JAPAN INTERNATIONAL COOPERATION AGENCY

CENTRO DE REHABILITACION DE MANABI (CRM)
THE REPUBLIC OF ECUADOR

THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE - PORTOVIEJO RIVER BASINS

FINAL REPORT
VOLUME VI

DESIGN CALCULATION REPORT

MARCH 1996

NIPPON KOEI CO., LTD.
Tokyo, Japan

JAPAN INTERNATIONAL COOPERATION AGENCY

CENTRO DE REHABILITACION DE MANABI (CRM)
THE REPUBLIC OF ECUADOR

THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE - PORTOVIEJO RIVER BASINS

FINAL REPORT
VOLUME VI

DESIGN CALCULATION REPORT

MARCH 1995

NIPPON KOEI CO., LTD.
Tokyo, Japan

FINAL REPORT

LIST OF REPORTS

Volume	Title
I.	MAIN REPORT (SUMMARY)
II.	MAIN REPORT
III.	MAIN REPORT (ANNEX 1)
	1. DESIGN CRITERIA
	2. HYDROLOGICAL STUDY
	3. WATER TRANSBASIN PLAN
IV.	MAIN REPORT (ANNEX 2)
	4. GEOLOGY AND CONSTRUCTION MATERIALS
V.	MAIN REPORT (ANNEX 3)
	5. ENVIRONMENTAL STUDY
VI.	DESIGN CALCULATION REPORT
VII.	QUANTITY CALCULATION REPORT
VIII.	CONSTRUCTION PLAN AND SCHEDULE
IX.	COST ESTIMATE
X.	IMPLEMENTATION PROGRAM
XI.	DESIGN DRAWINGS

1. Pump House

LIST OF CALCULATION SHEET

1. Pump House

1.1 Substructure

(1) Stability Analysis

(2) Structural Calculation

1.2 Superstructure

1.2.1 Pump House

1.2.2 Generator House

1.3 Utility

(1) Conductor Calculation

(2) Lighting Design

(3) Earthing System

(4) Ventilation and Air Conditioning

(5) Sanitary Installations

2. Penstock

2.1 Stability Analysis of Anchor Block

3. Head Tank

3.1 Structural Analysis of Head Tank

4. Open Channel

4.1 Hydraulic Calculation

4.2 Structural Calculation

5. Tunnels

5.1 Hydraulic Calculation of Diversion Tunnel

5.2 Tunnel Structural Analysis by FEM

5.3 Tunnel Structural Analysis for Inlet and Outlet Structures

5.3.1 Design conditions

5.3.2 Required Reinforcing Bar Areas

1.1 Substructure

1. PUMP HOUSE

1.1 Substructure

Preliminary Consideration of Structural System

Structural System

To determine the structural system of pump house substructure , following are considered and analysed for the finalization of design :

i) Stabilize the structure against great hydrostatic and earth pressure.
ii) Minimize the deflection of structure for overhead travelling crane.
iii) Consider the stress against temperature change before and after completion of structure.

To the above subject, following consideration and analysis were made and employed for the detailed design.

Frame structural system

To minimize the concrete volume and stabilize against great hydraulic and earth pressure acting on the structure , frame structural system was employed and designed instead of wall structural system or other system. Frame structural system also gives advantage to minimize the deflection of column for crane girder. Therefore, at the top of substructure, roof beams ridged with columns are employed.

Measure against crack of concrete and temperature force

To prevent objectionable intermediate crack in concrete generated by temperature change and heat of hydration , the expansion joint is provided betwen No.3 and No.4 pumping units. The contraction joint gives advantage to relieve tensile stresss induced by shrinkage and heat of hydrant. To keep the waterlighyness, PVC waterstop is provided. Reinforcement for shrinkage and temperature stress is also provided. To check the stress induced by temperature change and confirm the stability against cracks generated by stress (moment, shearing, etc.) , structural analysis and calculation are made.

1

(1) Stabilitv Analysis

(A) General

Pump house building is divided into two blocks by expansion joint , i.e. , transformer yard side block and erection bay side block.

The structural stability is analyzed to assure safety against overturning , sliding , floating , and bearing capacity of foundation rock.
The following three cases are included in the stability analysis :

Case - I : After completion of construction

The external forces acting on the substructure include dead load, minimum hydrostatic pressure by lake water, earth pressure at rest by backfill, surcharge pressure and uplift.

Case - II : Normal Condition

Pump station complete and operating without earthquake effects :

The external forces acting on the substructure include dead load, maximum hydrostatic pressure by lake water, earth pressure at rest by backfill, groundwater pressure, surcharge pressure and the uplift.

Case - III : Seismic Condition

Pump station complete and operating with earthquake :

In addition to the external forces in Case - II , earthquake load is considered.

(B) Structural Model

The pump house is divided into two blocks, i.e., transformer yard side machine bay and erection bay side machine bay. These blocks are built on sound rock foundation and each block is nearly symmetrical structure. The stability analysis is carried out for the transformer yard side block taking into consideration of symmetrical structure model.
The structural model for the stability analysis is shown in Fig.1.1.1

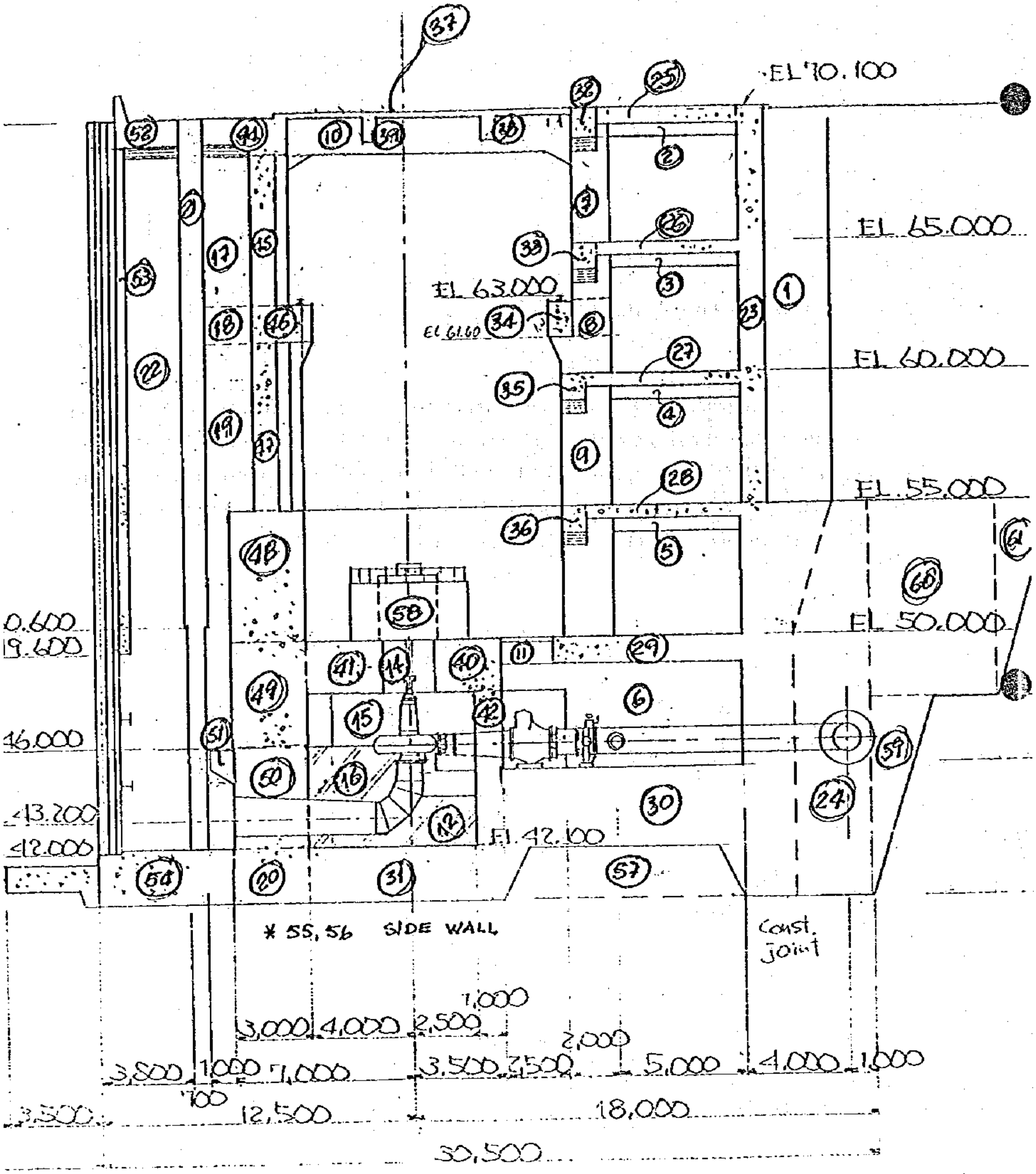


Fig.1.1.1 SECTION E-E SCALE A

4

(C) Self Weight and Center of Gravity

The self-weight and center of gravity of main body, pump and motor.

