

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF SETTLEMENT AND REGIONAL DEVELOPMENT  
THE REPUBLIC OF INDONESIA

**THE DETAILED DESIGN  
OF  
FLOOD CONTROL, URBAN DRAINAGE AND  
WATER RESOURCES DEVELOPMENT IN  
SEMARANG IN THE REPUBLIC OF INDONESIA**

**FINAL REPORT**

COMPILED BY  
JICA ENGINEERING INTERNATIONAL CO., LTD.

WITH THE ASSISTANCE OF  
PACIFIC CONSULTANTS INTERNATIONAL  
AND PASCO INTERNATIONAL INC.

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**FINAL REPORT**

**COMPONENT B:  
JATIBARANG MULTIPURPOSE DAM CONSTRUCTION**

**VOLUME III DESIGN NOTES**

**AUGUST 2000**

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## **CONSTITUTION OF THE REPORT**

- 1. SUMMARY**
- 2. COMPONENT A : WEST FLOODWAY/GARANG RIVER IMPROVEMENT**

<b>VOLUME I</b>	<b>MAIN REPORT</b>
<b>VOLUME II</b>	<b>DESIGN CRITERIA</b>
<b>VOLUME III</b>	<b>DESIGN NOTES</b>
<b>VOLUME IV</b>	<b>WORK QUANTITY CALCULATION</b>
<b>VOLUME V</b>	<b>CONSTRUCTION PLANNING</b>
<b>VOLUME VI</b>	<b>COST ESTIMATE</b>
<b>VOLUME VII</b>	<b>DATA BOOK</b>

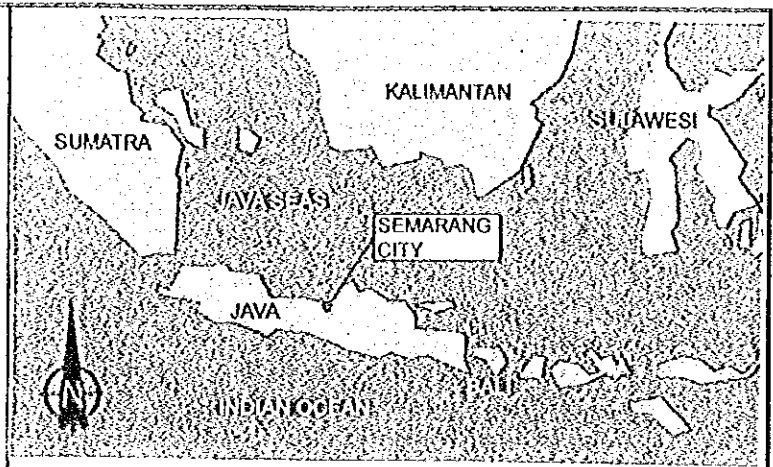
- 3. COMPONENT B : JATIBARANG MULTIPURPOSE DAM CONSTRUCTION**

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- 4. COMPONENT C : URBAN DRAINAGE SYSTEM IMPROVEMENT**

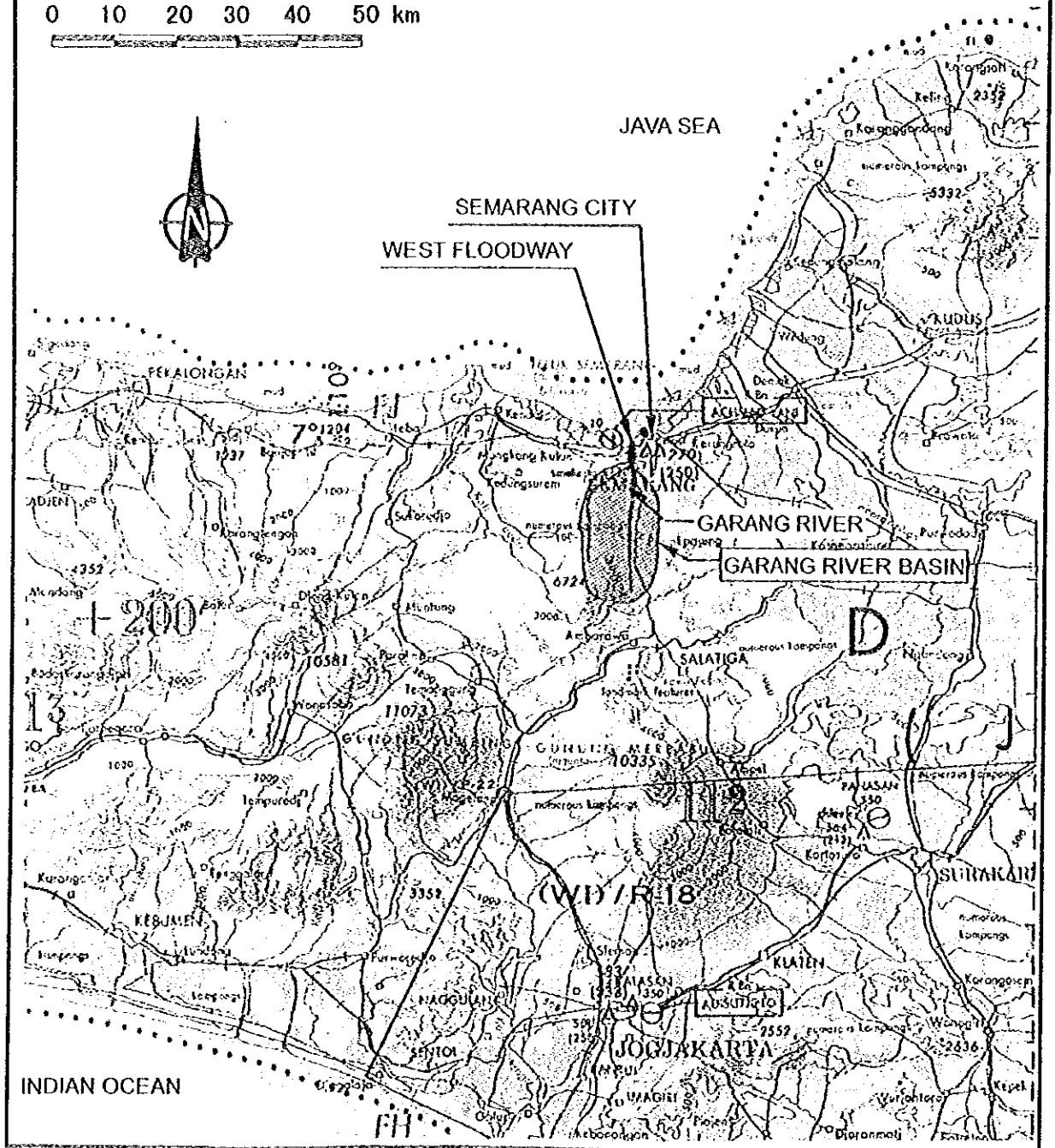
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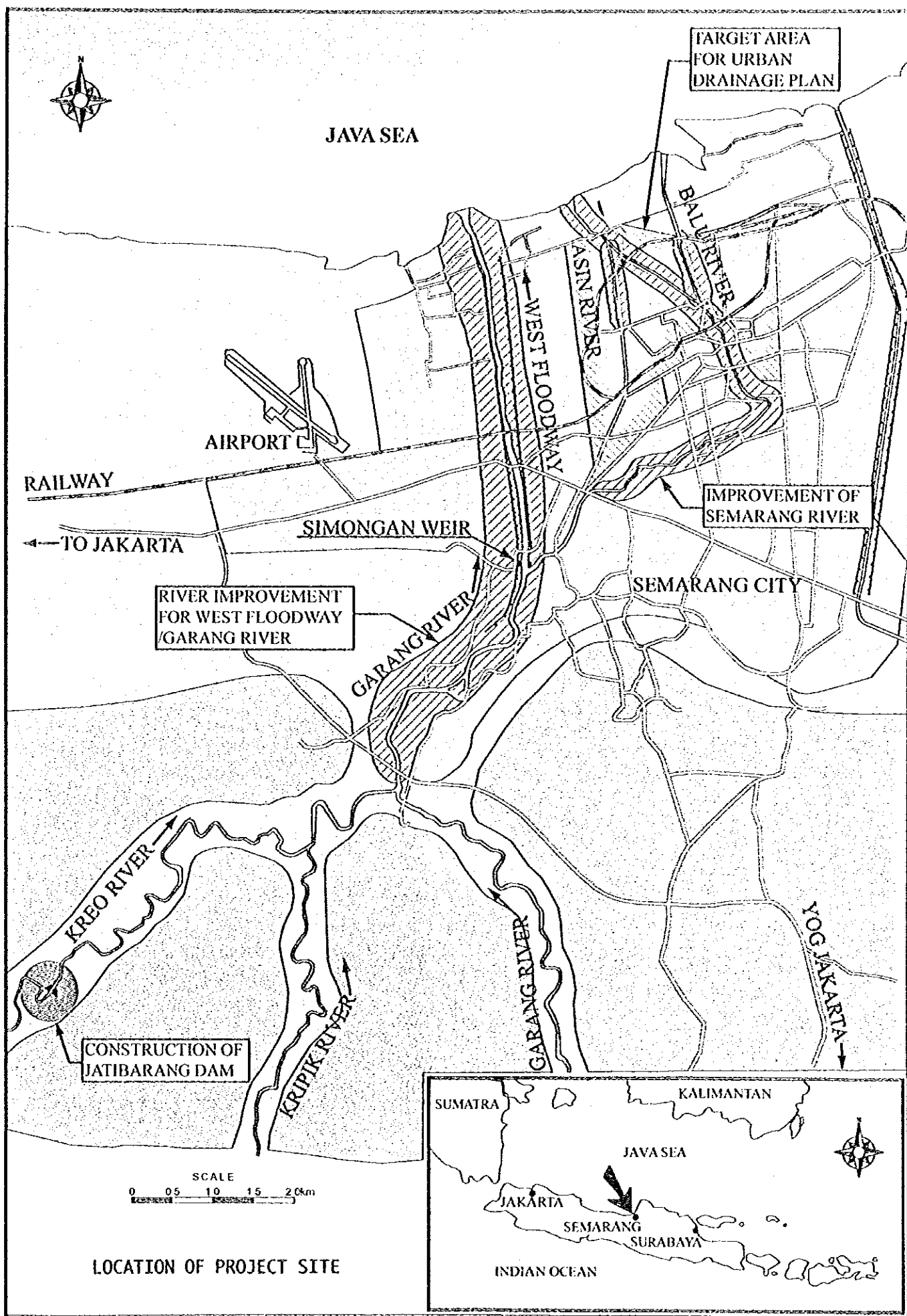
# GENERAL MAP



## SCALE

0 10 20 30 40 50 km





# VOLUME III DESIGN NOTES

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*Chapter 1*  
**GENERAL**

## CHAPTER 1 GENERAL

Jatibarang Multipurpose Dam planned on Kreo River is located in the southwest of Semarang City at about 13 km upstream from the confluence of Garang River. It will primarily function flood control, public water supply of Semarang City and hydropower generation.

Detailed discussion on selection of dam type has been given in VOLUME I Main Report. Based on the technical appraisal as well as construction cost, the center core rockfill type was found the most suitable for Jatibarang Multipurpose Dam. It was discussed between JICA Study Team and Indonesian Government and accepted by Indonesian Government in the Meeting held on 23 February 1999 in Jakarta.

This report (VOLUME III Design Notes) presents the structural calculation for the detailed design of Jatibarang Multipurpose Dam in accordance with the design criteria, which contain the codes/design standards, formulas, properties of structural materials, safety factors to be adopted for stability analysis and structural details.

The features are summarized hereinafter.

### (1) Dam and Reservoir

#### Reservoir

Catchment Area	: 53.0 km <sup>2</sup>
Reservoir Surface Area	: 1.10 km <sup>2</sup>
Maximum Water Surface	: EL. 155.300 m
Surcharge Water Surface	: EL. 151.800 m
Normal Water Surface	: EL. 148.900 m
Low Water Surface	: EL. 136.000 m
Gross Storage Capacity	: 20,400,000 m <sup>3</sup>
Effective Storage Capacity	: 13,600,000 m <sup>3</sup>
Flood Control Capacity	: 3,100,000 m <sup>3</sup>
Water Use Capacity	: 10,500,000 m <sup>3</sup>
Sediment Capacity	: 6,800,000 m <sup>3</sup>

## **Dam**

Dam Height above Foundation	: 77.0 m
Crest Elevation	: EL. 157.000 m
Foundation Elevation	: EL. 80.000 m
Crest Length	: 200.0 m
Crest Width	: 10.0 m
Upstream Slope	: 1 : 2.6
Downstream Slope	: 1 : 1.8

## **(2) Spillway**

### **Design Flood**

Probable Maximum Flood	: 1,600 m <sup>3</sup> /s (inflow into the reservoir)
100-year Probability	: 290 m <sup>3</sup> /s (inflow into the reservoir)
Design Discharge for Energy Dissipater	: 340 m <sup>3</sup> /s (100-year probable flood)
Design Discharge for Sidewall Height	: 1,310 m <sup>3</sup> /s (PMF outflow from reservoir)

### **Overflow Crest (Service Spillway)**

Crest Elevation	: EL. 148.900 m
Crest Length	: 15.0 m

### **Overflow Crest (Emergency Spillway)**

Crest Elevation	: EL. 151.800 m
Total Crest Length	: 60.0 m

Total Length of Spillway	: 307 m
Stilling Basin	: 24.0 m wide x 60.0 m long
Spillway Bridge (PC Girder Type)	: 5.0 m wide x 23.94 m long

## **(3) Outlet Facilities**

Maximum Design Discharge	: 6.0 m <sup>3</sup> /s
Minimum Design Discharge	: 0.26 m <sup>3</sup> /s
Intake Structure	: Inclined Type
Bulkhead Gate	: Clear Span 2.0 m x Clear Height 1.4 m
Emergency Gate	: Clear Span 2.0 m x Clear Height 1.4 m
Steel Outlet Pipe	: 393 m long x 1.4 m dia.
Control Gate	: 650 and 250 mm dia.

