2. Penstock

2. PENSTOCK

2.1 Stability Analysis

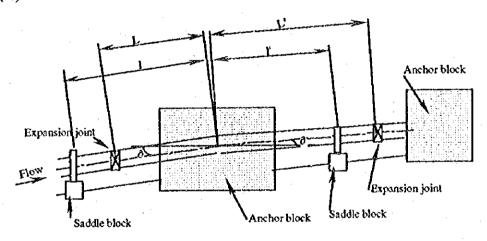
The anchor blocks No. 1-3 and 2-3 are to resist the centrifugal force caused by horizontal bend of Severino Penstock line and the resultant force of water pressure acting on the pipe. Stability calculations are therefore made for the Anchor Blocks No. 1-3 and 2-3.

Stability calculations of anchor blocks of IP-1, IP-2 and IP-4 are neglected since they are embedded in underground/ encased in mass concrete and small thrust forces.

Figure 1 shows the dimensions of Anchor Block No. 1-3 and 2-3.

(1) Method of Stability Analysis

(A) Definition of variables



 ∂ : vertical angle of upstream pipe axis (degree)

∂': vertical angle of downstream pipe axis (degree)

 $\boldsymbol{\sigma}$: vertical intersection angle between upstream and downstream pipe axes

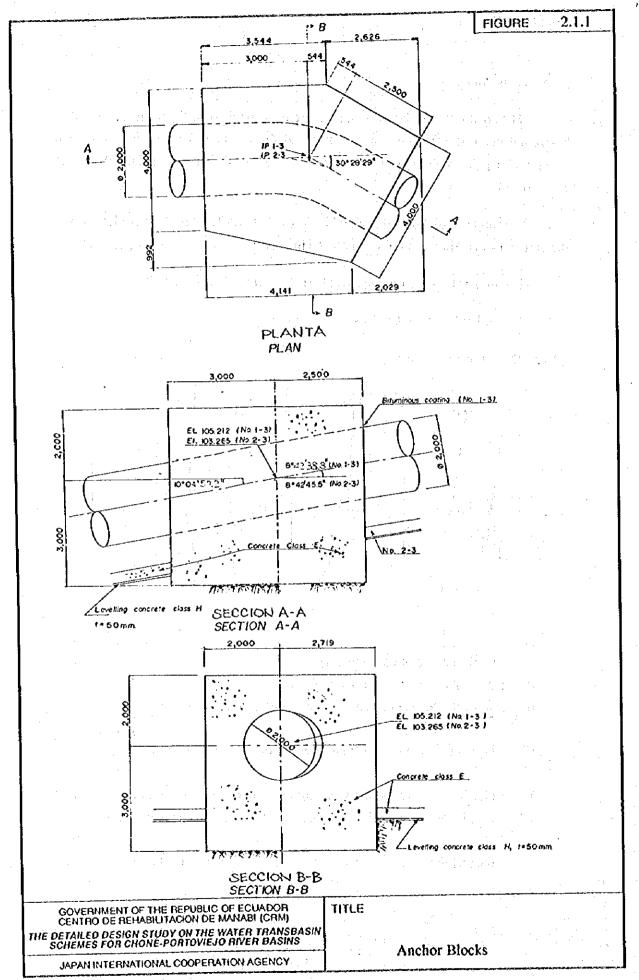
 $\varrho = \partial - \partial'$ (degree)

θ : horizontal intersection angle between upstream and downstream pipe axes (degree)

L: pipe length between I.P of anchor block and upstream expansion joint(m)

L': pipe length between I.P of anchor block and downstream expansion joint (m)

i pipe length between I.P of anchor block and upstream adjacent saddle pier (m)



1'	: pipe length between I.P of anchor block and downstre	am adjacent saddle
	pier	(m)
D	: inside diameter of penstock pipe	(m)
A	: inside sectional area of penstock pipe	(m ²)
ŧ	: thickness of upstream penstock pipe	(m)
ţ¹	: thickness of downstream penstock pipe	(m)
Н	: design head at I.P of anchor block	(m)
He	: design head at upstream expansion joint	(m)
He	: design head at downstream expansion joint	(m)
Q	: maximum pumping discharge	(m ³ /sec)
s	: weight of upstream penstock pipe shell per 1 m	(t/m)
	$s = \pi \cdot D \cdot t \cdot rs$	
s t	: weight of downstream penstock pipe shell per 1 m	(t/m)
	$s' = \pi \cdot D \cdot t' \cdot rs$	en e
rs	: density of steel	$=7.85 \text{ (t/m}^3)$
w	: weight of contained water in pipe per 1 m	(t/m)
c	: friction coefficient between pipe shell and saddle	(=0.25)
f	: friction coefficient between water and steel	(=0.02)
fe	: friction force of expansion joint per 1 m	=0.7 (t/m)
wc	: unit weight of plain concrete	$=2.3 \text{ (t/m}^3)$

(B) Acting Force on Anchor Block

(i) Thrust perpendicular to pipe axis due to dead weight of pipe and water in pipe

for upstream pipe $W = 1/2 \cdot (w+s) \cdot 1 \cdot \cos \theta$ for downstream pipe $W' = 1/2 \cdot (w+s') \cdot 1' \cdot \cos \theta'$ component force

Force	x-direction	y-direction	z-direction
W S	W•sin∂	0	-W•cos∂
W'	W'sinô'scos0	-W'•sin∂'•sinθ	-W'•cos∂'

(ii) Thrust along pipe axis due to dead weight of pipe

for upstream pipe $P_1 = s \cdot L \cdot sin \partial$ for downstream pipe $P_1' = s' \cdot L' \cdot sin \partial'$ component force

Force	x-direction	y-direction	z-direction
P ₁	-P1•cos∂	0	-P1•sin∂

refer to Figure 2.1.2

(iii) Thrust due to friction of water in pipe

for upstream pipe $P_2 = (2 \cdot f \cdot Q^2/g \cdot \pi \cdot D^3) \cdot L$ for downstream pipe $P_2' = (2 \cdot f \cdot Q^2/g \cdot \pi \cdot D^3) \cdot L'$ component force

Force	x-direction	y-direction	z-direction
P ₂	P2•cosô	0	P2•sinð
P2'	P2'•cosð'•cosθ	-P2'•cos∂'•sinθ	P2'•sin∂'

refer to Figure 2.1.2

(iv) Centrifugal force acting on bend point

due to vertical bend $P_V = 2 \cdot v^2/g \cdot A \cdot \sin(\alpha/2)$ due to horizontal bend $P_h = 2 \cdot v^2/g \cdot A \cdot \sin(\theta/2)$ component force

Force	x-direction	y-direction	z-direction
P _V	-P _V *sin(ø/2)	0	$P_{V} \cdot \cos(\alpha/2)$
Ph	Ph·sin(θ/2)	Ph·cos(θ/2)	0

refer to Figure 2.1.2

(v) Thrust due to inner pressure acting on expansion joint

for upstream pipe $P3 = He^{t}\pi^{*}D^{*}t$ for downstream pipe $P3' = He^{t}\pi^{*}D^{*}t'$ component force

 Force	x-direction	y-direction	z-direction_
P3	P3·cosd	0	P3•sinð
 P3'	P3'•cosθ'•cosθ	-P3'•cosô'•sin0	P3'•sinð'

refer to Figure 2.1.2

(vi) Unbalanced force due to water pressure acting on bend point

due to vertical bend $P_{rv} = 2 \cdot H \cdot A \cdot \sin(\alpha/2)$ due to horizontal bend $P_{rh} = 2 \cdot H \cdot A \cdot \sin(\theta/2)$ component force

Force	x-direction	y-direction	z-direction
Prv	-Prv'sin(o/2)	0	Prvcos(ø/2)
Prh	P _{rh} •sin(0/2)	P _{rh} •cos(θ/2)	0

refer to Figure 2.1.2

(vii) Thrust due to temperature change

for upstream pipe $F = F_1 + F_2$ for downstream pipe $F' = F_1' + F_2'$

- Thrust due to friction of supporting point

for upstream pipe

 $F_1 = c \cdot (w+s) \cdot (L-1/2) \cdot \cos \theta$

for downstream pipe

 $F_1' = c \cdot (w+s') \cdot (L'-l'/2) \cdot \cos \theta'$

- Thrust due to friction of expansion joint

for upstream pipe

 $F_2 = fe \cdot \pi \cdot (D + 2t)$

for downstream pipe

 $F2' = fe \cdot \pi \cdot (D + 2t')$

component force

Force	x-direction	y-direction	z-direction
k	F*cos0	0	-F•sin∂
F'	F'•cosð'•cosθ	-F'•cos∂'•sin0	F'•sinðʻ

refer to Figure 2.1.2

(viii) Dead weight of anchor block

 $W_A = wc \cdot V$

V: concrete volume of anchor block

(iv) Seismic force

 $F = F_{WA} + F_{D}$

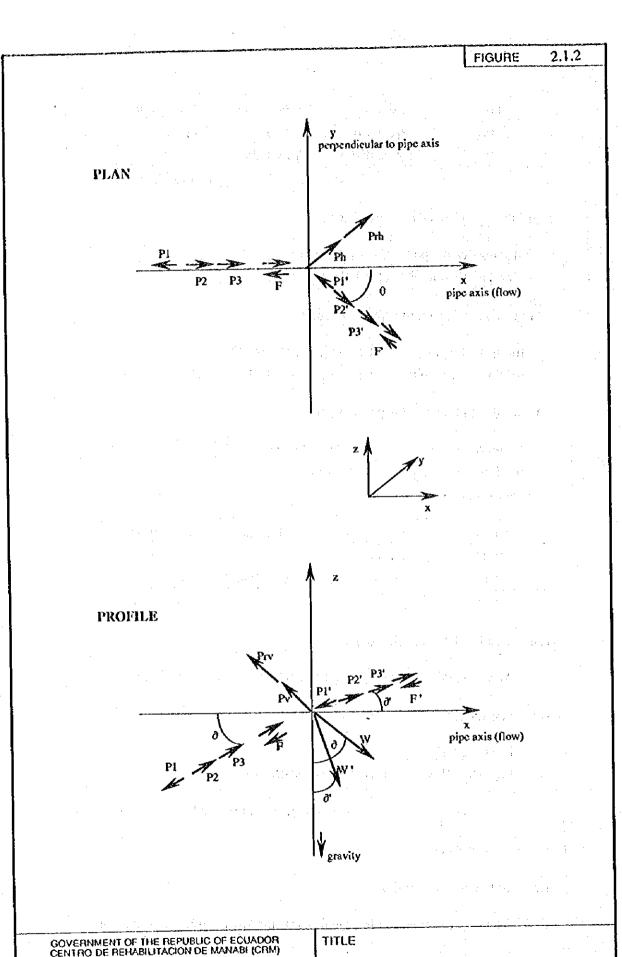
PWA= Kh'WA

 $P_p = K_h \cdot [(w+s) \cdot 1/2 + (w+s') \cdot 1'/2]$

Kh: coefficient of horizontal earthquake (= 0.15)

- (C) Check of Safety
 - (i) Safety for overturning

The safety for overturning can be confirmed by the following equation.



GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS

JAPAN INTERNATIONAL COOPERATION AGENCY

Direction of Thrust

$e = |B/2 - \sum M / \sum V| < B/6$

where, e : eccentricity of resultant force on base measured from center of

base

B: base length of anchor block

∑M: total moment

ΣV: total vertical force

(ii) Safety for sliding

$$F_S = \sum V \cdot \lambda / \sum H > 2.0$$

where, Fs: safety factor

ΣH: total horizontal force

 λ : friction coefficient of concrete and foundation = 0.65

(iii) Safety for bearing capacity

 σ max = $\sum V/A \cdot (1 \pm 6 \cdot e/B) < qa$

where, omax: maximum compressive stress

A : area of base

qa : bearing capacity of foundation

(2) Stability Analysis

(A) Cases for stability analysis

Direction of thrust forces due to temperature change (F and F') varies depending on expansion and shrinkage of penstock pipe. Other thrust forces (sum of other thrust forces indicated as "P") acts on a anchor block with a constant direction. Therefore, the following 4 cases are analyzed for stability of the anchor blocks considering the combination of the thrust forces due to temperature change and other thrust forces.

Case	Combination of Forces
1	P+F+F'
2	P+F-F'
3	P-F+F1
4	P-F-F

The analysis was conducted on 2 plains, i.e., x-z plain (flow direction) and y-z plain (perpendicular to flow direction). Moreover, earthquake force is considered

acting on the blocks in both ways for each plain, i.e., x and -x directions for x-z plain, and y and -y directions for y-z plain.

The values of component forces to x, y and z directions (Px, Py and Pz) are calculated and shown in Table 1 with input data.

- (B) Dead weight of anchor block, seismic force and center position of gravity of anchor block
- (a) WA: Dead weight of anchor block

$$W_A = 2.3 \times \{(4.992 \times 6.17 - 1/2 \times 2.626 \times 1.545 - 1/2 \times 3.447 \times 2.029 - 1/2 \times 0.992 \times 4.141) \times 5.0 - \pi/4 \times 2.0^2 \times 5.5\}$$
= 227.302 ton

(b) FwA: Seismic force for dead weight of anchor block

$$F_{WA} = 0.15 \times 227.302 = 34.095 \text{ ton}$$

(c) Fp: Seismic force for dead weight of penstock pipe and water in pipe

$$F_p = 0.15 \times (3.142 + 0.395) \times (10 + 12.062) / 2 = 5.852 \text{ ton}$$

(d) Distance to gravity center of anchor block

x-z plain

$$x = \sum A \cdot x / \sum A$$

$$\sum A \cdot x = 4.992 \times 6.17 \times 6.17 / 2 - 1/2 \times 0.992 \times 4.141 \times 1/3 \times 4.141$$

$$-1/2 \times 2.626 \times 1.545 \times (3.544 + 2/3 \times 2.626)$$

$$-1/2 \times 2.029 \times 3.447 \times (4.141 + 2/3 \times 2.029)$$

$$= 62.233 \text{ m}^3$$

$$\sum A = 4.992 \times 6.17 \times -1/2 \times 1.545 \times 2.626 - 1/2 \times 2.029 \times 3.447$$
$$-1/2 \times 0.992 \times 4.141$$
$$= 23.221 \text{ m}^2$$

therefore, x = 62.233 / 23.221 = 2.680 m

y-z plain

 $y = \sum A \cdot y / \sum A$

Table 2.1.1 Thrust Forces

	or Block No	.1.3	\$	4				
Anco Input		h1*3					component	
∂⇒	Data	10.0821067 (deg.)	5.55		Force	x-direction	y-direction	z-direction
∂'=		10.0821067 (deg.)		· W	12.687	2.221	0.000	-12.491
Ø=	∂-∂'=	0 (deg.)		W'	0.000	0.000	0.000	0.000
ð=	00-	30.4747222 (deg.)		P1	0.403	-0.397	0.000	-0.071
U= L=		5.188 (m)		Pi'	0.000	0.000	0.000	0.000
L'=		0.000 (m)		P2	0.078	0.076	0.000	0.014
= =		7.188 (m)		P2'	0.000	0.000	0.000	0.000
- '=		0.000 (m)		Pv	0.000	0.000	0.000	0.000
D=		2.000 (m)		Ph	1.573	0.414	1.518	0.000
A=		3.142 (m2)		P3	0.990	0.974	0.000	0.173
		0.009 (m)		P3'	0.000	0.000	0.000	0.000
(= *'		0.009 (m)		Prv	0.000	0.000	0.000	0.000
('==	4	15.500 (m)		Prh	25.596	6.727	24.696	0.000
H=			Total	of above	23,370	0.721	21.030	*****
He=	•	17.500 (m)	TOTAL	P	41.327	10.015	26.214	-12.375
He'=		0.000 (m)			41.321	10.013	20.214	12.510
Q=		9.6 (m3/sec)		F1	1.407			
s=	π·D·t·rs=	0.444 (t/m)		Fi'	0.000			
s'==	רי't'•rs=	0,444 (t/m)						
12=		7.85 (t/m3)		F2	4.438			
w=	$\pi \cdot D^2/4=$	3.142 (<i>U</i> m)	٠.	F2'	4.438	E 754	0.000	-1.023
c=		0.25		7=F1+F2	5.845	5.754		0.777
f=		0.02	F	=F1'+F2'	4,438	3.766	-2.216	
fe=		0.7	_			Px=	Py=	Pz=
wc=		2.3 (t/m3)	Case	Total		40.535	00.000	10.701
		,	1	P+F+F	51.609	19.535	23.998	-12.621
			2	P+F-F	42.734	12.004	28.430	-14.175
			3	P-F+F	39.920	8.027	23.998	-10.575
			4	P-F-F	31.044	0.495	28.430	-12.129
		•						
	ior Block N	0.2-3					aampanant	
Input	or Block N Data				r	. din diam	component	a dissetion
Input ∂=		10.0821067 (deg.)		117	Force	x-direction	y-direction	z-direction
Input ∂= ∂'=	Data .	10.0821067 (deg.) 10.0821067 (deg.)		w	14.244	2.494	y-direction 0.000	-14.024
Input ∂= ∂'= Ø=		10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.)		W'.	14.244 17.689	2.494 2.669	y-direction 0,000 -1,571	-14.024 -17.416
Input ∂= ∂'=	Data .	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.)		W'. P1	14.244 17.689 0.394	2.494 2.669 -0.388	y-direction 0,000 -1,571 0,000	-14.024 -17.416 -0.069
Input ∂= ∂'= Ø= θ= L=	Data .	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m)		W' P1 P1'	14.244 17.689 0.394 0.432	2.494 2.669 -0.388 -0.367	y-direction 0.000 -1.571 0.000 -0.216	-14.024 -17.416 -0.069 -0.076
Input ∂= ∂'= Ø= θ=	Data .	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m)		W' P1 P1' P2	14.244 17.689 0.394 0.432 0.076	2.494 2.669 -0.388 -0.367 0.075	y-direction 0.000 -1.571 0.000 -0.216 0.000	-14.024 -17.416 -0.069 -0.076 0.013
Input ∂= ∂'= Ø= θ= L=	Data .	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m)		W' P1 P1' P2 P2'	14.244 17.689 0.394 0.432 0.076 0.083	2.494 2.669 -0.388 -0.367 0.075 0.071	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042	-14.024 -17.416 -0.069 -0.076 0.013 0.015
Input ∂= ∂'= Ø= θ= L= L'=	Data .	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m)		W' P1 P1' P2 P2' Pv	14.244 17.689 0.394 0.432 0.076 0.083 0.000	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000
Input 0= 0'= 0= 0= L= L= 1=	Data .	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m)		W' P1 P1' P2 P2' Pv Ph	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518	-14.024 -17.416 -0.069 -0.076 0.013 0.015 -0.000 0.000
Input θ= θ'= θ= L= L'= l'=	Data .	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2)		W' P1 P1' P2 P2' Pv Ph P3	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.000
Input 0= 0'= 0= L= L'= 1= D= A= t=	Data .	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m)		W' P1 P1' P2 P2' Pv Ph P3 P3'	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.000 0.203 0.173
Input ∂= ∂= ∅= L= L'= I= I= A=	Data .	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2)		W' P1 P1' P2 P2' Pv Ph P3 P3' Prv	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494 0.000	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.000 0.203 0.173 0.000
Input 0= 0'= 0= L= L'= 1= D= A= t=	Data .	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m)		W' P1 P1' P2 P2' Pv Ph P3 P3' Prv	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.000 0.203 0.173
Input 0= 0'= 0 = L= L'= 1= D= A= t'=	Data .	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m)	Total	W' P1 P1' P2 P2' Pv Ph P3 P3' Prv	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000 30.963	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000 8.138	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494 0.000 29.874	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.000 0.203 0.173 0.000 0.000
Input 0= 0= 0= 0= L= L= L= 1= 1= L= H= H=	i Data ∂-∂'=	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m) 18.750 (m)	Total	W' P1 P1' P2 P2' Pv Ph P3 P3' Prv	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494 0.000	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.000 0.203 0.173 0.000
Input 0= 0= 0= 0= L= L= L= 1= 1= H= H= He= He'=	i Data ∂-∂'=	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m) 0.009 (m) 18.750 (m) 17.500 (m)	Total	W' P1 P1' P2 P2' Pv Ph P3 P3' Prv Prh of above	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000 30.963	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000 8.138	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494 0.000 29.874	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.000 0.203 0.173 0.000 0.000
Input 0= 0= 0= 0= L= L= L= 1= 1= L= H= H=	i Data ∂-∂'=	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m) 0.009 (m) 18.750 (m) 20.500 (m)	Total	W' P1 P1' P2 P2' Pv Ph P3 P3' Prv Prh of above	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000 30.963	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000 8.138	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494 0.000 29.874	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.000 0.203 0.173 0.000 0.000
Input 0= 0'= 0'= 0'= L'= L'= 1'= D= 4= t'= He= He= Q=	i Data ∂-∂'=	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m) 0.009 (m) 18.750 (m) 20.500 (m) 17.500 (m) 9.6 (m3/sec) 0.444 (Um)	Total	W' P1 P1' P2 P2' Pv Ph P3 P3' Prv Prh of above P	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000 30.963	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000 8.138	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494 0.000 29.874	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.000 0.203 0.173 0.000 0.000
Input 0= 0'= 0'= 0'= C'= L'= L'= L'= L'= L'= L'= C= C'= He= He= S'= S'=	Data ∂-∂'= π•D•t•rs=	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m) 0.009 (m) 18.750 (m) 20.500 (m) 17.500 (m) 9.6 (m3/sec) 0.444 (t/m)	Total	W' P1 P1' P2 P2' Pv Ph P3 P3' Prv Prh of above P	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000 30.963 67.604	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000 8.138	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494 0.000 29.874	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.000 0.203 0.173 0.000 0.000
Input 0= 0= 0= 0= L= L= L= 1= 1= L= H= H= He= He= S=	Data ∂-∂'= π•D•t•rs=	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m) 0.009 (m) 18.750 (m) 20.500 (m) 17.500 (m) 9.6 (m3/sec) 0.444 (t/m)	Total	W' P1 P1' P2 P2' Pv Ph P3 P3' Prv Prh of above P	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000 30.963 67.604	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000 8.138	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494 0.000 29.874	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.203 0.173 0.000 0.000
Input 0= 0= 0= 0= L=	Data ∂-∂'= π•D•t•rs= π•D•t•rs=	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m) 0.009 (m) 18.750 (m) 20.500 (m) 17.500 (m) 9.6 (m3/sec) 0.444 (Um) 7.85 (Um3) 3.142 (Um)		W' P1 P1' P2 P2' Pv Ph P3 P3' Prv Prh of above P	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000 30.963 67.604 0.913 0.488 4.438	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000 8.138	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494 0.000 29.874 29.153	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.203 0.173 0.000 0.000 -31.181
Input 0= 0= 0= 0= L= L= L= L= L= L= H= H= H= H= H= V= S= S= S= C=	Data ∂-∂'= π•D•t•rs= π•D•t•rs=	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m) 0.009 (m) 18.750 (m) 20.500 (m) 17.500 (m) 9.6 (m3/sec) 0.444 (Um) 7.85 (Um3) 3.142 (Um) 0.25	. 1	W' P1 P1' P2 P2' Pv Ph P3 P3' Prv Prh of above P F1 F1' F2 F2' F=F1+F2	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000 30.963 67.604 0.913 0.488 4.438	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000 8.138	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 -0.494 0.000 29.874 29.153	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.203 0.173 0.000 0.000
Input 0= 0= 0= 0= L= L= L= L= L= L= H= H= H= H= Y= S=	Data ∂-∂'= π•D•t•rs= π•D•t•rs=	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m) 0.009 (m) 18.750 (m) 20.500 (m) 17.500 (m) 9.6 (m3/sec) 0.444 (Um) 7.85 (Um3) 3.142 (Um) 0.25 0.02	. 1	W' P1 P1' P2 P2' Pv Ph P3 P3' Prv Prh of above P F1 F1' F2 F2'	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000 30.963 67.604 0.913 0.488 4.438 4.438 5.351	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000 8.138 15.085	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 -0.494 0.000 29.874 29.153	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.203 0.173 0.000 0.000 -31.181
Input 0= 0= 0= 0= L= L= L= L= L= L= L= H= H= H= H= C= S= S= S= F= F= F=	Data ∂-∂'= π•D•t•rs= π•D•t•rs=	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m) 0.009 (m) 18.750 (m) 20.500 (m) 17.500 (m) 9.6 (m3/sec) 0.444 (Um) 7.85 (Um3) 3.142 (Um) 0.25 0.02 0.7	· F	W' P1 P1' P2 P2' Pv Ph P3 P3' Prv Ph of above P F1 F1' F2 F2' F=F1+F2'	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000 30.963 67.604 0.913 0.488 4.438 4.438 5.351	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000 8.138 15.085	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494 0.000 29.874 29.153	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.203 0.173 0.000 0.000 -31.181
Input 0= 0= 0= 0= L= L= L= L= L= L= H= H= H= H= Y= S=	Data ∂-∂'= π•D•t•rs= π•D•t•rs=	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m) 0.009 (m) 18.750 (m) 20.500 (m) 17.500 (m) 9.6 (m3/sec) 0.444 (Um) 7.85 (Um3) 3.142 (Um) 0.25 0.02	. 1	W' P1 P1' P2 P2' Pv Ph P3 P3' Prv Ph of above P F1 F1' F2 F2' F=F1+F2 Total	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000 30.963 67.604 0.913 0.488 4.438 4.438 5.351	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000 8.138 15.085	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 -0.494 0.000 29.874 29.153	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.203 0.173 0.000 0.000 -31.181
Input 0= 0= 0= 0= L= L= L= L= L= L= L= H= H= H= H= C= S= S= S= F= F= F=	Data ∂-∂'= π•D•t•rs= π•D•t•rs=	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m) 0.009 (m) 18.750 (m) 20.500 (m) 17.500 (m) 9.6 (m3/sec) 0.444 (Um) 7.85 (Um3) 3.142 (Um) 0.25 0.02 0.7	F Case 1	W' P1 P1' P2 P2' Pv Ph P3 P3' Prv Ph of above P F1 F1' F2 F2' F=F1+F2 =F1'+F2' Total P+F+F	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000 30.963 67.604 0.913 0.488 4.438 4.438 4.438 5.351 4.926	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000 8.138 15.085 5.269 4.180 Px=	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494 0.000 29.874 29.153	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.000 0.203 0.173 0.000 0.000 -31.181
Input 0= 0= 0= 0= L= L= L= L= L= L= L= H= H= H= H= C= S= S= S= F= F= F=	Data ∂-∂'= π•D•t•rs= π•D•t•rs=	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m) 0.009 (m) 18.750 (m) 20.500 (m) 17.500 (m) 9.6 (m3/sec) 0.444 (Um) 7.85 (Um3) 3.142 (Um) 0.25 0.02 0.7	F Case	W' P1 P1' P2 P2' Pv Ph P3 P3' Prv Ph of above P F1 F1' F2 F2' F=F1+F2 =F1'+F2' Total P+F+F P+F-F'	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000 30.963 67.604 0.913 0.488 4.438 4.438 4.438 5.351 4.926	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000 8.138 15.085 5.269 4.180 Px=	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494 0.000 29.874 29.153 0.000 -2.460 Py= 26.694 31.613	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.203 0.173 0.000 0.000 -31.181 -0.937 0.862 Pz= -31.256 -32.980
Input 0= 0= 0= 0= L= L= L= L= L= L= L= H= L= H= H= H= C= S= S= S= F= F= F=	Data ∂-∂'= π•D•t•rs= π•D•t•rs=	10.0821067 (deg.) 10.0821067 (deg.) 0 (deg.) 30.4747222 (deg.) 5.070 (m) 5.564 (m) 8.070 (m) 10.022 (m) 2.000 (m) 3.142 (m2) 0.009 (m) 0.009 (m) 18.750 (m) 20.500 (m) 17.500 (m) 9.6 (m3/sec) 0.444 (Um) 7.85 (Um3) 3.142 (Um) 0.25 0.02 0.7	F Case 1	W' P1 P1' P2 P2' Pv Ph P3 P3' Prv Ph of above P F1 F1' F2 F2' F=F1+F2 =F1'+F2' Total P+F+F	14.244 17.689 0.394 0.432 0.076 0.083 0.000 1.573 1.159 0.990 0.000 30.963 67.604 0.913 0.488 4.438 4.438 4.438 5.351 4.926	2.494 2.669 -0.388 -0.367 0.075 0.071 0.000 0.414 1.141 0.840 0.000 8.138 15.085 5.269 4.180 Px=	y-direction 0.000 -1.571 0.000 -0.216 0.000 0.042 0.000 1.518 0.000 -0.494 0.000 29.874 29.153	-14.024 -17.416 -0.069 -0.076 0.013 0.015 0.000 0.203 0.173 0.000 0.000 -31.181 -0.937 0.862 Pz=

 $\sum A \cdot y = 4.992 \times 6.17 \times 2.496 - 1/2 \times 1.545 \times 2.626 \times 1/3 \times 1.545$ $- 1/2 \times 2.029 \times 3.447 \times (1.545 + 2/3 \times 3.447)$ $- 1/2 \times 0.992 \times 4.141 \times (4.0 + 2/3 \times 0.992)$ $= 52.821 \text{ m}^3$

therefore, y = 52.821 / 23.221 = 2.275 m

External forces acting on the anchor blocks are illustrated in Figure 2.1.3.