Self-weight and the center of gravity

No.	V (m3)	W (ton)	X (m)	Y (m)	W.X (t-m)	W.Y (t-m)
1	318.75	765.00	27.75	22.50	21228.75	17212.50
2	13.75	33.00	23.00	29.25	759.00	965.25
3	13.75	33.00	23.00	24.25	759.00	800.25
4	13.75	33.00	23.00	19.25	759.00	635.25
5	13.75	33.00	23.00	14.25	759.00	470.25
6	154.00	369.60	22.00	7.00	8131.20	2587.20
7	57.75	138.60	19.75	27.50	2737.35	3811.50
8	11.55	27.72	19.75	22.30	547.47	618.16
9	127.60	306.24	19.50	15.80	5971.68	4838.59
10	84.70	203.28	13.50	29.40	2744.28	5976.43
11	35.00	84.00	17.00	9.50	1428.00	798.00
12	85.50	205.20	13.75	2.95	2821.50	605.34
13	0.00	0.00	22.75	29.75	0.00	0.00
14	70.00	168.00	12.50	9.00	2100.00	1512.00
15	178.48	428.35	11.75	5.05	5033.14	2163.18
16	280.80	673.92	10.50	3.95	7076.16	2661.98
17	125.40	300.96	6.05	26.00	1820.81	7824.96
18	29.26	70.22	6.05	22.30	424.86	1566.00
19	407.55	978.12	11.75	15.75	11492.91	15405.39
20	159.00	381.60	7.00	1.00	2671.20	381.60
21	90.72	217.73	4.15	16.00	903.57	3483.65
22	585.20	1404.48	1.90	16.00	2668.51	22471.68
23	352.50	846.00	26.00	22.50	21996.00	19035.00
24	1987.50	4770.00	28.00	7.50	133560.00	35775.00
25	64.63	155.11	22.75	29.75	3528.80	4614.58
26	64.63	155.11	22.75	24.75	3528.80	3839.02
27	70.50	169.20	22.75	19.75	3849.30	3341.70
28	70.50	169.20	22.75	14.75	3849.30	2495.70
29	176.25	423.00	21.75	9.50	9200.25	4018.50
30	1258.75	3021.00	20.75	2.50	62685.75	7552.50
31	397.50	954.00	12.25	1.00	11686.50	954.00
32	19.80	47.52	19.50	29.45	926.64	1399.46
33	18.00	43.20	19.50	24.50	842.40	1058.40
34	32.90	78.96	18.50	22.30	1460.76	1760.81
35	18.00	43.20	19.00	19.50	820.80	842.40
36	18.00	43.20	19.00	14.50	820.80	626.40
37	51.70	124.08	13.50	29.90	1675.08	3709.99
38	10.58	25.39	11.25	29.35	285.66	745.26
39	10.58	25.39	15.75	29.35	399.92	745.26
40	117.50	282.00	14.75	9.00	4159.50	2538.00

(continued)

No.	V (m3)	W (ton)	X (m)	Y (m)	W.X (t-m)	W.Y (t-m)
41	141.00	338.40	10.00	9.00	3384.00	3045.60
42	126.85	304.44	15.50	5.05	4718.82	1637.42
43		0.00	2.75	1.05	0.00	0.00
44	82.25	197.40	6.25	29.50	1233.75	5823.30
45	133.95	321.48	7.00	25.55	2250.36	8213.81
46	63.00	151.20	7.75	22.30	1171.80	3371.76
47	155.10	372.24	7.00	18.30	2605.68	6811.99
48	352.50	846.00	7.00	12.50	5922.00	10575.00
49	282.00	676.80	7.00	8.00	4737.60	5414.40
50	274.95	659.88	7.00	3.95	4619.16	2606.53
51	18.90	45.36	5.03	5.30	228.16	240.41
52	58.75	141.00	2.45	29.50	345.45	4159.50
53	174.60	419.04	1.25	19.30	523.80	8087.47
54	258.50	620.40	2.75	1.00	1706.10	620.40
55	1087.50	2610.00	14.50	22.50	37845.00	58725.00
56	1305.00	3132.00	14.50	7.50	45414.00	23490.00
57	-153.00	-367.20	20.75	0.67	-7619.40	-246.02
58	-63.00	-151.20	20.75	2.50	-3137.40	-378.00
Motor	405.00	405.00	12.50	11.00	5062.50	4455.00
59	223.59	536.62	31.25	5.00	16769.25	2683.08
60	944.06	2265.74	32.88	11.25	74497.66	25489.62
61	223.59	536.62	36.00	12.50	19318.18	6707.70
TOTAL	13691.17	32291.81			569710.11	373275.10

W = 32291.81 ton

X = Mx/W = 17.64 m

Y = My/W = 11.56 m

(D) Stability Analysis

External forces acting on substructure such as earth pressure, hydrostatic pressure and uplift pressure and their center of gravity are calculated as below.
Stability analysis of the structure is made based on self-weight and the external forces calculated. The following criterion are adopted in the stability analysis.

Overturning $= \Sigma V.x / \Sigma H.y$

Sliding $= (\Sigma W\text{-}U).f + C.A / \Sigma H$

Bearing Capacity $= V/B.L\ (1 \pm 6e/L)$

Floating $= \Sigma W/U$

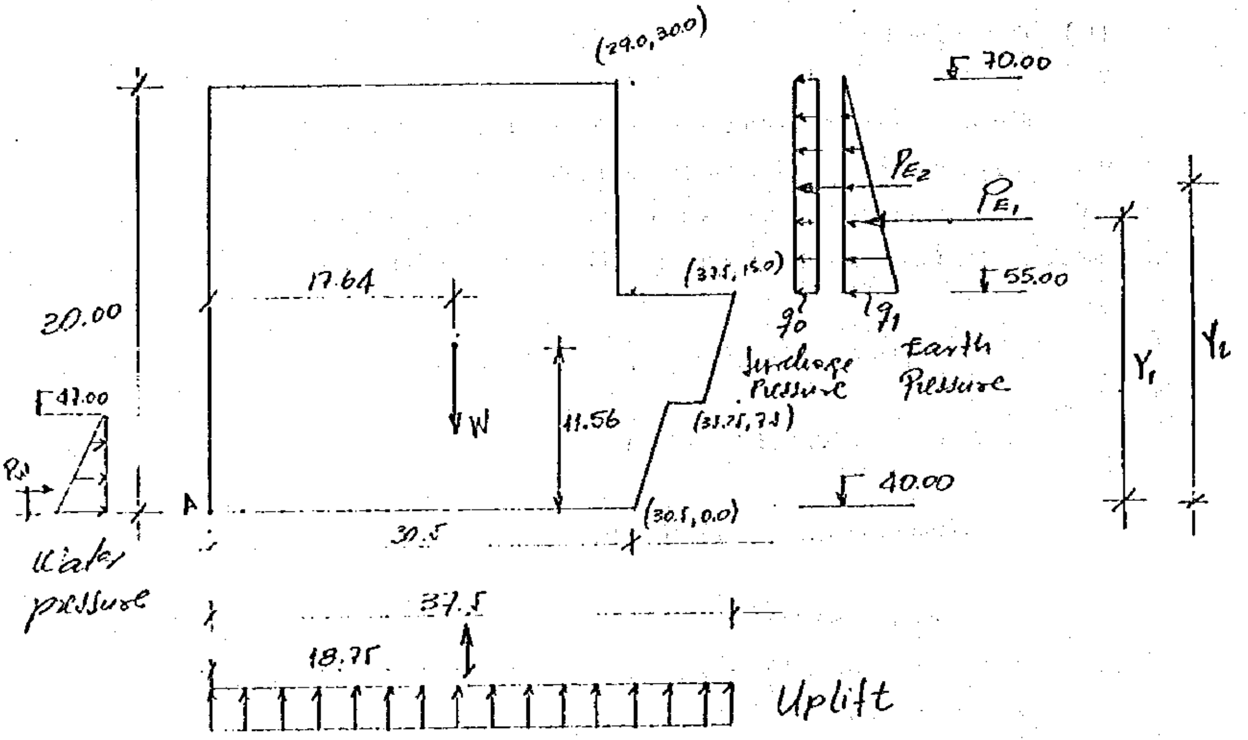
where : ΣV = Sum of vertical forces.
ΣH = Sum of horizontal forces.
x = distance from reference line to center of gravity.
y = distance from reference line to center of gravity.
ΣW = Sum of vertical forces except up-lift.
U = Uplift.
f = Coefficient of friction between concrete and foundation rock. (0.65)
C = Cohesion between concrete and foundation rock. (50 t/m2)
A = Area of base on foundation.
e = eccentricity.
B = width of foundation.
L = length of foundation.

Allowable minimum factors of safety are as follows :

Loading Conditions	overturning	sliding	flotation
Case I , III	1.1	2.0	1.1
Case II	1.2	4.0	1.2

The stability in each case mentioned in sub-section (A) is checked and calculated as below.

CASE I : AFTER COMPLETION OF CONSTRUCTION



1) LATERAL EARTH PRESSURE

i) INTENSITY OF EARTH PRESSURE AND SURCHARGE

$q_0 = \gamma t \cdot Ka \cdot h_1$, $q_1 = \gamma t \cdot Ka \cdot h_2$

$\gamma t = 1.8\ t/m^3$ $Ka = 0.5$ $h_1 = 0.61\ m$ $h_2 = 15.00\ m$.

$q_0 = 1.8\,(0.5)\,(0.61) = 0.55\ t/m^2$.

$q_1 = 1.8\,(0.5)\,(15.00) = 13.50$ "

ii) Earth Pressure and the acting point.

$P_{E1} = q_0 \cdot h_2 \cdot B = 0.55\,(15.0)\,(26.50) = 218.23\ t.$

$Y_1 = \frac{1}{2} h + 15.0 = 7.5 + 15.0 = 22.50\ m$

$P_{E_2} = \frac{1}{2}\,(13.50)\,(15.00)\,(26.5) = 2683.13\ t$

$Y_2 = \frac{1}{3} h_2 + 15 = \frac{1}{3}\,(15.00) + 15 = 20.0\ m.$

2) WATER PRESSURE (outlet side)

$P_W = \frac{1}{2}\,\gamma\, h^2 \cdot B = \frac{1}{2}\,(7.0)^2\,(26.50) = 649.25\ t.$

$Y = \frac{1}{3}h = 1/3(7.0) = 2.33$ m.