(4) Diversion Facilities

Design Discharge	: 280 m <sup>3</sup> /s (25-year probable flood)
Tunnel Section	: Horseshoe with the diameter of 5.6 m
Longitudinal Gradient	: 1/30
Tunnel Length	: 441 m
Tunnel Inlet Elevation	: EL. 98.500 m
Crest of Main Cofferdam	: EL. 113.000 m

(5) Hydropower Generation

Maximum Plant Discharge	: 3.0 m <sup>3</sup> /s
Maximum Gross head	: 65.5 m
Installed Capacity	: 1,560 kW
Number of Generator at Future Stage	: No extension
Annual Energy Production	: 6,020 MWh

(6) Dam Management Complex

Dam Administration Building	: 594.010 m <sup>2</sup> , 3 story
Staff House 1 (Guest House)	: 74.416 m <sup>2</sup> , 1 story
Staff House 2	: 49.110 m <sup>2</sup> x 4 units, 1 story
Mushola	: 72.300 m <sup>2</sup> , 1 story

(7) Hydropower Station Complex

Hydropower Station Buildig	: 389.640 m <sup>2</sup> , 2 story
Garage	: 183.600 m <sup>2</sup> , 1 story
Guard House	: 14.275 m <sup>2</sup> , 1 story

*Chapter 2*  
**D A M**

## **2.1 General**

This chapter presents results of structural design of Jatibarang Multipurpose Dam and its related facilities.

The studied facilities are mentioned hereunder.

- (a) Dam Embankment
- (b) Gallery
- (c) Spillway
- (d) Diversion Tunnel
- (e) Intake Structure
- (f) Gate Structure

## 2.2 Dam Embankment

### 2.2.1 Slope Stability Analysis of Dam Embankment

#### Loading Condition to be Considered

The varieties and combination of loads to be considered in embankment stability against sliding failure shall be determined in accordance with the reservoir water surface and seismic condition.

In principle, self weight, hydrostatic pressure, pore pressure and seismic body force shall be considered.

Load to be considered and the required safety factor for each condition of the dam are tabulated below:

Case	Condition of Dam	Combination of Loads	Required Safety Factor
1	Reservoir water level is at Normal Water Surface and seepage is steady.	Self weight Hydrostatic pressure Pore pressure 100 % of seismic body force	1.20
2	Reservoir water level is at Normal Water Surface and seepage is steady.	Self weight Hydrostatic pressure Pore pressure 0 % of seismic body force	1.50
3	Reservoir water level is at Maximum Water Surface	Self weight Hydrostatic pressure Pore pressure 0 % of seismic body force	1.20
4	Reservoir water level is being rapidly drawn down from Normal Water Surface to Low Water Surface and there is residual pore pressure	Self weight Hydrostatic pressure Residual pore pressure 100 % of seismic body force	1.10
5	Reservoir water level is being rapidly drawn down from Normal Water Surface to Low Water Surface and there is residual pore pressure.	Self weight Hydrostatic pressure Residual pore pressure 0 % of seismic body force	1.25
6	At the end of construction, there is residual pore pressure.	Self weight Pore pressure 50 % of seismic body force	1.20

#### Loads

##### (1) Self Weight

Self weight for analyzing the safety of the dam at the end of construction is calculated



based on the wet density of materials. Thus, those at the Maximum Water Surface and Low Water Surface of reservoir are estimated on the wet density and saturated density used for the portion above and below the seepage water line respectively.

Self weight will be calculated by following equation:

$$G = W \cdot V$$

Where,

- G : self weight (tf)
- W : wet or saturated density (tf/m<sup>3</sup>)
- V : volume of dam body (m<sup>3</sup>)

#### (2) Hydrostatic Pressure

Hydrostatic pressure acts perpendicularly on the surface of the embankment and its value will be determined using the following equation:

$$P = W_o \cdot h$$

Where,

- P : hydrostatic pressure (tf/m<sup>2</sup>)
- W<sub>o</sub> : unit weight of water (1.0 tf/m<sup>3</sup>)
- h : depth of water (m)

#### (3) Pore Pressure

Pore pressure is assumed to act perpendicularly on sliding faces and horizontally on the sides of a slice. In relation to the condition of the dam, three cases are considered in the calculation of pore pressure. At the end of construction, pore pressure is considered, which will be estimated by using 50 % of the self-weight above the point of the sliding face. At the Normal Water Surface, pore pressure that develops by seepage is considered (free surface of the seepage flow is explained in the next sub-clause). At rapid drawdown, residual pore pressure is considered.

#### (4) Seismic Body Force

For the seismic body force, the value of weight of the embankment multiplied by a seismic coefficient is applied and treated to act horizontally. The force can be calculated as follows:

$$G_k = G \cdot k$$

Where,

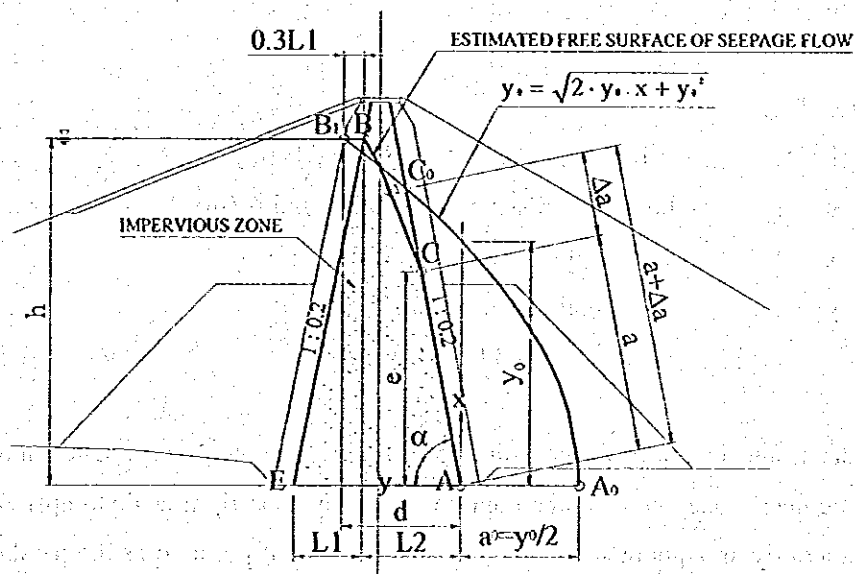
$G_k$  : seismic body force (tf)

**G** : self weight (tf)

**k** : seismic coefficient

### Seepage Flow in Dam Body

The pore pressures that exist within the impervious zone at any time are considered to be generated by gravity seepage flow. The seepage flow is estimated by Casagrande's method to clarify the pore pressure distribution in the impervious zone.



**L1:** horizontal distance between B and E (m)

**L2:** horizontal distance between B and A (m)

A : toe of downstream slope on pervious portion

$A_0$ : origin of coordinate which is  $y_0/2$  downstream from A

**B :** intersection of water level and upstream slope

$B_1$ : the point located at 0.3 L1 upstream from B

### Free Surface of Seepage Flow

According to A. Casagrande, the free surface of seepage flow (hereafter: top flow line) in the dam body (to be adequate distance from both upstream and downstream slopes) coincides with

standard parabola developed by J.S. Kozeny for a dam with downstream slope at 30° degree to the horizontal.

As shown in the figure, this parabola starts at point B<sub>1</sub>, slightly upstream of point B, while C<sub>0</sub> is obtained from the intersection of parabola with the downstream slope locates slightly higher than C, the actual breakout point of seepage on the downstream slope. The standard parabola concerned with the top flow line is as follows:

$$x = \frac{y^2 - y_0^2}{2y_0}$$

$$y = \sqrt{2y_0x + y_0^2}$$

$$y_0 = \sqrt{h^2 + d^2} - d$$

Where,

- h : vertical distance between A and B (m)
- d : horizontal distance between B<sub>1</sub> and A (m)
- x : vertical distance from A (m)
- y : horizontal distance from A (m)
- y<sub>0</sub> : value estimated from h and d

However, to determine the top flow line, some corrections to the parabola obtained in the above manner must be made. One, the entrance point to dam body, is at right angle to upstream slope that is simultaneously an equipotential line. Other, the breakout point so as the parabola, does not appear outside of the slope.

The top flow line (B-C-A) is obtained by corrections to the fundamental parabola (B<sub>1</sub>-C<sub>0</sub>-A<sub>0</sub>) for which the entrance point is as described above and C is lowered to C<sub>0</sub> with slope of Δa. The Δa exhibits a different value according to the angle of slope on the discharge face (at breakout point) and can be found by the following equation.

$$a + \Delta a = \frac{y_0}{1 - \cos \alpha}$$

Where,

- a : slope distance between point A and C (m)
- Δa : slope distance between point C<sub>0</sub> and C (m)

$\alpha$  : slope angle on discharge face (degree)

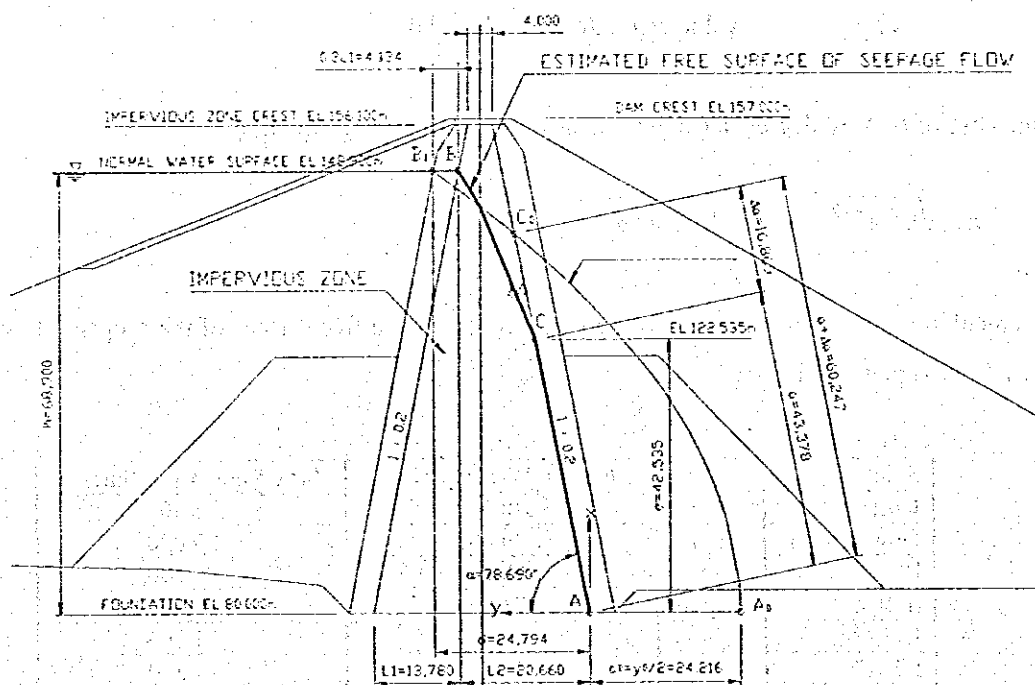
$y_0$  : value estimated from h and d

In the case of  $\alpha < 30$  degree, a can be obtained by the following equation.

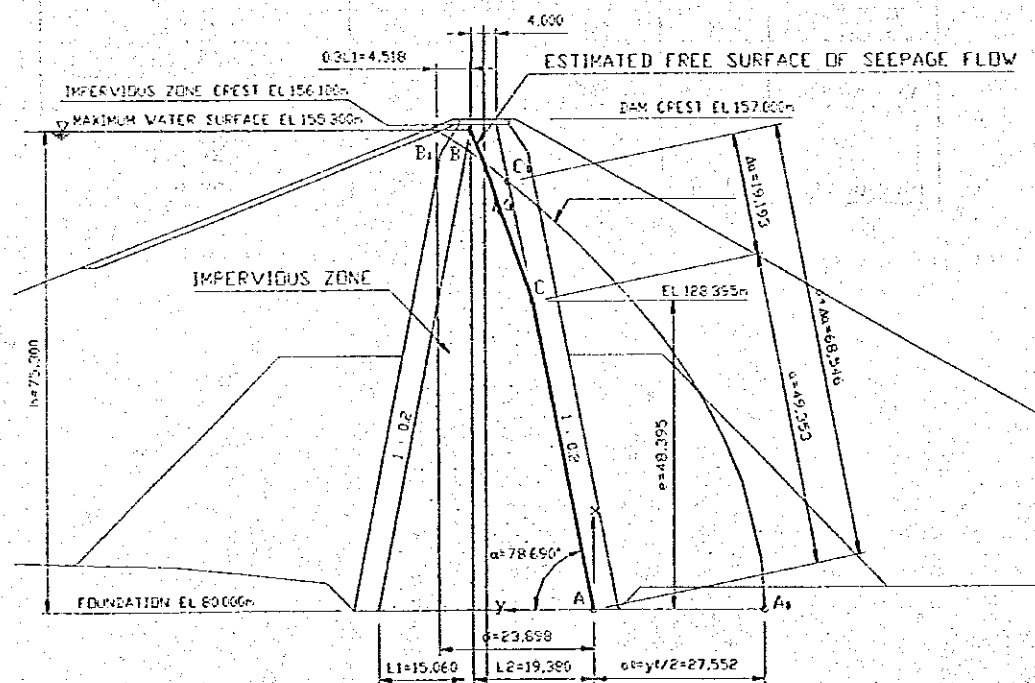
$$a = \sqrt{h^2 + d^2} - \sqrt{d^2 - h^2 \cot^2 \alpha}$$

The calculation results are given as follows and the estimated free surface of the seepage flow is shown in next page.

Symbol	Unit	Normal Water Surface	Maximum Water Surface
Upstream	EL. m	148.900	155.300
Downstream	EL. m	80.000	80.000
h	m	68.900	75.300
$\alpha$	degree	78.690	78.690
L1	m	13.780	15.060
L2	m	20.660	19.380
0.3L1	m	4.134	4.518
d	m	24.794	23.898
$y_0$	m	48.431	55.103
$y_0/2$	m	24.216	27.552
$a+\Delta a$	m	60.247	68.546
$\Delta a$	m	16.869	19.193
a	m	43.378	49.353
e	m	42.535	48.395
Elevation C	EL. m	122.535	128.395



DURING NORMAL WATER SURFACE



DURING MAXIMUM WATER SURFACE

## RESULTS OF STRESS-STRAIN ANALYSIS FOR GALLERY (VECTORS)

### **Method of Stability Analysis**

The stability analysis is carried out by slip circle method using the effective stress. The safety factor against sliding for an assumed circle is examined by the following equation:

$$SF = \frac{\Sigma \{C' * L + (N - U - Ne) * \tan \phi'\}}{\Sigma (T + Te)}$$

Where,

- SF : safety factor
- N : normal force acting on slip circle (tf/m)
- T : tangential force acting on slip circle (tf/m)
- U : pore pressure acting on slip circle (tf/m)
- Ne : normal force of earthquake load acting on slip circle (tf/m)
- Te : tangential force of earthquake load acting on slip circle (tf/m)
- $\phi'$  : effective internal friction angle on slip circle ( $^{\circ}$ )
- C' : effective cohesion on slip circle (tf/m)
- L : arc length of slip circle (m)

### **Design Values of Each Zone**

The design values of materials to be used in stability analysis are adopted from the limited test results on smaller samples. Cohesion and internal friction angle in terms of effective stresses are directly determined from the test results. Wet density and saturated density obtained from the laboratory tests can be converted into the design values considering a content ratio of a gravel coarser than the maximum size (19.0 mm) of samples in the laboratory. Estimated design values are given hereunder.