(C) Results of analysis

The summary of the calculation results are shown in Table 2.1.1 and calculation sheets are attached.

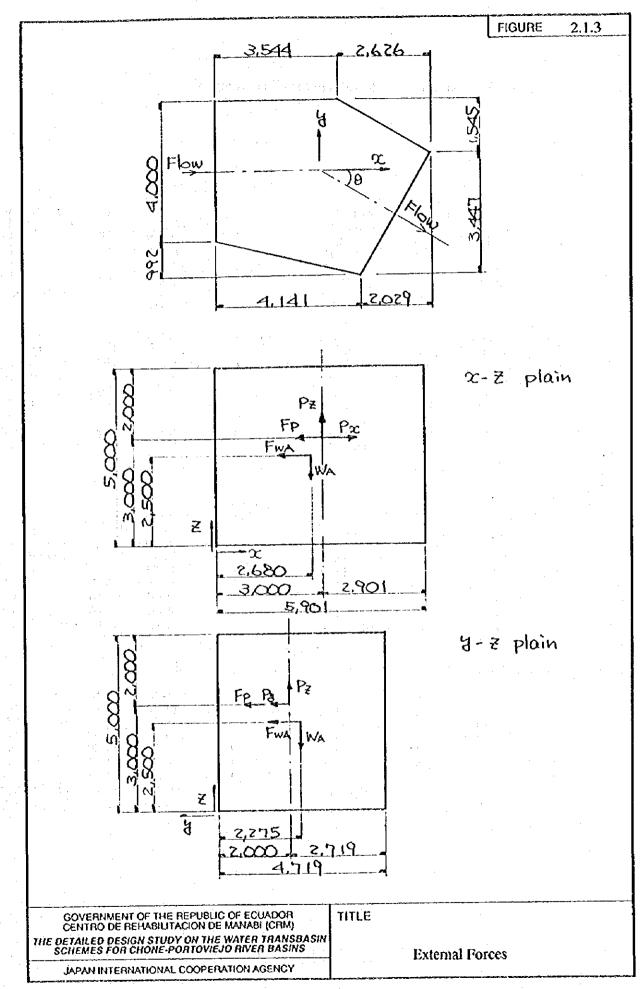


Table 2.1.2 Summary of Results of Stability Analysis

Anchor Block No. 1-3

1. x-z plain

1.1 earthquake -x-direction

safety for safety for safety for

Case overturning sliding bearing capacity
e (m) Fs OOmax (Vm2)

1 0.389 9.46 14.42

15.47 6.53 0.480 2 5.52 15.85 0.538 3 16.90 0.628 4.38 4 < qa = 100 t/m2> 2.0 <B/6= 0.984

1.2 earthquake x-direction

z cai myuant	A-GIRECTION		
Case	safety for overturning e (m)	•	safety for bearing capacity ÓÓmax (Vm2)
i	0.370	2.81	14.22
2	0.274	3.27	13.30
3	0.228	3.51	12.62
4	0.132	4.26	11.70
•	<b 6="<br">0.984	> 2.0	<qa =100="" m2<="" t="" td=""></qa>

2. y-z plain

-y-direction 2.1 earthquake safety for safety for safety for bearing capacity ÓÓmax (Um2) sliding overturning Case Fs 12.96 e (m) 0.178 12.67 12.04 0.124 20.66 2 12.85 12.55 3 0.177 11.92 20.48 0.122 4 <B/6= <9a =100 Vm2 > 2.0 0.787

2.2 earthquake y-direction

Case	safety for overturning e (m)	safety for sliding Fs	safety for bearing capacity ÓOmax (Um2)
1	0.581	2.60	17.96
2	0.630	2.44	18.72
3	0.589	2.58	17.91
4	0.638	2.41	18.68
·	<b 6="</td"><td>> 2.0</td><td>< qa = 100 Vm2</td>	> 2.0	< qa = 100 Vm2
	0.787		

Anchor Block No. 2-3

1. x-z plain 1.1 carthouske

.i earinguake	-x-unrectivi	1	
Case	safety for overturning e (m)	safety for sliding Fs	safely for bearing capacity ÓÓmax (t/m2)
	0.333	11.65	14.91
2	0.427	7.42	16.08
3	0.459	6.68	16.22
4	0.553	5.04	17.38
	<b 6="</td"><td>> 2.0</td><td><qa =100="" m2<="" t="" td=""></qa></td>	> 2.0	<qa =100="" m2<="" t="" td=""></qa>
	0.984		

1.2 earthquake x-direction

z earthquake	x-un extion		
Case	safely for overturning e (m)		safety for bearing capacity ÓÓmax (Um2)
1	0.439	2.65	16.10
2	0.340	3.07	15.08
3	0.319	3.15	14.64
4	0.220	3.77	13.62
•	<b 6="</td"><td>> 2.0</td><td>< ga = 100 U m2</td>	> 2.0	< ga = 100 U m2
	0.984		

2, y-z plain

2.1 carthquake -y-direction

i carinquake	-y-directio			
Case	safety for overturning e (m)		safety bearing ca ÓÓmax (t	pacity /m2)
1	0.194	13.70		13.88
2	0.139	23.03		13.18
3	0.193	13.60	100	13.77
4	0.137	22.86		13.07
	<b 6="</td"><td>> 2.0</td><td><qa 100<="" =="" td=""><td>Vm2</td></qa></td>	> 2.0	<qa 100<="" =="" td=""><td>Vm2</td></qa>	Vm2
	0.787	for Alleria		

2,2 earthquake y-direction

Case	safety for overturning e (m)		safety for bearing capacity OOmax (Um2)
 1	0.578	2.56	19.32
2	0.629	2.40	20.17
3	0.585	2.54	19.28
4	0.636	2.38	20.12
· ·	<b 6="</td"><td>> 2.0</td><td>$< qa = 100 t/m^2$</td>	> 2.0	$< qa = 100 t/m^2$
	0.787		•

Stability Analysis		i		Stability Analysis		1000	
x-z plain		5.901 m		ureld z-x	il M	5.901 m	
Case-1	earthquake: -:	-x-direction		Case-2	earthquake:	-x-direction	
tical	Force (ton)	x (m)	Moment	Vertical	Vertical Force (ton)	x (m)	Moment
		*	(ton-m)				(ton-m)
٨M	-227.302	2.680	-609.169	ΜA	-227.302	2.680	-005.100
8	-12.621	3.00	-37.864	2 <u>0</u>	-14.175	3.000	42.525
Σν=	-239.923	ΣV•x=	-647.034	Σv=	-241.477	=x-\3	-651.695
Horizontal Force (ton)	Force (ton)	z (m)	Moment	Horizontal	Horizontal Force (ton)	z (m)	Moment
	•	•	(ton-m)				(ton-m)
FwA	-34.095	2.500	-85.238	FwA	-34.095	2.500	-85.238
ដ	1 022	2000	-5.700	ŗ	1 033	3,000	-5.790
<u>.</u>	20201	200	20,505	ኢ	12.02	000	25.012
ZH.	-16.493	ΣH-2=	-32,431	ΣH=	-24.024	ΣH-7=	-55.025
	$\Sigma M = \Sigma$	ΣM= ΣV•×-ΣH•π=	-614.603	:	$\Sigma M = \lambda$	$\Sigma M = \Sigma V \cdot x \cdot \Sigma H \cdot z =$	-596.670
Safety for overturning	srturning			Safety for overturning	erturning		****
7.1 -3 -7 3 0	11	> x85.0	400.0	Coffee Cas of Alle		7 00+10	\$0.50 0.50
sarety for suding	in Source	0.46.7	0,0	Saidly for Su	rumg Fre =	653>	2.0
Safety for hea	Safety for hearing capacity	A	.	Safety for be	Safety for bearing capacity		
	=xemQQ	14.42 <	100 vm2		óómax≕	15.47 <	100 v/m2
Stability Analysis	lveic			Stability Analysis	alvsis		
x-z plain	-M	5.901 m		x-z plain	B	5.901 m	
		-x-direction		Case 4	earthquake:	-x-direction	
tical		×(B)	Moment	Vertical		x (m)	Moment
	•	•	(ton-m)		1	;	(ton-m)
WA	-227.302	2.680	-609.169	WA	-227.302	2.680	609.169
Pz	-10.575	3.00	-31.725	Pz	-12.129	3.000	-36.387
∑∨≖	-237.877	$\sum V^*x =$	-640.895	£∨=	-239.431	=x-∧3	-645.556
Horizontal	Horizontal Force (ton)	z (m)	Moment	Horizonta	Horizontal Force (ton)	z (m)	Moment
,	•	i i	(ton-m)	•		000	(ton-m)
FWA	-54.095	2200	\$57.58	¥¥4	CXO.42-	2007	-52.25
Ç,	-1.933	3.000	-5.799	q.	-1.933	3.000	\$\\.?
ፚ	8.027	3.00	24.080	ኟ	0.495	3.000	1.486
Σ H=	-28.001	ΣH-2=	-66.957	∑H=	-35.533	$\Sigma H \cdot z =$	-89.551
. * *	∑M= ∑	$\Sigma M = \Sigma V \cdot x \cdot \Sigma H \cdot z =$	-573.938		∑M=	$\Sigma M = \Sigma V \cdot x \cdot \Sigma H \cdot z =$	-556.005
Safety for overturning	erturning e=	0.538 <	0.984	Safety for overturning	verturning	0.628 <	0.984
Safety for sliding	Ļ	5 63 5	00	Safety for sliding	ţi		
Safety for he	FS = aring canacity	400	2	Safety for be	earing capacity		
Saucety 10s to	Salvey for warms, Somax=	15.85 <	100 t/m2		- Oomax=	16.90 <	100 Vm2

Sheet
alculation
10.1-3 C
Block
Anchor

lysis B= 5.901 m earthquake: x-direction Koment (ton-m) -227.302 2.680 -609.169 -14.175 3.000 -42.525 -241.477 \(\Sum_{v-x} \times \tim	(ton) z (m) Moment (ton-m) (595 2.500 85.238 933 3.000 5.799 .004 3.000 36.012 .032 ΣH•z= 127.049 ΣM= ΣV•x-ΣH•z= -778.744 \$\var{\mathbb{g}} = 0.274 < 0.984 \$\var{\mathbb{g}} = 13.30 < 100 \text{ \$\mathbb{m}\$} 2.0	ltysis B= 5.901 m earthquake: x-direction Force (ton) x (m) (ton-m) -227.302 2.680 -609.169 -12.129 3.000 -36.387 -239.431 \(\cutilde{\cuti	SM= ΣV·x-ΣH·σ= -738.079 ε= 0.132 < 0.984 4.26 > 2.0 pacity 11.70 < 100 t/m2
Stability Analysis X-z plain Case-2 Vertical Force (ton) WA -227.302 Pz -14.175 EV= -241.477	Horizontal Force (ton) FwA 34.095 Fp 1.933 Px 12.004 ΣH= 48.032 ΣM= Safety for overturning Safety for sliding Fs = Safety for bearing capacity Omax=	Stability Analysis X-z plain Case-4 earthquake: Vertical Force (ton) WA -227.302 Pz -12.129 ∑V= -239.431 Horizontal Force (ton) FwA 34.095 Fp 1.933 Px 0.495 YH= 36.524	Safety for overturning Safety for sliding Fs = Safety for bearing capacity Omax=
Moment (ton*m) -609.169 -37.864 -647.034	Moment (ton-m) 85.238 5.799 58.606 149.643 -796.677 0.984 2.0	A Moment (ton-m) -609.169 -31.725 -640.895 Moment (ton-m) 85.238 5.799 24.080 115.117	-756.012 c 0.984 - 2.0 c 100 t/m2
lysis B= 5.901 m earthquake: x-direction Force (ton) x (m) -227.302 2.680 -12.621 3.000 -239.923 Σ.V-x=	ce (ton) z (m) 34.095 2.500 1.933 3.000 19.535 3.000 55.564 ΣH-z= DME ΣV-x-ΣH-z= nmg 0.370 < capacity 2.81 > max= 14.22 <	tivis B= 5.901 m earthquake: x-direction -227.302 2.680 -10.575 3.000 -237.877 Σ.V·x= Force (ton) z (m) 34.095 2.500 1.933 3.000 8.027 3.000 44.055 Σ.H·z=	ΣM= ΣV·×·ΣH·π \$ e= 0.228 < 3.51 > pacity 12.62 <
Stability Analysis x-z plain Case-1 Care-1 Cartical Force (ton) WA -227.302 Pz -12.621 \$V= -239.923	Horizontal Force (ton) FwA 34.095 Fp 1.933 Px 19.535 YH= 55.564 XM= Safety for overturning Safety for sliding Fs = Safety for bearing capacity Omax=	Stability Analysis x-z plain Casc-3 carthquake: Vertical Force (ton) WA -227.302 Pz -10.575 \text{SV=} -237.877 Horizontal Force (ton) FwA 34.095 Fp 1.933 Py 8.027	Safety for overturning e= Safety for sliding Fs = Safety for bearing capacity Omax=

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alysis B= 4.719 m earthquake: -y-direction Moment Force (ton) y (m) (ton-m) -227.302 2.275 -517.112 -14.175 2.000 -28.350 -241.477 \(\text{LV-x=} \) -545.462	Horizontal Force (ton) z (m) Moment (ton·m) FwA -34.095 2.500 -85.238 Fp -1.933 3.000 -5.799 Py 28.430 3.000 85.290 ΣH= -7.598 ΣH-z= -5.747	Safety for overturning Safety for sliding Safety for sliding Fs = 20.66 > 2.0 Safety for bearing capacity Omnax = 12.04 < 100 t/m2	earthquake: -y-direction Force (ton) y (m) Moment -227.302 2.275 -517.112 -12.129 2.000 -24.258 -239.431 \$\subseteq V^* \times \times -541.370	Horizontal Force (ton) z (m) Moment (tou·m) FwA -34.095 2.500 -85.238 Fp -1.933 3.000 -5.799 Py 28.430 3.000 85.290 ΣH= -7.598 ΣH•z= -5.747	Safety for overturning $c=$ 0.122 < 0.787 Safety for sliding $Fs=$ 20.48 > 2.0 Safety for bearing capacity
Stability Analysis y-z plain Case-2 earth Moment Vertical Force (ton·m) -517.112 WA -2 -25.243 Pz542.355 EV= -2	Moment Horizonta (ton-m) -85.238 FwA -5.799 Fp 71.994 Py -19.043 ΣH=	-523.312 Safety for overturning 0.787 Safety for sliding 3.0 Safety for bearing cap 500 vm2	Stability Analysis y-z plain y-z plain Case-4 earth Moment Vertical Force (ton-m) -517.112 WA -2 -21.150 Pz538.262 ΣV= -2	Moment Horizonia (ton-m) -85.238 FwA -5.799 Fp 71.994 Py -19.043 £H=	-519.220 Safety for overturning 0.787 Safety for sliding 2.0 Safety for bearing cap.
4.719 m -y-direction y (m) 2.275 2.000 Σ.ν-x=	z (m) 2.500 3.000 3.000 ΣH-2=	ΣM= ΣV•x-ΣH•z= S = 0.178 < 0 Fs = 12.96 > 2 pacity 12.67 < 1	4.719 m -y-direction y (m) 2.275 2.000 Σ.ν•x=	z (m) 2.500 3.000 3.000 ΣH-7=	ΣV•x-ΣH•z= 0.177 < 12.85 >
Stability Analysis y-z plain Case-1 Vertical Force (ton) WA -227.302 Pz -12.621 EV= -239.923	Horizontal Force (ton) FwA -34.095 Fp -1.933 Py 23.998 ΣH= -12.030	Safety for overturning e= Safety for sliding F:s = Safety for bearing capacity Omax=	Stability Analysis y-z plain Casc-3 carthquake: Vertical Force (ton) WA -227.302 Pz -10.575 EV= -237.877	Horizontal Force (ton) FwA -34.095 Fp -1.933 Py 23.998 ΣH= -12.030	Safety for overturning Safety for sliding F.s. Safety for bearing, capacity

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Moment (ton-m)	-517.112 -28.350 -545.462	Moment (ton·m)	85.238 5.799	85.290 176.327	-721.789	0.787	2.0	100 t/m2			Moment (forest)	-517.112	-74.28	Moment	85.238 5.700	85.290	176.327	-717.697	0.787	20	100 t/m2
4.719 m y-direction y (m)	2.275 2.000 \(\nabla \cdot \c	z (m)	3.000 3.000	3.000 EH-z=	ΣM= ΣV·x-ΣH·π=	0.630 <	2.44 >	18.72 <	4.719 m	y-direction	y (E)	2275	ΣV•x=	z (m)	2500	300	ΣH-2=	ΣM= ΣV·x-ΣH·z=	0.638 <	. 41 ×	_
B= quake: c (ton)	-227.302 -14.175 -241.477	Force (ton)	34.095	28.430 64.458	∑.M= ∑	ertuming e=	iding Fs ==	Safety for bearing capacity Óómax=	alysis R=	earthquake:	Force (ton)	-227.302	-12.129	Force (ton)	34.095	28.430	64.458	ΣM=)	verturning e=	iding Es -	Safety for bearing capacity Óómax=
Stability Analysis y-z plain Case-2 earth Vertical Foro	wγ Σς Σς=	Horizontal	FwA	MA H	,	Safety for overturning	Safety for sliding Fs =	Safety for be	Stability Analysis	Case 4	Vertical	WA	Pz V=	Horizontal	FwA	ድፚ	ΣH=	e e ē	Safety tor overturning	Safety for sl	Safety for b
Moment (ton-m)	-517.112 -25.243 -542.355	Moment (ton•m)	85.238 5.799	71.994	-705.386	0.787	2.0	100 t/m2			Moment	(fon-m) -517.112	-21.150	Moment	(toa-m) 85.238	71.994	163.031	-701.294	0.787	ć	100 t/m2
B 8	2.275 -517.112 2.000 -25.243 ΣV-x= -542.355	z (m) Moment (ton•m)	, 🍑	3.000 71.994 ΣH•z= 163.031	_	v			A 710	4./19 m direction			2.000 -21.150 $\Sigma V - x = -538.262$	z (m) Moment	-	3,000 71.994			٧		100 t/m2
B= 4.719 m quake: y-direction s (ton) y (m)		(ff)	, 🍑	3.000 ΣH·z=	$\Sigma M = \Sigma V \propto - \Sigma H \cdot z = -705.386$	c= 0.581 <	2.60 ×	17.96 <	d	b = 4.719 m carthquake: y-direction	Force (ton) y (m)	2.275			2.500	3.000 3.000		M= \(\Substack \times \	> 0.589 <	03.0	17.91 < 100 t/m ²
B 8	2.275 2.000 \$\times V-x=	z (m)	3.000	23.998 3.000 = 100	_	v	2.60 >	apacity 17.96 <	Analysis	y-z plam b= 4./13 m Case-3 earthquake: y-direction	ncal Force (ton) y (m)	-227.302 2.275	2.000 XV-X=	z (Ħ)	34,095 2,500	3.000 3.000	= 60.026 \(\sum_{H^*Z^*}\)	M= \(\Substack \times \	٧	03.6	apacity 17.91 < 100 t/m2

Stability Analysis	N-z plain B= 5.901 m	tical Force (ton) x (m)	500 CCC	W. 727.302. 2000 De 22.000	000°C 000°C 71	7 v=x-7 707:007-	Horizontal Force (ton) z (m)		FwA -34.095 2.500	Fp 5.865	Px 16.1/4 3.000 48.522		Software Contraction of the Cont	Salety 101 Overtuning 6= 0.427 < 0.984		Fs 7.42 > 2.0	Safety for bearing capacity Oómax= 16.08 < 100 t/m2	Stability Analysis	#	earthquake: -x-direction	Vertical Force (ton) x (m)		- 0.00 c 201.77- Aw	55.10/ 5.000		Horizontal Force (ton) z (m)	FwA -34.095 2.500	Fp 4.865 3.000	Px 5.637 3.000	5 \(\sum_{H=} \) -33.324 \(\sum_{H*} \sum_{W=} \) -82.923		Satety for overturing $a=0.553 < 0.054$		Fs 5.04 > 2.0	California Contraction and an artist and an artist and artists are also an artist and artists and artists are artists and artists and artists are artists are artists and artists are arti
	ឧ	Moment	(ton-m)	003.109	101.0%	066.70/-	Moment	(ton-m)	-85.238	-14.595	73.601		50/0/0-	A 0.984		> 2.0	< 100 vm2		8		Moment	(ton-m)	607.600-	-88.140	-697.315	Moment	-85.238			-57.845	= -639.471	7800 70	,	3 > 2.0	
		-x-onection x (m)		7.000	i	7 ^ XII	z (m)		2.500		ir		Z.W= Z.v.x-ZH.Z	= 0.333		= 11.65 >	ty = 14.91		= 5.901 m	: -x-direction	× (m)		2.680	i	. Σν.χ=	z (m)	2.500		!	-Z-H3	ΣM=ΣV•x-ΣH•z=	0270	ĵ.	< 89.9	2
Stability Analysis	x-z plain B=	Case-1 cartoquare: Vertical Force (ton)		705.122- AW		%cc.&cz- =v_2	Horizontal Force (ton)				PX 24.534	•		Salety for overtuning	Safety for sliding	FS ==	Safety for bearing capacity Oomax=	Stability Analysis	x-z plain B=		Vertical Force (ton)		•		ΣV= -256.684	Horizontal Force (ton)	٠,٠	Fp 4.865		ΣH= -24.964	ΣM	Safety for overturning	Safety for sliding	FS=	Cofety for bearing consocity

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Moment (ton-m) -609.169 -98.941	Moment (ton·m) 85.238 14.595 48.522 148.356	-856.466 0.984 2.0 100 t/m2	Moment (ton-m) -609.169 -93.320 -702.489	Moment (ton-m) 85.238 14.595 16.910	-819.233 0.984 2.0 100 Vm2
5.901 m direction x (m) 2.680 3.000	z (π) 2.500 3.000 Σ.H-z=	\(\times \text{LV \cdot x} \cdot \text{H \cdot z} \) \(\text{c} \text{c} = 0.340 < \) \(\text{3.07 > pacity} \) \(\text{pacity} \) \(\text{15.08 < } \)	5.901 m direction x(m) 2.680 3.000 ΣV-x=	z (m) 2.500 3.000 3.000 Σ.H•z=	ΣM= ΣV·x-ΣH·z= ng c= 0.220 < 3.77 > apacity xx= 13.62 <
llysis. B= 5.90 earthquake: x-direction Force (ton) x (m) -227.302 2.680 -32.980 3.000	Force (ton) 34.095 4.865 16.174 55.134		ility Analysis Polain Set earthquake: x-direction Vertical Force (ton) x (m) WA -227.302 2.68C Pz -31.107 3.000 Ex -258.409 \(\Sigma\) x'x	Force (ton) 34.095 4.865 5.637 44.597	a
Ans	Horizontal Fw A Fp PX XX	Safety for overturning Safety for sliding Fs = Safety for bearing capa Ofmax=	Stability Analysis x-z plain Case-d earth Vertical Force WA -2. Pz Pz -2.	Horizontal FwA Fp Py Px YH=	Safety for overturning Safety for sliding Fs = Safety for bearing cap.
Moment (ton-m) -609.169	Moment (ton-m) 85.238 14.595 73.601 173.434	-876.370 0.984 2.0 100 t/m2	Moment (ton-m) -609.169 -88.146 -697.315	Moment (ton-m) 85.238 14.595 41.989 141.823	-839.138 0.984 2.0 100 vm2
5.901 m direction x (m) 2.680 3.000	z (m) z (m) 2.500 3.000 2.4.2	ΣM= ΣV•x-ΣH•z= ε 0.439 < 2.65 > pacity 16.10 < x= 16.10 <	5.901 m x-direction x (m) 2.680 3.000 Σ.0*x=	z(m) 2.500 3.000 3.000 Σ.Η·2=	ΣM= ΣV•x-ΣH•z= ε= 0.319 < 3.15 > pacity 14.64 <
plain B= 5.90 e-1 earthquake: x-direction Vertical Force (ton) x (m) WA -227.302 2.680 Pz -31.256 3.000	-228.538 Force (ton) 34.095 24.534 63.494	Safety for overturning Safety for sliding Fis = Safety for bearing capacity Omax=	B== quake: (ton) 27.302 29.382 56.684	Force (toa) 34.095 4.865 13.996 52.957	
Stability Analysis x-z plain Case-1 Vertical Force WA -2 Pz	Yv= Honzontal FwA Fp Px Px YH=	Safety for overturning Safety for sliding Fs = Safety for bearing cape	Stability Analysis x-z plain Cave-3 earth Vertical Force WA -2 Pz -2	Horizontal FwA Fp Px Px Px Xx	Safety for overturning Safety for sliding Fis == Safety for bearing capa OOmax=
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22.86 > 2.0