3) UPLIFT

$U = (47.0 - 40.0)(37.50)(26.50) = 6956.25$ t.

$X = L/2 = 37.5/2 = 18.75$ m.

STABILITY ANALYSIS (case I)

DESCRIPTION	V (ton)	H (ton)	X (m)	Y (m)	V . X (t-m)	H . Y (t-m)
Self-Weight	32291.81		17.64		569710.11	
Uplift	-6956.25		18.75		-130429.69	
Earth Pressure I		-218.23		22.50		-4910.18
Earth Pressure II		-2683.13		20.00		-53662.60
Water Pressure		649.25		2.33		1512.75
TOTAL	25335.56	-2252.11			439280.42	-57060.02

a) stability against overturning.

$$Fs = \frac{\sum V\,X}{\sum H.Y} = \frac{439280.42}{57060.02} = 7.7 > 1.1 \quad O.K.$$

b) Stability against sliding

$$n = \frac{f.V + \tau_o.B.L}{H}$$

donde

n = safety factor ≥ 2.0

f = coefficient of friccion $f = 0.65$

τ_o = shearing strength of foundation $= 50$ t/m²

H = horizontal force (t.)

L = resisting length of foundation (m)

V = vertical force (t)

$$n = \frac{0.65 \times 25335.56 + 50 \times 26.50 \times 37.50}{2252.11} = 29.4 > 2.0$$

O.K.

c) stability against floating.

$$F = \frac{\Sigma W}{u} = \frac{32291.81}{6956.25} = 4.6 > 1.1 \quad O.K.$$

1-1-10

d) Stability against bearing capacity of foundation (with uplift pressure)

$$e = \left| \frac{37.50}{2} - \frac{439280.42 - 57060.02}{25335.56} \right| = 3.66\,m.$$

$e < l/6$

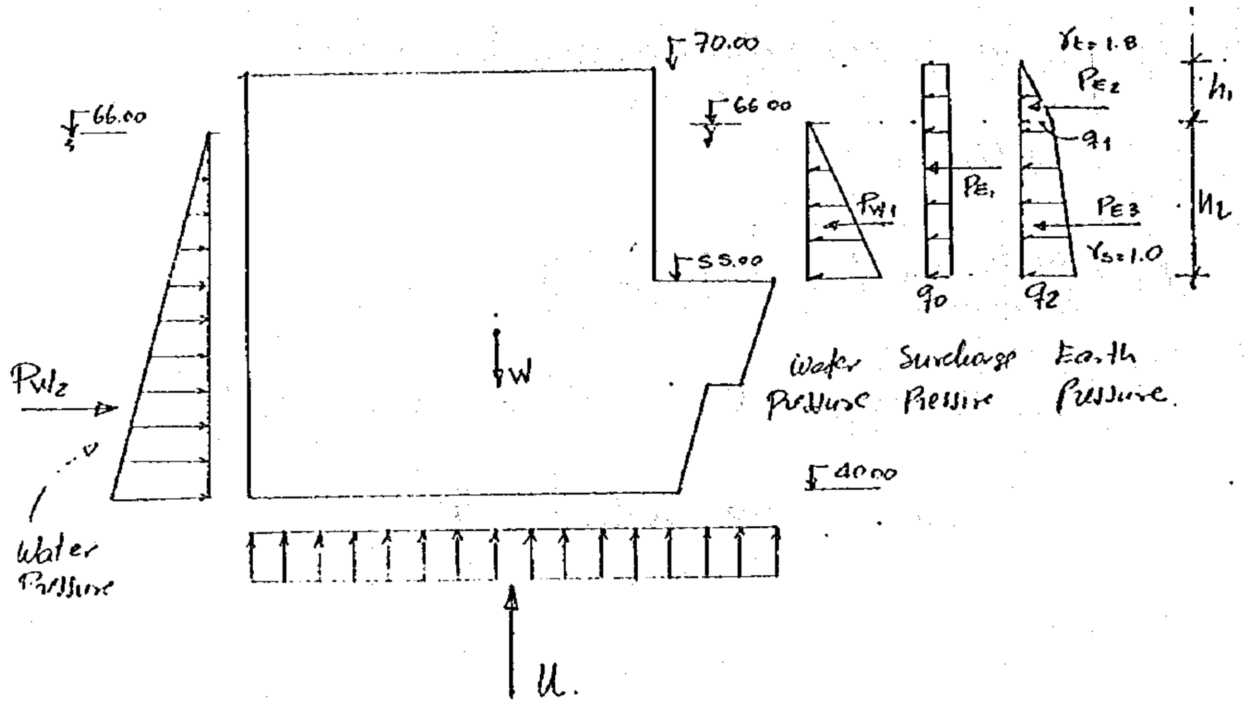
$$q = \frac{25335.56}{26.5 \times 37.5} \left(1 \pm \frac{6 \times 3.66}{37.50} \right) =$$

$q_{max} = 40.42\ t/m^2$ $q_{min} = 10.57\ t/m^2$

$q_{max} < 100\ t/m^2$ O.K.

1-1-11

CASE II : NORMAL CONDITION



1.-) LATERAL EARTH PRESSURE

1.1 Intensity of earth Pressure

$q_0 = \gamma_t \cdot K_a \cdot h_s = 1.8\,(0.5)(0.61) = 0.55\ t/m^2$

$q_2 = K_a \cdot \gamma_s \cdot h_2 + K_a \cdot \gamma_t \cdot h_1$

$q_2 = 0.5\,(1.0)(11.0) + 0.5\,(1.8)(4.00) = 9.10\ t/m^2$

$q_1 = 0.5(1.8)(4.0) = 3.60\ t/m^2$

1.2 Earth Pressure and the acting point

$P_{E1} = q_0 \cdot (h_1 + h_2) \cdot B = 0.55\,(15.0)(26.50) = 218.63\ t.$

$Y_1 = (h_1 + h_2)/2 + 15.0 = 22.50\ m.$

$P_{E2} = \frac{1}{2} \cdot q_1 \cdot h_1 \cdot B = 1/2\,(3.60)(4.0)(26.5) = 190.80\ t$

$Y_2 = \frac{1}{3} h_1 + 26.0 = 1/3\,(4.0) + 26.0 = 27.33\ m.$

$P_{E3} = \left(\frac{q_1 + q_2}{2}\right) h_2 \cdot B = \left(\frac{3.6 + 9.10}{2}\right) 11.0\,(26.50) = 1851.03\ t$

$$Y_3 = \frac{h_2}{3}\left(\frac{2q_1+q_2}{q_1+q_2}\right)+15 =$$

$$Y_3 = \frac{11.0}{3}\left(\frac{2\times 3.60 + 9.10}{3.60+9.10}\right)+15 = 19.71\ m.$$

1.3 Water Pressure I (Inlet side)

$$P_{w1} = \frac{1}{2}\cdot h^2\cdot B = \frac{1}{2}(11.0)^2(26.50) = 1603.25\ t.$$

$$Y_1 = \frac{1}{3}(11.0) + 15.0 = 18.67\ m$$

1.4 Water Pressure II (Outlet side)

$$P_{w2} = \frac{1}{2}\cdot h^2\cdot B = \frac{1}{2}\cdot(26.0)^2\cdot(26.50) = 8957.00\ t.$$

$$Y_2 = \frac{1}{3}(26.0) = 8.67\ m.$$

1.5 Uplift

$$U = (66.0-40.0)(37.50)(26.50) = 25837.50\ t.$$

$$X = L/2 = 18.75$$

2.- STABILITY ANALYSIS (case II)

DESCRIPTION	V (ton)	H (ton)	X (m)	Y (m)	V . X (t-m)	H . Y (t-m)
Self-Weight	32291.81		17.64		569710.11	
Uplift	-25837.50		18.75		-484453.13	
Earth Pressure I		-218.63		22.50		-4919.18
Earth Pressure II		-190.80		27.33		-5214.66
Earth Pressure III		-1851.03		19.71		-36483.80
Water Pressure I		-1603.25		18.67		-29932.68
Water Pressure II		8957.00		8.67		77657.19
TOTAL	6454.31	5093.29			85256.99	1106.97

a) Stability against overturning.

$$F_S = \frac{\Sigma V.x}{\Sigma H.Y} = \frac{85256.99}{1106.97} = 77.02 > 1.2 \quad O.K.$$

b) Stability against sliding.

$$n = \frac{f.V + T_o.B.L}{H}$$

$$n = \frac{0.65 \times 6454.31 + 50 \times 26.5 \times 37.50}{5093.29} = 10.6 > 4.0$$

O.K.

