)
      -DO-     ( -DO-:SEISMIC)..................    27657. (TON*M)
SLIDING FORCE  (BODY FORCE)....................    222.88 (TON)
      -DO-     (WATER PRESSURE)................      0.00 (TON)
      -DO-     (EARTHQUAKE)....................     26.28 (TON)
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*                          STABILITY ANALYSIS                                *
*                (MOST DANGEROUS SLIPPE CIRCLE)   (SEISMIC)                  *
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TRO DAM ORIGINAL SCHEME RAPID DRAWDOWN WL.155.5m 1:2.3 & 1:1.8 <MO-02>
------------------------------------------------------------------------------

CALCULATION NUMBER.........................          82

SLIPPE CIRCLE(X-COORDINATE)..................     -80.000 (M)
     -DO-    (Y-COORDINATE)..................      40.000 (M)
     -DO-    (RADIUS)........................     101.000 (M)

SAFETY FACTOR(NORMAL  CONDITION).............       2.067
     -DO-    (SEISMIC CONDITION).............       1.722

RESISTANCE MOMENT(TOTAL:NORMAL ).............     407556. (TON*M)
     -DO-        ( -DO-:SEISMIC).............     399822. (TON*M)
RESISTANCE FORCE (COHESION)..................        0.00 (TON)
     -DO-        (FRICTION:BODY FORCE     )...     5307.35 (TON)
     -DO-        (  -DO-  :WATER PRESSURE)...      104.14 (TON)
     -DO-        (  -DO-  :PORE  PRESSURE)...    -1376.29 (TON)
     -DO-        (  -DO-  :EARTHQUAKE     )...      -76.57 (TON)

SLIDING MOMENT(TOTAL:NORMAL )................     197136. (TON*M)
     -DO-      ( -DO-:SEISMIC)...............     232244. (TON*M)
SLIDING FORCE (BODY FORCE)...................     1957.06 (TON)
     -DO-      (WATER PRESSURE)..............       -5.22 (TON)
     -DO-      (EARTHQUAKE)..................      347.60 (TON)
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*   MINMIM SAFETY FACTOR AT EACH GRID POINT (NORMAL)   *
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TRO DAM ORIGINAL SCHEME RAPID DRAWDOWN WL.155.5m 1:2.3 & 1:1.8 <MO-02>