#### **(1) Impervious Zone**

Resulting from the laboratory tests, the design values of the impervious zone are estimated as follows.

No.	Item	Unit	Design Value
1	Average Specific Gravity (Gs)	t/m <sup>3</sup>	2.72
2	Average Natural Moisture Content (W)	%	12.6
3	Dry Density ( $\gamma_d$ )	t/m <sup>3</sup>	1.87
4	Wet Density ( $\gamma_t$ )	t/m <sup>3</sup>	2.11
5	Saturated Density ( $\gamma_{sat}$ )	t/m <sup>3</sup>	2.19
6	Effective Internal Friction Angle ( $\phi'$ )	°	25.0
7	Effective Cohesion (C')	t/m <sup>2</sup>	1.0

(2) Semi-pervious Zone

Resulting from the laboratory tests, the design values of the semi-pervious zone are estimated as follows.

No.	Item	Unit	Design Value		
			Upstream	Down-stream (fine)	Down-stream (coarse)
1	Specific Gravity (Gs)	t/m <sup>3</sup>	2.56	2.58	2.54
2	Natural Water Content (W)	%	1.6	2.0	1.0
3	Dry Density ( $\gamma_d$ )	t/m <sup>3</sup>	2.08	1.86	1.92
4	Wet Density ( $\gamma_t$ )	t/m <sup>3</sup>	2.11	1.90	1.94
5	Saturated Density ( $\gamma_{sat}$ )	t/m <sup>3</sup>	2.27	2.14	2.16
6	Effective Internal Friction Angle ( $\phi'$ )	°	35.0	35.0	45 ( $0 < \sigma' \leq 2.6$ )
					42 ( $2.6 < \sigma' \leq 6.3$ )
					37 ( $6.3 < \sigma'$ )
7	Effective Cohesion (C')	t/m <sup>2</sup>	0.0	0.0	0.0

(3) Pervious Zone

In general, rock materials for the pervious zone have high friction angle at low stress levels. The upper envelope of the circles on a Mohr diagram is typically concave downward with a slope that is steepest in the lower range of normal stress that decreases gradually with increasing stress.

For the rock materials for outer pervious zone, three (3) fixed values of friction angle depending on stress levels are adopted. Internal friction angle of them in inner pervious zone is reduced by about 5 % because the soft rocks from the required excavations, which have less desirable properties and are more erratic, are allowed to be mixed in this zone.

The design values of the pervious zone are estimated as follows.

No.	Item	Unit	Design Value	
			Inner Zone	Outer Zone
1	Specific Gravity (Gs)	t/m <sup>3</sup>	2.54	2.54
2	Natural Water Content (W)	%	1.0	1.0
3	Void Ratio		0.325	0.325
4	Dry Density ( $\gamma_d$ )	t/m <sup>3</sup>	1.92	1.92
5	Wet Density ( $\gamma$ )	t/m <sup>3</sup>	1.94	1.94
6	Saturated Density ( $\gamma_{sat}$ )	t/m <sup>3</sup>	2.16	2.16
7	Effective Internal Friction Angle ( $\phi'$ )	°	43 ( $0 < \sigma' \leq 2.6$ )	45 ( $0 < \sigma' \leq 2.6$ )
			40 ( $2.6 < \sigma' \leq 6.3$ )	42 ( $2.6 < \sigma' \leq 6.3$ )
			35 ( $6.3 < \sigma'$ )	37 ( $6.3 < \sigma'$ )
8	Effective Cohesion (C')	t/m <sup>2</sup>	0.0	0.0

Notes :  $\sigma'$  = Effective normal stress acting on the failure surface (kgf/cm<sup>2</sup>)

### Results of Slope Stability Analysis

In accordance with the aforesaid discussions, slope stability analysis is executed. The figures and tables of results are given in the following pages, and the most critical results are shown below:

Case	Reservoir Water Surface	Earthquake	Slope	Radius of Sliding Circle (m)	Safety Factor	
					Calculated	Required
1	Normal Water Surface	100% k=0.18	U/S	285.004	1.22	1.20--OK
			D/S	106.500	1.23	
2	Normal Water Surface	0% k=0.0	U/S	189.105	2.61	1.50--OK
			D/S	153.642	1.83	
3	Maximum Water Surface	0% k=0.0	U/S	285.004	2.62	1.20--OK
			D/S	106.500	1.80	
4	Rapid Drawdown to Low Water Surface	100% k=0.18	U/S	285.004	1.22	1.10--OK
			D/S	153.642	1.24	
5	Rapid Drawdown to Low Water Surface	0% k=0.0	U/S	139.104	2.39	1.25--OK
			D/S	153.642	1.83	
6	End of Construction	50% k=0.09	U/S	285.004	2.05	1.20--OK
			D/S	136.500	1.49	

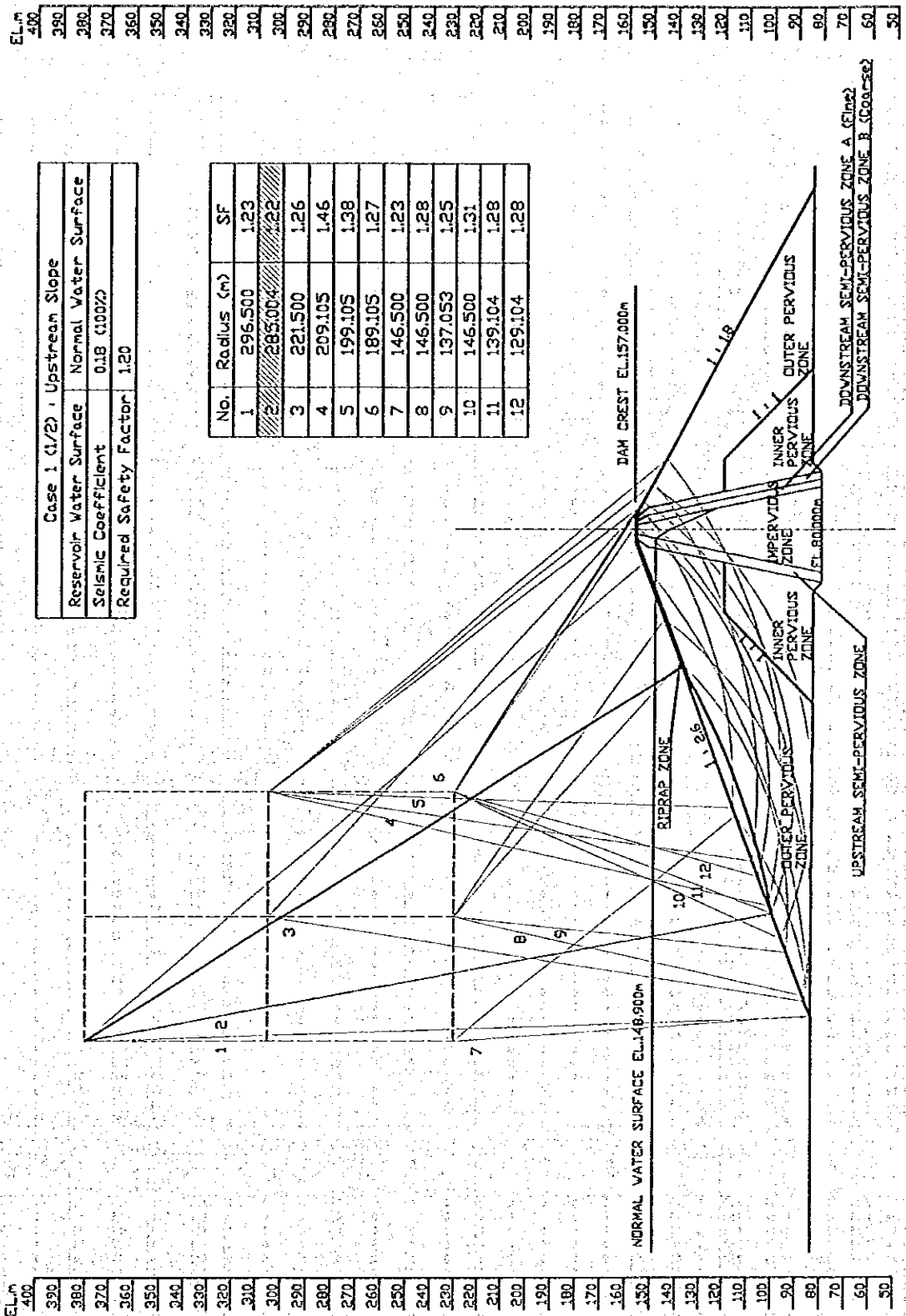
Note: U/S = Up Stream (1:2.6), D/S = Down Stream (1:1.8)

From these results, It is concluded that designed slopes of the dam embankment satisfy the required safety factor.



**Calculated Safety Factor by Each Case**

Case		1	2	3	4	5	6
Reservoir Water Surface		Normal Water Surface	Normal Water Surface	Maximum Water Surface	Rapid Drawdown to Low Water Surface	Rapid Drawdown to Low Water Surface	End of Construction
Earthquake		100%	0%	0%	100%	0%	50%
Required Safety Factor		1.20	1.50	1.20	1.10	1.25	1.20
Up Stream Slope = 1:2.6	1	1.23	2.66	2.67	1.25	2.55	2.16
	2	1.22	2.62	2.62	1.218	2.62	2.05
	3	1.26	2.67	2.78	1.25	2.48	2.06
	4	1.46	3.44	3.96	1.36	2.81	2.22
	5	1.38	3.02	3.41	1.34	2.58	2.17
	6	1.27	2.61	2.85	1.34	2.41	2.12
	7	1.23	2.65	2.65	1.23	2.65	2.07
	8	1.28	2.82	2.82	1.27	2.74	2.19
	9	1.25	2.74	2.74	1.25	2.73	2.12
	10	1.31	2.91	3.18	1.24	2.49	2.06
	11	1.28	2.74	2.95	1.222	2.39	2.08
	12	1.28	2.72	2.84	1.29	2.49	2.13
Minimum Safety Factor		1.22	2.61	2.62	1.22	2.39	2.05
Down Stream Slope = 1:1.8	1	1.28	1.89	1.89	1.28	1.89	1.54
	2	1.24	1.83	1.83	1.24	1.83	1.49
	3	1.28	1.92	1.87	1.28	1.92	1.50
	4	1.29	2.00	1.87	1.33	2.06	1.57
	5	1.34	2.02	1.94	1.34	2.02	1.55
	6	1.29	1.91	1.91	1.29	1.91	1.54
	7	1.28	1.90	1.90	1.28	1.90	1.54
	8	1.34	2.01	2.01	1.34	2.01	1.62
	9	1.32	1.96	1.96	1.32	1.96	1.59
	10	1.23	1.92	1.80	1.28	2.00	1.54
	11	1.28	1.96	1.87	1.30	1.99	1.53
	12	1.34	2.01	1.98	1.34	2.01	1.56
Minimum Safety Factor		1.23	1.83	1.80	1.24	1.83	1.49



Case 1 (1/2) : Upstream Slope

SF : Safety Factor

C: Effective Cohesion on Sfp Circle ( $\text{tf/m}^2$ )  
L: Arc Length of Sfp Circle (m)  
 $\gamma$ : Wet Density ( $\text{tf/m}^3$ )  
 $\text{int}$ : Saturated Density of Material ( $\text{tf/m}^3$ )  
b: Width of Sfp Circle (m)  
 $x, y$ : X or Y Coordinate of Center of Sfp Circle (m)

Case 1 (172): Upstream Slope   Slip Circle No. 8   Reservoir Water Surface   Normal Water Surface: EL 148.900m   Seismic Coefficient   0.18 (100%)   Required Safety Factor   1.25																			
No. of Slice	γ1	γsat	b	x	y	C	φ	tanφ	above the water surface			include the water surface			under the water surface			OL	
									N	T	U	N	T	U	N	T	U		
1	1.84	2.16	7.60	21.59	6.20	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
2	1.84	2.16	7.80	29.59	4.93	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
3	1.84	2.16	7.80	37.19	4.05	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
4	1.84	2.16	7.80	44.79	3.59	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
5	1.84	2.16	7.60	52.39	3.52	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
6	1.84	2.16	7.60	59.99	3.84	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
7	1.84	2.16	7.80	67.59	4.56	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
8	1.84	2.16	7.80	75.19	5.68	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
9	1.84	2.16	7.80	82.79	7.22	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
10	1.84	2.16	7.80	90.39	9.18	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
11	1.84	2.16	7.80	97.99	11.58	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
12	1.84	2.16	7.80	105.59	14.46	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
13	1.84	2.16	7.60	113.19	17.83	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
14	1.84	2.16	7.60	120.79	21.74	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
15	1.84	2.16	7.80	128.39	26.24	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
16	1.84	2.16	7.80	135.99	31.39	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
17	1.84	2.16	7.80	143.59	37.29	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
18	1.84	2.16	7.80	151.19	44.00	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
19	1.84	2.16	7.60	158.79	51.88	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
20	1.84	2.16	6.85	166.01	60.54	0	45	1.00	0	0	0	0	0	0	0	0	0	0.0	
Result of Calculation		SF = 1.278		> 1.20		OK		0	0	0	0	0	0	0	0	0	0	0	0.0
								3.546	405	1.221	-1.075	49	129	3.561	0	0	0	0	0.0

$$SF = \frac{\sum (C + L + N - U - Na) \tan \phi}{\sum (T + Te)}$$

SF: Safety Factor

N: Normal Force Acting on Slip Circle (t/m)  
T: Tangential Force Acting on Slip Circle (t/m)  
Na: Normal Force of Earthquake Load Acting on Slip Circle (t/m)  
Te: Tangential Force of Earthquake Load Acting on Slip Circle (t/m)  
U: Pore Pressure acting on Slip Circle (t/m)  
 $\phi$ : Effective Internal Friction Angle on Slip Circle (°)

C: Effective Cohesion on Slip Circle (t/m<sup>2</sup>)  
L: Arc Length of Slip Circle (m)  
 $\gamma$ : Wet Density (t/m<sup>3</sup>)  
 $\gamma_{sat}$ : Saturated Density of Material (t/m<sup>3</sup>)  
b: Width of Slip Circle (m)  
x, y: X or Y Coordinate of Center of Slip Circle (m)