1-1-14

c) Stability against floating

$$F_s = \frac{\Sigma W}{U} = \frac{32291.81}{25837.50} = 1.25 > 1.2$$

O.K.

d) stability against bearing capacity of foundation (with uplift pressure).

$$e = \left| \frac{37.50}{2} - \frac{85256.99 - 1106.97}{6454.31} \right| = 5.71$$

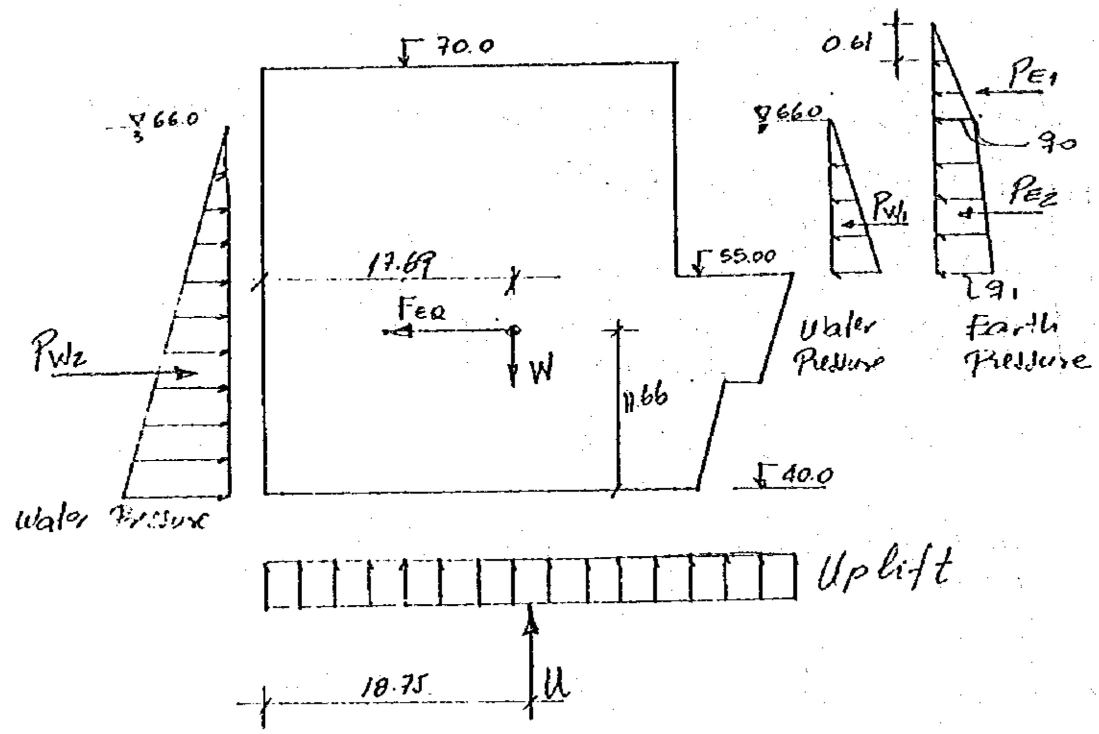
$L/6 = 6.25 \qquad e < L/6$

$$q = \frac{6454.31}{26.5 \times 37.5} \left(1 \pm \frac{6 \times 5.71}{37.5} \right) =$$

$q_{max} = 12.43\ t/m^2 \qquad q_{min} = 0.56\ t/m^2$

$q_{max} < q_a = 100\ t/m^2$

CASE III : SEISMIC CONDITION
(CASE II + EARTHQUAKE)



1.- LATERAL EARTH PRESSURE

1.1 Earth pressure and the acting point

P_{E1} = 218.63 t. Y_1 = 22.50 m.

P_{E2} = 190.80 t Y_2 = 27.33 m.
P_{E3} = 1851.03 t Y_3 = 19.71 m.

1.2 Water Pressure I (inlet side)

P_{W1} = 1603.25 t Y_1 = 18.67 m.

1.3 Water Pressure II (outlet side)

P_{W2} = 8957.0 t Y_2 = 8.67 m

1.4 Uplift

U = 25837,50 t X = 18.75 m.

1.5 Earthquake force

F_{EQ} = 0.15 W = 0.15(32291.81) = 4843.77 ton

Y = 11.56 m

1-1-16

STABILITY ANALYSIS (case III)

DESCRIPTION	V (ton)	H (ton)	X (m)	Y (m)	V . X (t-m)	H . Y (t-m)
Self-Weight	32291.81		17.64		569710.11	
Uplift	-25837.50		18.75		-484453.13	
Earth Pressure I		-218.63		22.50		-4919.18
Earth Pressure II		-190.80		27.33		-5214.66
Earth Pressure III		-1851.03		19.71		-36483.80
Water Pressure I		-1603.25		18.67		-29932.66
Water Pressure II		8957.00		8.67		77657.19
Earthquake Force		-4843.77		11.56		-55991.27
TOTAL	6454.31	249.52			85256.99	-54884.29

a) Stability against overturning

$$F_s = \frac{\sum V.X}{\sum H.Y} = \frac{85256.99}{54884.29} = 1.6 = 1.1 \quad O.K.$$

b) Stability against sliding

$$n = \frac{0.65 \times 6454.31 + 50 \times 26.5 \times 37.50}{249.52} = 215.9 > 2.0$$

O.K

1-1-17

c) Stability against floating

$$F_s = \frac{\Sigma W}{U} = \frac{32291.81}{25837.50} = 1.25 > 1.1 \quad O.K.$$

d) Stability against bearing capacity of foundation (with uplift).

$$e = \left| \frac{37.50}{2} - \frac{85256.99 - 249.52}{6464.31} \right| = 5.58$$

$$\frac{L}{6} = 6.25 \qquad e < L/6.$$

$$q = \frac{6454.31}{26.5 \times 37.5} \left(1 \pm \frac{6 \times 5.58}{37.5} \right)$$

$q_{max} = 12.29\ t/m^2 \qquad q_{min} = 0.70\ t/m^2$

$q_{max} < 100\ t/m^2 \qquad$ O.K.

SUMMARY			
CASE	1	II	III
Overturning	7.7	77.0	1.6
Sliding	29.4	10.6	215.9
Floating	4.6	1.3	1.3
B.Capacity :			
qmax =	40.42	12.43	12.29
qmin =	10.67	0.56	0.70

(2) Structural Calculation

(A) Structural Analysis Frame

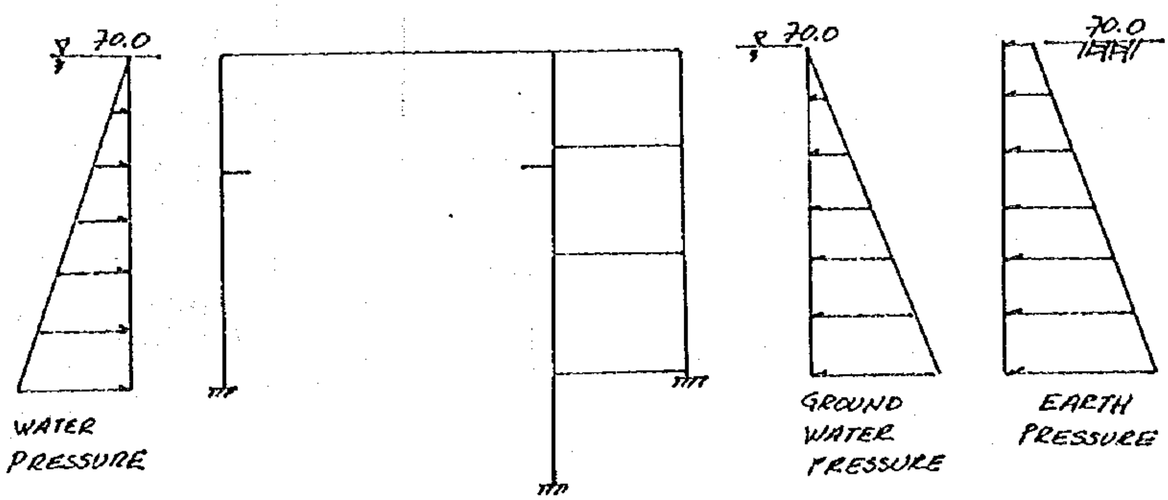
(a) Frame model

In analyzing the stress of respective structural members of the pump house, was made applying the SAP90 computer program, (Structural Analysis Program), that use the Finit Element Method. This program represent the research work conducted at the University of California, Berkeley, by Professor Edward L. Wilson.

(b) Loading condition

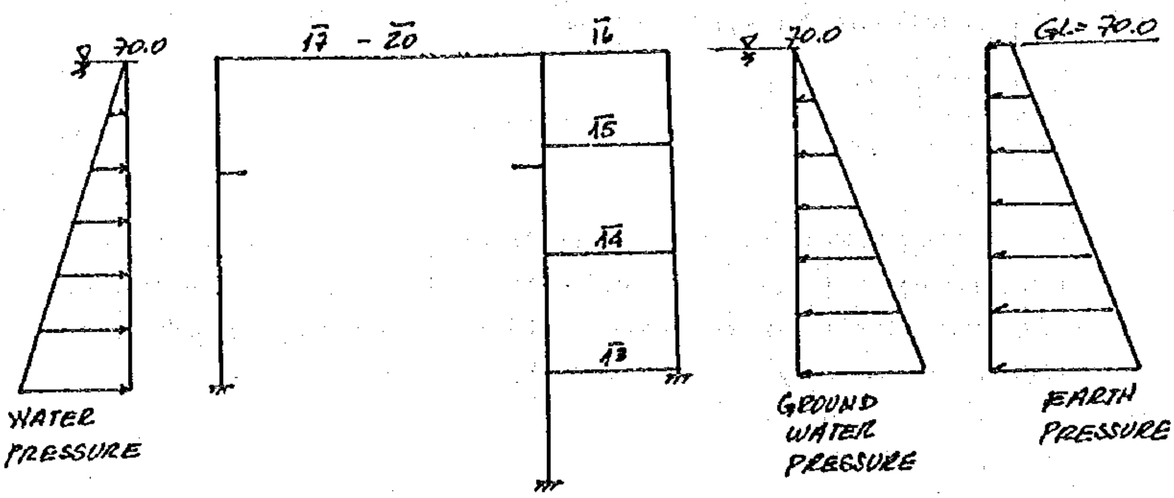
Loading condition of six cases are shown below figures as stated in Fig.1.1.