NUMBER	SLIPPE CIRCLE COORDINATE X	Y	RADIUS	STATIC SAFETY FACTOR	STATIC MOMENT RESISTANCE	STATIC MOMENT SLIDING	DYNAMIC SAFETY FACTOR	DYNAMIC MOMENT RESISTANCE	DYNAMIC MOMENT SLIDING
1	-200.000	160.000	221.000	2.533	44979.	17758.	1.917	43719.	22801.
2	-180.000	60.000	121.000	2.257	30126.	13345.	1.756	29174.	16610.
3	-180.000	80.000	141.000	2.473	45158.	18262.	1.886	43864.	23254.
4	-180.000	100.000	161.000	2.681	62702.	23384.	2.010	61048.	30373.
5	-180.000	120.000	181.000	2.884	82621.	28643.	2.128	80596.	37881.
6	-180.000	140.000	201.000	3.053	105981.	34714.	2.226	103546.	46508.
7	-160.000	0.000	61.000	2.338	22318.	9547.	1.813	21639.	11933.
8	-160.000	20.000	81.000	2.616	37274.	14250.	1.975	36273.	18370.
9	-160.000	40.000	101.000	2.866	55621.	19407.	2.117	54258.	25624.
10	-160.000	60.000	121.000	3.109	77074.	24794.	2.253	75331.	33431.
11	-160.000	80.000	141.000	3.103	106858.	34439.	2.267	104549.	46116.
12	-160.000	100.000	161.000	2.887	151426.	52449.	2.174	148198.	68161.
14	-160.000	120.000	181.000	2.663	214363.	80498.	2.068	209791.	101445.
15	-160.000	140.000	201.000	2.488	299248.	120283.	1.980	292838.	147873.
16	-160.000	160.000	221.000	2.361	409623.	173511.	1.914	400810.	209357.
18	-140.000	0.000	51.000	3.111	7672.	2466.	2.230	7502.	3365.
19	-140.000	20.000	81.000	3.512	67696.	19274.	2.474	66410.	26843.
21	-140.000	40.000	101.000	3.106	105730.	34045.	2.289	103657.	45294.
23	-140.000	60.000	121.000	2.769	159583.	57632.	2.123	156350.	73641.
25	-140.000	80.000	141.000	2.539	232920.	91738.	2.004	228085.	113791.
26	-140.000	100.000	161.000	2.382	328858.	138072.	1.920	321919.	167657.
27	-140.000	120.000	181.000	2.269	449976.	198333.	1.857	440377.	237142.
29	-140.000	140.000	201.000	2.201	597561.	271522.	1.820	584809.	321315.
31	-140.000	160.000	221.000	2.196	752959.	342849.	1.822	737381.	404658.
33	-120.000	0.000	61.000	3.330	66694.	20028.	2.407	65588.	27247.
35	-120.000	20.000	81.000	2.734	117522.	42988.	2.099	115347.	54964.
37	-120.000	40.000	101.000	2.443	188528.	77155.	1.939	184804.	95284.
39	-120.000	60.000	121.000	2.281	283240.	124184.	1.849	277423.	150056.
41	-120.000	80.000	141.000	2.181	405213.	185756.	1.794	396694.	221158.
43	-120.000	100.000	161.000	2.135	552277.	258672.	1.771	540705.	305384.

45	I	-120.000	120.000	181.000	I	2.152	704175.	327244.	I	1.786	689995.	386333.
48	I	-120.000	140.000	191.000	I	2.201	453631.	206056.	I	1.860	444792.	239167.
50	I	-120.000	160.000	211.000	I	2.250	571778.	254082.	I	1.897	561141.	295733.
52	I	-100.000	0.000	61.000	I	2.442	102909.	42141.	I	1.930	101043.	52346.