Case I (1/2): Upstream Slope [Slip Circle No. 9] Reservoir Water Surface: Normal Water Surface: EL. 143.900m										Seismic Coefficient						0.18 (100%)		Required Safety Factor			1.20																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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Case I (1/2): Upstream Slope [Slip Circle No. 10] Reservoir Water Surface: Normal Water Surface: EL. 143.900m										Seismic Coefficient			0.18 (100%)			Required Safety Factor			1.20																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
No. of Slice	rt	ysat	b	x	y	C	$\phi$	tan $\phi$	above the water surface					include the water surface					CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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1	1.94	2.16	10.60	45.47	13.63	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Case I (1/2): Upstream Slope [Slip Circle No. 11] Reservoir Water Surface: Normal Water Surface: EL. 143.900m										Seismic Coefficient			0.18 (100%)			Required Safety Factor			1.20	
No. of Slice	rt	ysat	b	x	y	C	$\phi$	tan $\phi$	above the water surface					include the water surface					CL	
									N	T	Na	Te	U	N	T	Na	Te	U		
1	1.94	2.16	9.90	56.21	17.51	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0.0	
2	1.94	2.16	9.90	68.11	15.09	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0.0	
3	1.94	2.16	9.90	78.01	12.98	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0.0	
4	1.94	2.16	9.90	85.91	11.61	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0.0	
5	1.94	2.16	9.90	95.81	10.98	2.6	42	0.90	0	0	0	0	0	0	0	0	0	0	0.0	
6	1.94	2.16	9.90	105.71	11.01	2.6	42	0.90	0	0	0	0	0	0	0	0	0	0	0.0	
7	1.94	2.16	9.90	115.61	11.77	2.6	42	0.90	0	0	0	0	0	0	0	0	0	0	0.0	
8	1.94	2.16	9.90	125.51	13.25	2.6	42	0.90	0	0	0	0	0	0	0	0	0	0	0.0	
9	1.94	2.16	9.90	135.41	15.48	2.6	42	0.90	0	0	0	0	0	0	0	0	0	0	0.0	
10	1.94	2.16	9.90	145.31	18.48	2.6	42	0.90	0	0	0	0	0	0	0	0	0	0	0.0	
11	1.94	2.16	9.90	155.21	22.32	2.4	40	0.84	0	0	0	0	0	0	0	0	0	0	0.0	
12	1.94	2.16	9.90	165.11	27.07	2.4	40	0.84	0	0	0	0	0	0	0	0	0	0	0.0	
13	1.94	2.16	9.03	174.60	32.59	0	43	0.93	0	0	0	0	0	0	0	0	0	0	0.0	
14	1.94	2.16	14.22	186.25	40.66	0	43	0.93	0	0	0	234	193	580	-245	104	132	501	0.0	
15	1.94	2.22	4.94	195.82	49.17	0	35	0.70	0	0	0	201	64	191	-67	34	38	134	0.0	
16	2.05	2.23	3.47	200.03	53.33	1	25	0.47	0	0	0	123	40	128	-39	23	22	77	0.0	
17	2.11	2.19	4.87	204.09	57.73	1	25	0.47	0	0	0	128	71	144	-63	25	23	48	0.0	
18	2.03	2.16	3.14	207.99	62.32	1	25	0.47	0	0	0	59	0	73	0	13	11	0	0.0	
19	1.93	2.16	4.72	211.92	67.40	0	35	0.70	0	0	0	47	0	63	0	11	3	0	0.0	
20	1.94	2.16	1.95	215.27	72.14	0	45	1.00	0	0	0	0	0	7	0	1	1	0	0.0	
Result of Calculation										SF = 1.216		> 1.20 --- OK		1.295 368		1.185 -413		213 233 761		10.278 521 1.410 -580 278 1.293 6.925 227.3

$$SF = \frac{1}{\sum (1 + \frac{C}{\gamma \cdot b \cdot \tan \phi})}$$

SF: Safety Factor

N: Normal Force Acting on Slip Circle (t/m)  
T: Tangential Force Acting on Slip Circle (t/m)  
Ne: Normal Force of Earthquake Load Acting on Slip Circle (t/m)  
Te: Tangential Force of Earthquake Load Acting on Slip Circle (t/m)  
U: Pore Pressure acting on Slip Circle (t/m)  
φ: Effective Internal Friction Angle on Slip Circle (°)

C: Effective Cohesion on Slip Circle (t/m<sup>2</sup>)  
L: Arc Length of Slip Circle (m)  
γt: Wet Density (t/m<sup>3</sup>)  
γsat: Saturated Density of Material (t/m<sup>3</sup>)  
b: Width of Slip Circle (m)  
x, y: X or Y Coordinates of Center of Slip Circle (m)

Case 1 (1/2): Upstream Slope [Slip Circle No. 1] Reservoir Water Surface: Normal Water Surface: EL.148.900m										Seismic Coefficient			0.18 (100%)		Required Safety Factor		1.20															
No. of Slice	γt	γsat	b	x	y	C	φ	tanφ	above the water surface					include the water surface					under the water surface					CL								
									N	T	Ne	Te	U	N	T	Ne	Te	U	N	T	Ne	Te	U									
1	1.54	2.16	9.50	14.25	3.84	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1.54	2.16	9.50	23.35	4.45	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1.54	2.16	9.50	33.25	5.37	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1.54	2.16	9.50	42.75	6.60	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	1.54	2.16	9.50	52.25	8.14	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	1.54	2.16	9.50	61.75	10.00	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	1.54	2.16	9.50	71.25	12.19	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	1.54	2.16	9.50	80.75	14.71	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1.54	2.16	9.50	90.25	17.57	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	1.54	2.16	9.50	99.75	20.78	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	1.54	2.16	9.50	109.25	24.36	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	1.54	2.16	9.50	118.75	28.32	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	1.54	2.16	9.50	128.25	32.67	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	1.54	2.16	9.50	137.75	37.44	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	1.54	2.16	9.50	147.25	42.65	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	1.54	2.16	9.50	156.75	48.32	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	1.54	2.15	9.50	166.25	54.49	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	1.54	2.16	8.15	175.07	60.70	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	1.54	2.16	6.62	182.45	66.28	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	1.54	2.16	5.78	188.65	71.25	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Result of Calculation										SF = 1.233	> 1.20 --- OK			54	8	42	-11	8	10	22	9.603	732	2.809	-1.553	283	768	8.045	0.0	0.0	0.0	0.0	0.0

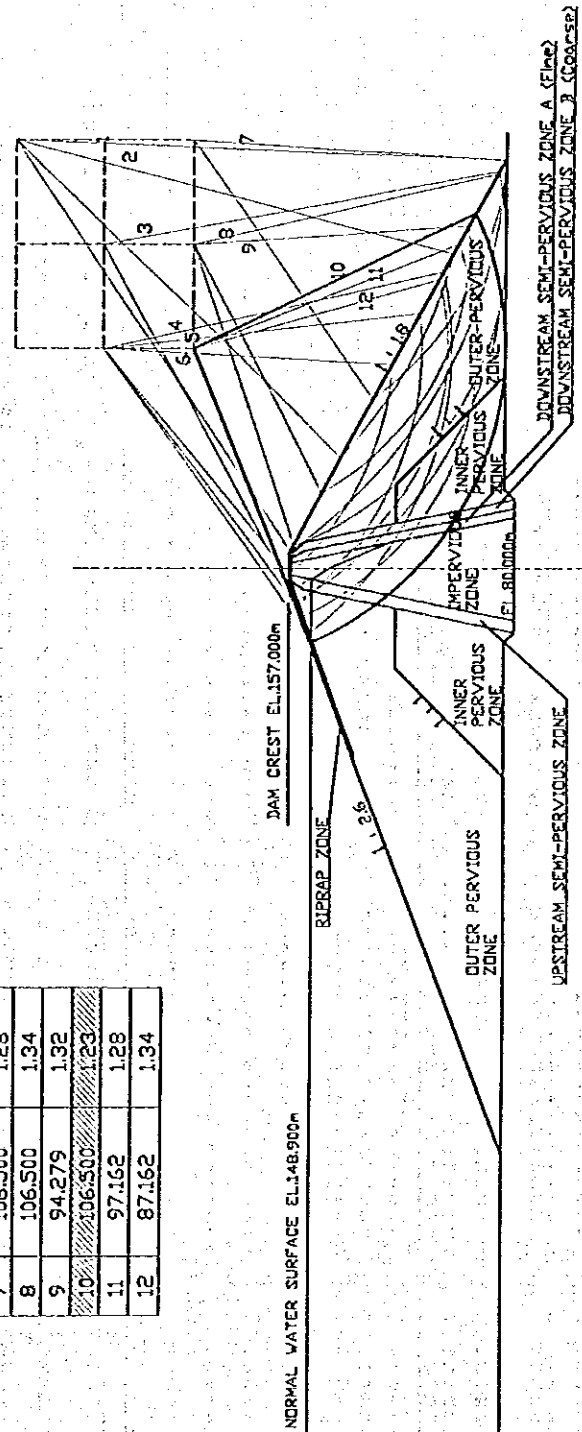
Case 1 (1/2): Upstream Slope [Slip Circle No. 2] Reservoir Water Surface: Normal Water Surface: EL.148.900m										Seismic Coefficient			0.18 (100%)		Required Safety Factor			1.20										
No. of Slice	γt	γsat	b	x	y	C	φ	tanφ	above the water surface					include the water surface					under the water surface					CL				
									N	T	Ne	Te	U	N	T	Ne	Te	U	N	T	Ne	Te	U					
																									solid water	solid water		
1	1.54	2.16	5.00	53.41	20.04	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	243	9	45	-46	0	1	249	0.0	
2	1.54	2.16	5.00	58.41	21.04	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	242	10	51	-49	1	3	244	0.0	
3	1.54	2.16	5.00	63.41	22.14	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	241	12	55	-52	1	4	240	0.0	
4	1.54	2.16	5.00	68.41	23.33	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	238	14	59	-55	1	6	235	0.0	
5	1.54	2.16	5.00	73.41	24.61	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	234	15	62	-57	2	7	229	0.0	
6	1.54	2.16	5.00	78.41	25.99	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	229	17	66	-59	2	8	223	0.0	
7	1.54	2.16	5.00	83.41	27.47	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	224	19	68	-61	3	9	217	0.0	
8	1.54	2.16	5.00	88.41	29.05	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	217	20	71	-62	3	9	210	0.0	
9	1.54	2.16	5.00	93.41	30.74	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	209	22	72	-63	3	10	202	0.0	
10	1.54	2.16	5.00	98.41	32.52	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	200	23	73	-63	4	10	194	0.0	
11	1.54	2.16	5.00	103.41	34.42	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	190	24	74	-63	4	10	185	0.0	
12	1.54	2.16	5.00	108.41	36.42	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	179	25	73	-62	4	9	176	0.0	
13	1.54	2.16	5.00	113.41	38.53	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	168	26	72	-60	4	9	166	0.0	
14	1.54	2.16	5.00	118.41	40.76	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	153	27	70	-58	4	8	155	0.0	
15	1.54	2.16	5.00	123.41	43.10	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	139	27	67	-56	4	8	143	0.0	
16	1.54	2.16	5.00	128.41	45.58	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	124	27	63	-53	3	7	131	0.0	
17	1.54	2.16	5.00	133.41	48.15	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	108	26	57	-49	3	5	117	0.0	
18	1.54	2.16	5.00	138.41	50.86	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	91	24	50	-44	2	4	103	0.0	
19	1.54	2.16	5.00	143.41	53.70	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	73	22	42	-38	1	2	88	0.0	
20	1.54	2.16	4.22	149.02	56.45	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	47	17	29	-27	0	1	61	0.0	
Result of Calculation										SF = 1.217	> 1.20 --- OK		0	0	0	0	0	0	0	0	3.546	405	1.221	-1.075	49	129	3.567	0.0

Case 1 (1/2): Upstream Slope [Slip Circle No. 3] Reservoir Water Surface: Normal Water Surface: EL 148.900m										Seismic Coefficient					0.18 (100%)		Required Safety Factor					1.20																																																																																							
No. of Slice	γt	γsat	b	x	y	C	φ	tanφ	above the water surface					include the water surface					under the water surface					CL																																																																																					
									N	T	Ne	Te	U	N	T	Ne	Te	U	N	T	Ne	Te	U																																																																																						
1	1.54	2.16	13.50	22.70	5.19	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	909	13	-113	106	-2	18	851	0.0																																																																																		
2	1.54	2.16	13.50	38.20	3.93	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	1,032	3	-64	55	-3	52	879	0.0																																																																																		
3	1.54	2.16	13.50	49.70	3.50	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	1,127	0	-2	1	-0	82	893	0.0																																																																																		
4	1.54	2.16	13.50	63.20	3.89	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	1,195	3	71	-52	6	107	879	0.0																																																																																		
5	1.54	2.16	13.50	78.70	5.11	2.8	42	0.90	0	0	0	0	0	0	0	0	0	0	0	1,234	13	150	-104	15	127	887	35.2																																																																																		
6	1.54	2.16	13.50	90.20	7.18	2.8	42	0.90	0	0	0	0	0	0	0	0	0	0	0	1,243	28	229	-151	28	142	841	35.6																																																																																		
7	1.54	2.16	13.50	103.70	10.11	2.8	42	0.90	0	0	0	0	0	0	0	0	0	0	0	1,222	48	305	-192	38	152	818	38.0																																																																																		
8	1.54	2.16	13.50	117.20	13.94	2.8	42	0.90	0	0	0	0	0	0	0	0	0	0	0	1,172	72	373	-225	50	156	719	38.7																																																																																		
9	1.54	2.16	13.50	130.70	18.72	2.8	42	0.90	0	0	0	0	0	0	0	0	0	0	0	1,091	97	427	-247	60	154	727	37.5																																																																																		
10	1.54	2.16	13.50	144.20	24.53	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	981	120	481	-255	89	147	662	0.0																																																																																		
11	1.54	2.16	13.50	157.70	31.44	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	842	137	468	-246	75	134	579	0.0																																																																																		
12	1.54	2.16	14.69	171.78	39.99	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	726	154	478	-234	82	124	509	0.0																																																																																		
13	1.54	2.16	6.64	182.48	47.47	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	260	63	194	-85	35	47	177	0.0																																																																																		
14	1.54	2.16	9.81	190.69	53.92	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	310	76	255	-93	48	56	189	0.0																																																																																		
15	1.99	2.24	4.88	198.03	80.23	0	35	0.70	0	0	0	0	0	0	0	0	0	0	0	123	25	110	-28	20	22	57	0.0																																																																																		
16	2.09	2.23	1.29	201.12	83.05	1	25	0.47	0	0	0	0	0	0	0	0	0	0	0	28	5	26	-5	5	5	10	0.0																																																																																		
17	2.11	2.19	2.04	202.78	64.63	1	25	0.47	0	0	0	0	0	0	0	0	0	0	0	39	8	37	-10	7	7	7	0.0																																																																																		
18	2.09	2.16	4.59	206.10	67.85	1	25	0.47	0	0	0	0	0	0	0	0	0	0	0	62	0	62	0	11	11	0	0.0																																																																																		
19	1.93	2.16	3.68	210.23	72.07	0	35	0.70	0	0	0	0	0	0	0	0	0	0	0	24	0	25	0	5	4	0	0.0																																																																																		
20	1.94	2.16	1.19	212.65	74.66	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0.0																																																																																		
Result of Calculation										SF = 1.256					X120 ... OK					0					0					0					848					179					21					-221					128					153					446					12,773					887					2,184					-1,544					416					1,396					8,296					107				