Case - I Normal condition

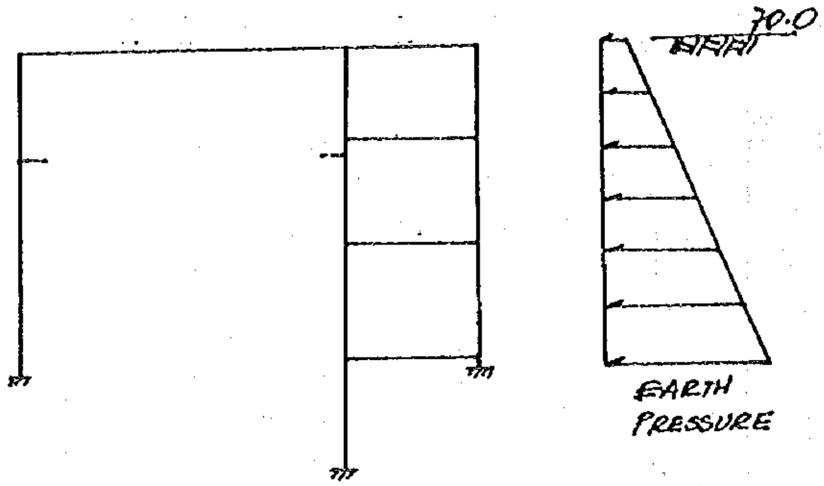


Case - II & III Temperature change

Under sudden 10 ° C increase (Case - II) and decrease (Case - III), eigtht members shown on the following figure are analyzed.

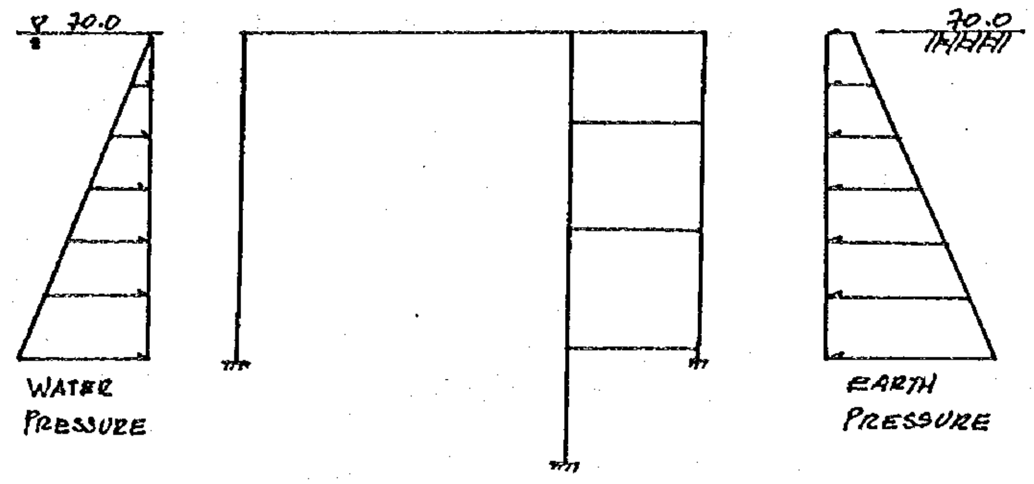


Case - IV Completion time - 1 (Just after completion)

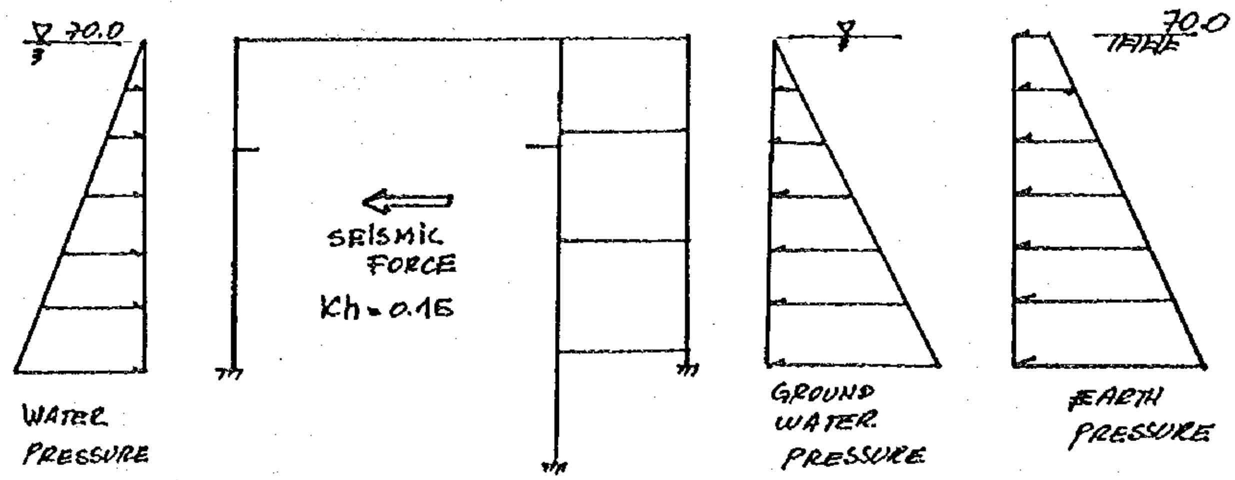


20

Case - V Completion - 2 (before operation)



Case - VI Seismic condition



(C) Structural calculation

(a) Nodes and members

Nodes, members and geometrical dimensions applied in this calculation are shown in table 1.1.1 and Fig. 1.1.2

Coordinates :

Joint	X	Y	Joint	X	Y
1	0.0	5.0	11	19.00	4.50
2	0.0	9.0	12	19.00	5.00
3	0.0	12.80	13	19.00	10.00
4	0.0	19.75	14	19.00	15.00
5	12.5	0.00	15	19.00	19.75
6	12.5	5.00	16	4.25	19.75
7	12.5	10.00	17	6.50	19.75
8	12.5	12.80	18	8.75	19.75
9	12.5	15.00	19	1.00	12.80
10	12.5	19.75	20	11.50	12.80

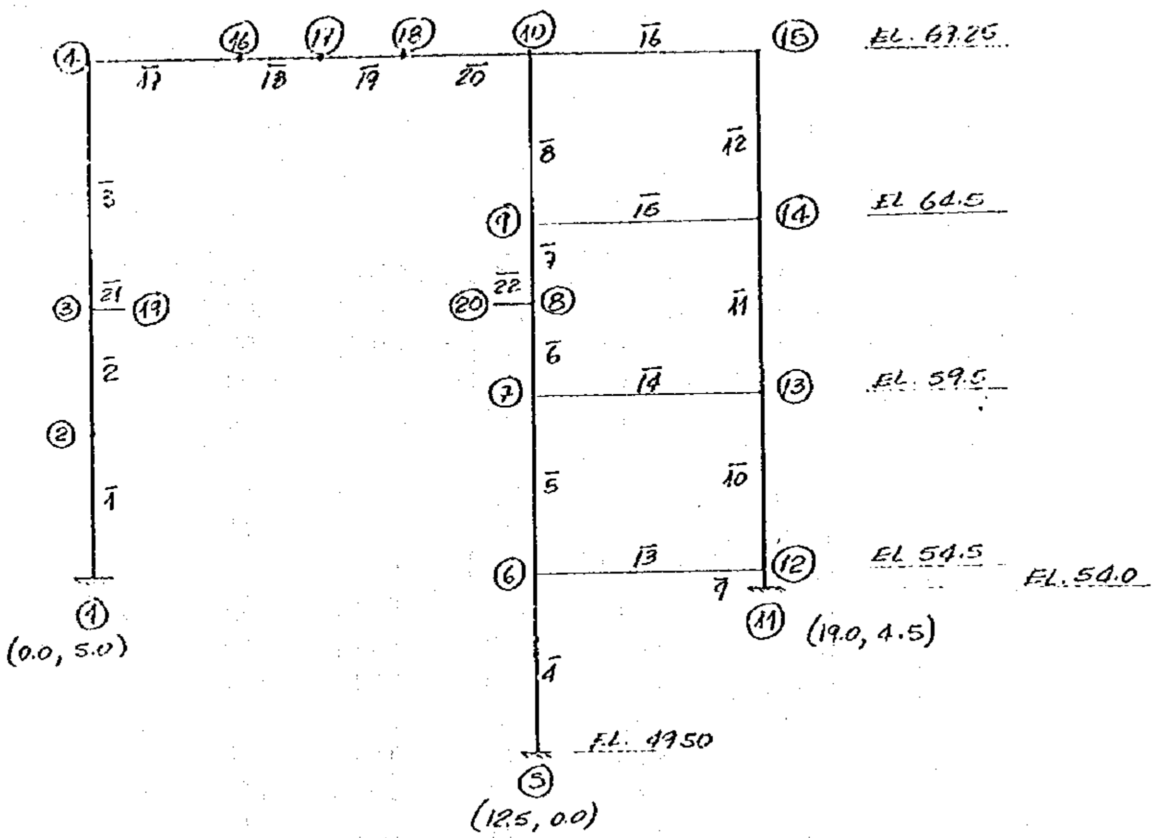
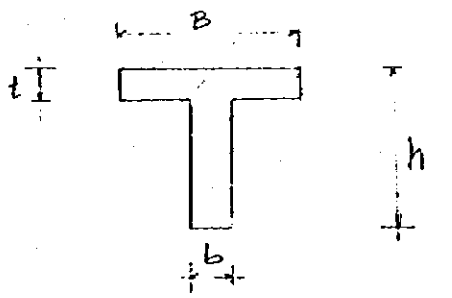


FIG. 1.1.2 NUMBER OF NODES AND MEMBERS

23

Table 1.1. Geometry of members

MEMBER	JOINT	B (m)	b (m)	t (m)	h (m)
1	1 - 2	4.00	2.00	1.00	4.00
2	2 - 3	4.00	2.00	1.00	4.00
3	3 - 4	4.00	2.00	1.00	3.50
4	5 - 6	2.00	2.00	-	2.00
5	6 - 7	2.00	2.00	-	2.00
6	7 - 8	2.00	2.00	-	2.00
7	8 - 9	2.00	2.00	-	2.00
8	9 - 10	2.00	2.00	-	2.00
9	11 - 12	4.00	2.00	1.00	3.50
10	12 - 13	4.00	2.00	1.00	3.50
11	13 - 14	4.00	2.00	1.00	3.50
12	14 - 15	4.00	2.00	1.00	3.50
13	6 - 12	1.65	1.00	0.50	1.00
14	7 - 13	1.65	1.00	0.50	1.00
15	9 - 14	1.65	1.00	0.50	1.00
16	10 - 15	1.65	1.50	0.50	1.50
17	4 - 16	1.50	1.50	-	1.50
18	16 - 17	1.50	1.50	-	1.50
19	17 - 18	1.50	1.50	-	1.50
20	18 - 10	1.50	1.50	-	1.50
21	3 - 19	2.00	2.00	-	1.50
22	20 - 8	2.00	2.00	-	1.50



(b) Loading condition in each member

Loading condition in each case and list of loads are shown in the following figures and tables.