54	I	-100.000	20.000	81.000	I	2.235	185203.	82847.	I	1.813	181565.	100128.
56	I	-100.000	40.000	101.000	I	2.130	296297.	139121.	I	1.754	290224.	165430.
60	I	-100.000	60.000	101.000	I	2.017	47201.	23398.	I	1.761	46220.	26244.
63	I	-100.000	80.000	121.000	I	2.011	88250.	43879.	I	1.757	86409.	49182.
66	I	-100.000	100.000	141.000	I	2.008	147920.	73654.	I	1.755	144830.	82524.
69	I	-100.000	120.000	161.000	I	2.048	221689.	108227.	I	1.786	217230.	121625.
72	I	-100.000	140.000	181.000	I	2.132	299520.	140508.	I	1.849	293888.	158947.
75	I	-100.000	160.000	201.000	I	2.242	379864.	169397.	I	1.932	373198.	193208.
78	I	-80.000	0.000	41.000	I	2.156	20860.	9677.	I	1.872	20454.	10929.
79	I	-80.000	20.000	81.000	I	2.079	272566.	131077.	I	1.730	267097.	154428.
82	I	-80.000	40.000	101.000	I	2.067	407556.	197136.	I	1.722	399822.	232244.
87	I	-80.000	60.000	101.000	I	2.066	158919.	76905.	I	1.802	155696.	86413.
91	I	-80.000	80.000	111.000	I	1.979	48959.	24739.	I	1.733	47921.	27657.
95	I	-80.000	100.000	131.000	I	2.015	89099.	44229.	I	1.760	87268.	49575.
99	I	-80.000	120.000	151.000	I	2.123	133837.	63038.	I	1.843	131316.	71246.
103	I	-80.000	140.000	171.000	I	2.262	180735.	79918.	I	1.946	177620.	91255.
107	I	-80.000	160.000	191.000	I	2.417	229212.	94818.	I	2.061	225576.	109466.
111	I	-60.000	0.000	31.000	I	2.175	9436.	4338.	I	1.888	9254.	4901.
115	I	-60.000	20.000	51.000	I	2.106	27732.	13166.	I	1.834	27179.	14818.
119	I	-60.000	40.000	71.000	I	2.078	59526.	28644.	I	1.812	58324.	32191.
123	I	-60.000	60.000	91.000	I	2.145	102585.	47830.	I	1.862	100663.	54060.
127	I	-60.000	80.000	111.000	I	2.293	148827.	64916.	I	1.970	146331.	74263.
132	I	-60.000	100.000	121.000	I	2.122	42166.	19875.	I	1.841	41372.	22467.
137	I	-60.000	120.000	141.000	I	2.307	64563.	27984.	I	1.980	63485.	32063.
142	I	-60.000	140.000	161.000	I	2.519	88113.	34976.	I	2.135	86794.	40657.
147	I	-60.000	160.000	181.000	I	2.741	112535.	41060.	I	2.292	111006.	48430.
152	I	-40.000	0.000	21.000	I	2.190	3162.	1444.	I	1.900	3101.	1632.
157	I	-40.000	20.000	41.000	I	2.098	13485.	6429.	I	1.827	13215.	7232.
162	I	-40.000	40.000	61.000	I	2.161	32397.	14993.	I	1.875	31797.	16962.
167	I	-40.000	60.000	81.000	I	2.386	54543.	22860.	I	2.039	53686.	26327.
172	I	-40.000	80.000	101.000	I	2.681	78399.	29244.	I	2.249	77334.	34383.
177	I	-40.000	100.000	121.000	I	3.004	103521.	34466.	I	2.471	102282.	41388.
182	I	-40.000	120.000	141.000	I	3.339	129657.	38836.	I	2.694	128269.	47616.
188	I	-40.000	140.000	151.000	I	2.990	24846.	8309.	I	2.458	24547.	9987.
194	I	-40.000	160.000	171.000	I	3.319	32750.	9867.	I	2.678	32399.	12098.