Fs = Safety for bearing capacity

13.60 > 2.0

Fs == Safety for bearing capacity

Safety for sliding

Safety for sliding

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Stability Analysis				Stability Analysis		012.7		
y-z plain	######################################	4.719 m		y-z piann Case-2	earthouske:	m V//y m		
rical	Force (ton)	y (m)	Moment	Vertical	Force (ton)	y (B)	Moment	
			(ton·m)				(ton-m)	
WA	-227.302	2.275	-517.112	WA	-227.302	2.275	-517.112	
Pz	-31.256	2.000	-62.511	Pz	-32.980	2.000	-65.960	
Σν=	-258.558	Σν-x=	-579.623	ΣV=	-260.282	∑∨•x=	-583.072	
Horizontal Force (ton)	Force (ton)	z (m)	Moment	Horizontal	Force (ton)	z (m)	Moment	
		4	(ton-m)	ſ	0000	0	(ton-m)	
FwA	4.093	2,500	-82.238	FWA F	24.095	200	857.08-	
£,	4.865	200	14.090	<u>C</u> , ¿	4.803	38	14590	
ν. ΣΕ.Ξ	-12.267	3.000 TH•27	80.081 -19.753	γ.γ Σ.Η:=	-7.348	ΣH.2=	4.995	
			020 033		C.W.	V.v.V.	750 878	
	= N 7	7'-Y-Y-Y-Y-Y-Y-	0/0/60-	C. C. C.	7 - var 7	-7-117-V-17-117		
Safety for overfurning	rtumng	0.194 <	0.787	sarety for overturning	/ermining	0.130 <	0.787	
Column fra clining		1 1 1 1 1 1	70.00	Cofatty fre clicing		,		
Salety for Suc	He =	13.70 >	20	sacify for sa	rumg Fis ==	23.03 >	2.0	
Safety for bearing capacity	mine capacity	•	ì	Safety for by	Safety for bearing capacity			
	Somax=	13.88 <	100 t/m2		Óómax=	13.18 <	100 vm2	
Crobitty Anglacie	. Janes			Stability Analysis	salveic			
v-z plain	n, rotes B=	4.719 m		v-z plain	B=	4.719 m		
Case-3	earthquake:	-v-direction		Case 4	earthquake:	-v-direction		
tical	Force (ton)	v (m)	Moment	Vertical		у (m)	Moment	
	•		(ton-m)				(ton-m)	
WA	-227.302	2.275	-517.112	ΜA	-227.302	2.275	-517.112	
P2	-29.382	5.000	-58.764	Σď	-31.107	2.000	-62213	
ΣΛ=	-256.684	$\sum V^* X =$	-575.876	ΣΛ=	-258.409	Σν-χ=	-579.325	
Horizontal	Horizontal Force (ton)	z (H)	Moment	Horizonta	Horizontal Force (ton)	z (m)	Moment	
ТWA	24 005	2.500	(ton-m) -85,238	й ЖЖ	-34.095	2.500	(ton-m) -85.238	
£	4.865	000	-14 595	£	4.865	3.000	-14.595	
<u>ት</u> ፈ	26.694	3,000	80.081	ት <mark>ል</mark>	31.613	3.000	94.839	
ΣΉ=	-12.267	ΣH•z=	-19.753	$\Sigma \dot{H}$ =	-7.348	Σ H-z=	4.995	
	ΣM=)	\$M=\$V•x-\$H•z=	-556.123		∑M= ∑	ΣM= ΣV•x-ΣH•z=	-574.330	
Safety for overturning	erturning	,	1	Safety for overturning	verturning		100	
	() 	v 661.0	/8/.0	C. C. L. C.	1	V.157 <	0.76/	
Safety for Sliding	Suit			Salety for suding	Iding			

	# a	÷25	32	ដឧ	\	3 8	72	45			Α)			ţ	a	22	3 23	i i	i	8 % 8 %	88	27.	%				7
	Moment	-517.112	-83.072	Moment (ton·m)	85238	94,839	194,672	-777.745	0.787	2.0	100 が配			Momen	(ton-m)	-517.112	-579.325	Moment	(ton-m)	85.238	94.839	194.672	-773.998	0.787		2.	100 t/m2
4.719 m	y-direction y (m)	2.275	Σν.x=	z (m)	2.500	000 000 000 000 000 000 000 000 000 00	2H·z=	ΣM= ΣV-x-ΣH•z=	0.629 <	2.40 >	20.17 <		4.719 m	-direction	(m) (c)	2275	×-7.5	; ; ;	(***) **	2.500 3.000 3.000	3,000	∑H•z=	$\Sigma M = \Sigma V \cdot x - \Sigma H \cdot z =$	0.636 <	6	6 00.7	20.12 <
Ä	e-2 earthquake: y- Vertical Force (ton)	-227.302	-52,390	Force (ton)	34.095	31.613	70.573	ΣM= Σ	erturnung	ding Fs =	Safety for bearing capacity Oomax=		E E	earthquake: y-direction	ronce (non)	-227.302	-51.10/	Entre (100)	(mon) and to	34.095 4 865	31.613	70.573	ΣM= }	erturning		FS = Safety for bearing capacity	Óomax=
Stability Analysis y-z plain	Case-2 Vertical	∀ ¥	πΛ ΣΛ=	Horizontal	FwA	ድል	ΣH=		Satety for overturning	Safety for sliding Fs =	Safety for be	Stability Analysis	y-z plain	Case 4	Vertical	W.A.	F2 7 V≡	L'Amirachanta I	TO TO TO	FwA G	ት ል	ΣΉ=		Safety for overturning	Safety for sliding	Safety for be	
•																-1.				۸۸ ۱۸	~		_				
	Moment	(ton•ra) -517.112	-62.511	Moment (forem)	85.238 35.238	14.595 80.081	179.915	-759.538	0.787	2.0	100 vm2		ú		(ton-m)	-517.112	-58.784 -575.878		(ton-m)	85.238	80.081	179.915	-755.791	0.787		7:0	100 Vm2
4.719 m	-		ΣV•x= -579.623	z (m) Moment	2.500 85.238		41		٧				4.719 m		y (m) Moment (ton-m)	2.275 -517.112		l K	<u> </u>		3,000			٧		254 > 2.0	1928 < 100 Vm2
Β =	: y-direction y (m)		2.000 \(\Sigma\) \(\sigma\)	•	2.500		NH-Z=	M= \$V•x-\$H•z=	c= 0.578 <	2.56 >	19.32 <	a VSIS	B	earthquake: y-direction	Force (ton) y (m)	2.275	,		i (III) z	258 288 288	36		ΣM= ΣV•x-ΣH•z= -755.791	> 585 0		254 v	1928 <
Stability Analysis y-z plain B= 4.719 m	earthquake: y-direction cal Force (ton) y (m)	-227.302 2.275	2.000 \(\Sigma\) \(\sigma\)	z (m)	2.500	4.865 3.000 3.000	NH-Z=	M= \$V•x-\$H•z=	٧	2.56 >	capacity 19.32 <	Stability Analysis	B	earthquake: y-direction	y (m)	-227.302 2.275	2:000	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	X (III) X	34.095 2.500	26.604 3.000	EH-27		٧		254 v	

3. Head Tank

3. HEAD TANK

3.1 Structural Calculation

(1) Structural model

The structural model type I and II are shown in the Fig. 3.

(2) Structural calculation

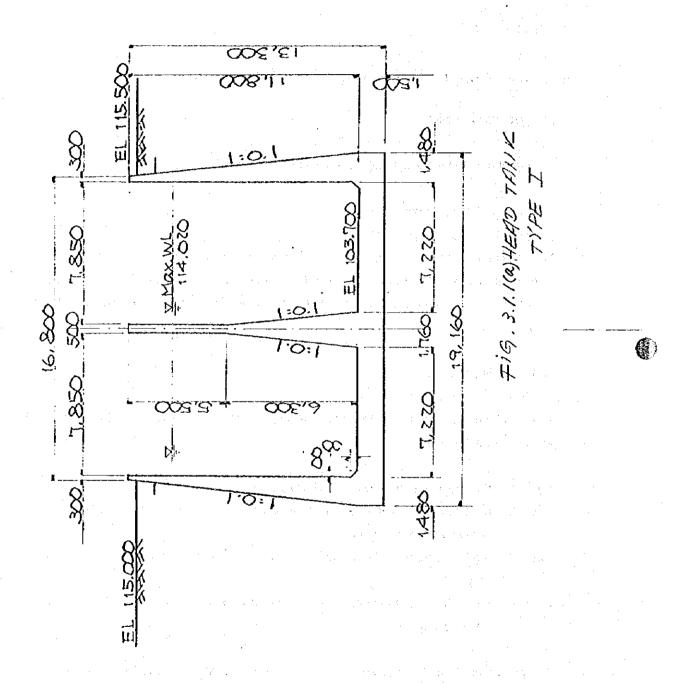
The structural analysis of frame were made by applying the SAP90 computer program, (Structural Analysis Program), that use the "Finite Element Method". This program represent the research work conducted at the University of California, Berkeley, by Professor Edward L. Wilson.

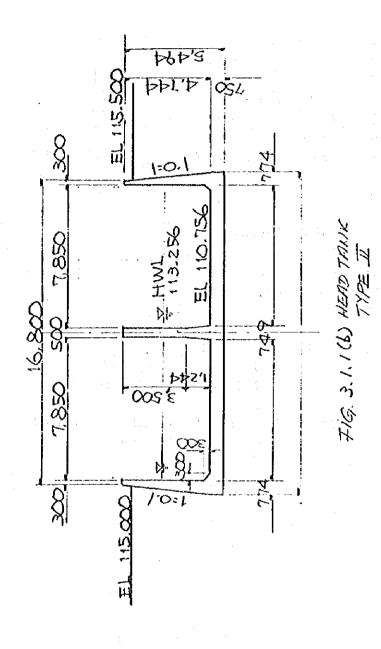
(3) Loading condition

The structural analysis were made for the loading conditions of the following four cases and are illustrated in Fig. $3 \cdot 1 \cdot 2$

- Case 1: the tank is empty without earthquake effect.
- Case 2: the one side of the tank is fulled with water at HWL and the other is empty without earthquake affect.
- Case 3: the both side of the tank is fulled with water and earthquake effect is not taken account.
- Case 4: the both side of the tank is also fulled with water and earthquake effect is taken into consideration.

The results of internal forces such as bending moment (M), shearing force (Q) and axial forces for each case are attached hereinafter.





LOADS HEAD TANK TYPE 1

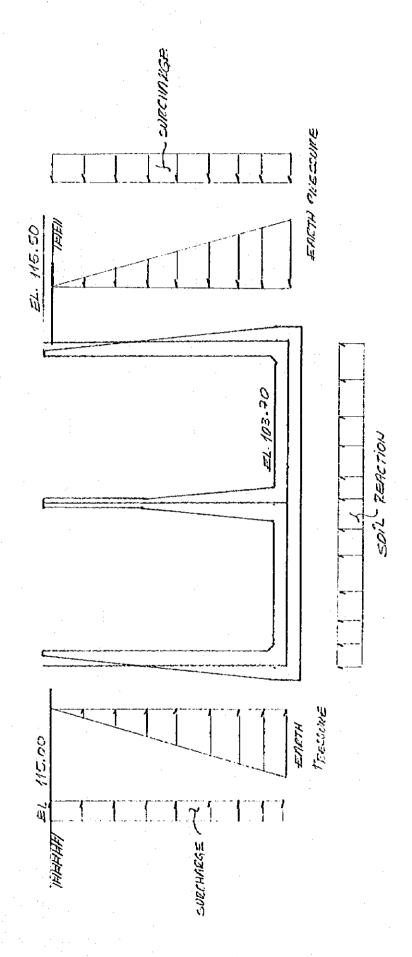
1	Self Weight	D
2	Earth Pressure due to Live Load	L
3	Earth Pressure	H
4	Foundation Reaction (1)	Rí
5	Water Pressure (1)	F1
6	Foundation Reaction (2)	R2
7	Foundation Reaction (3)	R3
8	Water Pressure (2)	F2
9	Earthquake	٤

COMBINATIONS

C1	D÷L	+H-	+R1

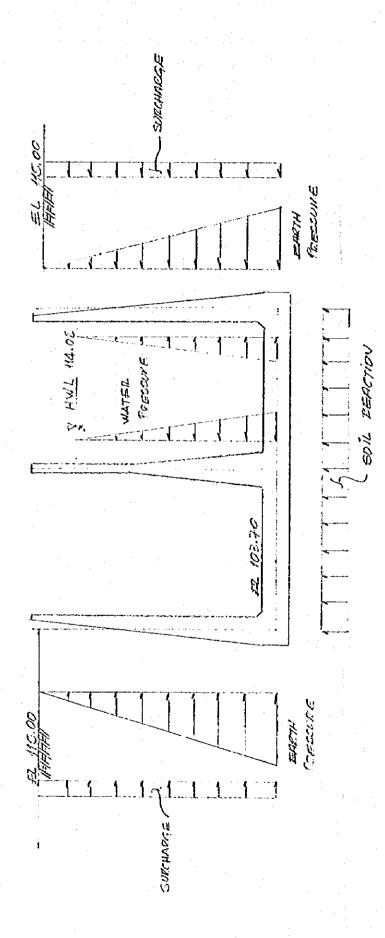
- C2 D+L+H+R1+F1+R2
- C3 D+L+H+R1+F1+R2+R3+F2
- C4 D+L+H+R1+F1+R2+R3+F2+E
- C5 1.4D+1.7L+1.7H+1.4B1
- C6 1.4D+1.7L+1.7H+1.4R1+1.4F+1.4R2
- C7 1.4D+1.7L+1.7H+1.481+1.4F+1.4R2+1.4F2
- C8 1.05D+1.28L+1.28H+1.05R1+1.05F1+1.05R2+1.05R3+1.05F2+1.4E
- C9 0.90D+1.7H+1.4R1+1.4F1+1.4R2+1.4R3+1.4F2+1.43E

ELIPTY WITHOUT EPRTHOUAKE HEND THINK TYPE I CASE Fig 3.1.2(0)

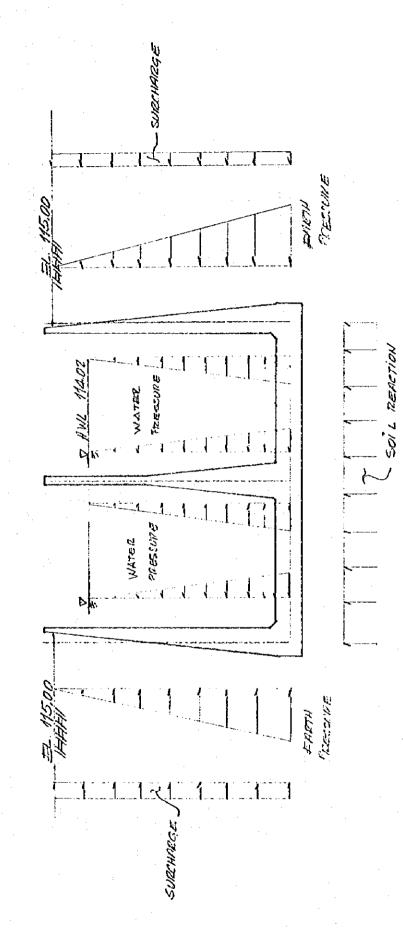


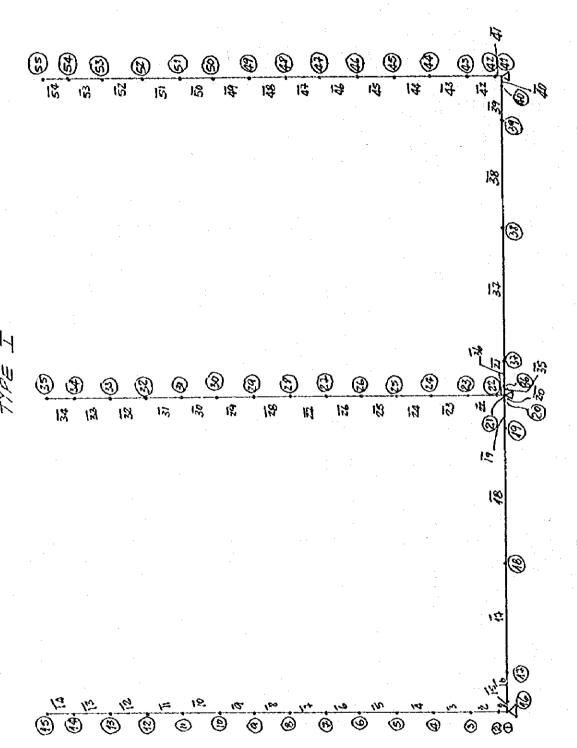
TOSLASS CHOM IN TIME IN ONE THE OFFICER

HEND THINK TYPE I



HERD TRILK TYPE I HWL IL BOTH CIDE WITHOUTE HWL IN YOTH C'OF WITH EDIKTHENNER F12. 3.1.2(c) CASE 4.





HEAD TANK TYPE I

JOINT	- x	Y	q soil	<u>d</u> (m)	Weight
			wine		
1	0.00	0.00	11.03	-1.500	3.60
5	0.00	0.01	11.02	1,500	3.60
3	0.00	1.00	10.13	1.475	3.54
4	0.00	2.00	923	1.375	3.30
5	0.00	3.00	8.33	1.275	3.06
6	0 00	4.00	7.43	1.175	2.82
7	0.00	5.00	6.53	1.075	2,58
8	0.00	6.00	5.63	0.975	2.34
9	0.00	7.00	4.73	0.875	2.10
10	0.00	8.00	3.83	0.775	1.85
11	0.00	9.00	2.93	0.875	1.62
12	0.00	10.00	2.03	0.575	1.38
13	0.00	11.00	1.13	0.475	1.14
14	0.00	12.00	0.23	0.375	0.90
15	0.00	12.75		0.300	3.72
16	0.01	0.00			<u> </u>
17	0.75	0.00		<u> </u>	
18	4 43	0.00	[<u> </u>]
19	7.95	0.00			
20	8.84	0.00	}		
21	3.85	0.00	11.57	1.80	4.32
55	8.85	0.01	11.56	1.80	4.32
23	8 85	1.00	10.57	1.75	4.20
24	8.85	2.00	9 57	1.55	3.72
25	8.83	3.00	8.57	1.36	3.24
25	8.65	4.00	7.57	1.15	2.76
27	3.55	5.00	6.57	0.95	2 28
25	8.55	5,00	6.57	0.75	1,80
29	6,83	7.00	4.57	0.65	1.32
30	8.85	8.00	3 57	0.50	1.20
31	8.85	9.00	2.57	0.50	1.20
32	8.65	10.00	1.57	0.50	1.20
33	8.85	11,00	0.57	0.50	1.20
?4	885	12 00	j	0.50	120
35	8.83	12.75	1	0.50	1.20
36	8.83	0.00]	<u> </u>
37	9.75	0.00			<u>. </u>
26	13.28	0.00	<u> </u>		
35	16.95	0.00			<u>.</u>
40	. 17.69	0.00	1	<u>.</u>	i .i
41	17.70	0.00	j	1	1
42	17.70	0 01	ļ		
43	17.70	1.00			
44	17,70	2.00	4		
45	17.70	3.00			
45	17.70	4.00		ļ	<u> </u>
47	17.70	5.00	1		
43	17.70	6.00	1		<u>.</u>
42	17.70	7.00			
: £0	17.70	C0.3		<u> </u>	.ļ
51	17.70	9.00	j	1	_
52	17.70	10 00	<u> </u>		
53	17.70	11.00			
54	17.70	12.00	1		.
55	17.70	12.75			ł
*	J		 		. المعادية المالية

HEAD TANK TYPE I

LOADS

CASE 1.

Earth Pressure + Surcharge

1.1 Self Weight:

Element	٧	W	
	(m3)	(ton)	
Bottom slab	28.8	69.12	
Side Wall (2)	21.66	52.45	
Central Wait	10.23	24.55	
Total		145.14	lor

1.2 Foundation Reaction :

8 =

17.7 m

qs1 = W/B=

8.26 t/m

1.3 Earth Pressure:

H ==

12.25 m

ج= ۲

1.8 t/m3

Ka =

0.5

 $\rho = c.KaH =$

11.09 t/m°

1.4 Surcharge:

h =

0.61 m

r =

1.6 l/m3

Ka=

0.5

p = r.Ka.H =

0.55 t/m°

CASE 2.

Earth Pressure + Surcharge + Water Pressure (one side)

2.1 Water:

h⇔

11.67 m

b⇒

8,85 m

Ww =

102.39 ton

2.2 Foundation Reaction:

B =

17.70 m

W + Ww =

248.53 Ion

= 8 \ (w\ + \ \ \) = Sep

14.04 I/m

q92 - q91 ==

5.79 l/m

CASE 3. Earth Pressure + Surcharge + Water Pressure (two side)