List of Loads: Case - I (Just after completion)

Self-Weight and Uniform load

Symbol	Load	unit	Remarks
N1	33.60	t	(4x2+1x6)x2.4
N2	33.60	t	(4x2+1x6)x2.4
N3	31.20	t	(3.5x2+1x6)x2.4
N4	9.60	t	2x2x2.4
N5	9.60	t	2x2x2.4
N6	9.60	t	2x2x2.4
N7	7.20	t	2x1.5x2.4
N8	7.20	t	2x1.5x2.4
N9	31.20	t	(3.5x2+1X6)X2.4
N10	31.20	t	(3.5x2+1X6)X2.4
N11	31.20	t	(3.5x2+1X6)X2.4
N12	31.20	t	(3.5x2+1X6)X2.4
P1	34.20	t	
P2	34.20	t	
P3	34.07	t	
P4	28.32	t	
P5	28.32	t	
P6	96.74	t	
P7	84.45	t	
W1	1.20	t/m	1x5x2.4
W2	1.20	t/m	1x5x2.4
W3	1.20	t/m	1x5x2.4
W4	5.40	t/m	1.5x1.5x2.4
W5	5.04	t/m	1.4x1.5x2.4
W6	3.60	t/m	1.5x1x2.4
W7	13.20	t/m	(2.4x0.5+1)x6/2x2
W8	13.20	t/m	(2.4x0.5+1)x6/2x2
W9	12.10	t/m	(2.4x0.5+1)x5.5/2x2
W10	12.10	t/m	(2.4x0.5+1)x5.5/2x2
W11	3.16	t/m	(0.2x2.4+0.2x2+0.18)x3
W12	4.24	t/m	(0.2x2.4+0.2x2+0.18)x4
W13	3.16	t/m	

External Loads

Symbol	Load	unit	Remarks
Water pressure			
Pw1	118.00	t/m²	14.75x8
Pw2	86.00	t/m²	10.75x8
Pw3	55.60	t/m²	6.95x8.0
Pw4	118.00	t/m²	14.75x8.0
Pw5	114.00	t/m²	14.25x8.0
Pw6	74.00	t/m²	9.25x8.0
Pw7	34.00	t/m²	4.25x8.0
Earth pressure			
qo	2.44	t/m²	1.0x0.5x0.61x8.0
q1	61.00	t/m²	1.0x0.5x15.25x8.0
q2	59.00	t/m²	1.0x0.5x14.75x8.0
q3	39.00	t/m²	1.0x0.5x9.75x8.0
q4	19.00	t/m²	1.0x0.5x4.75x8.0

List of Loads: Case - II y III (Before operation)

Self-Weight and Uniform load (same case I)

External loads :

Water pressure	(same as case I)
Earth pressure	(same as case I)
Temperature	+10 °C , -10 °C

List of Loads: Case - IV (Just after completion)

Self-Weight and Uniform load (same case I)

External loads :
Earth Pressure

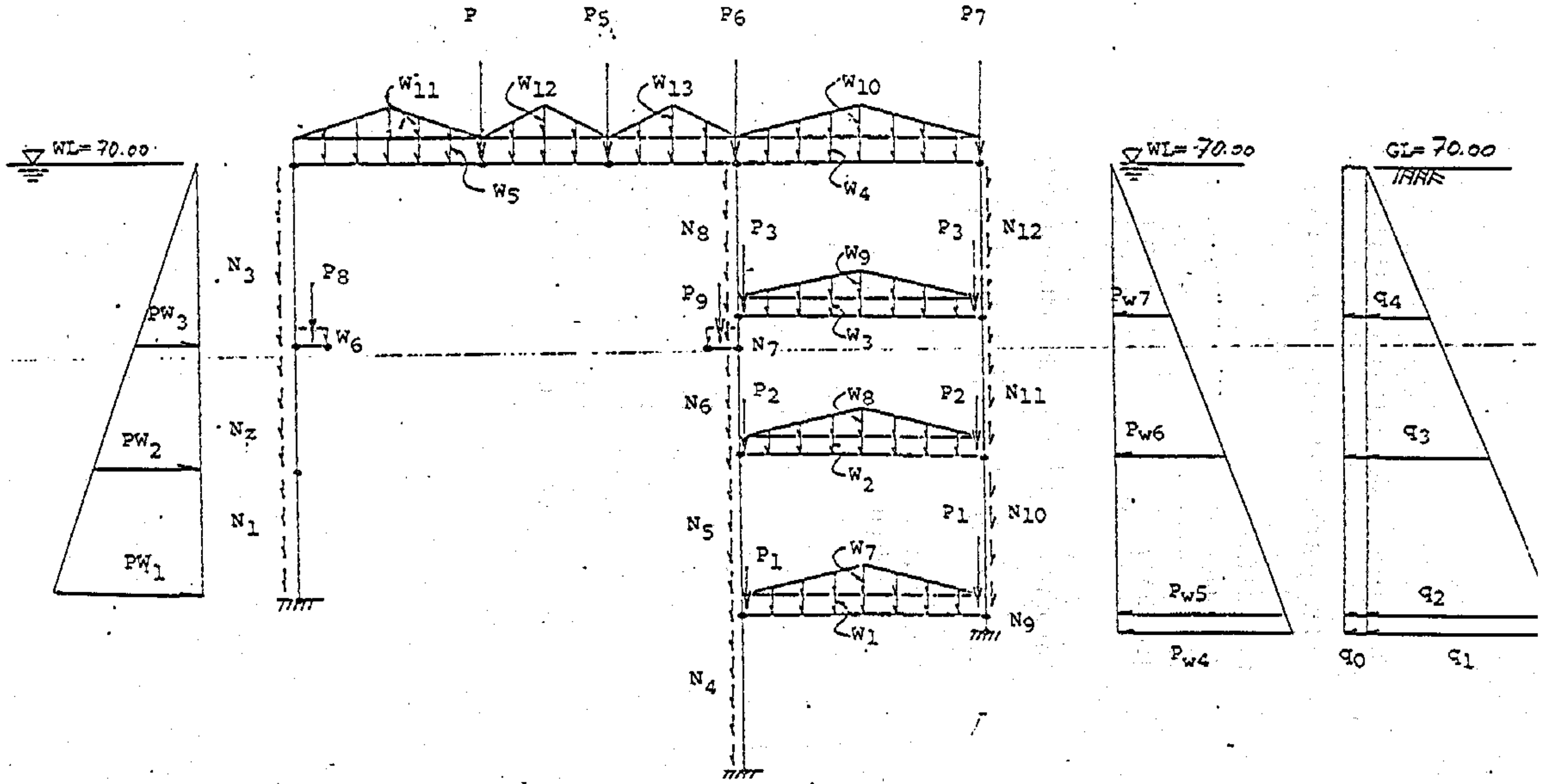
Symbol	Load	unit	Remarks
qo	4.39	t/m	1.80x0.5x0.61x8.0
q1	109.80	t/m	1.80x0.5x15.25x8.0
q2	106.20	t/m	1.80x0.5x14.75x8.0
q3	70.20	t/m	1.80x0.5x9.75x8.0
q4	34.20	t/m	1.80x0.5x4.75x8.0

FIG. 1.1.3 LOADING CONDITION

CASE - 1 NORMAL CONDITION.