MINMIM SAFETY FACTOR AT EACH GRID POINT (SEISMIC)

TRO DAM ORIGINAL SCHEME RAPID DRAWDOWN WL.155.5m 1:2.3 & 1:1.8 <MO-02>

NUMBER	SLIPPE CIRCLE COORDINATE X	SLIPPE CIRCLE COORDINATE Y	RADIUS	STATIC SAFETY FACTOR	STATIC MOMENT RESISTANCE	STATIC MOMENT SLIDING	DYNAMIC SAFETY FACTOR	DYNAMIC MOMENT RESISTANCE	DYNAMIC MOMENT SLIDING
1	-200.000	160.000	221.000	2.533	44979.	17758.	1.917	43719.	22801.
2	-180.000	60.000	121.000	2.257	30126.	13345.	1.756	29174.	16610.
3	-180.000	80.000	141.000	2.473	45158.	18262.	1.886	43864.	23254.
4	-180.000	100.000	161.000	2.681	62702.	23384.	2.010	61048.	30373.
5	-180.000	120.000	181.000	2.884	82621.	28643.	2.128	80596.	37881.
6	-180.000	140.000	201.000	3.053	105981.	34714.	2.226	103546.	46508.
7	-160.000	0.000	61.000	2.338	22318.	9547.	1.813	21639.	11933.
8	-160.000	20.000	81.000	2.616	37274.	14250.	1.975	36273.	18370.
9	-160.000	40.000	101.000	2.866	55621.	19407.	2.117	54258.	25624.
10	-160.000	60.000	121.000	3.109	77074.	24794.	2.253	75331.	33431.
11	-160.000	80.000	141.000	3.103	106858.	34439.	2.267	104549.	46116.
12	-160.000	100.000	161.000	2.887	151426.	52449.	2.174	148198.	68161.
14	-160.000	120.000	181.000	2.663	214363.	80498.	2.068	209791.	101445.
15	-160.000	140.000	201.000	2.488	299248.	120283.	1.980	292838.	147873.
16	-160.000	160.000	221.000	2.361	409623.	173511.	1.914	400810.	209357.
18	-140.000	0.000	51.000	3.111	7672.	2466.	2.230	7502.	3365.
20	-140.000	20.000	71.000	3.532	13475.	3815.	2.445	13210.	5403.
21	-140.000	40.000	101.000	3.106	105730.	34045.	2.289	103657.	45294.
23	-140.000	60.000	121.000	2.769	159583.	57632.	2.123	156350.	73641.
25	-140.000	80.000	141.000	2.539	232920.	91738.	2.004	228085.	113791.
26	-140.000	100.000	161.000	2.382	328858.	138072.	1.920	321919.	167657.
27	-140.000	120.000	181.000	2.269	449976.	198333.	1.857	440377.	237142.
29	-140.000	140.000	201.000	2.201	597561.	271522.	1.820	584809.	321315.
31	-140.000	160.000	221.000	2.196	752959.	342849.	1.822	737381.	404658.
33	-120.000	0.000	61.000	3.330	66694.	20028.	2.407	65588.	27247.
35	-120.000	20.000	81.000	2.734	117522.	42988.	2.099	115347.	54964.
37	-120.000	40.000	101.000	2.443	188528.	77155.	1.939	184804.	95284.
39	-120.000	60.000	121.000	2.281	283240.	124184.	1.849	277423.	150056.
41	-120.000	80.000	141.000	2.181	405213.	185756.	1.794	396694.	221158.
43	-120.000	100.000	161.000	2.135	552277.	258672.	1.771	540705.	305384.
45	-120.000	120.000	181.000	2.152	704175.	327244.	1.786	689995.	386333.