EL.m 400 390 380 370 360 350 340 330 320 310 300 290 280 270 260 250 240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50

Case 1 (2/2) : Downstream Slope		
Reservoir Water Surface	Normal Water Surface	
Seismic Coefficient	0.18 (100%)	
Required Safety Factor	1.20	

No.	Radius (m)	SF
1	166.500	1.28
2	153.642	1.24
3	136.500	1.28
4	118.387	1.29
5	108.387	1.34
6	98.387	1.29
7	106.500	1.28
8	106.500	1.34
9	94.279	1.32
10	106.500	1.23
11	97.162	1.28
12	87.162	1.34



EL.m 400 390 380 370 360 350 340 330 320 310 300 290 280 270 260 250 240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50

Case 1 (2/2) : Downstream Slope

$$SF = \frac{\sum [C + L(N - U - Ne) \tan \phi]}{\sum (T + Te)}$$

SF: Safety Factor

N: Normal Force Acting on Slip Circle (tf/m)  
T: Tangential Force Acting on Slip Circle (tf/m)  
Ne: Normal Force of Earthquake Load Acting on Slip Circle (tf/m)  
Te: Tangential Force of Earthquake Load Acting on Slip Circle (tf/m)  
U: Pore Pressure Acting on Slip Circle (tf/m)  
 $\phi$ : Effective Internal Friction Angle on Slip Circle (°)

C: Effective Cohesion on Slip Circle (tf/m<sup>2</sup>)  
L: Arc Length of Slip Circle (m)  
 $\gamma$ : Wet Density (tf/m<sup>3</sup>)  
 $\gamma_{sat}$ : Saturated Density of Material (tf/m<sup>3</sup>)  
b: Width of Slip Circle (m)  
x, y: X or Y Coordinate of Center of Slip Circle (m)

Case 1 (2/2): Downstream Slope			Slip Circle No. 1		Reservoir Water Surface		Normal Water Surface: EL 148.900m		Seismic Coefficient		0.18 (100%)		Required Safety Factor		1.20																	
No. of Slice	yt	ysat	b	x	y	C	$\phi$	tan $\phi$	above the water surface			include the water surface			under the water surface			CL														
									N	T	Ne	Ta	U	N	T	Ne	Ta		U	N	T	Ne	Ta	U								
1	1.84	2.16	6.60	9.83	3.79	0	45	1.00	0	0	0	0	21	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	1.84	2.16	6.60	18.43	4.31	0	45	1.00	0	0	0	0	0	61	0	6	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	1.84	2.16	6.60	23.03	5.10	0	45	1.00	0	0	0	0	0	98	0	14	2	18	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	1.84	2.16	6.60	29.63	6.16	0	45	1.00	0	0	0	0	0	130	0	23	0	4	23	0	0	0	0	0	0	0	0	0	0	0	0	
5	1.84	2.16	6.60	35.23	7.45	0	45	1.00	0	0	0	0	0	158	0	35	0	6	28	0	0	0	0	0	0	0	0	0	0	0	0	
6	1.84	2.16	6.60	42.83	9.10	0	45	1.00	0	0	0	0	0	182	0	48	0	9	33	0	0	0	0	0	0	0	0	0	0	0	0	
7	1.84	2.16	6.60	49.43	11.01	2.6	42	0.90	0	0	0	0	0	201	0	63	0	11	36	0	0	0	0	0	0	0	0	0	0	0	17.9	
8	1.84	2.16	6.60	55.03	13.21	2.6	42	0.90	0	0	0	0	0	216	0	77	0	14	39	0	0	0	0	0	0	0	0	0	0	0	18.2	
9	1.84	2.16	6.60	62.63	15.73	2.6	42	0.90	0	0	0	0	0	228	0	92	0	17	41	0	0	0	0	0	0	0	0	0	0	0	18.4	
10	1.84	2.16	6.60	69.23	18.58	2.6	42	0.90	0	0	0	0	0	232	0	106	0	19	42	0	0	0	0	0	0	0	0	0	0	0	18.8	
11	1.84	2.16	6.60	75.83	21.77	2.6	42	0.90	0	0	0	0	0	232	0	119	0	21	42	0	0	0	0	0	0	0	0	0	0	0	19.2	
12	1.84	2.16	6.60	82.43	25.34	2.6	42	0.90	0	0	0	0	0	228	0	130	0	23	41	0	0	0	0	0	0	0	0	0	0	0	19.7	
13	1.84	2.16	6.60	89.03	29.30	0	45	1.00	0	0	0	0	0	218	0	138	0	25	39	0	0	0	0	0	0	0	0	0	0	0	0	
14	1.84	2.16	6.60	95.63	33.70	0	45	1.00	0	0	0	0	0	204	0	143	0	26	37	0	0	0	0	0	0	0	0	0	0	0	0	
15	1.84	2.16	6.60	102.23	38.58	0	45	1.00	0	0	0	0	0	184	0	143	0	26	33	0	0	0	0	0	0	0	0	0	0	0	0	
16	1.84	2.16	6.60	108.83	43.99	0	45	1.00	0	0	0	0	0	160	0	138	0	25	29	0	0	0	0	0	0	0	0	0	0	0	0	
17	1.84	2.16	6.60	115.43	50.01	0	45	1.00	0	0	0	0	0	130	0	125	0	23	23	0	0	0	0	0	0	0	0	0	0	0	0	
18	1.84	2.16	6.60	122.03	56.73	0	45	1.00	0	0	0	0	0	98	0	104	0	19	17	0	0	0	0	0	0	0	0	0	0	0	0	
19	1.84	2.16	6.60	128.63	64.28	0	45	1.00	0	0	0	0	0	58	0	71	0	13	11	0	0	0	0	0	0	0	0	0	0	0	0	
20	1.84	2.16	5.88	134.87	72.57	0	45	1.00	0	0	0	0	0	17	0	24	0	4	3	0	0	0	0	0	0	0	0	0	0	0	0	
Result of Calculation		SF = 1.281		> 1.20 --- OK		0		0		0		0		3.052		0		288		549		9		0		0		0		0		112.2

Case 1 (2/2): Downstream Slope		Slip Circle No. 2		Reservoir Water Surface		Normal Water Surface: EL 148.900m		Seismic Coefficient		0.18 (100%)		Required Safety Factor		1.20																	
No. of Slice	yt	ysat	b	x	y	C	$\phi$	tan $\phi$	above the water surface			include the water surface			under the water surface			CL													
									N	T	U	N	T	U	N	T	U														
1	1.84	2.16	3.50	39.82	21.61	0	45	1.00	0	0	0	0	0	3	0	1	0	0	0.0												
2	1.84	2.16	3.50	43.32	22.59	0	45	1.00	0	0	0	0	0	10	0	3	0	0	0.0												
3	1.84	2.16	3.50	49.82	23.66	0	45	1.00	0	0	0	0	0	15	0	5	0	0	0.0												
4	1.84	2.16	3.50	50.32	24.83	0	45	1.00	0	0	0	0	0	20	0	7	0	0	0.0												
5	1.84	2.16	3.50	53.82	26.09	0	45	1.00	0	0	0	0	0	24	0	9	0	0	0.0												
6	1.84	2.16	3.50	57.32	27.45	0	45	1.00	0	0	0	0	0	28	0	11	0	0	0.0												
7	1.84	2.16	3.50	60.82	28.91	0	45	1.00	0	0	0	0	0	30	0	13	0	0	0.0												
8	1.84	2.16	3.50	64.32	30.47	0	45	1.00	0	0	0	0	0	32	0	15	0	0	0.0												
9	1.84	2.16	3.50	67.82	32.14	0	45	1.00	0	0	0	0	0	34	0	17	0	0	0.0												
10	1.84	2.16	3.50	71.32	33.91	0	45	1.00	0	0	0	0	0	34	0	18	0	0	0.0												
11	1.84	2.16	3.50	74.82	35.81	0	45	1.00	0	0	0	0	0	34	0	19	0	0	0.0												
12	1.84	2.16	3.50	78.32	37.82	0	45	1.00	0	0	0	0	0	33	0	20	0	0	0.0												
13	1.84	2.16	3.50	81.82	39.96	0	45	1.00	0	0	0	0	0	32	0	20	0	0	0.0												
14	1.84	2.16	3.50	85.32	42.22	0	45	1.00	0	0	0	0	0	29	0	20	0	0	0.0												
15	1.84	2.16	3.50	88.82	44.63	0	45	1.00	0	0	0	0	0	26	0	18	0	0	0.0												
16	1.84	2.16	3.50	92.32	47.19	0	45	1.00	0	0	0	0	0	22	0	17	0	0	0.0												
17	1.84	2.16	3.50	95.82	49.90	0	45	1.00	0	0	0	0	0	18	0	14	0	0	0.0												
18	1.84	2.16	3.50	99.32	52.77	0	45	1.00	0	0	0	0	0	12	0	11	0	0	0.0												
19	1.84	2.16	3.50	102.82	55.83	0	45	1.00	0	0	0	0	0	7	0	6	0	0	0.0												
20	1.84	2.16	1.70	105.42	58.23	0	45	1.00	0	0	0	0	0	1	0	1	0	0	0.0												
Result of Calculation		SF = 1.242		> 1.20 --- OK		0		0		0		0		445		243		0		44		80		0		0		0		0.0	

Case 1 (2/2): Downstream Slope		Slip Circle No. 3		Reservoir Water Surface		Normal Water Surface: EL 148.900m		Seismic Coefficient		0.18 (100%)		Required Safety Factor		1.20																							
No. of Slice	yt	ysat	b	x	y	C	$\phi$	tan $\phi$	above the water surface			include the water surface			under the water surface			CL																			
									N	T	U	N	T	U	N	T	U																				
1	1.84	2.16	9.30	14.59	4.97	0	45	1.00	0	0	0	0	0	60	0	-9	0	-2	11	0	0.0																
2	1.84	2.16	9.30	24.29	3.92	0	45	1.00	0	0	0	0	0	172	0	-14	0	-2	31	0	0.0																
3	1.84	2.16	9.30	33.59	3.51	2.6	42	0.90	0	0	0	0	0	273	0	-3	0	-1	49	0	24.1																
4	1.84	2.16	9.30	42.89	3.73	2.6	42	0.90	0	0	0	0	0	352	0	21	0	4	65	0	24.1																
5	1.84	2.16	9.30	52.19	4.59	2.6	42	0.90	0	0	0	0	0	437	0	55	0	10	79	0	24.3																
6	1.84	2.16	9.30	61.49	6.10	2.6	42	0.90	0	0	0	0	0	497	0	98	0	18	89	0	24.8																
7	1.84	2.16	9.30	70.79	8.28	2.6	42	0.90	0	0	0	0	0	541	0	147	0	26	97	0	25.0																
8	1.84	2.16	9.30	80.09	11.16	2.6	42	0.90	0	0	0	0	0	588	0	199	0	35	102	0	25.5																
9	1.84	2.16	9.30	89.39	14.81	2.6	42	0.90	0	0	0	0	0	577	0	251	0	45	104	0	26.3																
10	1.84	2.16	9.30	98.69	19.27	2.4	40	0.84	0	0	0	0	0	587	0	299	0	54	102	0	25.8																
11	1.84	2.16	9.30	107.99	24.66	2.4	40	0.84	0	0	0	0	0	539	0	341	0	61	97	0	28.7																
12	1.84	2.16	9.30	117.29	31.10	2.4	40	0.84	0	0	0	0	0	490	0	371	0	67	88	0	29.3																
13	1.84	2.16	8.55	125.22	37.58	2.4	40	0.84	0	0	0	0	0	305	0	269	0	48	55	0	21.2																
14	1.93	2.16	7.53	132.25	44.22	0	35	0.70	0	0	0	0	0	298	0	303	0	55	54	0	0.0																
15	1.95	2.16	2.35	137.19	49.51	1	25	0.47	0	0	0	0	0	81	0	92	0	18	15	0	3.5																
16	2.07	2.19	8.87	142.70	56.14	1	25	0.47	0	0	0	0	0	232	-19	298	14	54	42	48	14.1																
17	2.10	2.22	1.04	147.57	62.80	1	25	0.47	0	0	0	0	0	18	8	27	-5	5	3	11	1.9																
18	2.03	2.27	3.05	148.63	65.89	0	35	0.70	0	0	0	0	0	37	12	58	-8	10	7	18	0.0																
19	1.84	2.16	0.38	151.34	68.80	0	45	1.00	0	0	0	0	0	3	0	1	1	0	0	0	0.0																
20	1.84	2.16	3.30	153.17	71.87	0	45	1.00	0	0	0	0	0	11	0	20	0	4	2	0	0.0																
Result of Calculation		SF = 1.281		> 1.20 --- OK		0		0		0		6.089		1		2.827		1		509		1.053		77		0		0		0		0		0		295.5	

$$SF = \frac{\sum (C + (1 - U) \cdot N) \cdot \tan \phi}{\sum (T + T_e)}$$

SF: Safety Factor

N: Normal Force Acting on Slip Circle (t/m)  
T: Tangential Force Acting on Slip Circle (t/m)  
N<sub>e</sub>: Normal Force of Earthquake Load Acting on Slip Circle (t/m)  
T<sub>e</sub>: Tangential Force of Earthquake Load Acting on Slip Circle (t/m)  
U: Pore Pressure acting on Slip Circle (t/m)  
φ: Effective Internal Friction Angle on Slip Circle (°)

C: Effective Cohesion on Slip Circle (t/m<sup>2</sup>)  
L: Arc Length of Slip Circle (m)  
γ: Wet Density (t/m<sup>3</sup>)  
γ<sub>sat</sub>: Saturated Density of Material (t/m<sup>3</sup>)  
b: Width of Slip Circle (m)  
x, y: X or Y Coordinate of Center of Slip Circle (m)