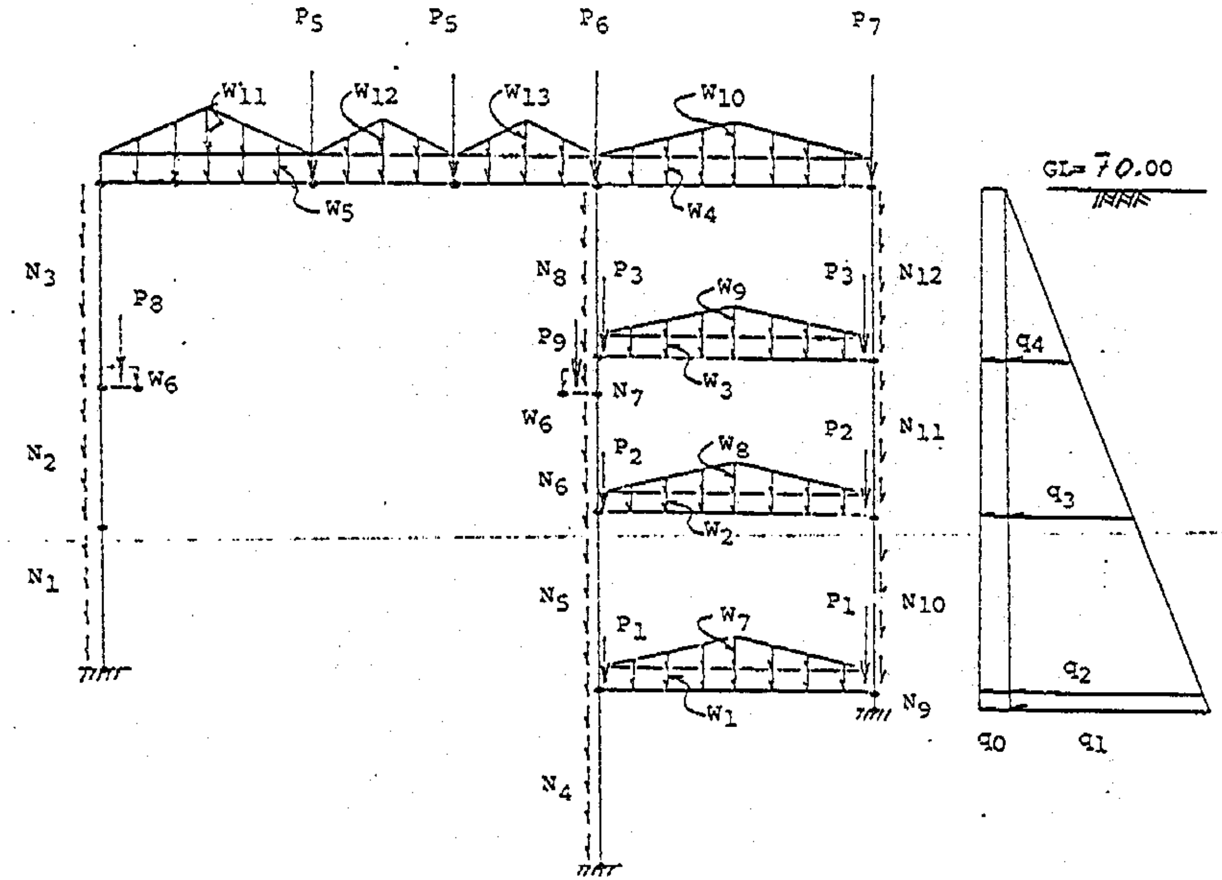
CASE - 2 TEMPERATURE CHANGE (+10°C)

CASE - 3 TEMPERATURE CHANGE (-10°C)



1-1-38

FIG. 1.1.4 LOADING CONDITION
CASE - 4



List of Loads: Case・V (Before operation)

Self-Weight and Uniform load (same case I)

External loads :
Earth pressure

Symbol	Load	unit	Remarks
qo	4.39	t/m	(same as case IV)
q1	109.80	t/m	(same as case IV)
q2	106.20	t/m	(same as case IV)
q3	70.20	t/m	(same as case IV)
q4	34.20	t/m	(same as case IV)

Water pressure

Symbol	Load	unit	Remarks
Pw1	118.00	t/m^2	(same as case I)
Pw2	86.00	t/m^2	(same as case I)
Pw3	55.60	t/m^2	(same as case I)
Pw4	118.00	t/m^2	(same as case I)
Pw5	114.00	t/m^2	(same as case I)
Pw6	74.00	t/m^2	(same as case I)
Pw7	34.00	t/m^2	(same as case I)

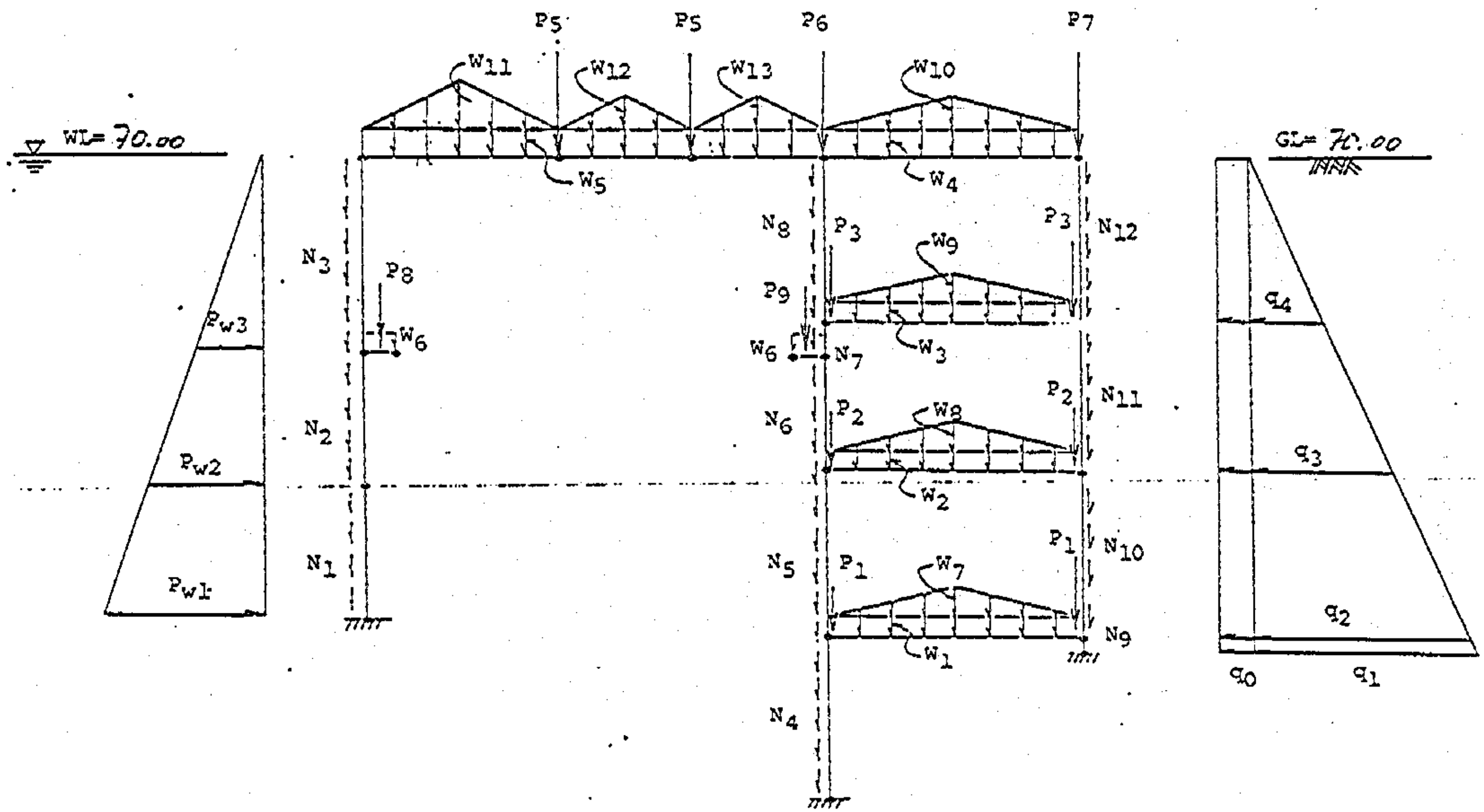


Fig. 1.1.5 Loading Condition, Case-V

List of Loads: Case - VI (Seismic condition)

Self-Weight and Uniform load (same case I)

External loads :

Symbol	Load	unit	Remarks
Water pressure			
Pw1	118.00	t/m^2	(same as case I)
Pw2	86.00	t/m^2	(same as case I)
Pw3	55.60	t/m^2	(same as case I)
Pw4	118.00	t/m^2	(same as case I)
Pw5	114.00	t/m^2	(same as case I)
Pw6	74.00	t/m^2	(same as case I)
Pw7	34.00	t/m^2	(same as case I)
Earth pressure			
qo	2.44	t/m^2	(same as case I)
q1	61.00	t/m^2	(same as case I)
q2	59.00	t/m^2	(same as case I)
q3	39.00	t/m^2	(same as case I)
q4	19.00	t/m^2	(same as case I)