47	I	-120.000	140.000	201.000	I	2.206	858010.	388948.	I	1.825	841545.	461133.
49	I	-120.000	160.000	221.000	I	2.283	1015085.	444686.	I	1.878	996576.	530529.
52	I	-100.000	0.000	61.000	I	2.442	102909.	42141.	I	1.930	101043.	52346.
54	I	-100.000	20.000	81.000	I	2.235	185203.	82847.	I	1.813	181565.	100128.
56	I	-100.000	40.000	101.000	I	2.130	296297.	139121.	I	1.754	290224.	165430.
58	I	-100.000	60.000	121.000	I	2.082	436002.	209427.	I	1.730	427027.	246790.
61	I	-100.000	80.000	141.000	I	2.106	581428.	276050.	I	1.750	570048.	325820.
66	I	-100.000	100.000	141.000	I	2.008	147920.	73654.	I	1.755	144830.	82524.
69	I	-100.000	120.000	161.000	I	2.048	221689.	108227.	I	1.786	217230.	121625.
72	I	-100.000	140.000	181.000	I	2.132	299520.	140508.	I	1.849	293888.	158947.
75	I	-100.000	160.000	201.000	I	2.242	379864.	169397.	I	1.932	373198.	193208.
76	I	-80.000	0.000	61.000	I	2.189	153701.	70220.	I	1.797	150805.	83907.
79	I	-80.000	20.000	81.000	I	2.079	272566.	131077.	I	1.730	267097.	154428.
82	I	-80.000	40.000	101.000	I	2.067	407556.	197136.	I	1.722	399822.	232244.
85	I	-80.000	60.000	121.000	I	2.148	547514.	254910.	I	1.775	537925.	303042.
91	I	-80.000	80.000	111.000	I	1.979	48959.	24739.	I	1.733	47921.	27657.
95	I	-80.000	100.000	131.000	I	2.015	89099.	44229.	I	1.760	87268.	49575.
99	I	-80.000	120.000	151.000	I	2.123	133837.	63038.	I	1.843	131316.	71246.
103	I	-80.000	140.000	171.000	I	2.262	180735.	79918.	I	1.946	177620.	91255.
107	I	-80.000	160.000	191.000	I	2.417	229212.	94818.	I	2.061	225576.	109466.
108	I	-60.000	0.000	61.000	I	2.227	215479.	96758.	I	1.848	211558.	114474.
112	I	-60.000	20.000	81.000	I	2.151	338180.	157215.	I	1.783	332566.	186562.
119	I	-60.000	40.000	71.000	I	2.078	59526.	28644.	I	1.812	58324.	32191.
123	I	-60.000	60.000	91.000	I	2.145	102585.	47830.	I	1.862	100663.	54060.
127	I	-60.000	80.000	111.000	I	2.293	148827.	64916.	I	1.970	146331.	74263.
132	I	-60.000	100.000	121.000	I	2.122	42166.	19875.	I	1.841	41372.	22467.
137	I	-60.000	120.000	141.000	I	2.307	64563.	27984.	I	1.980	63485.	32063.
142	I	-60.000	140.000	161.000	I	2.519	88113.	34976.	I	2.135	86794.	40657.
147	I	-60.000	160.000	181.000	I	2.741	112535.	41060.	I	2.292	111006.	48430.
152	I	-40.000	0.000	21.000	I	2.190	3162.	1444.	I	1.900	3101.	1632.
157	I	-40.000	20.000	41.000	I	2.098	13485.	6429.	I	1.827	13215.	7232.
162	I	-40.000	40.000	61.000	I	2.161	32397.	14993.	I	1.875	31797.	16962.
167	I	-40.000	60.000	81.000	I	2.386	54543.	22860.	I	2.039	53686.	26327.
172	I	-40.000	80.000	101.000	I	2.681	78399.	29244.	I	2.249	77334.	34383.
177	I	-40.000	100.000	121.000	I	3.004	103521.	34466.	I	2.471	102282.	41388.
182	I	-40.000	120.000	141.000	I	3.339	129657.	38836.	I	2.694	128269.	47616.
188	I	-40.000	140.000	151.000	I	2.990	24846.	8309.	I	2.458	24547.	9987.
194	I	-40.000	160.000	171.000	I	3.319	32750.	9867.	I	2.678	32399.	12098.

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*                           STABILITY ANALYSIS                              *
*                (MOST DANGEROUS SLIPPE CIRCLE)   (NORMAL)                  *
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TRO DAM ORIGINAL SCHEME RAPID DRAWDOWN WL.155.5m 1:2.3 & 1:1.8 <MO-02>
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CALCULATION NUMBER..........................       199

SLIPPE CIRCLE(X-COORDINATE)..................     140.000 (M)
      -DO-    (Y-COORDINATE)..................     140.000 (M)
      -DO-    (RADIUS).........................     191.000 (M)

SAFETY FACTOR(NORMAL  CONDITION).............       1.533
      -DO-    (SEISMIC CONDITION).............       1.367

RESISTANCE MOMENT(TOTAL:NORMAL )..............     99232. (TON*M)
      -DO-        ( -DO-:SEISMIC).............     96517. (TON*M)
RESISTANCE FORCE (COHESION)...................       0.00 (TON)
      -DO-        (FRICTION:BODY FORCE     )...     519.54 (TON)
      -DO-        (   -DO-  :WATER PRESSURE)...       0.00 (TON)
      -DO-        (   -DO-  :PORE  PRESSURE)...       0.00 (TON)
      -DO-        (   -DO-  :EARTHQUAKE    )...     -14.21 (TON)

SLIDING MOMENT(TOTAL:NORMAL )..................    -64710. (TON*M)
      -DO-     ( -DO-:SEISMIC)................    -70623. (TON*M)
SLIDING FORCE  (BODY FORCE)....................    -338.80 (TON)
      -DO-     (WATER PRESSURE)................       0.00 (TON)
      -DO-     (EARTHQUAKE)....................     -30.96 (TON)
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