3.1 Water :

h =

11.57 m

b =

8.65 m

Ww =

204.79 Ion

3.2 Foundation Reaction:

 $= 8 \setminus (W + W) + 62p$

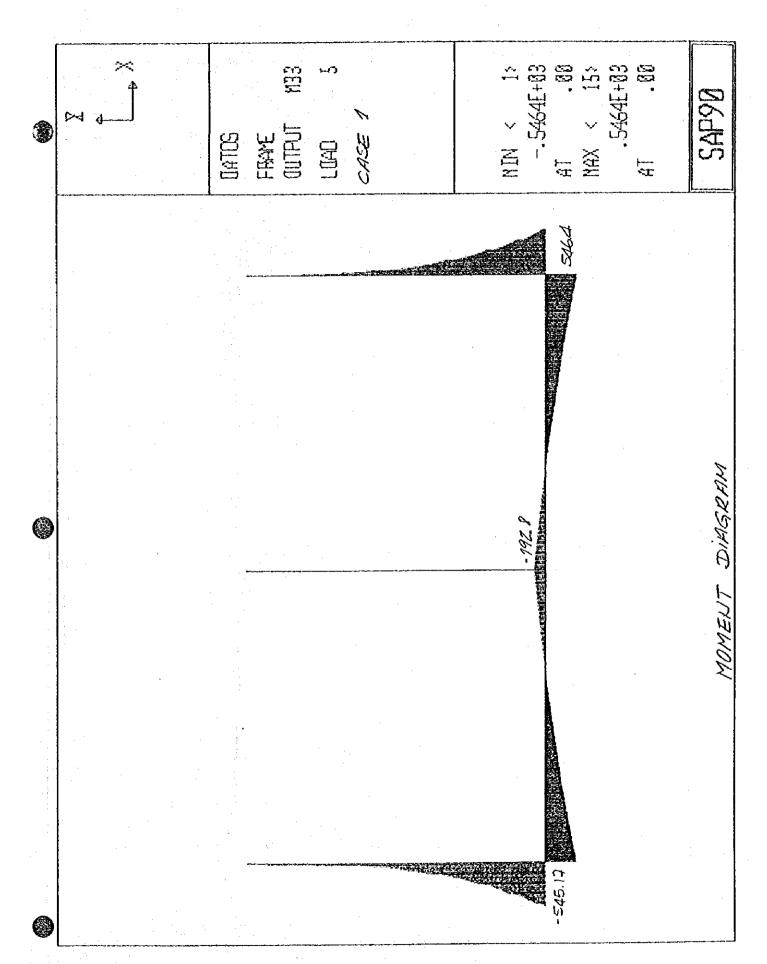
8 =

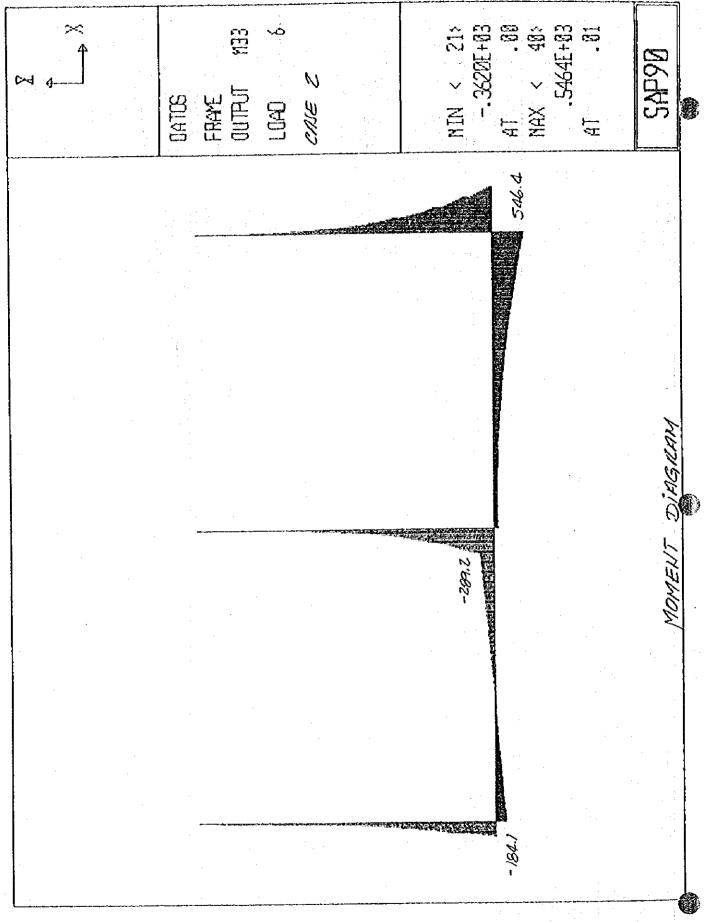
17.70 m

W + Ww =

350.93 ton

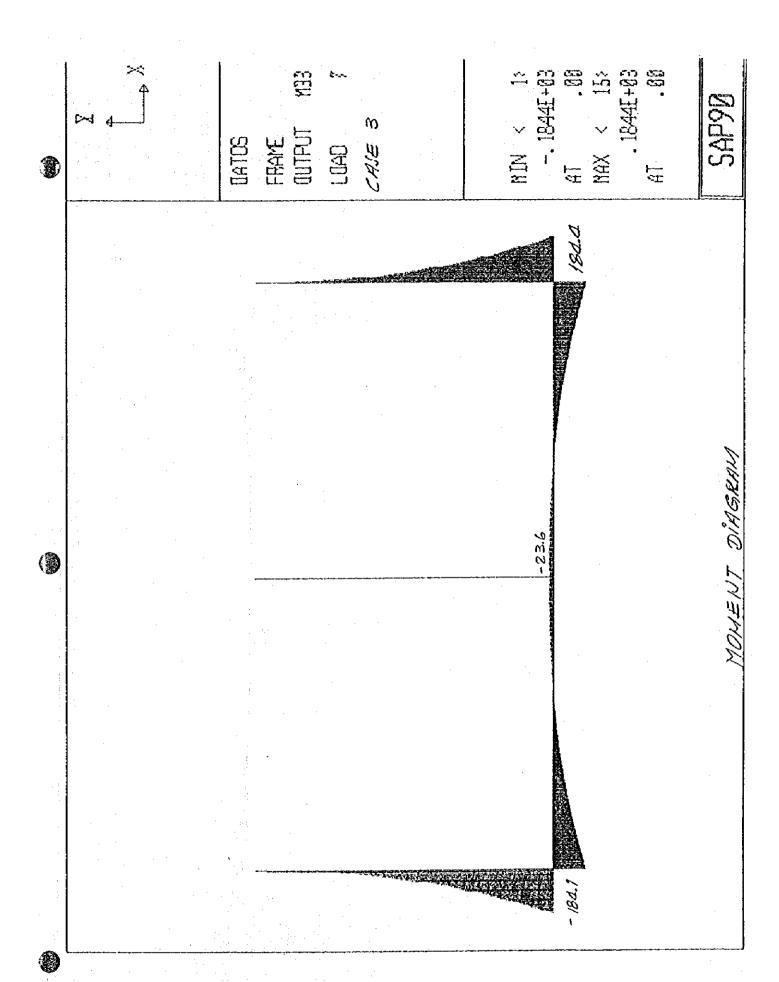
19.63 I/m 6.79 t/m

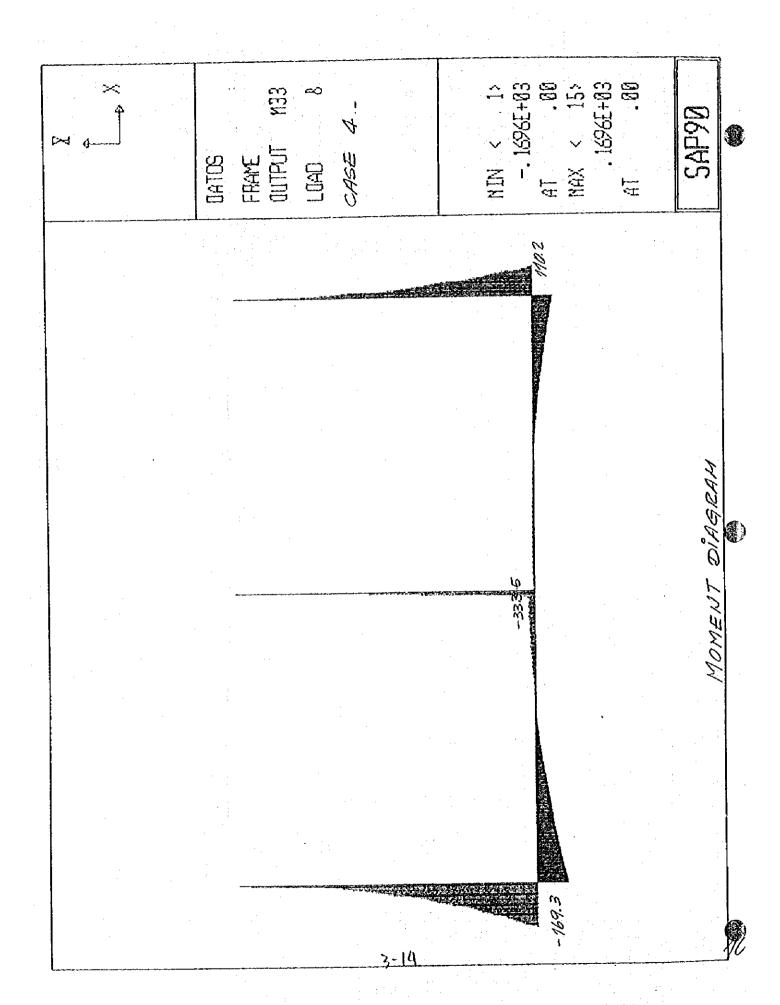


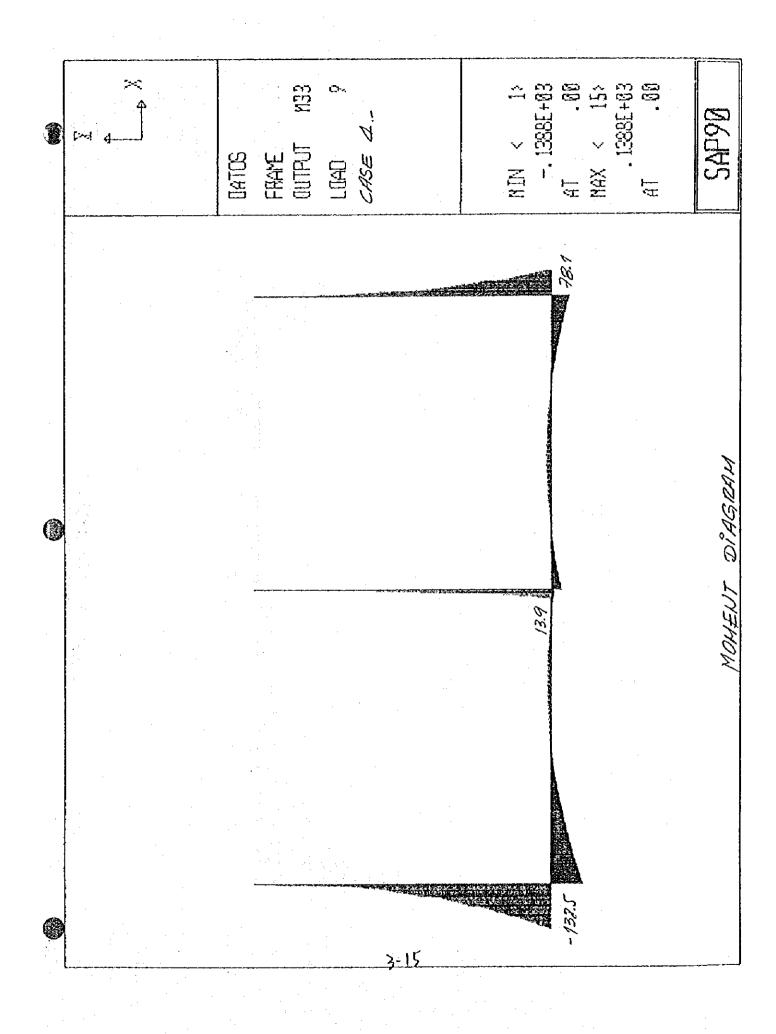


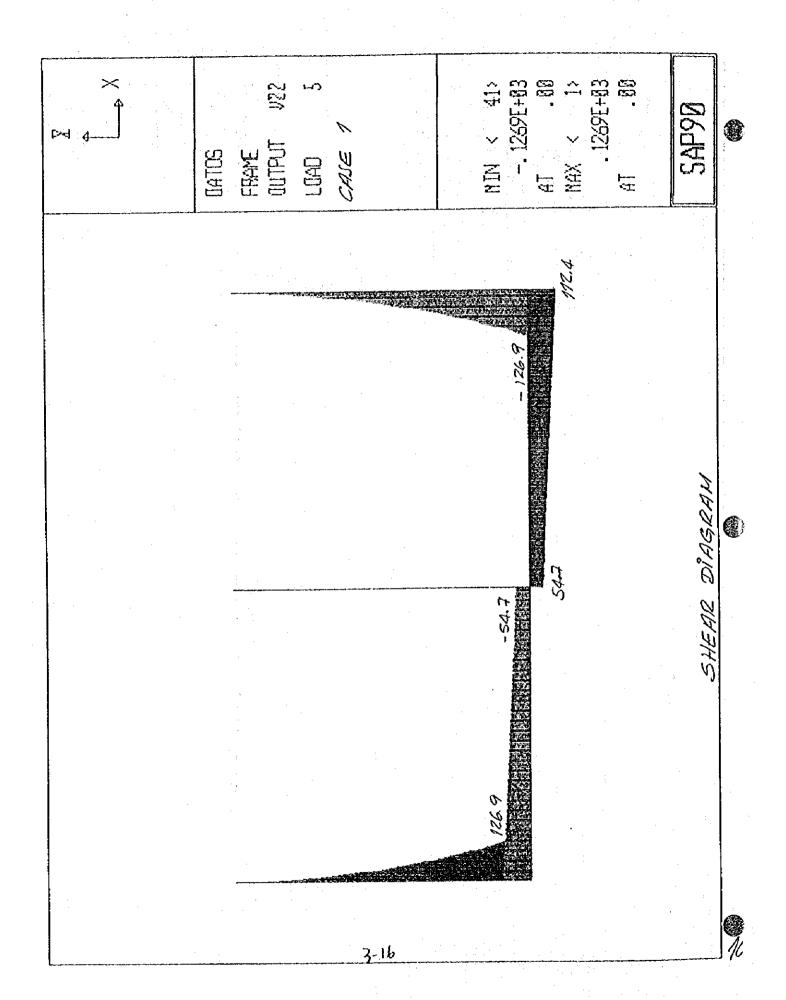
103

3-12

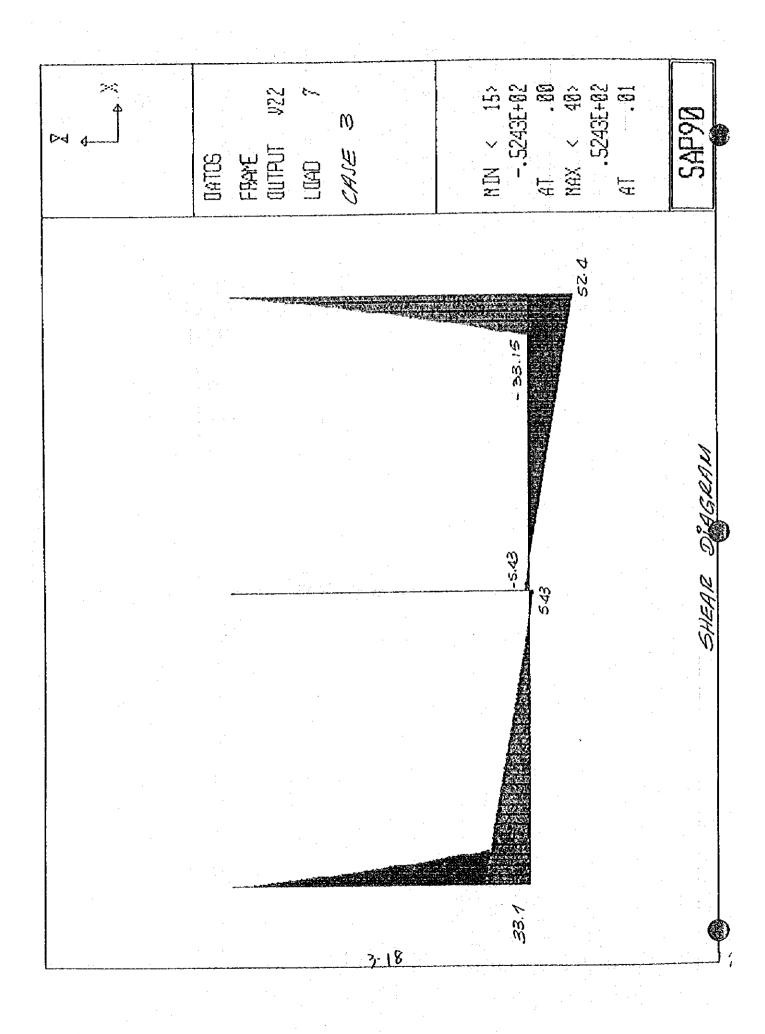


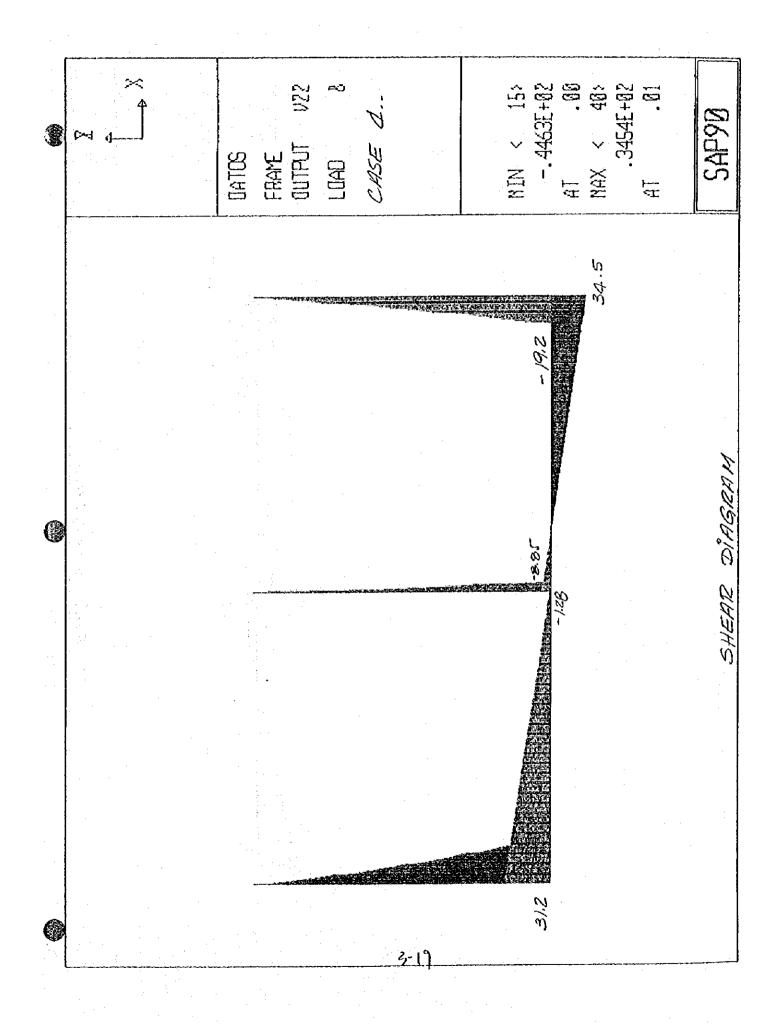


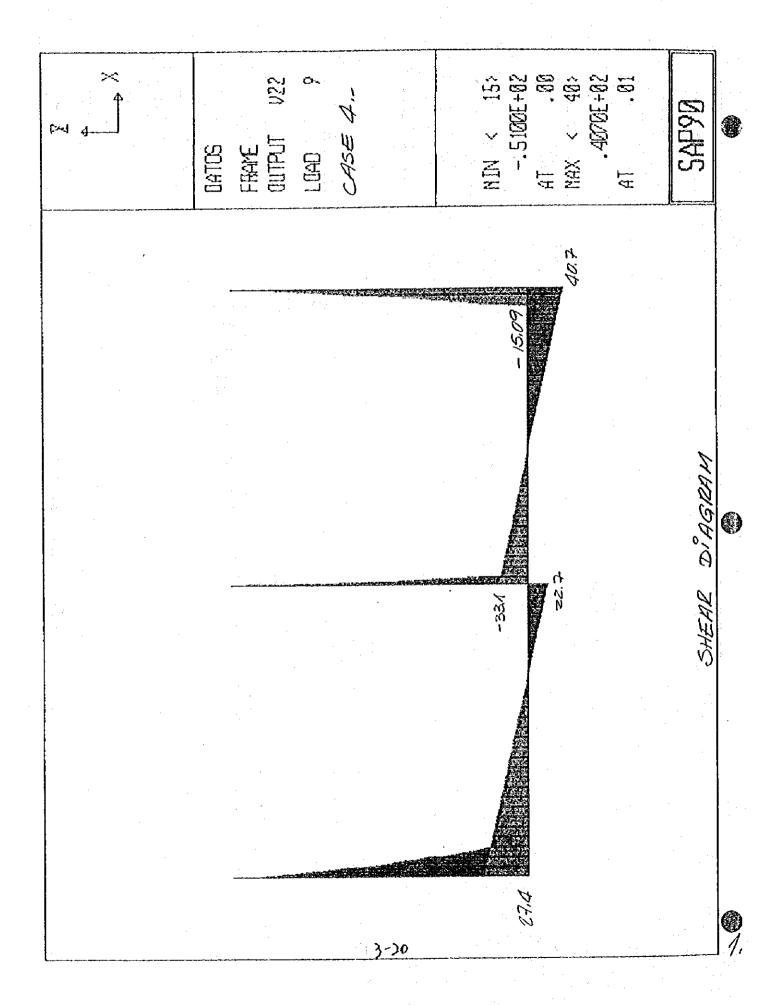




×	IATOS FIRAME QUITPUT V22 LOAD 6	CASE 2	NIN < 418 1269E+83 AT . 88 NRX < 488 AT . 1182E+83	SAP9B
			-60.5 126.9 11.22 11.	SHEAR D'AGRAH
			5. 5.	







HEAD TANK TYPE I

GIVEN:

fc =

210 kg/cm²

fv =

4200

SHEAR STRENGTH DESIGN

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)
2	107.99	100.0	165.41	180.0	175.00	114.25
3	90.59	100.0	138.77	140.0	135.00	88.13
4	74.73	100.0	114.47	127.5	122.50	79.97
5	60.40	100.0	92.52	117.5	112.50	73.44
6	47.60	100.0	72.91	107.5	102.50	66.92
7	36.33	100.0	55.65	97.5	92.50	60.39
8	26,59	100.0	40.73	87.5	82.50	53.86
. 9	18.38	100.0	28.15	77.5	72.50	47.33
10	11.70	100.0	17.92	67.5	62.50	40.80
11	6.55	100.0	10.03	57.5	52.50	34.27
12	2.93	100.0	4.48	47.5	42.50	27.75
13	0.86	100.0	1.31	37.5	32.50	21.22
14	0.01	100.0	0.01	30.0	25.00	16.32
16	107.50	100.0	164.67	170.0	165.00	107.72
17	83.53	100.0	127.94	150,0	145.00	94.66
23	78.26	100.0	119.88	175	170.00	110.98
28	14.67	100.0	22.47	50	45.00	29.38
39	107.50	100.0	164.67	170.0	165,00	107.72
]		! 		

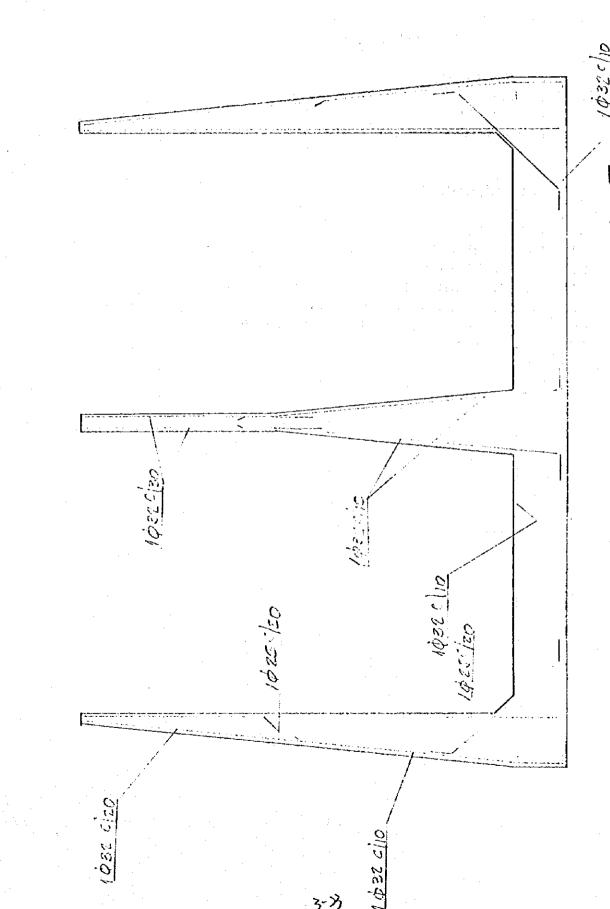
HEAD TANK TYPE I

FLEXURE STRENGTH DESIGN

GIVEN:

Fc = 219 Kg/m² fy = 4200 * f = 7.5 cm pmax=075pb = 161 (%) ps = 090 (%)

72.72	1				7					
10	Nu	ь	ħ	6			As(min)	As(temp)	As(adop1)	i i
FLEN	(t m)	(cm)	(c ¬)	(0:0)	(%)	(30,)	(00)	(an)	(20)	(varilles)
				i						
1	543 43	100	150 0	142.5	0.76	111.79	47.53	18 75		
2	545 16	100	1500	142.5	0.78	111.50	47,50	18 75		
3	429.11	100	147.5	140.0	0.63	87.55	45.67	16,44		
4	329.95	160	137.5	1,00	0.55	71.83	43 33	17,19	80 43	1 # 32 # 10 m.
5	247.41	100	127.5	1200	0.48	57.63	40.00	15 84	60 43	1 d 32 to 10 on a
6	79.97	100	117.5	110.0	0.41	45 50	36 67	14,69	40.21	1 a 32 to 10 ms
7	126 09	100	107.5	1000	0 35	34.79	33.33	13.44	40.21	1 x 32 @ 20 cm
្ទ	E4 26	100	975	90.0	0.58	25.63	30.00	12.19	40.21	1 @ 32 % 20 on a
٤	52 92	100	67.5	60.0	0.22	17.98	26 67	10.94	40.21	ា ៩ភីឌ មី 20 mi
10	30.57	100	77.5	700	017	11,79	23 33	9.69	24.54	1 # 32 to 20 on .
11	15.68	100	67.5	60.0	0.12	7.00	20,00	6.44	24 54	1 # 32 @ 20 mi
.5	6.65	100	57.5	530	. 0.07	3 55	15 67	7.19	24.54	1 x 32 @ 20 cm
13	203	100	47.5	40.0	0.03	1.36	1333	594	24.54	1 # 32 @ 20 on a
14	0.50	100	37.5	. 300	0.01	0.26	1000	4.69	24.54	1 ± 32 @ 20 cm.
15	546 43	100	150.0	1425	0.78	111.79	47.50	18.75		
16	645 30	100	1500	1425	0.78	111.54	47 50	18.75		100
17	453.964	100	1500	1425	0.66	93 35	47.53	16.75	€0 43	1 a 32 to 10 cm
18	140 94	100	1500	1425	0.19	26.76	47.50	18 75	53 62	1 a 32 @ 10 cm
19	289 56	100	150.0	1425	0.39	55 18	47.50	18 75	57.45	1 & 32 ft 10 mi
26	28816	100	1500	1425	0.40	55 31	47.50	1875	57.45	1' ± 32 @ 10 cm
21	362 00	100	1500	1725	0.34	57.80	57.50	22 50	'	
23	351.07	. 100	1750	167.5	0.38	59.52	\$5,83	21,68		
23	276 11	100	155 0	147.5	0,85	51.65	49.17	19.58	53 62	1 & 32 © 15 ora
24	502.05	100	1850	127.5	035	44.28	42 50	16.86	53 62	1 & 32 to 15 or c
25	147 32	100	1150	107.5	0 35	37.82	35.83	14.33	53 62	1 # 32 @ 15 cm
25	101.63	100	95,0	87.5	937	32.12	29.17	11.83	40.21	1 \$32 @ 15 cm
27	69 52	100	750	67.5	041	27.33	22.50	936	40.51	1 # 32 19 15 cm
3	40.63	100	55.0	47.5	051	24.06	1583	6.83	40.51	1 p 32 tt 15 on
29	22 51	100	500	42.5	034	1461	1417	6 25	15.71	1 # 32 # 30 cm
30	10.61	100	500	125	016	1	14.17	6.25	15.71	1 # 32 6 30 cm.
3 3 3	4 10	160	50 0	. 425	9.08	257	14.17	625	15.71	1 6 3 2 13 30 mi
33	1 00	j 100	500	42.5	0 01	0.63	14,17	625	1571	1 x 32 tt 30 cm
33	1 033	100	50 0	125	130	0.25	14 17	6 2 3	15,71	1 & 32 % 30 mi
34	0.07	169	50 0	42.5	660	0.04	14 17	5 25	1	1 a 32 @ 30 on
35	192.78	100	150 0	1425	0.25	36 92	47 50	1875	53 62	1 x 32 @ 10 mi
36	192 23	100	1500	1425	026	28.61	17.50	1875	53 62	1 # 52 @ 10 mx
37	165 43	100	150.0	142.5	0.22	31 73	:		7	1 # 32 # 10 on
35	45396	100	1500	142.5	068	93 25	1	18.75	t	1 × 32 10 mi
38	\$45.30	150	1500	1425	0.78	111.54	1		L	
40	545 43	160	1500	1/2 5	0.79	111.79	1	3		
j 41	545.43	100	150.0	142.5	0.7€	111.28	ŧ		•	
42	545 16	100	1500	1435	0.78	111.50	1	L		
4.3	429.11	100	147.5	140.0	0.83	1	1			
44	229.95	100	137.5	130 0	Q 55	71.83	43.33	1		1 x 32 0 10 mi
;	247.41	•	127.5	1200	0.43	57.83	49 00	1		1
. 4>	172.97	190	117.5	1100	C 41	45 50	38 67	14,69		1 # 32 B 10 on
37	128 08	160	107.5	1600	0.35	34 79	33 33	1544		1 # 32 \$20 mi
4?	84 95	100	97.5	900	0.38	25 63	1	1		1 # 32 to 20 cm
ļ 47	53 52	100	97.5	80.0	0.22	17.98	26 €7	1091	40.21	1 #32 @ 20 on
50	;	i		700	617	. 11.79	29 33	9.63	3 .	4
31	1565		•	600	012	7 65	20,00	5.44	21.54	1 832 @ 20 mg
52	Ť	1	57.5	500	0.07	3 55	16 67	7.19	24.54	1 832 920 64
5 53	j.	1		40.0	0.03	1.30	13 33	5 94	24,54	1 # 32 @ 20 mg.
= =4	1	1	i			1	10.00	4 69	24 54	1 # 32 G 20 ma
4		1	Į.	ì	i	i .	1	1	1	
5			1	:		1 .		1	4	The state of the s

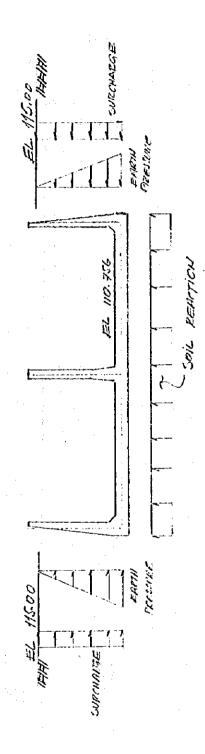


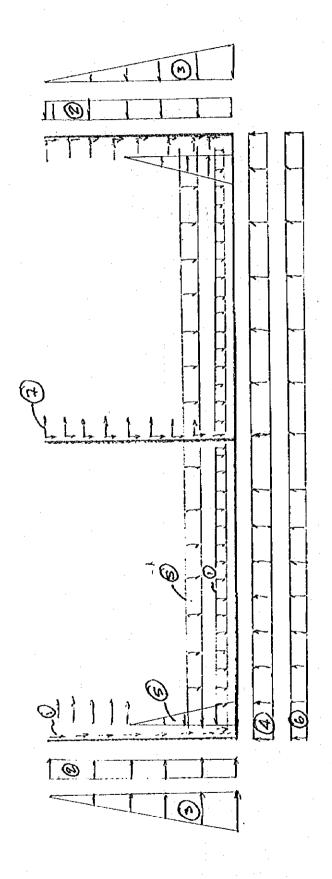
VENTOUCEMENT HEAD TANK TYPE I

LOADS HEAD TANK TYPE II

No.	DESCRIPTION	
1	Self Weight	D
2	Earth Pressure due to Live Load	L
3	Earth Pressure	H
4	Foundation Reaction (1)	RI
5	Water Pressure	F
5'	Water Weight	F
6	Foundation Reaction (2)	R2
7	Earthquake	E
	COMBINATIONS	
C1	D+L+H+R1	•
C2	D+L+H+R1+F+R2	*
C3	D+L+H+R1+F+R2+E	
C4	1.4D+1.7L+1.7H+1.4R1	
C5	1.4D+1.7L+1.7H+1.4R1+1.4F+1.	4R2
C6	0.75(1.4D+1.7L+1.7H+1.4R1+1.4	F+1.4R2+1.87E)
C7	0.9D+1.7H+1.4Ri+1.43E	