Case 1 (2/2): Downstream Slope				Slip Circle No. 5		Reservoir Water Surface		Normal Water Surface: EL 148.900m		Seismic Coefficient		0.18 (100%)		Required Safety Factor		1.20														
No. of Slice	γt	γsat	b	x	y	C	φ	tanφ	above the water surface					include the water surface					under the water surface					CL						
									N	T	Ns	Ts	U	N	T	Ns	Ts	U	N	T	Ns	Ts	U							
1	1.94	2.18	5.80	60.99	31.99	0	45	1.00	0	0	0	0	0	21	0	-2	0	4	0	0	0	0	0	0	0	0	0	0	0	
2	1.94	2.18	5.80	64.79	31.66	0	45	1.00	0	0	0	0	0	81	0	-2	0	-0	11	0	0	0	0	0	0	0	0	0	0	
3	1.94	2.18	5.80	72.59	31.64	0	45	1.00	0	0	0	0	0	58	0	2	0	0	18	0	0	0	0	0	0	0	0	0	0	
4	1.94	2.18	5.80	78.39	31.94	0	45	1.00	0	0	0	0	0	130	0	10	0	2	23	0	0	0	0	0	0	0	0	0	0	
5	1.94	2.18	5.80	84.19	32.55	2.6	42	0.90	0	0	0	0	0	159	0	21	0	4	29	0	0	0	0	0	0	0	0	0	152	
6	1.94	2.18	5.80	89.99	33.47	2.6	42	0.90	0	0	0	0	0	183	0	34	0	8	33	0	0	0	0	0	0	0	0	0	153	
7	1.94	2.18	5.80	95.79	34.73	2.6	42	0.90	0	0	0	0	0	202	0	49	0	9	36	0	0	0	0	0	0	0	0	0	155	
8	1.94	2.18	5.80	101.59	35.32	2.6	42	0.90	0	0	0	0	0	217	0	65	0	12	39	0	0	0	0	0	0	0	0	0	157	
9	1.94	2.18	5.80	107.39	36.26	2.6	42	0.90	0	0	0	0	0	228	0	83	0	15	41	0	0	0	0	0	0	0	0	0	160	
10	1.94	2.18	5.80	113.19	40.59	2.6	42	0.90	0	0	0	0	0	230	0	100	0	18	41	0	0	0	0	0	0	0	0	0	164	
11	1.94	2.18	5.80	118.99	43.31	2.6	42	0.90	0	0	0	0	0	229	0	116	0	21	41	0	0	0	0	0	0	0	0	0	168	
12	1.94	2.18	5.80	124.79	45.48	2.6	42	0.90	0	0	0	0	0	222	0	130	0	23	40	0	0	0	0	0	0	0	0	0	174	
13	1.94	2.18	2.69	129.03	49.10	2.6	42	0.90	0	0	0	0	0	99	0	64	0	12	18	0	0	0	0	0	0	0	0	0	83	
14	1.93	2.18	7.03	133.89	52.45	0	35	0.70	0	0	0	0	0	240	0	175	0	32	43	0	0	0	0	0	0	0	0	0	0.0	
15	2.00	2.18	4.23	139.52	56.85	1	25	0.47	0	0	0	0	0	131	0	109	0	20	24	0	0	0	0	0	0	0	0	0	55	
16	2.11	2.19	5.40	144.34	61.12	1	25	0.47	0	0	0	0	0	133	-9	125	10	22	24	19	0	0	0	0	0	0	0	0	7.4	
17	2.11	2.23	0.85	147.47	64.19	1	25	0.47	0	0	0	0	0	18	3	17	-3	3	3	6	0	0	0	0	0	0	0	0	1.2	
18	2.03	2.27	3.29	149.54	65.37	0	35	0.70	0	0	0	0	0	48	6	52	-6	9	9	12	0	0	0	0	0	0	0	0	0.0	
19	1.94	2.18	0.63	151.50	69.54	0	45	1.00	0	0	0	0	0	8	0	7	-0	1	1	0	0	0	0	0	0	0	0	0	0.0	
20	1.94	2.18	4.28	153.94	71.43	0	45	1.00	0	0	0	0	0	18	0	23	0	4	3	0	0	0	0	0	0	0	0	0	0.0	
Result of Calculation										SF = 1.339	> 1.20 --- OK		0	0	0	0	0	2.658	1	1.180	1	212	480	37	0	0	0	0	0	150.7

Case 1 (2/2): Downstream Slope		Slip Circle No. 6		Reservoir Water Surface		Normal Water Surface: EL 148.900m		Seismic Coefficient		0.18 (100%)		Required Safety Factor		1.20												
No. of Slice	γt	γsat	b	x	y	C	φ	tan φ	above the water surface					include the water surface					under the water surface					CL		
									N	T	N <sub>e</sub>	T <sub>e</sub>	U	N	T	N <sub>e</sub>	T <sub>e</sub>	U	N	T	N <sub>e</sub>	T <sub>e</sub>	U			
1	1.94	2.18	3.60	78.95	41.88	0	45	1.00	0	0	0	0	0	8	0	0	1	0	0	0	0	0	0	0	0.0	
2	1.94	2.18	3.60	80.55	42.18	0	45	1.00	0	0	0	0	0	18	0	2	0	3	0	0	0	0	0	0	0	0.0
3	1.94	2.18	3.60	84.15	42.64	0	45	1.00	0	0	0	0	0	28	0	4	0	1	5	0	0	0	0	0	0	0.0
4	1.94	2.18	3.60	87.75	43.23	0	45	1.00	0	0	0	0	0	38	0	7	0	1	7	0	0	0	0	0	0	0.0
5	1.94	2.18	3.60	91.35	43.95	0	45	1.00	0	0	0	0	0	45	0	10	0	2	8	0	0	0	0	0	0	0.0
6	1.94	2.18	3.60	94.95	44.83	0	45	1.00	0	0	0	0	0	54	0	14	0	3	10	0	0	0	0	0	0	0.0
7	1.94	2.18	3.60	98.55	45.85	0	45	1.00	0	0	0	0	0	60	0	18	0	3	11	0	0	0	0	0	0	0.0
8	1.94	2.18	3.60	102.15	47.01	0	45	1.00	0	0	0	0	0	64	0	22	0	4	12	0	0	0	0	0	0	0.0
9	1.94	2.18	3.60	105.75	48.34	0	45	1.00	0	0	0	0	0	68	0	26	0	5	12	0	0	0	0	0	0	0.0
10	1.94	2.18	3.60	109.35	49.82	0	45	1.00	0	0	0	0	0	70	0	31	0	5	13	0	0	0	0	0	0	0.0
11	1.94	2.18	3.60	112.95	51.48	0	45	1.00	0	0	0	0	0	71	0	34	0	6	13	0	0	0	0	0	0	0.0
12	1.94	2.18	3.60	116.55	53.32	0	45	1.00	0	0	0	0	0	70	0	38	0	7	13	0	0	0	0	0	0	0.0
13	1.94	2.18	3.60	120.15	55.35	0	45	1.00	0	0	0	0	0	68	0	41	0	7	12	0	0	0	0	0	0	0.0
14	1.94	2.18	3.60	123.75	57.59	0	45	1.00	0	0	0	0	0	65	0	43	0	8	12	0	0	0	0	0	0	0.0
15	1.94	2.18	3.60	127.35	60.05	0	45	1.00	0	0	0	0	0	61	0	44	0	8	11	0	0	0	0	0	0	0.0
16	1.94	2.18	4.17	131.29	62.99	0	45	1.00	0	0	0	0	0	63	0	50	0	9	11	0	0	0	0	0	0	0.0
17	1.94	2.18	3.64	135.14	66.27	0	35	0.70	0	0	0	0	0	47	0	41	0	7	8	0	0	0	0	0	0	0.0
18	1.93	2.15	3.73	138.89	69.70	0	35	0.70	0	0	0	0	0	38	0	37	0	7	7	0	0	0	0	0	0	0.0
19	2.08	2.18	4.12	142.75	73.77	1	25	0.47	0	0	0	0	0	19	0	20	0	4	3	0	0	0	0	0	0	8.1
20	2.11	2.16	0.76	145.19	76.55	0	35	0.70	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0.0
Result of Calculation		SF = 1.238		> 1.20 --- OK		0	0	0	0	0	0	0	0	954	0	483	0	87	172	0	0	0	0	0	0	8.1

Case 1 (2/2): Downstream Slope		Slip Circle No. 7		Reservoir Water Surface		Normal Water Surface: EL 148.900m		Seismic Coefficient		0.18 (100%)		Required Safety Factor		1.20																
No. of Slice	γt	γsat	b	x	y	C	φ	tan φ	above the water surface					include the water surface					under the water surface					CL						
									N	T	Ns	Te	U	N	T	Ns	Te	U	N	T	Ns	Te	U							
1	1.94	2.18	4.00	8.68	3.83	0	45	1.00	0	0	0	0	0	7	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	1.94	2.18	4.00	12.68	4.26	0	45	1.00	0	0	0	0	0	21	0	3	0	0	4	0	0	0	0	0	0	0	0	0	0	0
3	1.94	2.18	4.00	16.68	4.81	0	45	1.00	0	0	0	0	0	34	0	5	0	1	6	0	0	0	0	0	0	0	0	0	0	0
4	1.94	2.18	4.00	20.68	5.53	0	45	1.00	0	0	0	0	0	45	0	9	0	2	8	0	0	0	0	0	0	0	0	0	0	0
5	1.94	2.18	4.00	24.68	6.40	0	45	1.00	0	0	0	0	0	55	0	13	0	2	10	0	0	0	0	0	0	0	0	0	0	0
6	1.94	2.18	4.00	28.68	7.43	0	45	1.00	0	0	0	0	0	64	0	18	0	3	11	0	0	0	0	0	0	0	0	0	0	0
7	1.94	2.18	4.00	32.68	8.64	0	45	1.00	0	0	0	0	0	70	0	23	0	4	13	0	0	0	0	0	0	0	0	0	0	0
8	1.94	2.18	4.00	36.68	10.01	0	45	1.00	0	0	0	0	0	75	0	28	0	5	14	0	0	0	0	0	0	0	0	0	0	0
9	1.94	2.18	4.00	40.68	11.57	0	45	1.00	0	0	0	0	0	79	0	33	0	6	14	0	0	0	0	0	0	0	0	0	0	0
10	1.94	2.18	4.00	44.68	13.32	0	45	1.00	0	0	0	0	0	81	0	37	0	7	15	0	0	0	0	0	0	0	0	0	0	0
11	1.94	2.18	4.00	48.68	15.28	0	45	1.00	0	0	0	0	0	81	0	42	0	8	15	0	0	0	0	0	0	0	0	0	0	0
12	1.94	2.18	4.00	52.68	17.44	0	45	1.00	0	0	0	0	0	80	0	45	0	8	14	0	0	0	0	0	0	0	0	0	0	0
13	1.94	2.18	4.00	56.68	19.83	0	45	1.00	0	0	0	0	0	77	0	43	0	9	14	0	0	0	0	0	0	0	0	0	0	0
14	1.94	2.18	4.00	60.68	22.48	0	45	1.00	0	0	0	0	0	72	0	50	0	9	13	0	0	0	0	0	0	0	0	0	0	0
15	1.94	2.18	4.00	64.68	25.39	0	45	1.00	0	0	0	0	0	65	0	50	0	9	12	0	0	0	0	0	0	0	0	0	0	0
16	1.94	2.18	4.00	68.68	28.60	0	45	1.00	0	0	0	0	0	57	0	43	0	9	10	0	0	0	0	0	0	0	0	0	0	0
17	1.94	2.18	4.00	72.68	32.15	0	45	1.00	0	0	0	0	0	47	0	44	0	8	8	0	0	0	0	0	0	0	0	0	0	0
18	1.94	2.18	4.00	76.68	36.09	0	45	1.00	0	0	0	0	0	35	0	35	0	7	6	0	0	0	0	0	0	0	0	0	0	0
19	1.94	2.18	4.00	80.68	40.43	0	45	1.00	0	0	0	0	0	22	0	28	0	5	4	0	0	0	0	0	0	0	0	0	0	0
20	1.94	2.18	4.04	84.70	45.44	0	45	1.00	0	0	0	0	0	8	0	10	0	2	1	0	0	0	0	0	0	0	0	0	0	0
Result of Calculation		SF = 1.280		≥ 1.20 --- OK										1.075		547		102		194								0.0		



$$SF = \frac{1}{2} \frac{[C(L-N-U) \tan \phi]}{T(T+U)}$$

SF: Safety Factor

N: Normal Force Acting on Slip Circle (t/m)  
T: Tangential Force Acting on Slip Circle (t/m)  
Ne: Normal Force of Earthquake Load Acting on Slip Circle (t/m)  
Te: Tangential Force of Earthquake Load Acting on Slip Circle (t/m)  
U: Pore Pressure acting on Slip Circle (t/m)  
 $\phi$ : Effective Internal Friction Angle on Slip Circle (°)

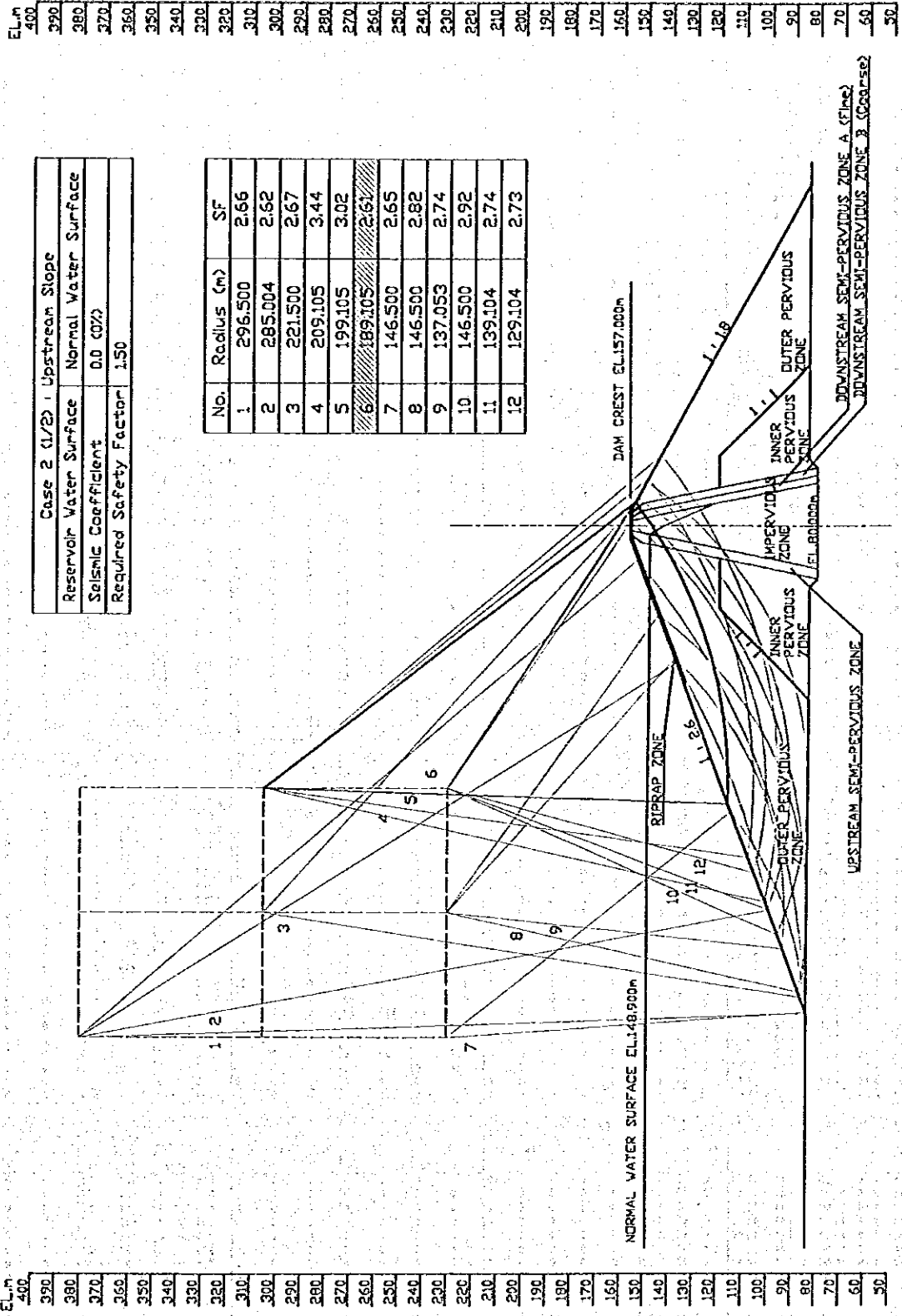
C: Effective Cohesion on Slip Circle (t/m<sup>2</sup>)  
L: Arc Length of Slip Circle (m)  
 $\gamma$ : Wet Density (t/m<sup>3</sup>)  
 $\gamma_{sat}$ : Saturated Density of Material (t/m<sup>3</sup>)  
b: Width of Slip Circle (m)  
x, y: X or Y Coordinate of Center of Slip Circle (m)