HEAD THINK TYPE II CASE 1. EMPTY WITHOUT EMETHOUNIKE





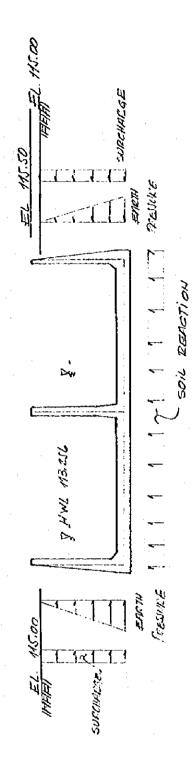
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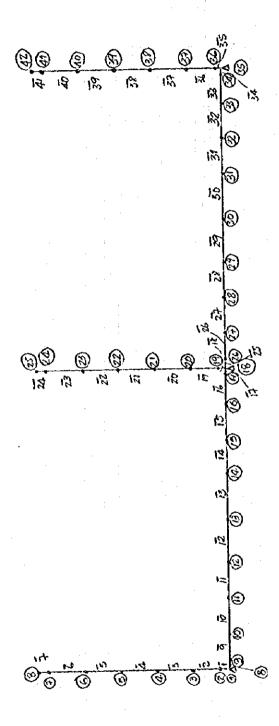
116

(1)

HEAD TIMK TYPE I

CASE 2. HWL IN BOTH SIDE WITHOUT EARTH OUNKE





HEAD TANK TYPE II

TRICL	×	Y	a soil	d (m)	Weight
verenne en ja		ry salvarite ut n 1		A CONTRACTOR	en en en en en en en
1	0.00	0.00	4.32	0.790	1.90
2	0.00	0.01	4.31	0.790	1.90
3	0.00	1.00	3.42	6.730	1.75
4	0.00	2.00	2.52	0.630	1 51
5	0.00	3.00	1.62	0.530	1.27
6	0.00	4.60	0.72	0.430	1.03
7	0.00	5.00		0.330	0.79
8 ,	0.00	5.30		0.300	0.72
9 1	0.01	0.00			
10	1.00	0.00			
11	2.00	0.00			1 ·
12	3.00	0.00			
13	4.25	0.00			
14	5.50	0.90			
15	5.50	0.00			
15	7.50	0.00			
17	8.49	0.00			
18	5.50	0.00		0.88	2.11
19	8.50	0.01		68.0	2,11
20	8.50	1.00	İ	0.76	1.82
21	8.50	2.03		0,56	1.34
22	8.50	3.00		0.5	1.20
53	8.50	4.00		0.5	1.20
24	8.50	5.00		0.5	1.20
25	8.50	5.00 j		0.5	1.20
26	8.51	9.00			
27	9.50	0.00			
28	10.50	0.00			
59	11.50	000 [
39	12.74	0.00			
31	13.99	0.00			
32	14.99	0.00			
33	15,99	0.00			
34	16.93	0.00			
35	16.99	0.00 j 0,01 j			· - · ·
36 37	16.99	1.00		بالمناء بسيسان سياد	<u>.</u>
38	16.99	2,00			
39	16.99	3.00 (
40	16.99	4.00			
40 <u>1</u>	15 99	5.00	-	1 7	
42	18.99	5.20			
,_					

HEAD TANK TYPE II

LOADS

CASE 1.- Earth Pressure + Surcharge

1.1 Self Weight:

Etement	ν .	W	
	(m3)	(ton)	
Bottom slab	14.22	34.13	
Side Wall	5.43	13.03	}
Central Wall	2.81	6.74	
Total		53.90	ton

1.2 Foundation Reaction:

Ω

16.99 m

qs1 = W/B =

3.17 t/m

1.3 Earth Pressure:

H ==

4.8 m

Ր ==

1.8 t/m3

Ka =

0.5

 $\rho = r.Ka.H$

4.32 t/m²

1.4 Surcharge:

h =

0.61 m

ւ =

1.8 t/m3

Ka =

0.5

р = г.Ка.Н

0.55 t/m²

CASE 2.-

Earth Pressure + Surcharge + Water Pressure (two sides)

2.1 Water:

h ==

2.9 m

b =

8.50 m

Ww =

49.27 ton

2.2 Foundation Reaction:

₿≕

16.99 m

W + Ww =

103.18 ton

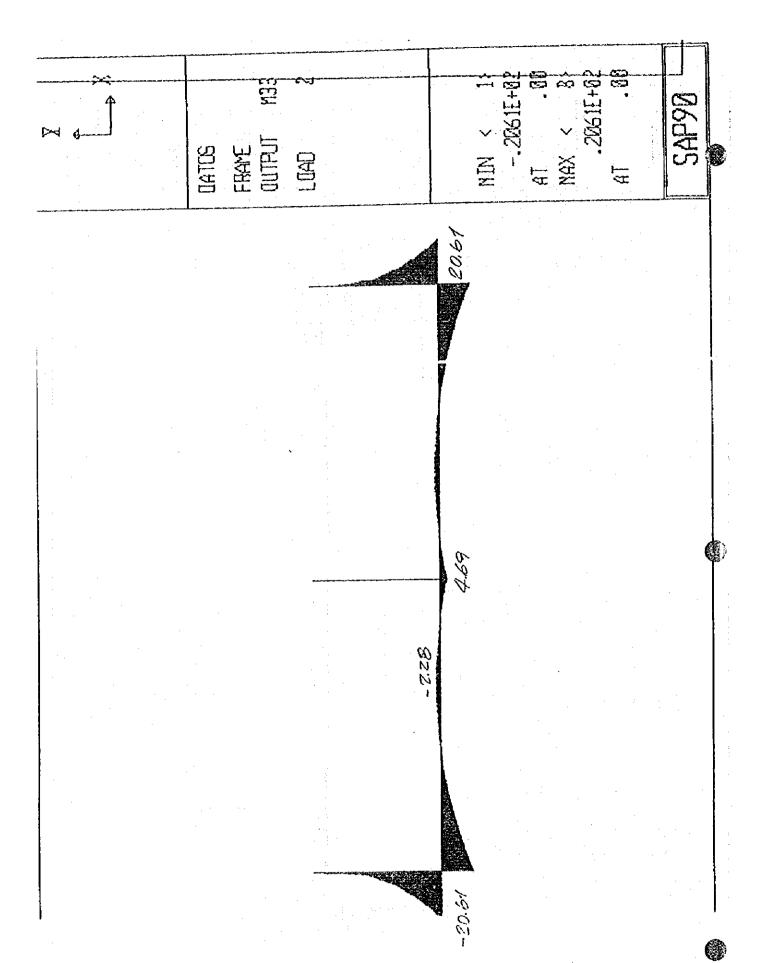
qs2 = (W + Ww) / B =

6.07 t/m

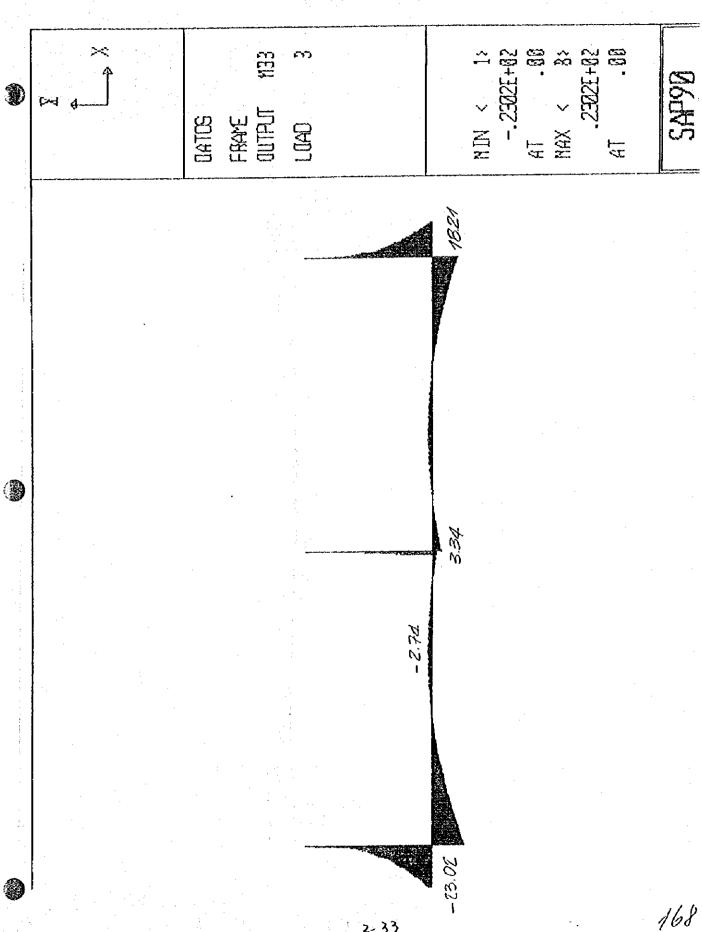
 $qs2 \cdot qs1 =$

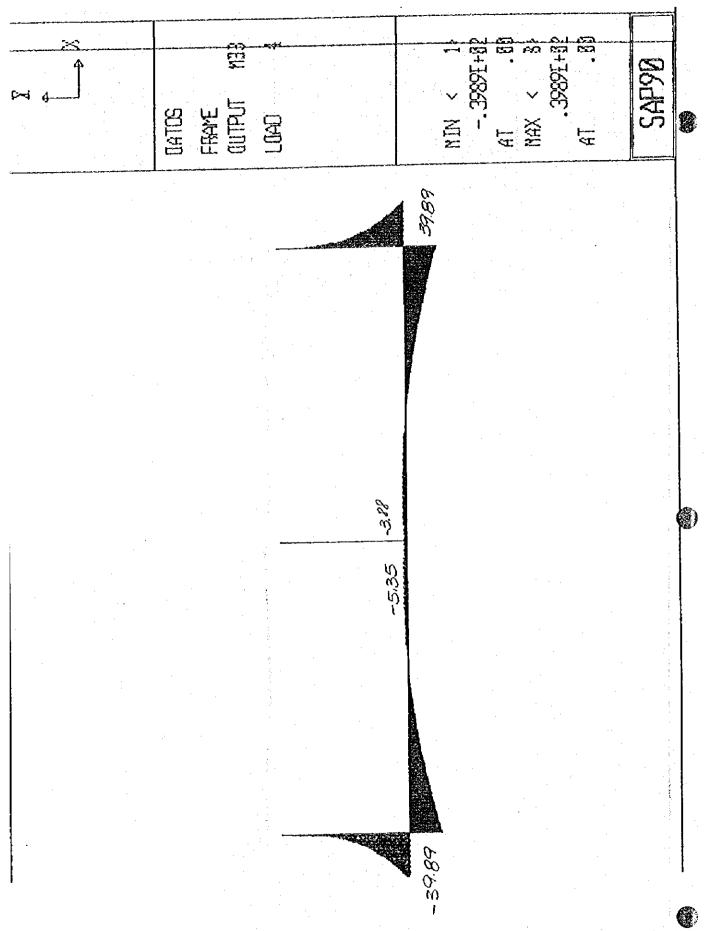
2.90 t/m

	UATOS FRAYE	OUTPUT M33				2346E+02	NAX × SAX	28+1955- AT TA	Водо	5
					13:46		·			
							·			
					•					
•										
		: 		2	3					
				-2.6						
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			The state of the s							
				3-31		· ·				/
				•						

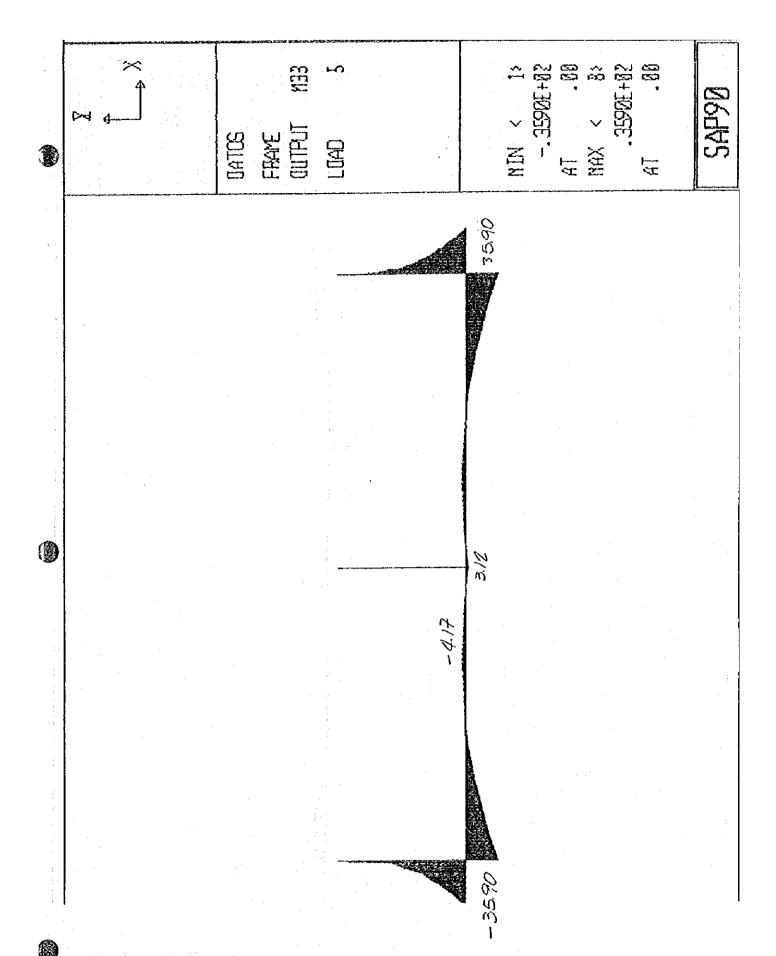


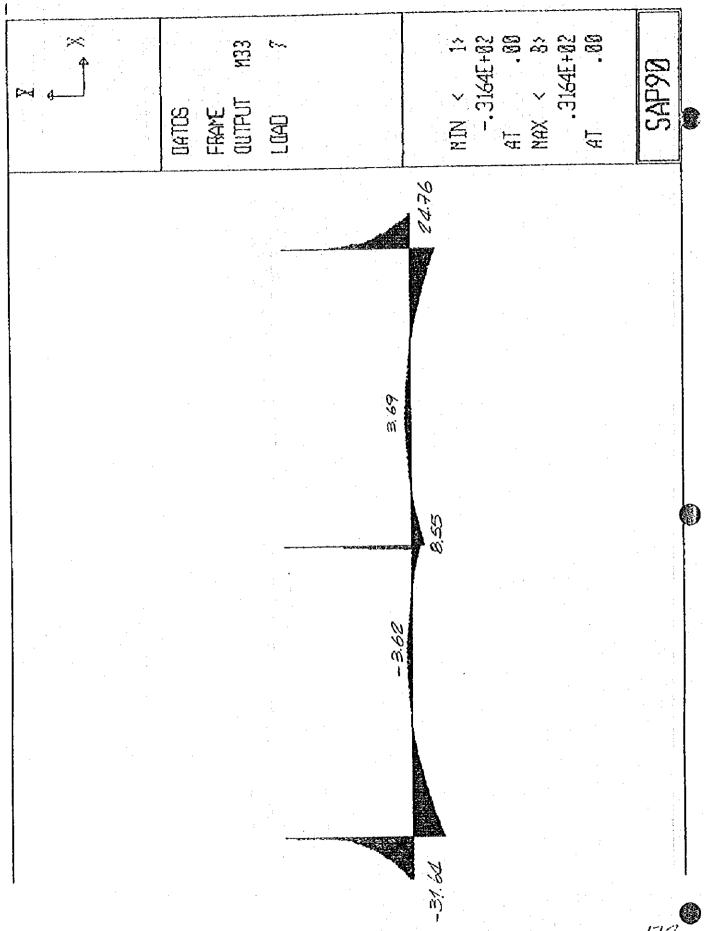
3-32





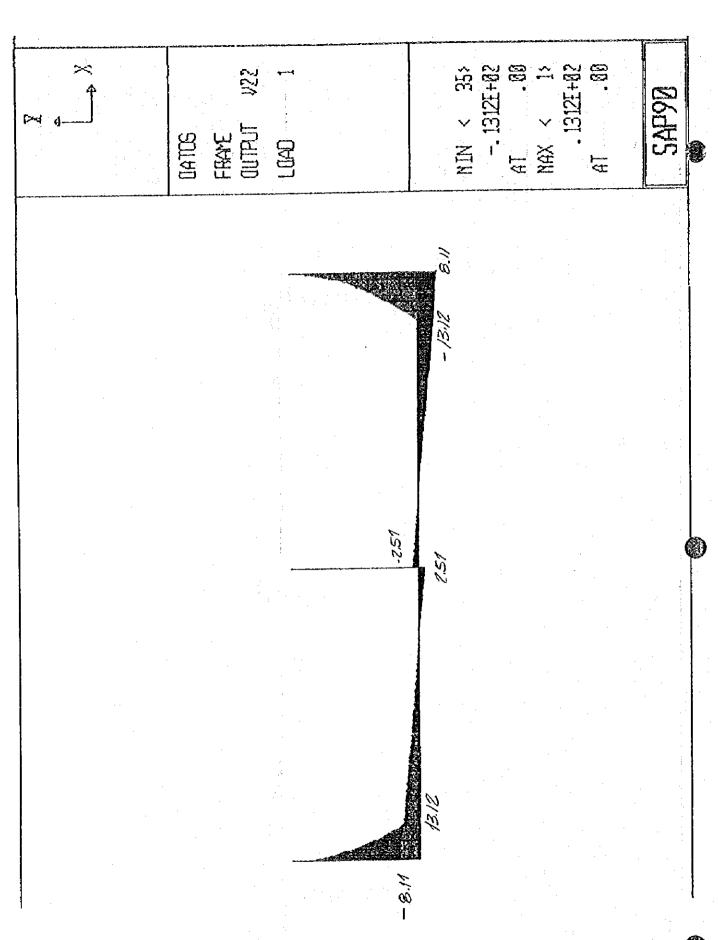
3-39

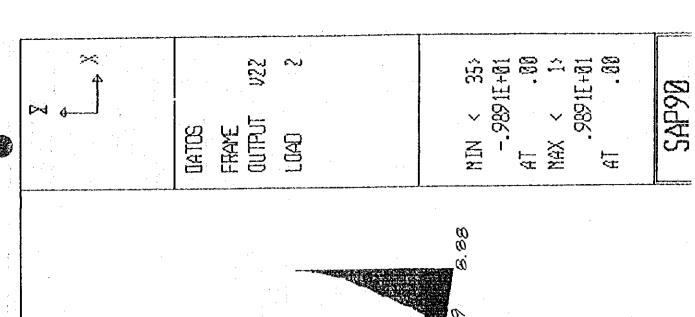


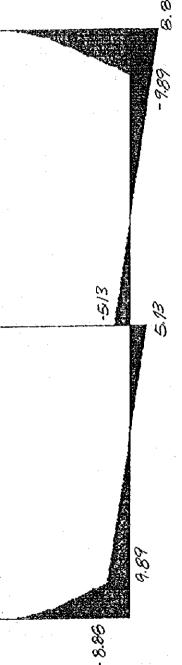


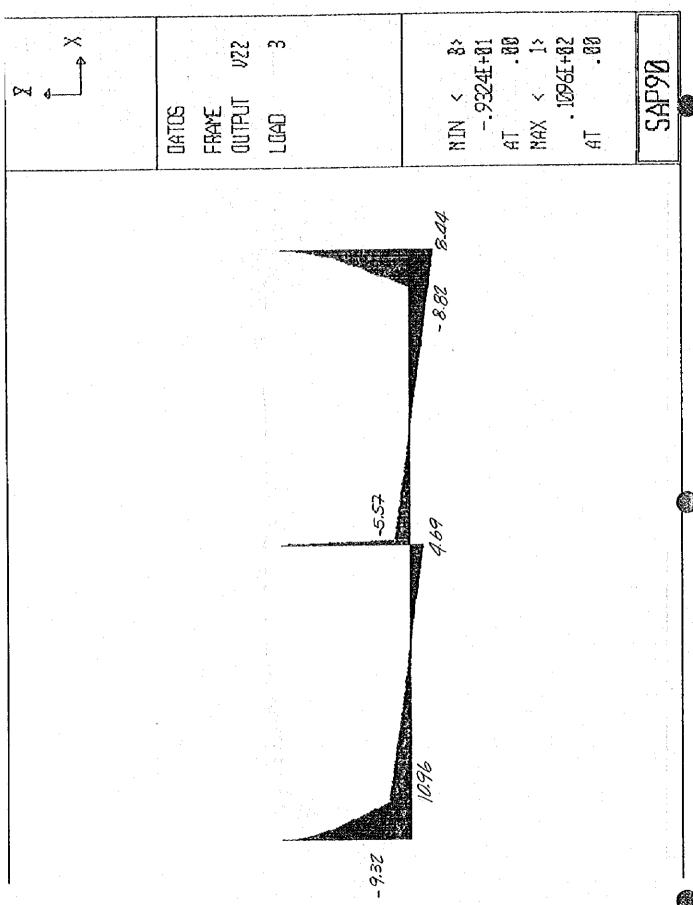
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IATIOS TATOS TATOS	CONTRUT M33		AT	. 3041L+62
		43.67		
		040		
		-379		
				: :

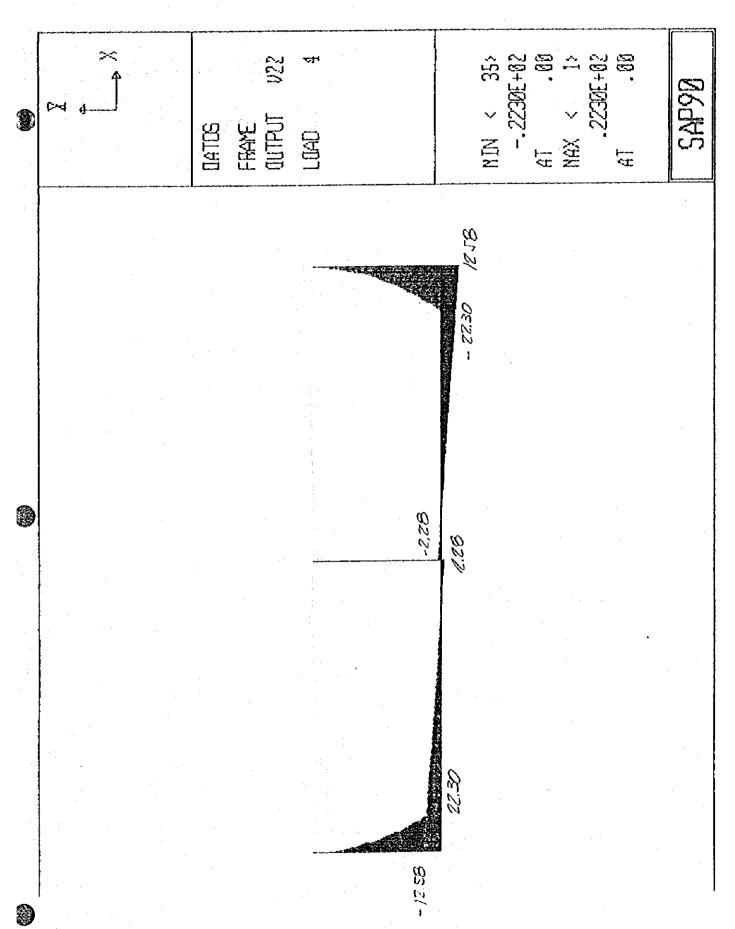




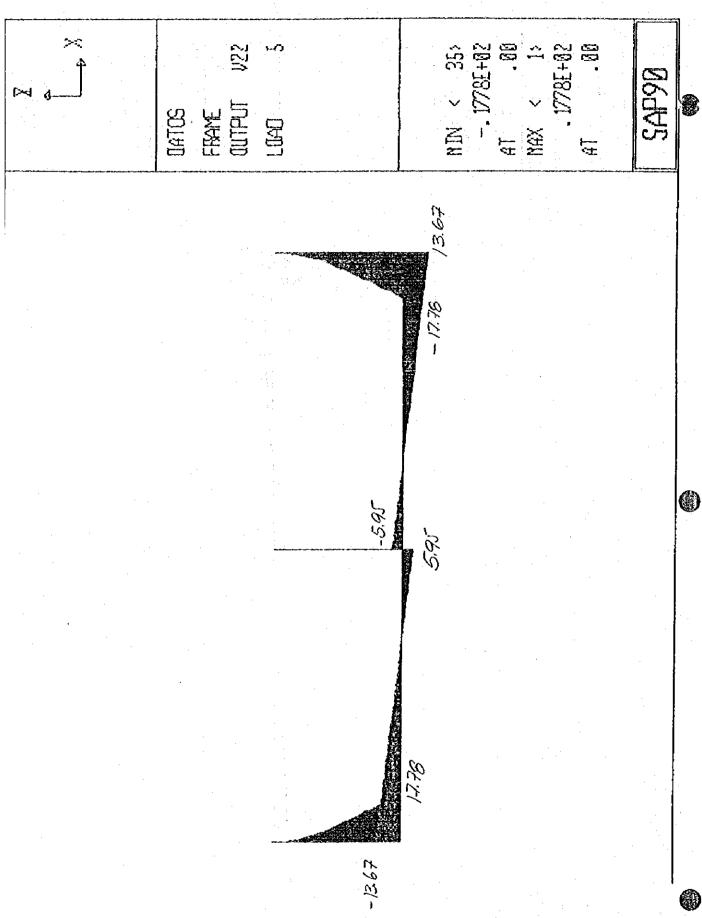




3-40



3-41



×	4	2	DATOS	FRAME	CUTPUT #22	LOAD ?				RTN < 35>	1609E+02	AT . 088	NAX < 15	. 1915E+02	AT .00	SAP9B	
					:			40.		t6:21 60:91-							
								50:01-									
										8.79							
								1.23	D15								
							7	7-19						•		17	9