Case 1 (2/2): Downstream Slope				Slip Circle No. 9		Reservoir Water Surface		Normal Water Surface: EL.148.900m		Seismic Coefficient		0.18 (100%)		Required Safety Factor		1.20					
No. of Slice	yt	ysat	b	x	y	C	$\phi$	tan $\phi$	above the water surface					under the water surface					CL		
									N	T	Ne	Te	U	N	T	Ne	Te	U		N	T
1	1.94	2.16	4.50	30.93	15.81	0	45	1.00	0	0	0	0	0	12	-1	0	0	0	0	0.0	
2	1.94	2.16	4.50	35.43	15.72	0	45	1.00	0	0	0	0	0	35	0	0	0	0	0	0.0	
3	1.94	2.16	4.50	39.93	15.85	0	45	1.00	0	0	0	0	0	55	3	0	0	0	0	0.0	
4	1.94	2.16	4.50	44.43	16.19	0	45	1.00	0	0	0	0	0	74	7	0	1	13	0	0.0	
5	1.94	2.16	4.50	48.93	16.76	0	45	1.00	0	0	0	0	0	90	13	0	2	16	0	0.0	
6	1.94	2.16	4.50	53.43	17.54	0	45	1.00	0	0	0	0	0	104	21	0	4	19	0	0.0	
7	1.94	2.16	4.50	57.93	18.55	0	45	1.00	0	0	0	0	0	115	29	0	5	21	0	0.0	
8	1.94	2.16	4.50	62.43	19.80	0	45	1.00	0	0	0	0	0	124	38	0	7	22	0	0.0	
9	1.94	2.16	4.50	66.93	21.29	0	45	1.00	0	0	0	0	0	131	47	0	8	23	0	0.0	
10	1.94	2.16	4.50	71.43	23.04	0	45	1.00	0	0	0	0	0	134	56	0	10	24	0	0.0	
11	1.94	2.16	4.50	75.93	25.07	0	45	1.00	0	0	0	0	0	135	65	0	12	24	0	0.0	
12	1.94	2.16	4.50	80.43	27.39	0	45	1.00	0	0	0	0	0	132	73	0	13	24	0	0.0	
13	1.94	2.16	4.50	84.93	30.03	0	45	1.00	0	0	0	0	0	127	79	0	14	23	0	0.0	
14	1.94	2.16	4.50	89.43	33.02	0	45	1.00	0	0	0	0	0	119	84	0	15	21	0	0.0	
15	1.94	2.16	4.50	93.93	36.41	0	45	1.00	0	0	0	0	0	108	88	0	15	19	0	0.0	
16	1.94	2.16	4.50	98.43	40.25	0	45	1.00	0	0	0	0	0	93	85	0	15	17	0	0.0	
17	1.94	2.16	4.50	102.93	44.62	0	45	1.00	0	0	0	0	0	78	79	0	14	14	0	0.0	
18	1.94	2.16	4.50	107.43	49.85	0	45	1.00	0	0	0	0	0	56	67	0	12	10	0	0.0	
19	1.94	2.16	4.50	111.93	55.50	0	45	1.00	0	0	0	0	0	34	48	0	9	6	0	0.0	
20	1.94	2.16	4.03	116.19	62.08	0	45	1.00	0	0	0	0	0	10	17	0	3	2	0	0.0	
Result of Calculation		SF = 1.320		> 1.20 --- OK		0		0		0		0		1.763		0		0		0.0	

Case 1 (2/2): Downstream Slope [Slip Circle No. 10] Reservoir Water Surface										Normal Water Surface: EL.148.900m					Seismic Coefficient			0.18 (100%)		Required Safety Factor			1.20																
No. of Slice	yt	ysat	b	x	y	C	φ	tanφ	above the water surface					under the water surface					under the water surface					CL															
									N	T	Ne	Te	U	N	T	Ne	Te	U	N	T	Ne	Te	U																
1	1.94	2.16	7.90	28.55	11.90	0	45	1.00	0	0	0	0	55	-24	0	-4	10	0	0	0	0	0	0	0.0															
2	1.94	2.16	7.90	34.45	8.92	0	45	1.00	0	0	0	0	165	-55	0	-10	30	0	0	0	0	0	0	0.0															
3	1.94	2.16	7.90	44.35	6.84	2.6	42	0.90	0	0	0	0	288	-68	0	-12	48	0	0	0	0	0	0	21.1															
4	1.94	2.16	7.90	52.25	4.89	2.6	42	0.90	0	0	0	0	363	-61	0	-11	65	0	0	0	0	0	0	20.8															
5	1.94	2.16	7.90	60.15	3.98	2.6	42	0.90	0	0	0	0	450	-42	0	-8	81	0	0	0	0	0	0	20.5															
6	1.94	2.16	7.90	68.05	3.52	11.8	37	0.75	0	0	0	0	525	-10	0	-2	95	0	0	0	0	0	0	93.6															
7	1.94	2.16	7.90	75.95	3.67	11.8	37	0.75	0	0	0	0	590	33	0	6	106	0	0	0	0	0	0	93.7															
8	1.94	2.16	7.90	83.85	4.40	11.2	35	0.70	0	0	0	0	641	84	0	15	115	0	0	0	0	0	0	89.1															
9	1.94	2.16	7.90	91.75	5.74	11.2	35	0.70	0	0	0	0	679	142	0	25	122	0	0	0	0	0	0	90.2															
10	1.94	2.16	7.90	99.65	7.71	11.2	35	0.70	0	0	0	0	701	203	0	37	128	0	0	0	0	0	0	92.0															
11	1.94	2.16	7.90	107.55	10.34	11.2	35	0.70	0	0	0	0	709	267	0	48	128	0	0	0	0	0	0	94.4															
12	1.94	2.16	7.90	115.45	13.68	11.2	35	0.70	0	0	0	0	699	330	0	59	128	0	0	0	0	0	0	97.7															
13	1.94	2.16	4.83	121.71	16.90	11.2	35	0.70	0	0	0	0	398	221	0	40	72	0	0	0	0	0	0	59.2															
14	1.79	2.16	8.88	127.47	20.33	0	35	0.70	0	0	0	0	524	338	0	60	94	0	0	0	0	0	0	0.0															
15	1.93	2.19	3.98	132.90	24.08	1	25	0.47	0	0	0	0	318	-85	231	118	42	57	42	0	0	0	0	4.9															
16	2.02	2.19	12.15	140.96	30.59	1	25	0.47	0	0	0	0	888	-254	793	285	143	160	403	0	0	0	0	18.3															
17	2.02	2.22	5.29	149.69	39.34	1	25	0.47	0	0	0	0	285	132	321	-117	58	51	235	0	0	0	0	8.0															
18	1.94	2.21	3.18	153.92	44.43	0	35	0.70	0	0	0	0	129	78	165	-61	30	23	128	0	0	0	0	0.0															
19	1.94	2.18	6.40	158.72	51.08	0	45	1.00	0	0	0	0	165	141	248	-94	45	30	203	0	0	0	0	0.0															
20	1.94	2.16	6.53	165.18	62.22	0	45	1.00	0	0	0	0	52	72	103	-38	19	8	92	0	0	0	0	0.0															
Result of Calculation		SF = 1.233		> 1.20 --- OK		0		0		0		0		8.600		84		3,220		93		580		1,548		1,101		0		0		0		0		0		801.1	

Case 1 (2/2): Downstream Slope										Slip Circle No. 11				Reservoir Water Surface				Normal Water Surface: EL.148.900m				Seismic Coefficient				0.18 (100%)				Required Safety Factor				1.20	
No. of Slice	yt	ysat	b	x	y	C	φ	tanφ	above the water surface					under the water surface					under the water surface					CL											
									N	T	Ne	Te	U	N	T	Ne	Te	U	N	T	Ne	Te	U												
1	1.94	2.18	7.30	38.58	18.07	0	45	1.00	0	0	0	0	0	45	-15	0	-3	8	0	0	0	0	0	0	0	0	0	0	0	0.0					
2	1.94	2.18	7.30	45.88	15.86	0	45	1.00	0	0	0	0	0	132	-34	0	-6	24	0	0	0	0	0	0	0	0	0	0	0	0.0					
3	1.94	2.18	7.30	53.18	14.31	2.6	42	0.90	0	0	0	0	0	212	-37	0	-7	38	0	0	0	0	0	0	0	0	0	0	0	19.2					
4	1.94	2.18	7.30	60.48	13.31	2.6	42	0.90	0	0	0	0	0	288	-28	0	-5	51	0	0	0	0	0	0	0	0	0	0	0	19.0					
5	1.94	2.18	7.30	67.78	12.86	2.6	42	0.90	0	0	0	0	0	351	-8	0	-1	63	0	0	0	0	0	0	0	0	0	0	0	18.9					
6	1.94	2.18	7.30	75.08	12.97	2.6	42	0.90	0	0	0	0	0	408	21	0	4	73	0	0	0	0	0	0	0	0	0	0	0	18.9					
7	1.94	2.18	7.30	82.38	13.63	2.6	42	0.90	0	0	0	0	0	451	53	0	10	81	0	0	0	0	0	0	0	0	0	0	0	19.1					
8	1.94	2.18	7.30	89.68	14.85	2.4	40	0.84	0	0	0	0	0	485	100	0	18	87	0	0	0	0	0	0	0	0	0	0	0	18.1					
9	1.94	2.18	7.30	96.98	16.65	11.2	35	0.70	0	0	0	0	0	508	146	0	26	91	0	0	0	0	0	0	0	0	0	0	0	84.9					
10	1.94	2.18	7.30	104.28	19.08	2.4	40	0.84	0	0	0	0	0	515	194	0	35	93	0	0	0	0	0	0	0	0	0	0	0	19.0					
11	1.94	2.18	7.30	111.58	22.18	2.4	40	0.84	0	0	0	0	0	510	241	0	43	92	0	0	0	0	0	0	0	0	0	0	0	19.8					
12	1.94	2.18	7.30	118.88	26.02	2.4	40	0.84	0	0	0	0	0	490	285	0	51	88	0	0	0	0	0	0	0	0	0	0	0	20.5					
13	1.94	2.18	4.07	124.55	29.59	2.4	40	0.84	0	0	0	0	0	259	178	0	32	47	0	0	0	0	0	0	0	0	0	0	0	12.0					
14	1.94	2.16	7.13	130.15	33.69	0	35	0.70	0	0	0	0	0	419	330	0	59	75	0	0	0	0	0	0	0	0	0	0	0	0.0					
15	1.92	2.19	1.18	134.30	37.18	1	25	0.47	0	0	0	0	0	84	-8	57	9	10	12	4	0	0	0	0	0	0	0	0	0	1.8					
16	2.02	2.19	12.15	140.98	43.63	1	25	0.47	0	0	0	0	0	578	-111	816	104	111	104	204	0	0	0	0	0	0	0	0	0	17.8					
17	2.07	2.23	2.84	148.48	52.66	1	25	0.47	0	0	0	0	0	89	51	121	-37	22	18	78	0	0	0	0	0	0	0	0	0	4.8					
18	1.98	2.24	3.08	151.41	58.97	0	35	0.70	0	0	0	0	0	68	47	104	-30	19	12	66	0	0	0	0	0	0	0	0	0	0.0					
19	1.94	2.10	5.10	155.49	63.83	0	45	1.00	0	0	0	0	0	52	40	98	-21	17	9	51	0	0	0	0	0	0	0	0	0	0.6					
20	1.94	2.18	1.89	158.88	70.75	0	45	1.00	0	0	0	0	0	3	0	7	0	1	1	0	0	0	0	0	0	0	0	0	0	0.0					
Result of Calculation		SF = 1.279				> 1.20 --- OK				0	0	0	0	0	5.918	18	2,429	24	437	1,085	403	0	0	0	0	0	0	0	0	263.4					

Case 1 (2/2): Downstream Slope		Slip Circle No. 12		Reservoir Water Surface		Normal Water Surface: EL.148.900m		Seismic Coefficient		0.18 (100%)		Required Safety Factor		1.20															
No. of Slice	yt	xst	b	x	y	above the water surface										under the water surface													
						O					N					N					N								
						φ	tanφ	N	T	Ho	To	U	N	T	Ho	To	U	N	T	Ho	To	U	CL						
1	1.84	2.18	5.40	49.48	25.29	0	45	1.00	0	0	0	0	0	22	solid water	solid water	-1	4	0	0	0	0	0	0	0	0	0	0.0	
2	1.84	2.18	5.40	54.88	24.18	0	45	1.00	0	0	0	0	0	85	0	-12	0	-2	12	0	0	0	0	0	0	0	0	0.0	
3	1.84	2.18	5.40	60.28	23.38	0	45	1.00	0	0	0	0	0	105	0	-12	0	-2	19	0	0	0	0	0	0	0	0	0.0	
4	1.84	2.18	5.40	65.98	22.85	2.8	42	0.90	0	0	0	0	0	142	0	-7	0	-1	25	0	0	0	0	0	0	0	0	0.0	
5	1.84	2.18	5.43	71.08	22.64	2.8	42	0.90	0	0	0	0	0	174	0	2	0	0	31	0	0	0	0	0	0	0	0	14.0	
6	1.84	2.18	5.40	76.48	23.08	2.8	42	0.90	0	0	0	0	0	203	0	15	0	3	36	0	0	0	0	0	0	0	0	14.0	
7	1.84	2.18	5.40	81.88	23.95	2.8	42	0.90	0	0	0	0	0	227	0	31	0	6	41	0	0	0	0	0	0	0	0	14.1	
8	1.84	2.18	5.40	87.28	24.57	2.8	42	0.90	0	0	0	0	0	246	0	50	0	9	44	0	0	0	0	0	0	0	0	14.3	
9	1.84	2.18	5.40	92.68	25.84	2.8	42	0.90	0	0	0	0	0	258	0	70	0	13	47	0	0	0	0	0	0	0	0	14.5	
10	1.84	2.18	5.40	98.08	27.48	2.8	42	0.90	0	0	0	0	0	298	0	91	0	16	48	0	0	0	0	0	0	0	0	14.8	
11	1.84	2.18	5.40	103.48	29.52	2.8	42	0.90	0	0	0	0	0	270	0	113	0	20	49	0	0	0	0	0	0	0	0	15.1	
12	1.84	2.18	5.43	108.88	31.99	2.4	40	0.84	0	0	0	0	0	297	0	133	0	24	48	0	0	0	0	0	0	0	0	14.7	
13	1.84	2.18	5.40	114.28	34.92	2.4	40	0.84	0	0	0	0	0	258	0	152	0	27	46	0	0	0	0	0	0	0	0	15.2	
14	1.84	2.18	5.40	119.68	36.36	2.4	40	0.84	0	0	0	0	0	242	0	168	0	30	44	0	0	0	0	0	0	0	0	16.0	
15	1.84	2.18	5.40	125.08	42.45	2.8	42	0.90	0	0	0	0	0	220	0	179	0	32	40	0	0	0	0	0	0	0	0	18.0	
16	1.84	2.18	1.90	128.73	45.59	0	45	1.00	0	0	0	0	0	70	0	64	0	12	13	0	0	0	0	0	0	0	0	0.0	
17	1.83	2.16	7.83	133.49	50.28	0	35	0.70	0	0	0	0	0	241	0	256	0	48	43	0	0	0	0	0	0	0	0	0.0	
18	2.05	2.18	9.89	142.15	61.09	1	25	0.47	0	0	0	0	0	177	0	282	0	47	32	0	0	0	0	0	0	0	0	17.3	
19	2.06	2.18	2.23	148.11	71.32	0	35	0.70	0	0	0	0	0	12	0	23	0	4	2	0	0	0	0	0	0	0	0	0.0	
20	1.84	2.18	1.18	149.81	74.96	0	45	1.00	0	0	0	0	0	1	0	3	0	1	0	0	0	0	0	0	0	0	0	0.0	
Result of Calculation						SF = 1.341		> 1.20 --- OK		0		0		3.470		0.1577		284		625		0		0		0		199.0	



Case 2 (1/2) : Upstream Slope

$$SF = \frac{\sum (C + L(N-U-N_s) \tan \phi)}{\sum (T + T_e)}$$

SF: Safety Factor

N: Normal Force Acting on Slip Circle (tf/m)  
T: Tangential Force Acting on Slip Circle (tf/m)  
N<sub>e</sub>: Normal Force of Earthquake Load Acting on Slip Circle (tf/m)  
T<sub>e</sub>: Tangential Force of Earthquake Load Acting on Slip Circle (tf/m)  
U: Pore Pressure acting on Slip Circle (tf/m)  
φ: Effective Internal Friction Angle on Slip Circle (°)

C: Effective Cohesion on Slip Circle (tf/m<sup>2</sup>)  
L: Arc Length of Slip Circle (m)  
γ<sub>1</sub>: Wet Density (tf/m<sup>3</sup>)  
γ<sub>sat</sub>: Saturated Density of Material (tf/m<sup>3</sup>)  
b: Width of Slip Circle (m)  
x, y: X or Y Coordinate of Center of Slip Circle (m)

Case 2 (1/2): Upstream Slope					Slip Circle No. 1	Reservoir Water Surface	Normal Water Surface: EL.148.900m				Seismic Coefficient			0.00 (0%)		Required Safety Factor			1.50															
No. of Slice	γt	γsat	b	x	y	C	φ	tanφ	above the water surface				Include the water surface				under the water surface				CL													
									N	T	Ne	Te	U	N	T	Ne	Te	U	N	T		Ne	Te	U										
1	1.94	2.16	5.50	14.25	3.84	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	635	1	31	-30	0	0	819	0.0							
2	1.94	2.16	9.50	23.75	4.45	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	662	4	53	-49	0	0	614	0.0							
3	1.94	2.16	9.50	33.25	5.37	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	681	8	77	-68	0	0	607	0.0							
4	1.94	2.16	9.50	42.75	6.60	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	693	12	101	-85	0	0	559	0.0							
5	1.94	2.16	9.50	52.25	8.14	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	698	18	125	-102	0	0	588	0.0							
6	1.94	2.16	9.50	61.75	10.00	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	695	25	148	-117	0	0	572	0.0							
7	1.94	2.16	9.50	71.25	12.19	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	688	32	170	-129	0	0	555	0.0							
8	1.94	2.16	9.50	80.75	14.71	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	669	40	189	-140	0	0	535	0.0							
9	1.94	2.16	9.50	90.25	17.57	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	644	47	208	-148	0	0	512	0.0							
10	1.94	2.16	9.50	99.75	20.78	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	613	55	219	-154	0	0	485	0.0							
11	1.94	2.16	9.50	109.25	24.36	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	574	62	228	-156	0	0	455	0.0							
12	1.94	2.16	9.50	118.75	28.32	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	529	67	231	-154	0	0	421	0.0							
13	1.94	2.16	9.50	128.25	32.67	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	478	71	228	-149	0	0	382	0.0							
14	1.94	2.16	9.50	137.75	37.44	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	418	73	218	-139	0	0	338	0.0							
15	1.94	2.16	9.50	147.25	42.65	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	350	71	200	-124	0	0	287	0.0							
16	1.94	2.16	9.50	156.75	48.32	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	278	64	173	-103	0	0	260	0.0							
17	1.94	2.16	9.50	166.25	54.43	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	200	52	135	-77	0	0	135	0.0							
18	1.94	2.16	8.15	175.07	60.70	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	104	29	76	-39	0	0	83	0.0							
19	1.94	2.16	8.62	182.45	66.28	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0						
20	1.94	2.16	5.78	188.65	71.25	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0						
Result of Calculation									SF = 2.658		> 1.20 --- OK		0		0		0		0		22		9,603		132		2,809		-1,563		0		0.045	

Case 2 (1/2): Upstream Slope				Slip Circle No. 2		Reservoir Water Surface		Normal Water Surface: EL.148.900m		Seismic Coefficient		0.00 (0%)		Required Safety Factor		1.50																						
No. of Slice	γ <sub>1</sub>	γ <sub>sat</sub>	b	x	y	C	φ	tan φ	above the water surface					Include the water surface					under the water surface					CL														
									N	T	N <sub>e</sub>	T <sub>e</sub>	U	N	T	N <sub>e</sub>	T <sub>e</sub>	U	N	T	N <sub>e</sub>	T <sub>e</sub>	U															
1	1.94	2.16	5.00	53.41	20.04	0	45	1.00	0	0	0	0	0	0	0	0	243	9	45	-46	0	0	243	0.0														
2	1.94	2.16	5.00	58.41	21.04	0	45	1.00	0	0	0	0	0	0	0	0	242	10	51	-49	0	0	244	0.0														
3	1.94	2.16	5.00	63.41	22.14	0	45	1.00	0	0	0	0	0	0	0	0	241	12	55	-52	0	0	240	0.0														
4	1.94	2.16	5.00	68.41	23.33	0	45	1.00	0	0	0	0	0	0	0	0	238	14	59	-55	0	0	235	0.0														
5	1.94	2.16	5.00	73.41	24.61	0	45	1.00	0	0	0	0	0	0	0	0	234	15	62	-57	0	0	229	0.0														
6	1.94	2.16	5.00	78.41	25.99	0	45	1.00	0	0	0	0	0	0	0	0	229	17	66	-58	0	0	223	0.0														
7	1.94	2.16	5.00	83.41	27.47	0	45	1.00	0	0	0	0	0	0	0	0	224	19	68	-61	0	0	217	0.0														
8	1.94	2.16	5.00	88.41	29.05	0	45	1.00	0	0	0	0	0	0	0	0	217	20	71	-62	0	0	210	0.0														
9	1.94	2.16	5.00	93.41	30.74	0	45	1.00	0	0	0	0	0	0	0	0	209	22	72	-63	0	0	202	0.0														
10	1.94	2.16	5.00	98.41	32.52	0	45	1.00	0	0	0	0	0	0	0	0	200	23	73	-63	0	0	194	0.0														
11	1.94	2.16	5.00	103.41	34.42	0	45	1.00	0	0	0	0	0	0	0	0	190	24	74	-63	0	0	185	0.0														
12	1.94	2.16	5.00	108.41	36.42	0	45	1.00	0	0	0	0	0	0	0	0	179	25	73	-62	0	0	176	0.0														
13	1.94	2.16	5.00	113.41	38.53	0	45	1.00	0	0	0	0	0	0	0	0	166	26	72	-60	0	0	169	0.0														
14	1.94	2.16	5.00	118.41	40.76	0	45	1.00	0	0	0	0	0	0	0	0	153	27	70	-58	0	0	155	0.0														
15	1.94	2.16	5.00	123.41	43.10	0	45	1.00	0	0	0	0	0	0	0	0	139	27	67	-56	0	0	143	0.0														
16	1.94	2.16	5.00	128.41	45.58	0	45	1.00	0	0	0	0	0	0	0	0	124	27	63	-53	0	0	131	0.0														
17	1.94	2.16	5.00	133.41	48.15	0	45	1.00	0	0	0	0	0	0	0	0	108	26	57	-49	0	0	117	0.0														
18	1.94	2.16	5.00	138.41	50.86	0	45	1.00	0	0	0	0	0	0	0	0	91	24	50	-44	0	0	103	0.0														
19	1.94	2.16	5.00	143.41	53.70	0	45	1.00	0	0	0	0	0	0	0	0	73	22	42	-38	0	0	88	0.0														
20	1.94	2.16	4.22	148.02	56.45	0	45	1.00	0	0	0	0	0	0	0	0	47	17	29	-27	0	0	81	0.0														
Result of Calculation									SF = 2.621		> 1.20 --- OK		0		0		0		0		0		3,545		405		1,221		-1,075		0		0		3,587		0.0	

Case 2 (1/2): Upstream Slope				Slip Circle No. 3		Reservoir Water Surface		Normal Water Surface: EL.148.900m		Seismic Coefficient				0.00 (0%)		Required Safety Factor				1.50																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
No. of Slice	γ <sub>1</sub>	γ <sub>sat</sub>	b	x	y	C	φ	tan φ	above the water surface				Include the water surface				under the water surface				CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
									N	T	N <sub>e</sub>	T <sub>e</sub>	U	N	T	N <sub>e</sub>	T <sub>e</sub>	U	N	T		N <sub>e</sub>	T <sub>e</sub>	U																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
1	1.94	2.16	13.50	22.70	5.19	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Case 2 (1/2): Upstream Slope		Slip Circle
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SF: Safety Factor

- 0: Effective Cohesion on Slip Circle ( $\text{tf/m}^2$ )
- L: Arc Length of Slip Circle (m)
- $\gamma$ : Wet Density ( $\text{tf/m}^3$ )
- $\gamma_{\text{sat}}$ : Saturated Density of Material ( $\text{tf/m}^3$ )
- b: Width of Slip Circle (m)
- x, y: X or Y Coordinate of Center of Slip Circle (m)

[illegible]

SF: Safety Factor

- C: Effective Cohesion on Slip Circle (tf/m<sup>2</sup>)
- L: Arc Length of Slip Circle (m)
- $\gamma$ : Wet Density (tf/m<sup>3</sup>)
- $\gamma_{sat}$ : Saturated Density of Material (tf/m<sup>3</sup>)
- b: Width of Slip Circle (m)
- x, y: X or Y Coordinate of Center of Slip Circle (m)

Case 2 (1/2): Upstream Slope										Sip Circle No. 12			Reservoir Water Surface			Normal Water Surface : EL.149.900m			Seismic Coefficient			0.00 (%)			Required Safety Factor			1.50					
No. of Slices	x <sub>L</sub>	y <sub>L</sub>	b	x	y	O	φ	Tan φ	above the water surface			include the water surface			under the water surface			Cl															
									N	T	U	N	T	U	N	T	U																
1	1.94	2.18	8.70	70.46	24.32	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
2	1.94	2.18	8.70	79.16	22.59	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
3	1.94	2.18	8.70	87.86	21.47	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
4	1.94	2.18	8.70	96.56	20.94	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
5	1.94	2.18	8.70	105.26	21.00	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
6	1.94	2.18	8.70	113.96	21.85	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
7	1.94	2.18	8.70	122.66	22.90	2.6	42	0.90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
8	1.94	2.18	8.70	131.36	24.78	2.8	42	0.80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
9	1.94	2.18	8.70	140.06	27.27	2.8	42	0.90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
10	1.94	2.18	8.70	148.78	30.45	2.8	42	0.90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
11	1.94	2.18	8.70	157.48	34.39	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
12	1.94	2.18	8.70	166.18	39.13	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
13	1.94	2.18	8.54	174.82	44.79	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
14	1.94	2.18	9.00	183.64	51.85	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
15	1.94	2.18	8.78	192.53	59.97	0	45	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
16	1.94	2.21	8.84	197.34	65.19	0	35	0.70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
17	2.02	2.27	2.69	199.11	67.26	0	35	0.70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
18	2.09	2.18	1.75	201.33	70.00	0	35	0.70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
19	2.11	2.16	3.86	204.03	73.55	1	25	0.47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
20	2.11	2.16	0.82	206.17	78.55	0	35	0.70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Result of Calculation									SF = 2.725		> 1.20		-- OK --		0	0	0	0	534	148	516	-180	0	0	323	6.954	398	1311	-647	0	0	4306	100.0