HEAD TANK TYPE II

GIVEN:

f'c =

210 Kg/cm²

fy =

4200

SHEAR STRENGTH DESIGN

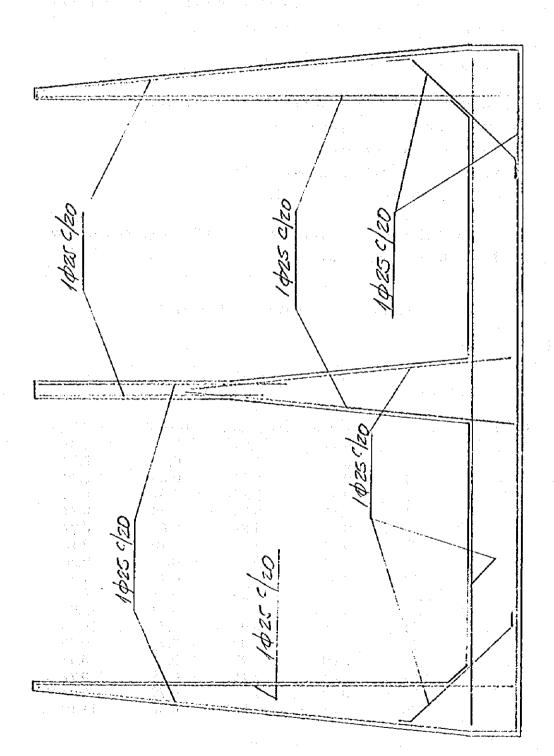
ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)
	22.30	100	34.16	79.0	71.50	46.68
2	22.22	100	34.03	73.0	65.50	42.76
3	14.79	100	22.65	63.0	55.50	36.23
4	8,80	100	13.48	53.0	45,50	29.70
5	4.35	100	6.66	43.0	35.50	23.18
6	1.43	100	2.18	33.0	25.50	16.65
7	0.03	100	0.05	30.0	22.50	14.69
9	14.20	100	21.75	80.0	72,50	47.33
19	1.62	100	2.48	88.0	80.50	52.55
21	0.86	100	1.32	50.0	42.50	27.75
					. [

FLEXURE STRENGTH DESIGN

GIVEN :

fc = 210 ky/m² fy = 4200 f = 7.5 cm pmax=0.75pb = 1.61 (%) ps = 0.90 (%)

		·						As(temp)	As(sdopt)	As(adop1)
10	Mu	ь	h.	đ	P	As	A#(mln)	(cm,)	(001)	(eslinay)
EFEN	(l-m)	(cm)	(cm)	(cw)	(%)	(m*)	(m)	(on)	1000	(48111103)
	~~ ~~	100	79.0	71.5	0.21	15,14	23.83	9.88	24.54	1 & 25 @ 20 on
1	39.89	100	73.0	65.5	0.25	16.51	21.83	9 13	24 54	1 ø 25 Ø 20 cm
2	39.67	160	63.0	55.5	0.19	10.47	18.50	7.88	24.54	1 ø 25 @ 20 cm
3	21.47	100	53.0	45.5	0.13	5.79	15,17	6 63	15.71	1 ø 20 @ 20 cm
4	9,81	100	43.0	35.5	0.07	2.52	11.83	5.38	15.71	1 ø 20 @ 20 cm
5	3 36 39 76	100	80.0	72.5	0.21	14,87	24.17	10.00	24.54	1 ø 25 @ 20 cm
9	28.18	100	80.0	72.5	0.14	10.46	24.17	10.00	24 54	1 ø 25 @ 20 cm
10	18.22	100	80.0	72.5	0.09	6.72	24.17	10.00	24.54	1 ø 25 Ø 20 cm
11		100	80.0	72.5	0.05	3.68	24.17	10.00	24.54	1 ø 25 19 20 ന
12	10.02 5.72	100	80.0	72.5	0.03	209	24.17	10.00	24.54	1 s 25 @ 20 cm
13 14	5.72 5.64	100	80.0	72.5	0.03	2.06	24.17	10.00	24.54	1 ø 25 @ 20 cm
	5.54	100	80.0	72.5	0.03	1.96	24.17	10.00	24.54	1 ø 25 @ 20 cm.
15 16	8.45	199	80.0	72.5	0.04	3.10	24.17	10.00	24.54	1 ø 25 Ø 20 cm
18	3 76	100	88.0	80.5	0.02	1.24	26.83	11.00	30.79	1 ø 28 @ 20 cm
19	3.83	100	88.0	80.5	0.02	1.26	26.83	11.00	30.79	1 s 28 @ 20 on
20	2.43	100	76.0	68.5	0.01	0.94	22.83	9.50	24.54	1 ø 25 @ 20 cm
25	12 39	100	80.0	72.5	0,06	4,55	24.17	10.00	24 54	1 ø 25 @ 20 cm
28	5.59	100	80.0	72.5	0.03	2.04	24.17	10,00	24.54	1 ø 25 @ 20 om
29	6.26	100	80.0	72.5	0.03	2 29	24.17	10.00	24,54	1 ø 25 € 20 cm
30	10.02	100	80.0	725	0.05	3 68	24.17	10.00	24.54	1 ø 25 🕸 20 cm
31	13.18	100	80.0	72.5	0.07	4,65	24.17	10.00	24.54	1 x 25 \$ 20 cm
32	28.18	100	80.0	72.5	0.14	10.46	24.17	10.00	24.54	1 ø 25 @ 20 cm
33	39.76	100	80.0	72.5	0 21	14,87	24.17	10.00	24.54	1 at 25 to 20 cm.
34	39.89	100	80.0	72.5	0.21	14.92	24.17	10.00	24.54	1 ø 25 60 20 cm
36	39,67	100	73.0	65.5	0.25	16.51	21.83	9.13	24.54	1 ø 25 😚 20 om
97	21.47	100	63.0	55.5	0.19	10.47	18.50	7.88	24.54	1 ø 25 19 20 cm
38	9.81	100	53.0	45.5	0.13	5.79	15.17	6.63	24.54	1 ø 25 kð 20 cm
.39	3,36	100	43.0	35.5	0.07	2.52	11,83	5 38	24 54	1 # 25 € 20 on
1	ļ		1	1	i	L	L	<u> </u>	<u> </u>	<u> </u>



HEAD TANK TYPE REINFORCEMENT

Determination of Water Depth on Overflow Weir of Severino Head Tank

Length of the overflow weir was determined based on the required width of the settling basin of the head tank. The overflow depth on the weir is calculated in the condition of complete overflow by the following formula.

$L = Q/C \cdot Ho^{1.5} + 2 \cdot Ka \cdot Ho$

where, L: length of overflow weir (= 7.85 m for each weir)

Q: overflow discharge (m³/sec)

Ho: overflow depth (m)

Ka: coefficient of contraction (=0.02)

C: coefficient of overflow (= 2.0)

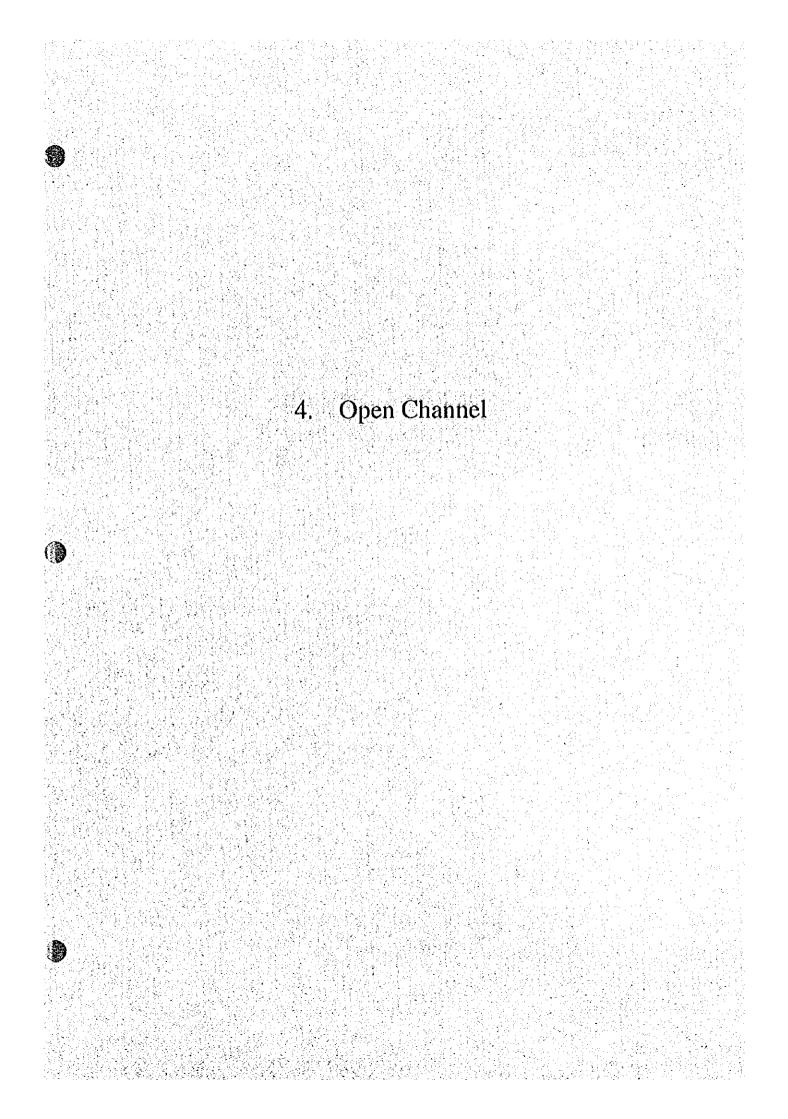
The following table shows various overflow depth on the weir versus overflow discharges calculated by the above formula.

Table Overflow Depth on Weir in Head Tank

 $L = Q/CHo^{1.5} + 2KaHo$

C= 2.00 Ka= 0.02 L= 7.85 m for each weir

Ho (m)	Q (m ³ /sec)	Ho (m)	Q (m ³ /sec)	Ho (m)	Q (m ³ /sec)
0.30	2.58	0.47	5.05	0.64	8.01
0.31	2.71	0.48	5.21	0.65	8.20
0.32	2.84	0.49	5.37	0.66	8.39
0.33	2.97	0.50	5.54	0.67	8.58
0.34	3.11	0.51	5.70	0.68	8.77
0.35	3.25	0.52	5.87	0.69	8.97
0.36	3.38	0.53	6.04	0.70	9.16
0.37	3.53	0.54	6.21	0.71	9.36
0.38	3.67	0.55	6.39	0.72	9.56
0.39	3.82	0.56	6.56	0.73	9.76
0.40	3.96	0.57	6.74	0.74	9.96
0.41	4.11	0.58	6.91	0.75	10.16
0.42	4.26	0.59	7.09	0.76	10.36
0.43	4.42	0.60	7.27	0.77	10.57
0.44	4.57	0.61	7.46	0.78	10.77
0.45	4.73	0.62	7.64	0.79	10.98
0.46	4.89	0.63	7.83	0.80	11.19



4. Open Channel

Contents

1

4.1 Hydraulic Calculation

- 1. Section of open channel
- 2. Head loss of open transition
- 3. Head loss of siphon
- 4. Discharge of crossing streams/river
- 5. Side channel spllway at Siphon No.1
- 6. Side channel

4.2 Structural Calculation

- 1. General
- 2. Open channel
- 3. Box culvert
- 4. Open transition
- 5. Siphon
- 6. Pedestrian bridge

4.1 Hydraulic Calculation

1. Section of open channel

Decision of open channel section adopt the Manning formula as follows.

$$\frac{Q \cdot n}{\sqrt{S_0}} = A \cdot R^{2/3}$$

where,

Q: discharge

 $= 16 \text{ m}^3/\text{s}$

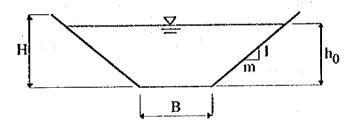
n: coefficient of roughness = 0.015

So: longitudinal slope

= 1/3,000

A : sectional area (as shown below)

R : hydraulic radius



B: bottom width

 $= 1.6 \, \mathrm{m}$

m: Side slope ratio = 1.2

ho: Water depth

 $A = (B + mh_0) h_0$

$$R = \frac{(B + mh_0)h_0}{B + 2\sqrt{1 + m^2}h_0}$$

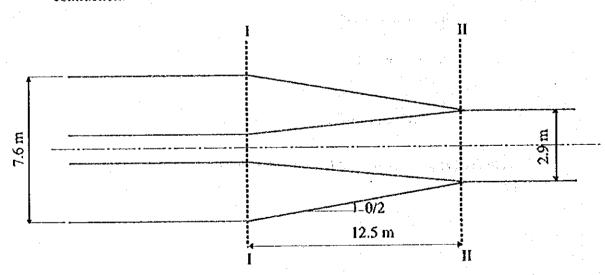
Velocity (v) and discharge(Q) for each water depth are shown in the following table.

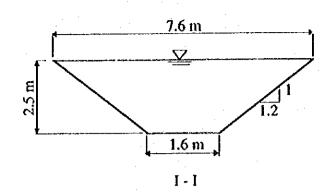
h _o (m)	h ₀ /H (%)	v (n√s)	Q (m ³ /s)
0.28	10	0.442	0.240
0.56	20	0.638	0.812
0.84	30	0.786	1.721
1.12	40	0.910	3.001
1.40	50	1.021	4.690
1.68	60	1.124	6.826
1.96	70	1.220	9.446
2.24	80	1.310	12.587
2.50	89.20	1.391	16.000
2.52	90	1.397	16.283
2.80	100	1.481	20.568

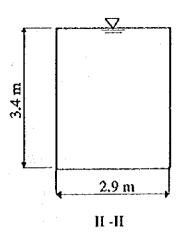
2. Head loss of open Transition

1) Inlet open transition

Head loss calculation of inlet open transition applies for the case of gradual contraction.







$$A_1 = 11.5 \text{ m}^2$$

 $V_1 = 1.391 \text{ m/s}$

$$A_2 = 9.86 \text{ m}^2$$

 $V_2 = 1.623 \text{ m/s}$

$$\tan\frac{\theta}{2} = \frac{\frac{7.6 - 2.9}{2}}{12.5} = 0.188$$

$$\therefore \theta = 21.294^{\circ}$$

$$\frac{A_2}{A_1} = \frac{11.5}{9.86} = 0.857$$

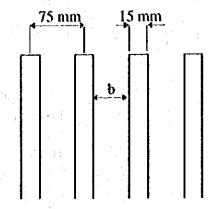
:
$$f_c = 0.0025$$

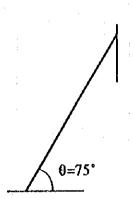
$$\Delta h_c = f_c \cdot \frac{V_2^2}{2g} + \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g}\right)$$

$$= 0.0025 \times \frac{1.623^2}{2 \times 9.8} + \left(\frac{1.623^2}{2 \times 9.8} - \frac{1.391^2}{2 \times 9.8}\right)$$

$$= 0.036 \text{ (m)}$$

- Trash rack





$$b = 75 - 15 = 60 \text{ (mm)}$$

$$\frac{t}{b} = \frac{15}{60} = 0.25$$

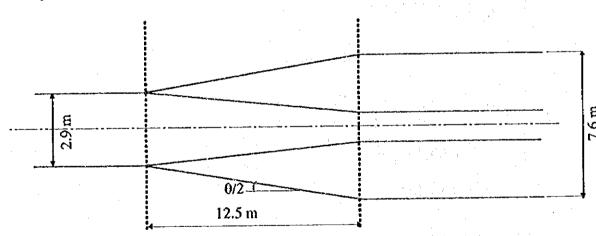
$$b = 2.42$$
, $0 = 75^{\circ}$, $V = 1.623$ m/s

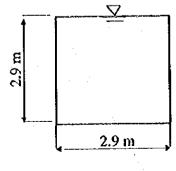
$$fr = b \sin \theta \cdot \left(\frac{t}{b}\right)^{\frac{4}{3}}$$
= 2.42 × sin 75° × 0.25^{4/3}
= 0.368

$$\triangle h_r = f_r \frac{V^2}{2g} = 0.368 \times \frac{1.623^2}{2 \times 9.8}$$
= 0.049 (m)

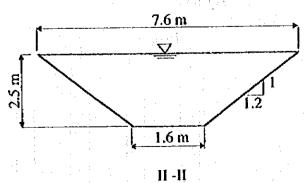
2) Outlet open transition

Head loss calculation of outlet open transition applies for the case of gradual enlargement.





I - I



$$A_1 = 11.5 \text{ m}^2 A_2 = 9.86 \text{ m}^2$$

$$V_1 = 1.391 \text{ m/s}$$
 $V_2 = 1.623 \text{ m/s}$

$$h_{ge} = f_{gc} \frac{\left(V_1 - V_2\right)^2}{2g} = f_{ge} \left\{ 1 - \left(\frac{A_1}{A_2}\right) \right\}^2 \frac{V_1^2}{2g}$$
$$= f_{gc} f_{se} \frac{V_1^2}{2g}$$

$$0 = 21.294^{\circ}$$
 : $f_{ge} = 0.4$

$$f_{ge}=0.4$$

$$\sqrt{\frac{A_1}{A_2}} = \sqrt{\frac{8.41}{11.5}} = 0.855$$

:
$$f_{se} = 0.081$$

$$h_{ge} = 0.0805 \times 0.4 \times \frac{1.902^2}{2 \times 9.8} = 0.006 \text{ (m)}$$

3. Head loss of siphon

1) Siphon No. 1

- Basic condition

Selection

: 2.9 m x 2.9 m (Rectangular type)

Hydraulic radius

R = 0.967

Length

: L = 40.105 (m)

Velocity

v = 1.902 (m/s)

Radius of curvature : $\rho = 15.0$ (m)

- Coefficient of entrance loss: fe

$$A_1 = 11.5 \text{ (m}^2\text{)}$$

$$a = 8.41 \text{ (m}^2\text{)}$$

$$\sqrt{\frac{a}{A_1}} = \sqrt{\frac{8.41}{11.5}} = 0.855 \quad \text{(sudden contract)}$$

$$\therefore$$
 f_e = 0.12 (same as all siphon)

- Coefficient of bending loss: Σf_b

$$\rho = 15m$$

$$\frac{\rho}{D} = \frac{15}{2.9} = 5.172$$

:. $fb_1 = 0.08$ (same as all siphon)

$$\theta_1 = 25.565^{\circ}$$

$$f_{b21} = 0.45$$

$$\theta_2 = 25.565^{\circ}$$

$$f_{b22} = 0.45$$

$$\Sigma f_b = 0.08 \times 0.45 \times 2$$

= 0.072

- Coefficient of friction lost : $f \frac{L}{R}$

$$f'\frac{L}{R} = \frac{2gn^2}{R^{\frac{1}{3}}} \cdot \frac{L}{R} = \frac{2 \times 9.8 \times 0.015^2}{0.967^{\frac{1}{3}}} \times \frac{49.105}{0.967}$$
$$= 0.226$$

- Coefficient of outlet loss: fo

$$A_1 = 11.5 \text{ (m}^2\text{)}$$

$$a = 8.41 (m^2)$$

$$\sqrt{\frac{a}{A_2}} = 0.855$$

:.
$$f_0 = 0.081$$
 (same as all siphon)

- Total head loss : Δh_s

$$\Sigma f = f_e + \Sigma f_b + f \frac{L}{R} + f_o = 0.12 + 0.072 + 0.226 + 0.081$$
$$= 0.499$$

$$\Delta h_s = \Sigma f \cdot \frac{v^2}{2g} = 0.499 \times \frac{1.902^2}{2 \times 9.8}$$

= 0.092 (m)

2) Siphon No. 2

- Basic condition (r: rectangular type, c: circular type)

Section

2.9 x 2.9 m (rectangular type)

: R = 0.967 (rectangular type) Hydraulic radius

 $V_r = 1.902 \text{ m/s}$

Velocity $V_c = 1.989 \text{ m/s}$

Length

: $L_r = 141.028 \text{ m}$ $L_c = 74.663 \text{ m}$

Radius of curvature : p = 15.0 m

- Coefficient of entrance loss : fe

 $f_e = 0.12$

- Coefficient of bending loss: Σf_{br}, Σf_{bc}

 $f_{b1} = 0.08$

 $\theta_1 = 14.532^{\circ}$

 $f_{b21} = 0.28$

 $\theta_2 = 29.899^{\circ}$

 $f_{b22} = 0.50$

 $\theta_3 = 29.745^{\circ}$

:. $f_{b23} = 0.50$

 $\theta_4 = 14.507^{\circ}$

 $f_{b24} = 0.28$

 $\Sigma f_{bc} = 0.08 \times 0.28 = 0.022$ (rectangular part)

 $\Sigma f_{bc} = 0.08 \times (0.50 + 0.50 + 0.28) = 0.102$ (circular part)

- Coefficient of friction lose: $f'\frac{L_r}{R}$, $f\frac{L_c}{D}$

$$f \frac{L_r}{R} = \frac{2gn^2}{R^{\frac{1}{3}}} \cdot \frac{L_r}{R} = \frac{2 \times 0.98 \times 0.015^2}{0.967^{\frac{1}{3}}} \cdot \frac{141.028}{0.967}$$
$$= 0.650$$

$$f\frac{L_c}{D} = \frac{124.5n^2 L_c}{D^{\frac{4}{3}}} = \frac{124.5 \times 0.015^2 \times 74.663}{3.2^{\frac{4}{3}}}$$
$$= 0.444$$

- Coefficient of outlet loss: fo

$$f_0 = 0.081$$

- Total head loss : Δh_s

$$\Sigma f_r = f_e + \Sigma f_b + f' \frac{L_r}{R} + f_o = 0.12 + 0.022 + 0.650 + 0.081 = 0.873$$

$$\Sigma f_c = \Sigma f_{bc} + f' \frac{L_c}{D} = 0.12 + 0.444 = 0.546$$

$$\Delta h_{sr} = \Sigma f_r \times \frac{V_r^2}{2g} = 0.863 \times \frac{1.902^2}{2 \times 9.8} = 0.161$$

$$\Delta h_{sr} = \Sigma f_c \times \frac{V_c^2}{2g} = 0.546 \times \frac{1.989^2}{2 \times 9.8} = 0.110$$

$$\Delta h_s = \Delta h_{sr} + \Delta h_{sc} = 0.161 + 0.110$$

= 0.271 (m)

3) Siphon No. 3

- Basic condition (r: rectangular type, c: circular type)

Section

2.9 x 2.9 m (rectangular type) 3.2 m diameter (circular type)

Hydraulic radius

: R = 0.967 (rectangular type)

Velocity

: $V_r = 1.902 \text{ m/s}$ $V_c = 1.989 \text{ m/s}$

Length

: $L_r = 129.874 \text{ m}$ $L_c = 187.960 \text{ m}$

Radius of curvature : $\rho = 15.0 \text{ m}$

- Coefficient of entrance loss: fe

$$f_e = 0.12$$

- Coefficient of bending loss : $\sum f_{br}$, $\sum f_{bc}$

$$f_{b1} = 0.08$$

$$\theta_1 = 13.859^{\circ}$$

:
$$f_{b21} = 0.27$$

$$\theta_2 = 24.969^{\circ}$$

$$f_{b22} = 0.45$$

$$0_3 = 29.953^{\circ}$$

$$f_{b23} = 0.50$$

$$\theta_4 = 16.659^{\circ}$$
 : $f_{b24} = 0.30$

$$\Sigma f_{tr} = 0$$
 (rectangular part)
 $\Sigma f_{to} = 0.08 \times (0.27 + 0.45 + 0.50 + 0.30) = 0.122$ (circular part)

- Coefficient of friction lose: $f(\frac{L_r}{R})$, $f(\frac{L_c}{D})$

$$f \frac{L_r}{R} = \frac{2gn^2}{R^{\frac{1}{3}}} \cdot \frac{L_r}{R} = \frac{2 \times 0.98 \times 0.015^2}{0.967^{\frac{1}{3}}} \cdot \frac{129.874}{0.967}$$
$$= 0.599$$

$$f\frac{L_c}{D} = \frac{124.5n^2 L_c}{D^{\frac{4}{3}}} = \frac{124.5 \times 0.015^2 \times 187.960}{3.2^{\frac{4}{3}}}$$
$$= 1.117$$

- Coefficient of outlet loss: f_0 $f_0 = 0.081$
- Total head loss: Δh_s $\Sigma f_r = f_e + \Sigma f_b + f' \frac{L_r}{R} + f_o = 0.12 + 0.599 + 0.081 = 0.800$ $\Sigma f_c = \Sigma f_{tc} + f' \frac{L_c}{D} = 0.122 + 1.117 = 1.239$

$$\Delta h_{sr} = \Sigma f_r \times \frac{V_r^2}{2g} = 0.800 \times \frac{1.902^2}{2 \times 9.8} = 0.148$$

$$\Delta h_{sr} = \Sigma f_c \times \frac{V_c^2}{2g} = 1.239 \times \frac{1.989^2}{2 \times 9.8} = 0.250$$

$$\Delta h_s = \Delta h_{sr} + \Delta h_{sc} = 0.148 + 0.250$$

= 0.348 (m)

4) Siphon No. 4

- Basic condition

Selection : 2.9 m x 2.9 m (Rectangular type)

Hydraulic radius : R = 0.967Length : L = 50.6 (m)

Velocity : v = 1.902 (m/s)

Radius of curvature : $\rho = 15.0$ (m)

- Coefficient of entrance loss: fe

$$A_1 = 11.5 \text{ (m}^2\text{)}$$

 $a = 8.41 \text{ (m}^2\text{)}$

$$\sqrt{\frac{a}{A_1}} = \sqrt{\frac{8.41}{11.5}} = 0.855 \quad \text{(sudden contract)}$$

 \therefore f_e = 0.12 (same as all siphon)

- Coefficient of bending loss: Σf_b

$$\rho = 15m$$

$$\frac{\rho}{D} \cdot \frac{15}{2.9} = 5.172$$

:. $fb_1 = 0.08$ (same as all siphon)

$$\theta_1 = 12.881^{\circ}$$

$$f_{b21} = 0.26$$

$$\theta_2 = 15.201^{\circ}$$

:.
$$f_{b22} = 0.29$$

$$\Sigma f_b = 0.08 \times (0.26 + 0.29) = 0.044$$

- Coefficient of friction lost : $f'\frac{L}{R}$

$$\Gamma \frac{L}{R} = \frac{2gn^2}{R^{\frac{1}{3}}} \cdot \frac{L}{R} = \frac{2 \times 9.8 \times 0.015^2}{0.967^{\frac{1}{3}}} \times \frac{50.60}{0.967}$$
$$= 0.233$$

- Coefficient of outlet loss: fo

$$f_0 = 0.081$$

- Total head loss: Δhs

$$\Sigma f = f_e + \Sigma f_b + f \frac{L}{R} + f_o = 0.12 + 0.044 + 0.233 + 0.081$$
$$= 0.478$$

$$\Delta h_s = \Sigma f \cdot \frac{v^2}{2g} = 0.478 \times \frac{1.902^2}{2 \times 9.8}$$

= 0.088 (m)

5) Siphon No. 5

- Basic condition

Selection

2.9 m x 2.9 m (Rectangular type)

Hydraulic radius

R = 0.967

Length

: L = 153.089 (m)

Velocity

v = 1.902 (m/s)

Radius of curvature : $\rho = 15.0$ (m)

Coefficient of entrance loss: fe

$$f_e = 0.12$$

Coefficient of bending loss: Σf_b

$$p = 15m$$

$$\frac{\rho}{D} \cdot \frac{15}{2.9} = 5.172$$

:. $fb_1 = 0.08$ (same as all siphon)

$$\theta_1 = 18.736^{\circ}$$

:
$$f_{b21} = 0.34$$

$$\theta_2 = 12.868^{\circ}$$

$$f_{b22} = 0.25$$

$$\Sigma f_b = 0.08 \times (0.34 + 0.25) = 0.047$$

- Coefficient of friction lost: $f \frac{L}{R}$

$$\Gamma \frac{L}{R} = \frac{2gn^2}{R^{\frac{1}{3}}} \cdot \frac{L}{R} = \frac{2 \times 9.8 \times 0.015^2}{0.967^{\frac{1}{3}}} \times \frac{153.809}{0.967}$$
$$= 0.706$$

- Coefficient of outlet loss: fo

$$f_0 = 0.081$$

Total head loss: Ahs

$$\Sigma f = f_e + \Sigma f_b + f \frac{L}{R} + f_o = 0.12 + 0.047 + 0.706 + 0.081$$
$$= 0.954$$

$$\Delta h_s = \Sigma f \cdot \frac{v^2}{2g} = 0.954 \times \frac{1.902^2}{2 \times 9.8}$$

= 0.176 (m)

4. Discharge of crossing streams/rivers

Crossing stream discharge along the Severino open channel are calculated depend on design criteria. There are thirty-three parts which include twenty-eight streams for drainage culverts and five for siphons. Results of calculation are shown in the following table.

No.	Area	Max	Min.	Difference	Length of	Time of	Qmax	Drainage
		Contour	Contour	height	Stream	concentration	Tr=25	Culvert &
		(m)	(m)	(m)	(m)	(min)	(m3/s)	Siphon No.
ı	0.049	184	105	79	250	2.13	1.33	Siphon No.1
2	0.435	355	90	265	875	5.69	11.79	Siphon No.2
3	0.020	145	103	42	230	2.47	0.55	CD-1
4	0.013	145	103	42	250	2.72	0.36	CD-2
5	0.126	200	102	98	600	5.40	3.42	CD-3
6	0.046	175	105	70	350	3.30	1.25	CD-4
7	0.014	145	112	33	170	1.91	0.38	CD-5
8	0.064	300	112	188	750	5.43	1.73	CD-6
9	0.017	160	107	53	300	3.07	0.47	CD-7
10	0.053	250	102	148	550	4.16	1.42	CD-8
11	0.011	150	103	47	210	2.13	0.30	CD-9
12	0.161	300	110	190	610	4.26	4.36	CD-10
13	0.023	155	113	42	250	2.72	0.63	CD-11
14	0.060	170	112	58	460	4.24	1.63	CD-12
15	0.018	140	113	27	200	2.49	0.49	CD-13
16	0.017	175	115	60	230	2.15	0.47	CD-14
17	6.934	416	70	346	3125	HYMO Model	78.40	Siphon No.3
18	0.009	155	105	50	220	2.19	0.25	CD-15
19	0.028	140	112	28	200	2.46	0.75	CD-16
20	0.037	156	110	46	200	2.03	1.00	CD-17
21	0.010	133	108	25	140	1.70	0.28	CD-18
22	0.150	165	110	55	500	5.46	4.06	CD-19
23	0.072	200	112	88	600	5.63	1.94	CD-20
24	0.024	150	110	40	250	2.77	0.65	CD-21
25	0.090	250	110	140	500	3.81	2.45	CD-22
26	0.010	144	108	36	150	1.60	0.26	CD-23
27	0.220	290	105	185	600	4.23	5.96	Siphon No.4
28	0.015	150	107	43	150	1.49	0.41	CD-24
29	0.236		104	286	825	5.16	6.41	CD-25
30	0.094	285	112	173	450	3.11	2.54	CD-26
31	1.071	447	93	354	1750	11.33	29.05	Siphon No.
32	0.018		.105	50	220	2.19	0.49	CD-27
33	0.056		105	115	300	2.28	1.51	CD-28

5. Side channel spillway at Siphon No. 1

1). Overflow Section

Condition

Discharge in channel upstream of weir

Discharge in channel downstream of weir

Discharge to spill out from weir

 $Q_1 = 20.8 \text{ m}^3/\text{sec}$

 $Q_2 = 16.0 \text{ m}^3/\text{sec}$

 $Q_d = Q_1 - Q_2 = 4.8 \text{ m}^3/\text{sec}$

Weir height

Overflow coefficient (for broad-crest weir)

Water depth in channel at Q = 20.8 m³/sec

Water depth in channel at $Q = 16.0 \text{ m}^3/\text{sec}$

Overflow depth at downstream end of weir

 $H_d = 2.5 \text{ m}$

K = 1.7 m

 $h_1 = 2.814 \text{ m}$

 $h_2 = 2.5 \text{ m}$

 $H_2 = h_1 - h_2 = 0.314 \text{ m}$

Calculation

(INPUT)

$$H_1 = 0.275 \,\mathrm{m}$$

$$H_2 = 0.314 \,\mathrm{m}$$

 $Q_1 = 20.800 \text{ m}^3/\text{sec}$

 $Q_2 = 16.000 \text{ m}^3/\text{sec}$

$$V_2 = Q_2/A_2 = 1.142 \text{ m/sec}$$

$$A_2 = 14.005 \text{ m}^2$$

$$V_1 = Q_1/A_1 = 1.520 \text{ m/sec}$$

 $A_1 = 13.681 \text{ m}^2$

$Q_d = K \cdot L \{ (H_1 + H_2) / 2 \}^{2/3}$

$$L = 17.667 \, \text{m}$$

≈ 18.000 m

(Check)

- Friction loss in side weir portion

$$H_t = (I_1 + I_2)/2 \times L$$

$$I_1 = (nV_1)^2 / R_1^{4/3} = 0.000354815$$

$$I_2 = (nV_2)^2 / R_2^{4/3} = 0.000197271$$

$$n = 0.015$$

$$R_1 = 1.332$$

$$R_2 = 1.347$$

$$h_f = 0.005$$

$$H_b = f_b(V_1^2/2g)$$

 $f_b = 0.5807Q_r - (0.0788Q_r + 0.003)^{0.5} + 0.0171$

$$Q_r = Q_0/Q_1 = 0.2308$$
 $F_b = 0.0151$
 $H_b = 0.0018$

$$E_1 = H_1 + H_d + V_1^2 / 2g = 2.893$$

$$E_1' = E_2 + H_d + z + H_f + H_b$$

= $H_2 + V_2^2 / 2g + L / 3000 + H_f + H_b = 2.893$

$$E_1 = E_1'$$
 (O.K.)

6. Side Channel

Condition

Discharge in channel upstream of weir

Water depth at downstream end

Channel width at downstream end

Channel gradient of rapid slope portion

Channel gradient of gentle slope portion

Slope gradient of overflow side

 $Q = 4.8 \,\mathrm{m}^3/\mathrm{sec}$

d

B d/B = 0.5

 $i_1 = 1/13.0$

i2

1:m = 0

$$d^{3}B^{2}(1 + \frac{m}{2} \frac{d}{B})^{3} / (1 + m \cdot \frac{d}{B}) = \frac{Q^{2}}{g} \frac{1}{F_{r}^{2}}$$

$$d = 0.480 \times (Q / F_{r})^{0.4}$$

$$F_{r} = 0.44 \sim 0.5$$

$$d = 1.25 \sim 0.19 = 1.2 \text{ (m)}$$

$$B = 2.4 \text{ (m)}$$

$$F_{r} = 0.486$$

Length of channel with gentle slope portion

$$1 = > 4d$$
$$= 4.8$$

= 5.0 m

 $i_2 = gn^2Fr^2(1 + \frac{2d}{B})^{4/3}\frac{1}{d^{1/3}}$

= 1/809.70

: 1/810

4.2 Structural Calculation

GENERAL

The structural elements were designed in order to obtain the design strength in all sections at least same as the required strength calculated to withstand the weighted loads and the strength stipulated in the Ecuadorian Construction code (CEC) and American Concrete Institute (ACI).

Furthermore within the analysis and design the structures guarantee an adecuated performance for the service loads.

For the analysis and design of different elements the following structures have been foreseen, box structures for the box culverts, walls and foundation for transition, box of inner and outer rectangular cross section and box of outer rectangular cross section and inner circular cross section.

These patterns have been selected taking into account the stresses to which these structures have to work.

The utilized loads are the service loads and own load; these loads will be analyzed afterward.

LOADS

Before to the load analysis an elements predesign was carried out in order to estimate the real service loads due to own load plus surcharge. The given values in the analysis table for each structure correspond to several conditions and surcharge height, the calculation procedure is detailed on the data preparation for each structure.

For the loads calculation the following input data were used:

Gs = 1.8 t/m^3 as soil unit weight

Ge = 2.4 t/m^3 as concrete unit weight

Ka = active earth pressure coefficient

Ec = 2.1 x 10⁵ kg/cm² concrete elasticity modulus

Es = $2.1 \times 10^6 \text{ kg/cm}^2$ steel elasticity modulus

DETAIL OF APPLIED LOADS TO EACH STRUCTURE BOX CULVERTS, SIPHONS, TRANSITIONS

W₁ = live load of a HS-20-44 truck

W₂ = vertical load due to earth surcharge plus weight of the structure

cover

W₃ = uplift surcharge in the foundation

 W_4 = foundation reaction

Wt = soil pressure

 $W_W = water pressure$

Pw = inner water pressure

Pw₁ = inner water pressure due to the water surcharge

Pc = Concrete wall weight

With the above mentioned data and load condition previously stated the structural analysis was made by using the software SAP90.

STRUCTURAL ANALYSIS

For the structural analysis the software SAP90 was fully utilized, this software uses the FEM analysis method. The subroutine frame was utilized for the structural analysis.

This software allow us for examine the structures as well as to model them. All loads were included for the analysis purpose. After the software graphical check which allow as to know the free body scheme, sections, total and local axis, loads in each bar and in the different states too, the analysis was carried out and getting as output the graphical and analytical displacement, moments, shear and axial load.

For the following each load combination and for each structural element, solutions were obtained:

ANALYSIS CONDITION

- General

Wu = 1.4 DL + 1.7 LL + Ep + 1.7 Pw

 $D_1 = dead load$

L₁ = live load

Ep = earth pressure

Pw = water pressure

- Box culvert

 $Wu = 1.4 W_2 + 1.7 W_2 = 1.7 W_3 + 1.4 W_4 + 1.7 W_4 + 1.7 W_1$

 $W_U = 1.4 W_2 + 1.4 W_4 + 1.7 Pw$

- Transition

 $Wu = 1.4 W_4 + 1.7 Wt$

 $Wu = 1.4 W_4 + 1.7 Wt + 1.7 Pw$

 $Wu = 1.4 W_4 + 1.7 Pw$

- Siphon

 $Wu = 1.4 W_2 + 1.7 W_2 + 1.7 W_3 + 1.4 W_4 + 1.7 W_4 + 1.7 Wt$

 $Wu = 1.4 W_2 + 1.7 W_2 + 1.7 W_3 + 1.4 W_4 + 1.7 W_4 + 1.7 W_t + W_w$

 $W_{U} = 1.4 W_{2} + 1.4 W_{4} + 1.7 Pw + 1.7 Pw_{1}$

DESIGN

With the final reactions coming from the structural analysis the design was carried out.

With the final reactions (ultimate moments, shear and stresses) the elements were designed using for this purpose the plastic design. The following general criterias were considered:

- Concrete

Pu ≤ Pd

Mu ≤ Md

Vu ≤ Vd

- Materials Characteristics

f'c = 210 kg/cm² compressive strength of concrete

fy = $4,200 \text{ kg/cm}^2$ steel yield point

 $b = 100 \, cm$

d = effective height of the concrete cross section

r = 7.0 cm covering of the concrete cross section

The designs were carried out for all elements due to moment, shearing, moment and axial load.

The form used for design purpose is detailed in each analysis attached herewith.

Diseño Estructural de Canal Abierto Structural Design of Open Channel

1. Datos/Data

fc : 210 kg/cm² fy : 4,200 kg/cm²

Ø : 30° (Angulo de friccion interna del suelo/ Internal friction angle)

 α : 39°48'20" (Angulo de inclinación de talua/ Inclination angle)

m : 1:1.2

γ : 2,000 kg/m³ (Peso unitario del suelo/ Unit weight of sand)

Nf : 1.00 m (Nivel del agua subterránea/ Groundwater level)

2. Diseño/ Design

1) Factor de cohesion/Cohesion factor

$$K = \frac{\cos^2(\theta + \alpha)}{\cos^3(1 + \frac{\sin\theta}{\cos\alpha})^2} = \frac{0.119}{0.997} = 0.119$$

2) Empjes/Thrust

$$E = \frac{1}{2}\gamma \times h^2 \times K$$
 (Formula para triangulo/Formula for triangle)

 $E = \gamma \times h^2 \times K$ (Formula para cuadrado/Formula for square)

$$E_1 = \frac{1}{2}\gamma \times h^2 \times K = \frac{1}{2} \times 2000 \times 1.8 \times 1.2 \times 0.119 = 463 \text{ kg}$$
 (Suelo seco/Dry soil, Triangulo/Triangle)

 $E_2 = 1.2 \times 1.8 \times 1 \times 1.000 \times 0.119 = 257 \text{ kg}$ (Suelo saturado/Saturated soil, Rectangulo/Rectangular)

 $E_3 = 0.5 \times 12 \times 1 \times 1.000 \times 0.119 = 60 \text{ kg}$ (Suelo saturado/Saturated soil, Triangulo/Triangle)

 $E_w = 0.5 \times 1.2 \times 1 \times 1.000y = 600 \text{ kg}$

 $E_1 = E_1 + E_2 + E_3 + E_w = 1380 \text{ kg}$

3) Momentos/Moment

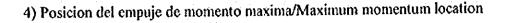
$$M = E \times L$$

$$M_1 = E_1 \times 1.60 = 741 \text{kg} - \text{m}$$

$$M_2 = E_1 \times 0.50 = 129 \text{kg} - \text{m}$$

$$M_3 = E_3 \times 0.39 = 20 \text{kg} - \text{m}$$

$$M_4 = E_4 \times 0.33 = 198 \text{kg} - \text{m}$$



$$h = \frac{M}{T} = \frac{1088 \text{kg} - \text{m}}{1380 \text{kg}} = 0.79 \text{m}$$

5) Momento ultimo/Ultimate moment

$$M_n = 1.7 \times M = 1.7 \times 1088 \text{kg} - \text{m} = 1850 \text{kg} - \text{m}$$

6) Calculo de penalte/Thickness calculation

$$d = \sqrt{\frac{Mu}{1 \times b}} = \sqrt{\frac{1850 \text{ kg-m}}{30.55 \times 1.00}} = 7.9 < 12 \text{cm}, \text{ OK}$$

7) Calculo de Ku/ Calculation of Ku

$$K_v = \frac{M_v}{b \times d} = \frac{1850 \text{kg} - \text{m}}{1.00 \times 12} = 12.85 \text{kg/cm}^2$$

8) Calculo de la cuantos de acero/ Calculation of minimum reinforcement

$$\rho = 0.85 \frac{\text{f c}}{\text{fy}} \left(1 - \sqrt{1 - \frac{2.36 \text{K}_u}{\phi \text{ f c}}} \right) = 0.85 \times \frac{210}{4200} \left(1 - \sqrt{1 - \frac{2.36 \times 12.85}{0.9 \times 210}} \right) = 0.0036$$

9) Calculo de seccion de acero/ Calculation of reinforcement

$$A_1 = \rho \times b \times t = 0.0036 \times 100 \times 12 = 4.32 \text{cm}^2$$

de acero/ # of reinforcement 4.32cm²/0.785cm²=5.5\phi10mm=6.0\phi10mm

10) Carga sobre losa de fondo/ Load acting on slab (Peso propio revestimiento/Dead load)

$$P_{pr} = \frac{1}{6} [(8.74 \times 0.15 \times 2400) \cos 39^{\circ} 48'20" + (0.15 \times 1.71 \times 2400)] = 505 \frac{\text{kg}}{\text{m}^2}$$

(Subpresion/Uplift) $S_p = 1000 \times 1.00 = 1000 \frac{kg}{m^2}$

(Reaccion del terreno/ Soil reaction)
Rt=Pw+Pt+Ppn-Sp=0+0+505-1000=495 kg/m²

(Peso propio losa inferior/ Dead load of bottom slab)

$$P_{pli} = 0.15 \times 2400 = 360 \frac{kg}{m^2}$$

(Carga sobre losa inferior/ Load acting on upper slab) $W=R_t+S_p-P_{pli}=495+1000-360=1135 \text{ kg/cm}^2$

$$M = \frac{W \times L^2}{8} = \frac{1135 \times 1.11^2}{8} = 415 \text{kgm}$$

$$M_u = 1.7 \times 415 = 704 \text{kgm}$$

$$d = \sqrt{\frac{704}{330.55 \times 1.00}} = 4.8 < 12$$

$$K_u = \frac{704}{1.00 \times 12^2} = 4.89$$

$$\rho = 0.85 \frac{f'c}{fy} \left(1 - \sqrt{l - \frac{2.36 \times 4.89}{0.9 \times 210}} \right) = 0.0013$$

 ρ =14/f_y=0.0033

 $A_s = 0.0033 \times 1.00 \times 12 = 3.96 \text{cm}^2$ 1\phi 10mm, c/20cm,

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DAULE-PERIPA-LA ESPERANZA TRANSBASIN (TRASVASE DAULE PERIPA-LA ESPERANZA)	Calculated by:	<u> </u>	MS.
MEMBRILLO OUTLET ACCESS ROAD (CAMINO DE ACCESO SALIDA MEMBRILLO)	Calculado por: _Sheet	And the second	of I
General AUDITION AND DESIGN OF BOX CULVERT	Hoja 	**	de
- Concrete prolection for reinforcement CEC 7.7			
-shrukeye and temperature 4200 Ky/cm², rot area: 0.0000 CEC 7.12.2.1	Ho. ol. le	un Faccom	
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Vn=4(1c+Vs) Vc = nominal shear strength supplied by the Vs = 11 11 strength supplied by the for member subjected to shear and flexion		west.
Vc = \$0.53 \fo bwd Ow = Vl Of Vu > Vc require Av with steel OV = Av fyd Av = shear fy = yield	fective di reinforcer strength ion of sh ement in f	epth ment avea h. ne av
$A_5 = \frac{M_0}{\varnothing f_y \left(d - \frac{a}{2}\right)}$	exure forcement	ement ave Nation of the
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(2)

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X COUCRETE = 2.400 Kg/m3 UNIT WEIGHT

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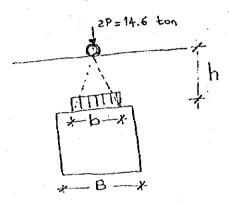
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LUALYSIS FOR WI

WI = LIVE WAD OF HS-20-44 TRAILER

$$W_1 = \frac{14.60}{4.21 \times 3.05} = 112 \text{ T/m}^2$$

$$h'_{5} = \frac{1.12}{1.8} = 0.622m^{\frac{1}{2}} = 0.65m^{\frac{1}{2}}$$
 0.65m^{\text{m}} (soil Equivalent HEISTH)



$$h_s = \frac{0.15}{1.8} = 0.15 \text{ TOU/m}^2$$
 $h_s(\min) = 0.65 \text{ m}^{\frac{1}{2}} \text{ (ASSHTO)}$

1

Wi= vertical load (tor/m2) 2 support coefficient P = rear wheel load (ton) a = Distribution width [m] b = Distribution Longth (m)

N = number of longs h = earth coverage depth.

$$a = 2 \times 5 + 2.25 = 12.25$$

 $b = 2 \times 5 + 0.2 = 10.20$

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JAPAN INTERNATIONAL COOPERATION AGENCY - AGENCIA INTERNACIO	NAL DE COOF	ERACION	IDEL JAPON
JICA STUDY TEAM • GRUPO DE ESTUDIOS JICA	_ Date:	1	9-1x-94
DAULE-TERIFA-LA ESFERANZA TRANSDASIN (TRASVASE DAULE PERIPA-LA ESPERANZA)	Feelia: Calculated by:	·	C.M.S.
MEMBRILLO OUTLET ACCESS ROAD (CAMINO DE ACCESO SALIDA MEMBRILLO)	Calculado por: _ Sheet		of 6
DESIGN LOAD	iloja 		di
proposition of the Control of the Co		- The Resident of the Section of the	Andrewski and a second
1,5 DESIGH WAD			
		الماره	s val.
WI = LIVE LOAD OF H5-2044 TRAILER WI can be neglected because W2 (remind load	of earth u	veight)	> AA.
WI can be neglected because	MOUSIN	OF 701	2 502
WY CAN BE NEGLECTED WEIGHT AND SELF WE THEN (Unit weight) & h + V COUCCETE	Contractif) . thick	Kness
= 8 EDETH (unit weight) × N + 0 concrete	(onto or of	, ^ .	
W3 = SURCHOLER OF THE UPLIET ACT ON BOTTON	5040	1	
= 8 water outs x H H: (Groundwater Les	uel - (Sotto	m llvil	;)
W4 = REACTION WAS ACT OH BOTTON SLAB			
= W1 + W2 + 2PE			
Pc = 6 ad of concrete of the walls			
· ·			
WT = Lateral earth pressure			
WT = Laterol edit = (unit weight) x N x Ka		•	
= (EVELH (OUIL MED)			
A 99 T/m	Ka=	0.5	٠
Wz = 1.80 x 5.150 + 2.4 x 030 = 9.99 T/m			
. Ws = 0.0 T/m			
W4 = 9.27 + 0.72 + 2 × 0.30x2.4 x 1.5	• 1		
1 43 T/m	•		1
$= 9.27 + 0.72 + 2 \times 1.08 = 11.43 \text{ T/m}$			
WT1= 1.80x 5.15 x 0.50 = 4.64 T/m			
Wrz = 1.80 x 6.65 x 0.50 = 5.99 7m			<u> </u>
$ML^{5} = 1.80 \times 0.02 $	•		1
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Revision (Checked by Date (Fecha) Approved by: Date (Fecha) Revision (Checked by: Revisido por Revisido por		probed by:	Date (Fecto) Accobado por:
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JAVAN INTERNATIONAL COOPERATION AGENCY - AGENCIA INTERNACIO		
JICA STUDY TEAM - GRUFO DE ESTUDIOS JICA	Date: Fecha:	19-12-94
DAULE-PERIPA-LA ESPERANZA TRANSBASIN (TRASVASE DAULE PERIPA-LA ESPERANZA)	Calculated by: Calculado por:	C.M.S
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JAPAN INTERNATIONAL COOPERATION ACENCY - AGENCIA INTERNACIONAL DE COOPERACION DEL JAPON HCA STUDY TEAM - GRUPO DE ESTUDIOS HCA Date: Feeha; Calculated by: CESAR MEDINA S. DAULIE-PERIPA-LA ESPERANZA TRANSDASIN (TRASVASE DAULE PERIPA-LA ESPERANZA) Calculado por: MEMBRILLO OUTLET ACCESS ROAD (CAMINO DÉ ACCESO SALIDA MEMBRILLO) Sheet Hoja 15 x 1.5 x 0.3 CULVERT ARE AS FOLLOWS : THE LOADS APPLIED IN THE DESIGN OF WITH WAD OF HS-20-44 TRAILER WE VERTICAL LOAD OF EARTH WEIGHT AND SELF WEIGHT OF TOP BLAD WE : SURGIAGE OF THE UPLIFT ACT ON BUTTON SIAB. WA: REACTION WAD ACT ON BOSTON SLAB WT: LATERAL EARTH PRESSURE PW: LATERAL WATER PRESURE DATA PC: LOAD OF CONCRETE Soil = 1.8 T/H3 DHIT WEIGHT DECONCRIE = 24 THS UNIT WEIGHT THE PROPERTY OF THE PARTY OF TH Ka = 0.5 COEFFICIENT OF EARTH PRESSURE h fc = 180 KB/cm2 STRENGTH OF CONCRETE WT wT. FY=1200 Kg/cm2 YIELD STEEKGHT Pc Pc. OF REFORCING BAR Econocete = 2.1,105 MONTHS OF (Kg/ N= 1.87/ 6.15; 11.15 1.60 Pw $P_{\underline{w}}$ YT2 5-M3 -1. 80 - 1 Ru h WIG W12 412 W N_3 6.0 11.07 **կ մ** [.5.],3 5,54 4.80 7,16 1.30 0,72 2.16 0.3 20.03 11.0 20.07 10.04 11.66 1.80 15,1.5 1.30 2,16 0.72 0.3 Date (iecha) Approbed by: Oute (Fetha) Checked by: Revision Chicked by Approved by: Date (Fecha) Date (Fecha) Aprohada rec Aprobado por: <u>Raisso cor</u> Aprobada por: Reviewdo por

JAPAN INTERNATIONAL COOPERATION AGENCY - AGENCIA INTERNACIONAL DE COOPERACION DEL JAPON Date: Fecha: Calculated by: DAULE-PERIFA-LA ESPERANZA TRANSDASIN (TRASVASE DAULE PERIPA-LA ESPERANZA) Calculado por: MEMBRILLO OUTLET ACCESS ROAD (CAMINO DE ACCESO SALIDA MEMBRILLO) Sheet Hoja BOX CULUZET 1.5 x 1.5 ///X/// WW. H MID 6.0 11.0 H 2,10 2.10 H. 1,50 1.50 B 2.10 01.5 Bı 1.50 1.50 t 0.30 0.30 0.30 0.30 Ł٠ 0.30 0.30 £3 0.15 0.15 Approbed by: Approbado por: Revision Date ((ccha) Checked by Oate (Fecha) Approved by: Oate (Fecha) Checked by: Date (Fecha) Aprobado por: Revisado por Aprobably pre: Revisado por

AMAN INTERNATIONAL CODPERATION AGENCY - AGENCIA INTERNACIONAL DE COOPERACION DEL JAPON ACA STUDY TEAM - GRUPO DE ESTUDIOS ACA Fecha: Calculated by CEDAR MEDINA 5. DAULE PERIFA-LA ESPERANZA TRANSBASIN (TRASVASE DAULE PERIFA-LA ESPERANZA) Calculado por: MEMBRILLO OUTLET ACCESS ROAD (CAMINO DE ACCESO SALIDA MEMBRILLO) Sheet Hoja BOX COWERT 20 < 2.0 < 0.3 ARE AS FOLLOWS : THE LOADS APPLIED IN THE DESIGN OF WIT LIVE WAD OF HS-20-44 TRAILER WE VERTICAL LOAD OF EARTH WEIGHT AND SELF WEIGHT OF TOP SLAB WI: DECHARGE OF THE UPLIFT ACT ON BOTTON SIAR. WILL HOLLOW POLL BY THE WILL BE STON STOR WT: LATERAL EARTH PRESSURE .. PW: LATERSL WATER PRESURE Pc: LOAD OF CONCRETE Soil = 1.8 Th3 with WEIGHT & = 200 MIGHE OF INTEREST FRACTION THE TAXABLE PARTY OF THE PARTY BEOLEGEE = 24 THS UNIT WEIGHT Ka = 0.5 CONFRICIENT OF EARTH h PRESSURE fc = 180 K8/cm2 STRENGTH OF Wa CONCRETE WT. WT. Pe Pe FY=1200 Kg cm YIELD STRENGHT OF REFOICING BAR Econocieté = 2.1×10⁵ Moorus OF (Kg/ 1.8 Ks. 1.8 Ks 3,65 , 9,15 $\bar{P}_{\underline{W}}$ 7.30 MTz. r^{M3} - 2,30-¥ Pw ·P \₁ V_3 W₄ Wi SiM 6.57 6.57 2.020 3.5 3,29 5.36 1,66 2,30 0.72 216 ٥٠3 2.0,2.0 16.47 16,47 9.0 2.3 8,24 10.31 1.66 2.16 0.3 0.72 Checked by Date (Fecha) Approved by: Date (Fecha) Raision Oxected by: Date (lecha) Approved ty: Date (Feeha)

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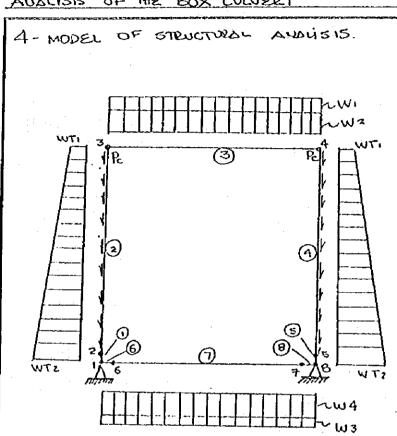
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JAPAN INTERNATIONAL COOPERATION AGENCY - AGENCIA INTERNACIONAL DE COOPERACION DEL JAPON

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DAULE-TERIPA-LA ESPERANZA TRANSDASIN (TRASVASE DAULE PERIPA-LA ESPERANZA)	Feelia: Calculated by:	C.M.S.
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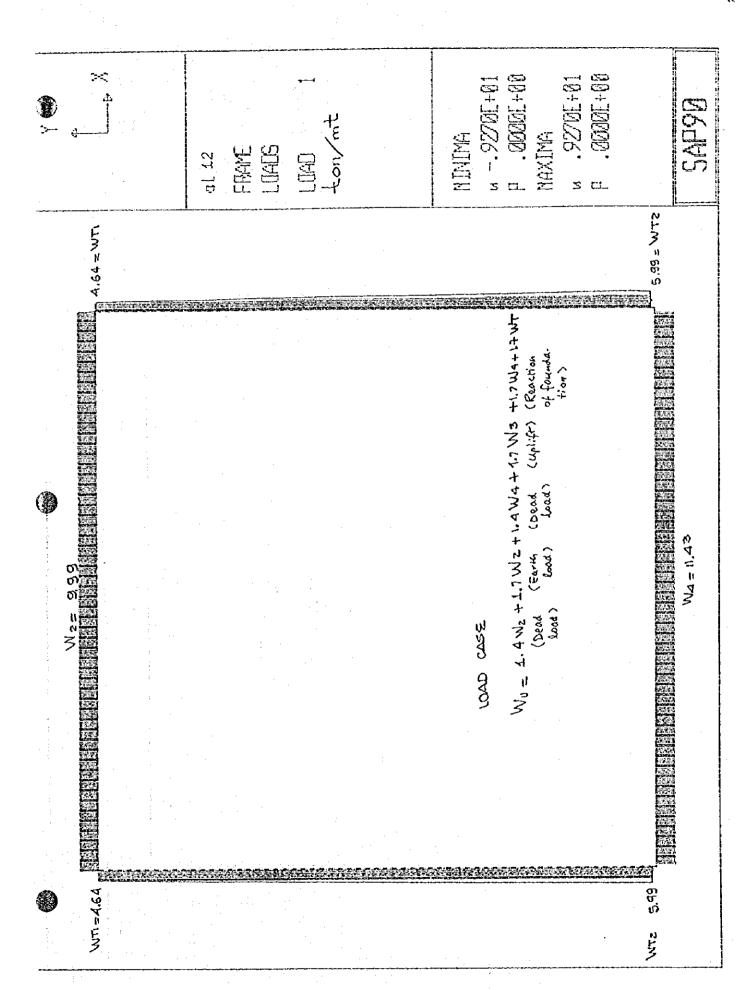
LA CONSIDERACION DE CARGA ES LA SIGUIENTE:

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SE PEDIZO LA EJECUCIÓN DEL PROGRAMA, OBTENIENDOSE MOHENTOS, CORTES, CARGAS AXIALES Y TOLSIÓN COMO SE INDÍCA EN 105 GRAFICOS QUE ADJUNTO.

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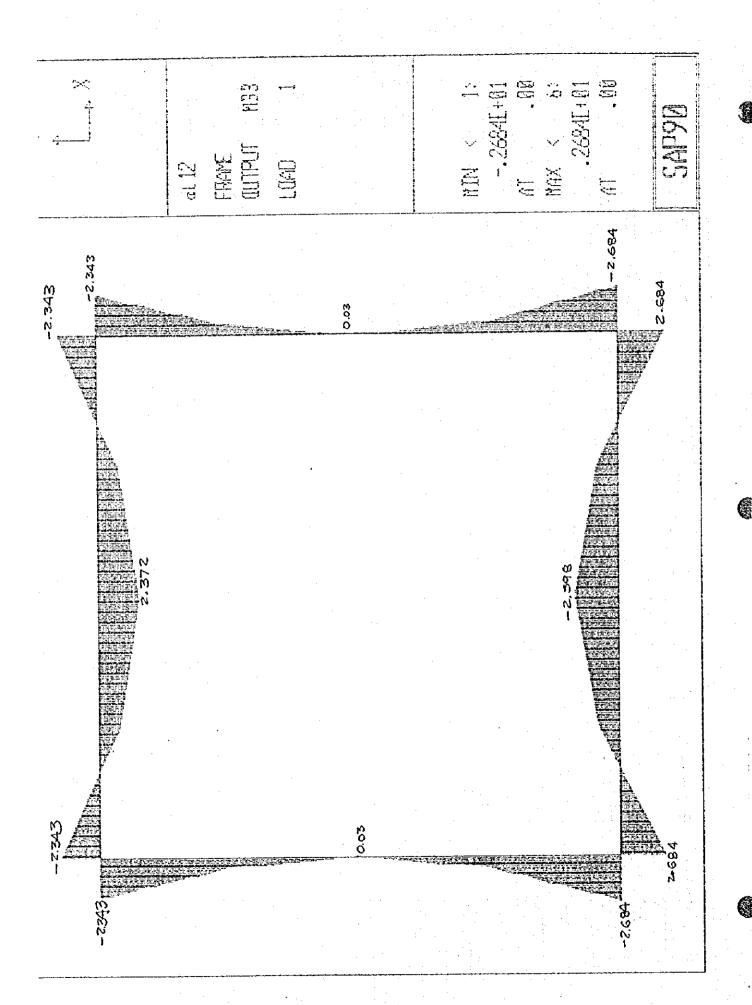
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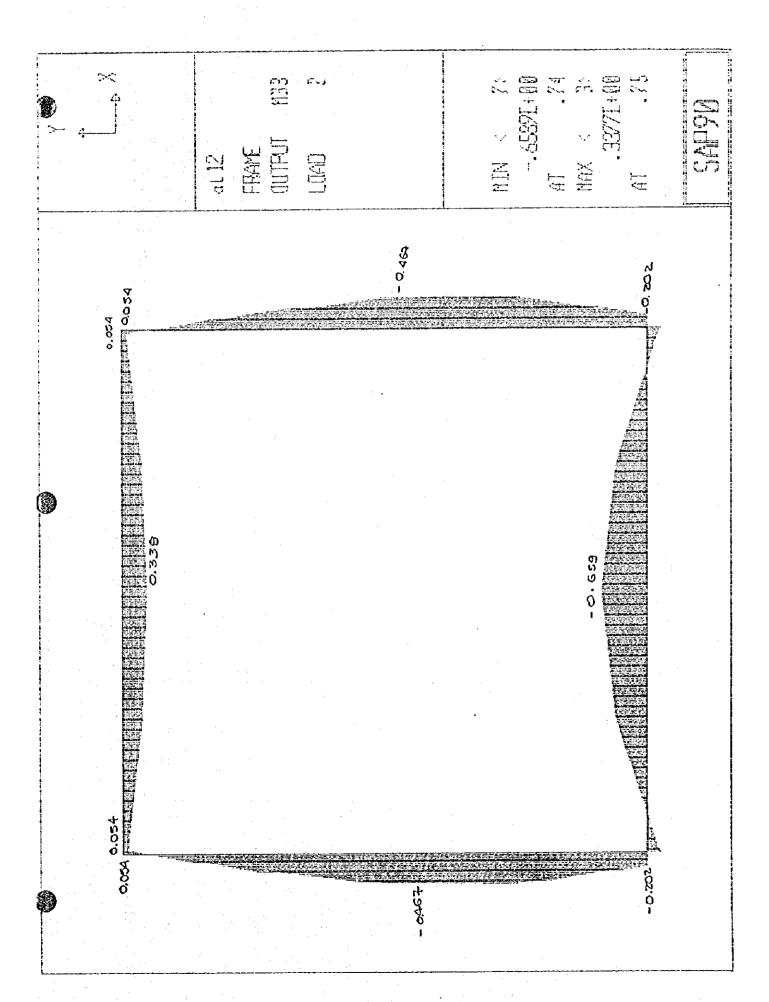
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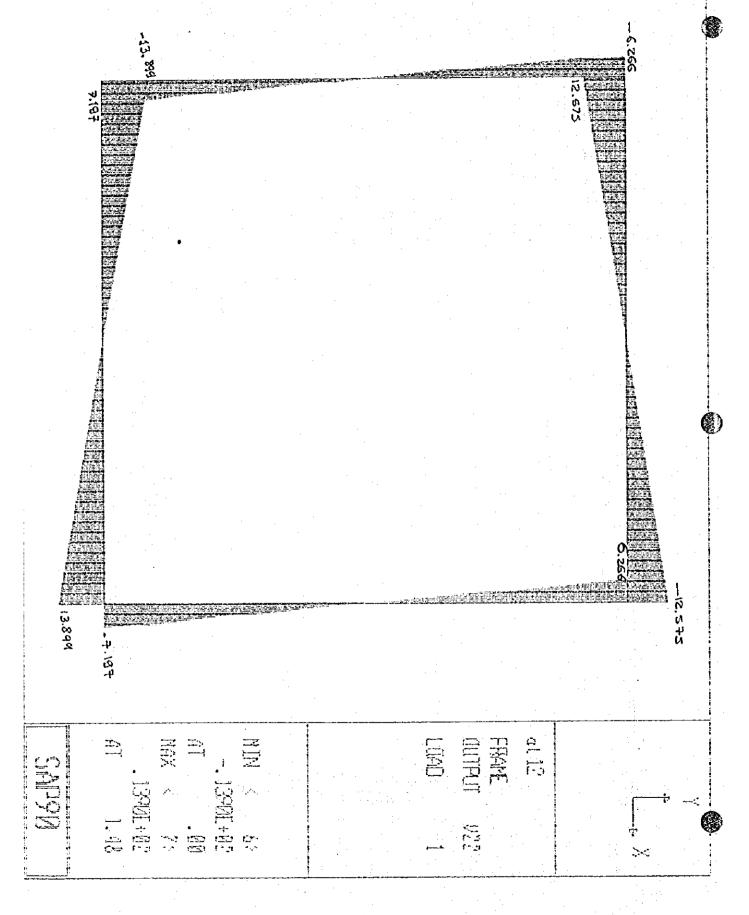
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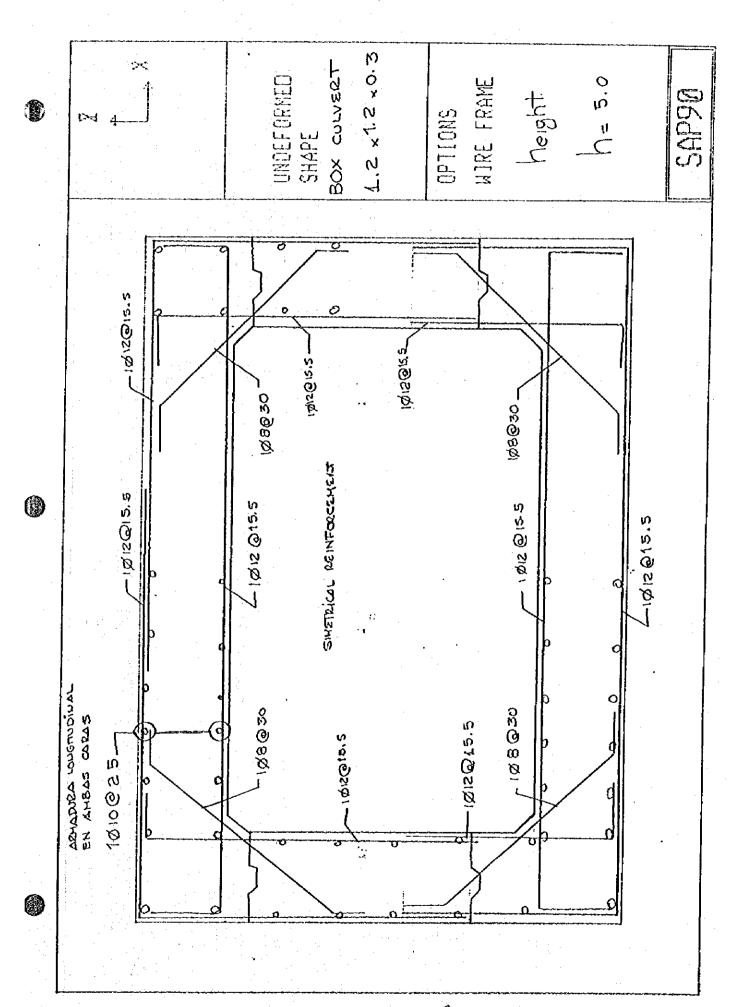




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19-12-94 C.MS Calculado por: MEMBRILLO OUTLET ACCESS ROAD (CAMINO DE ACCESO SALIDA AUALYSIS AND DETIGN OF BOX COLVERT 1.2.1.2. OF DEIN FOIL CEMENT E-DATA FUR CALCULATION Mu = 2.684 ton-mt. fi = 180 kg/cm2 fy = 4200 Kg/cm2 b = 100 cm d= 23cm P= 45 = 3.16 =0.001372 += 7 cm $A_5 = \frac{2.684 \times 10^5}{0.9 \times 4200 \left(23 - \frac{3}{2}\right)} = 3.64 \text{ cm}^2$ P< Pmin As=0.0032 b. d =7.69 cm2 => 1012@16 0.85 x 180 x 100 $A_5 = \frac{2.684 \times 10^5}{0.9 \times 4200 (23 - 0.50)} = 3.16 \, \text{cm}^2$ As= 7.66=) 7 \$12 = 1\$12@16 WITH BEAM DESIGN PROGRAM _ SHEAR STRESS CHECK 10 > No "OK" Vu= 7.197-ton Vc = 0.85.0.53 / 180 x100 x23 = 13.901.41 Kg. Vu = 13899 ton NO LEGUIPED STIPPLUPS

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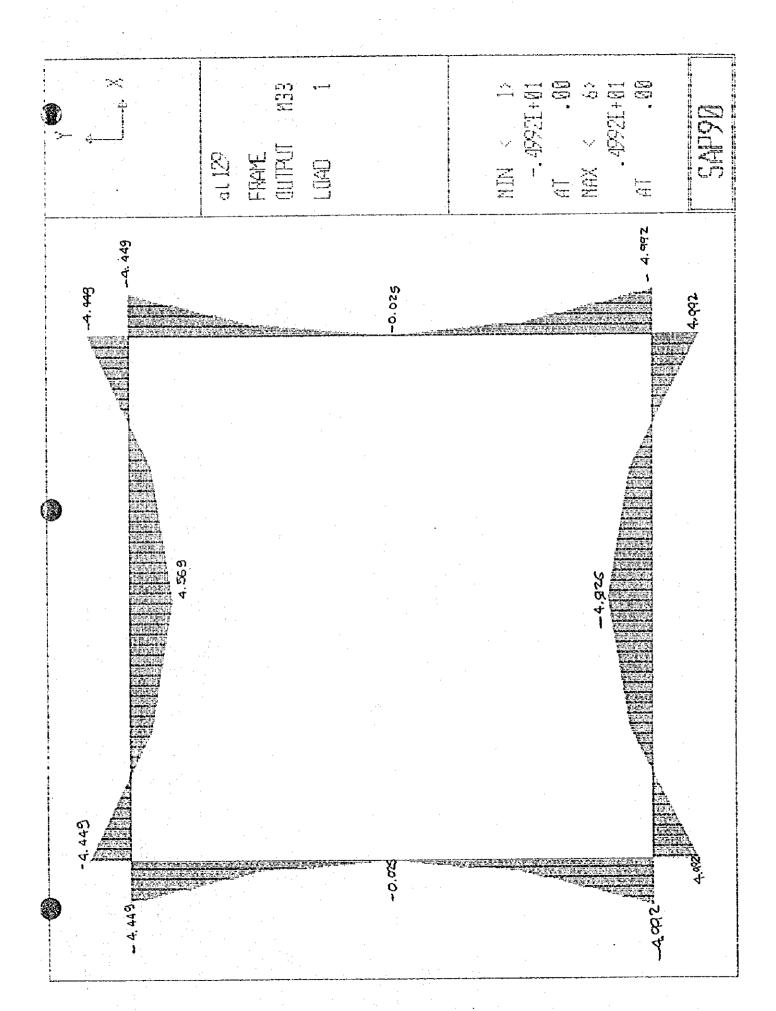
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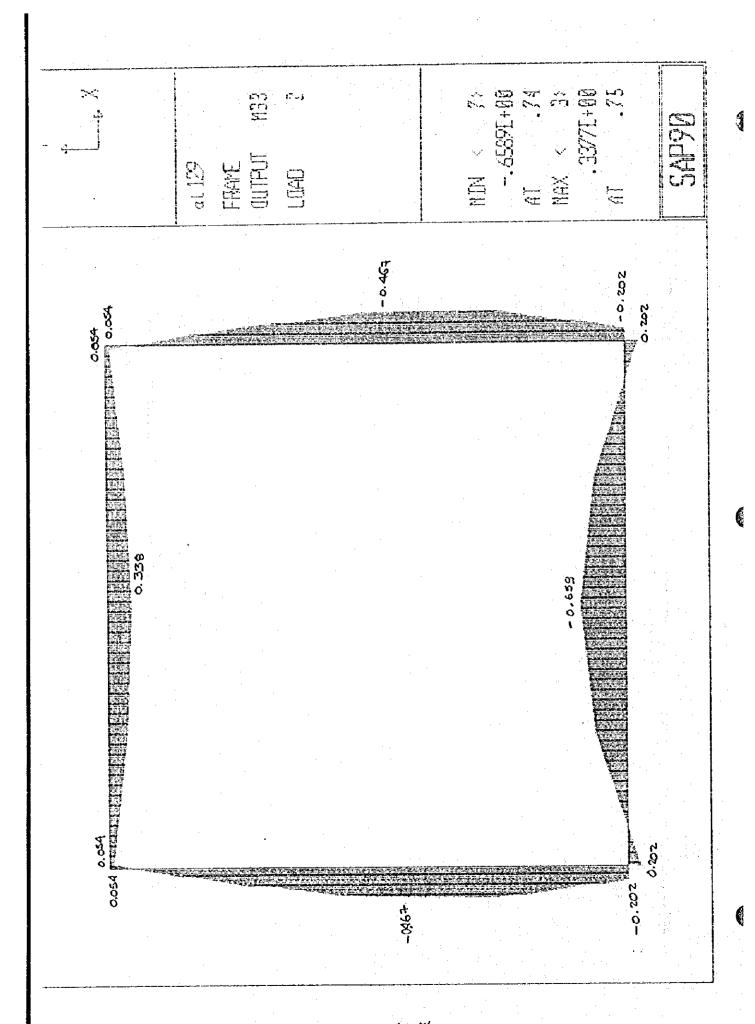
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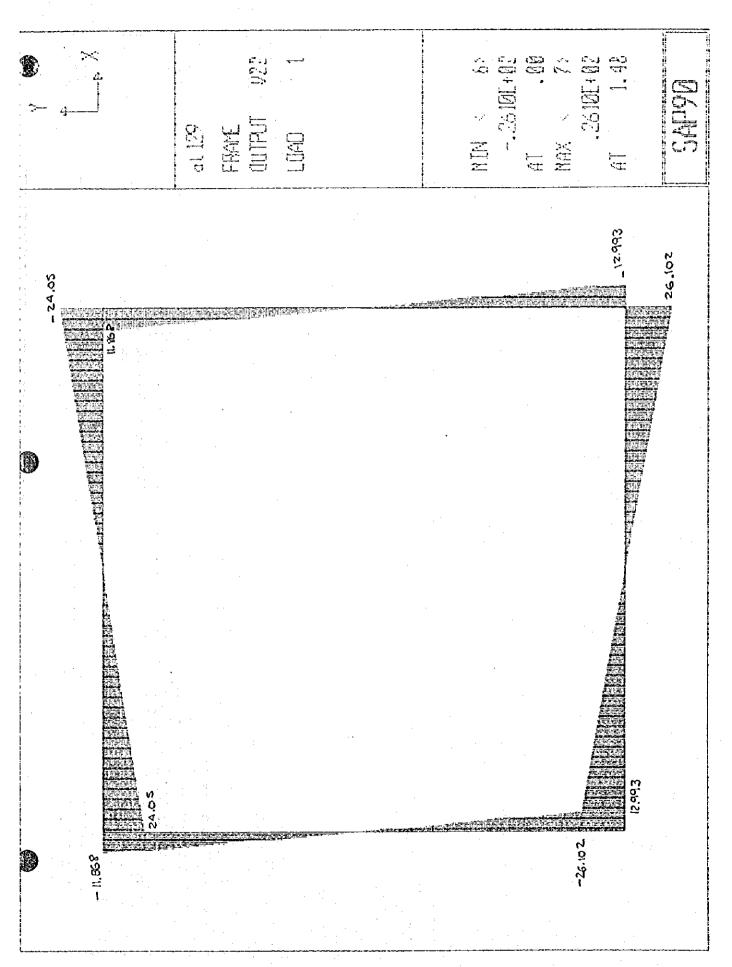
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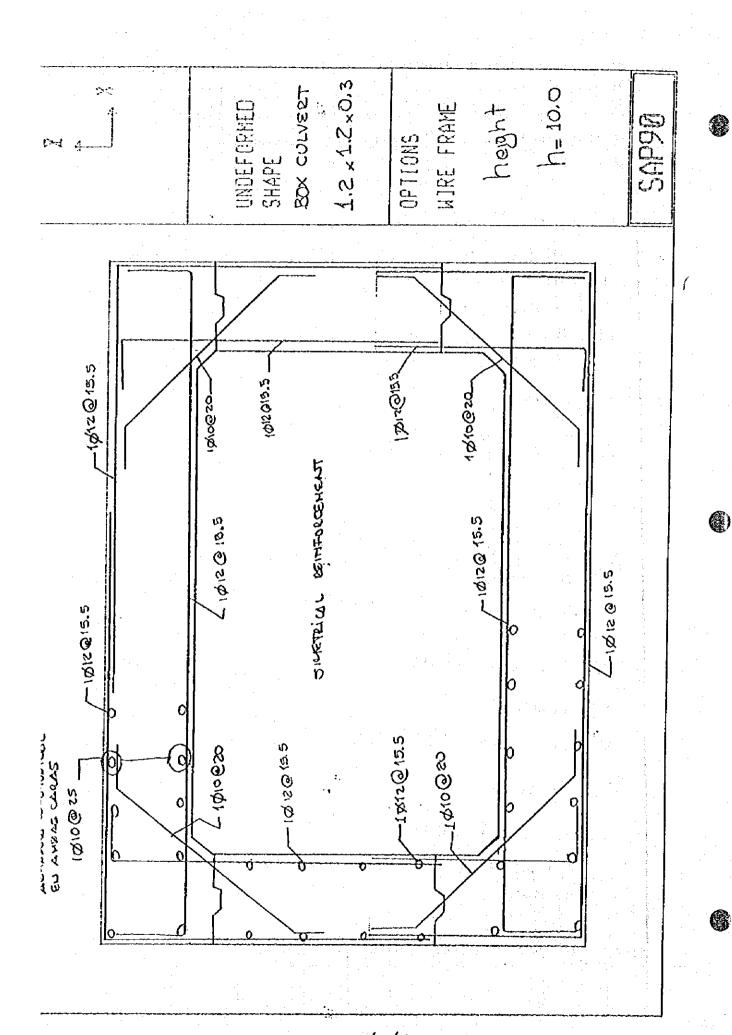


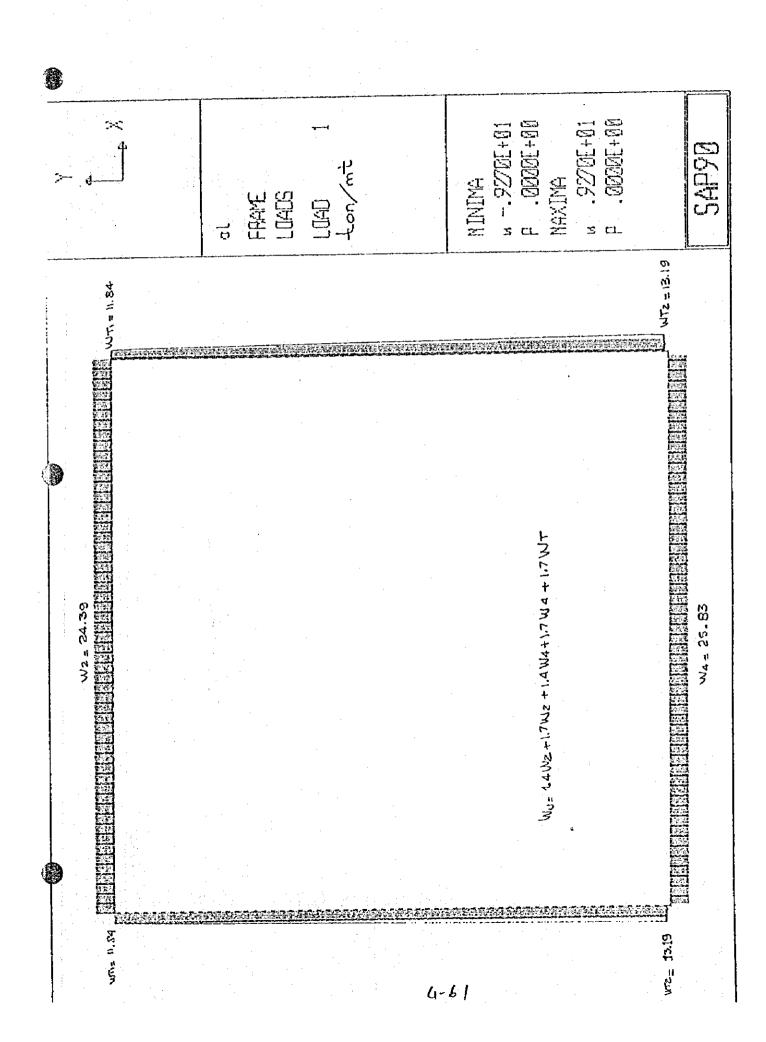




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