Seismic Force
E = 0.15 W

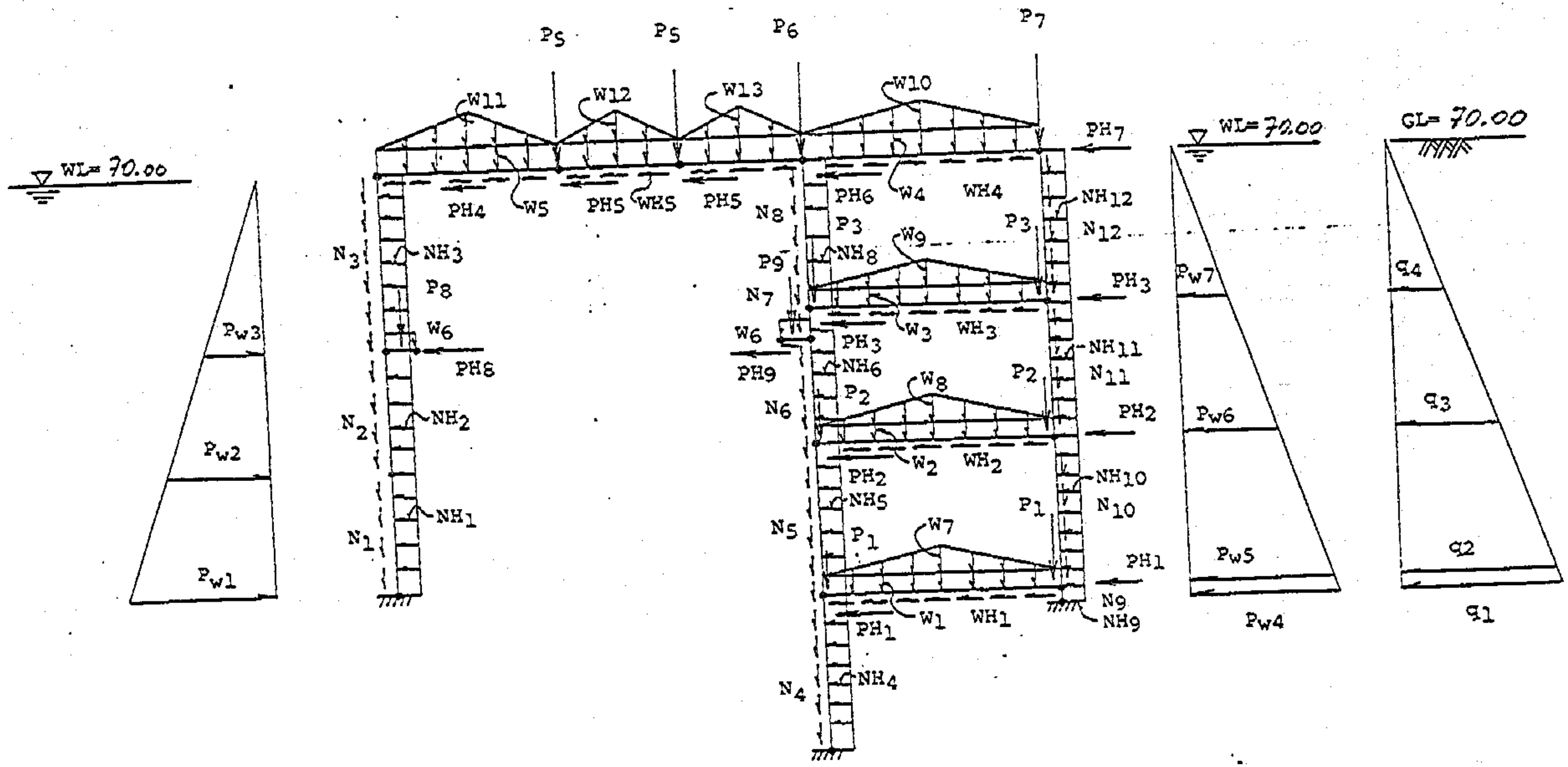


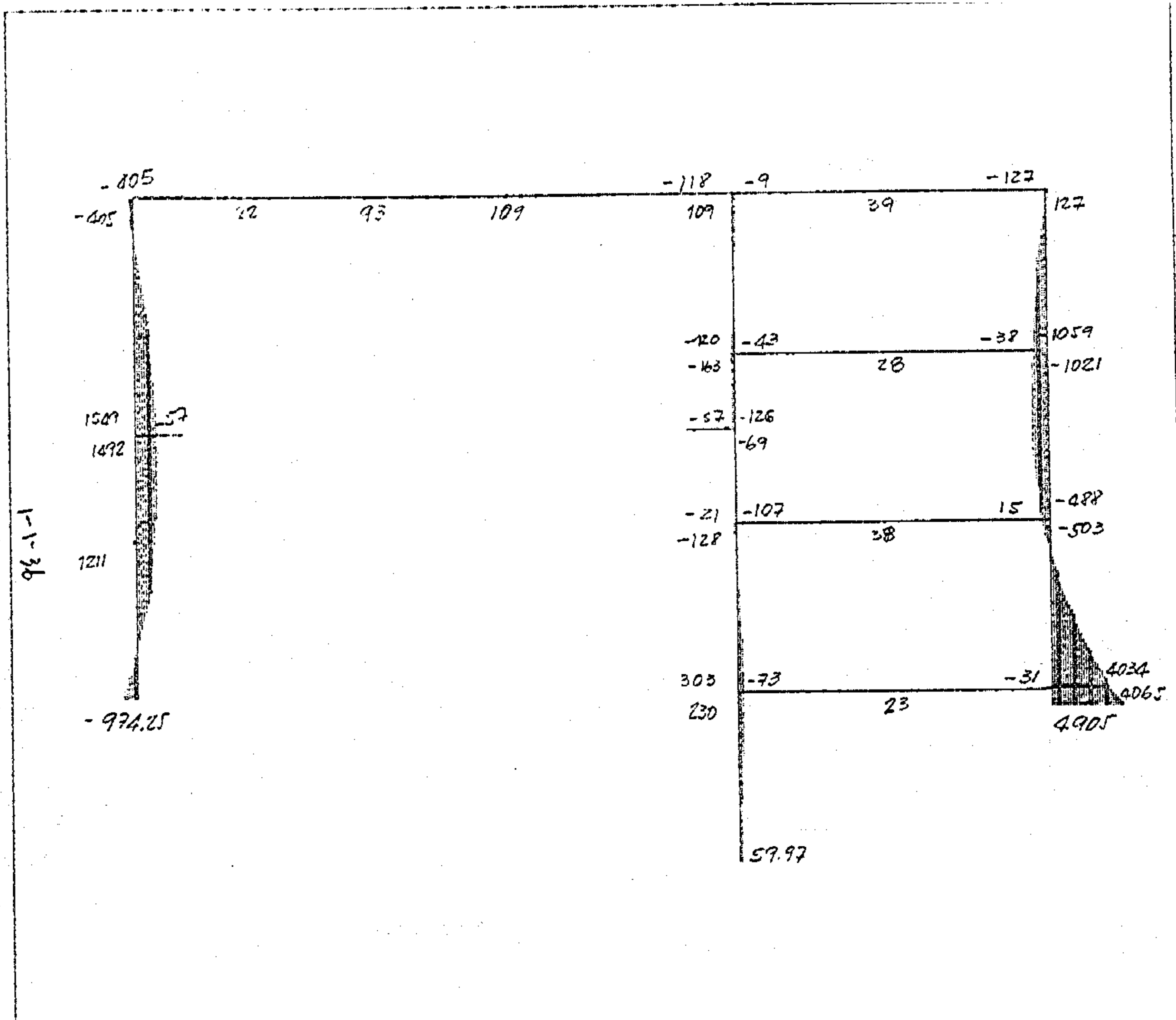
Fig. 1.1.6 Loading Condition, Case-VI

(c) Structural analysis

The structural analysis of FRAME were made by computer and results of internal forces such as bending moment (M), shearing force (Q) and axial forces for each case are summarized in Table 1.1.1 and shown in Fig. 1.1.7 to 1.1.13. The deflection of members in each case are also summarized in Table 1.1.1. The output of calculation by computer is attached hereinafter.

Table 1.1.1 SUMMARY OF CALCULATION

LOAD COND	MEMBER STRESS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	REMARKS
	M	-1211	1554	-1549	250	705	-69	-125	-120	4205	4054	-1189	-1052	-73	-107	-40	-127	-405	33	102	-118	57	-57	
I	Q	547	278	-371	34	-86	-17	-17	28	-1747	-1493	-677	325	-77	-65	-50	-112	121	42	19	-75	115	-115	Normal
8	N	-219	-715	-424	910	-720	-513	-577	-205	-1076	-927	-694	-320	120	-67	-85	-343	-371	-371	-371	-371	0	0	Condition
	M	-1206	1532	1547	232	123	-60	-131	115	3407	2904	-975	-340	-24	-73	-41	-137	-325	60	75	-95	-43	-43	Temperature
II	Q	855	177	-509	-55	-52	-2	4	40	-1300	-1102	-529	262	-55	-51	-64	-155	92	33	16	-57	86	-56	Change
9	N	-540	-400	-520	-610	-470	-567	-205	-172	-625	-751	-372	-300	17	-47	-50	-262	308	-308	-304	-306	0	0	+ 10 °C
	M	-1147	752	977	251	225	-34	-124	-77	2250	2240	-816	-741	-45	-80	-47	-53	-252	50	69	-79	-45	-45	Temperature
III	Q	865	250	-242	10	-73	-21	-21	27	-1401	-1130	-271	222	-80	-46	-58	-120	69	30	15	-80	98	-98	Change
10	N	-672	-402	-517	-675	-665	-402	-502	-255	-791	-715	-741	-285	164	-57	-48	-222	-249	-249	-249	-249	0	0	- 10 °C
	M	2452	1642	262	245	513	52	-127	-41	4554	3926	-678	952	-70	-120	-56	-113	-426	100	129	129	-57	-57	
IV	Q	-193	-199	-173	46	-79	-50	-50	1	-1372	-1129	-425	120	-73	95	-67	-151	-27	45	25	-72	115	-115	Completion
11	N	-912	-724	-450	-998	-729	-558	-421	-577	-1552	-922	-425	-955	110	-59	-51	-195	-199	-199	-199	-192	0	0	Time - 1
	M	-1657	1212	1202	147	207	-53	-129	145	3370	2750	-925	-517	-25	-79	-50	-159	-358	104	111	-141	-57	-57	
V	Q	528	125	-532	20	25	-8	-4	92	-1256	-1057	-325	260	-70	-73	-56	-195	115	36	14	-93	115	-115	Completion
12	N	-301	-592	-419	-721	-704	-506	-370	-246	-1101	-927	-460	-195	35	-59	-61	-249	-522	-522	-522	-522	0	0	Time - 2
	M	-1505	985	1097	126	175	-55	-113	152	3015	2426	-900	-752	-48	-62	-43	-145	-266	78	81	-112	-43	-43	
VI	Q	742	258	-275	24	-63	-5	-5	53	-1176	-1012	-255	228	-59	-54	-66	152	98	26	10	-62	50	-56	Earthquake
13	N	-675	-537	-212	-557	-521	-372	-262	-175	-832	-757	-375	-302	86	-65	-61	-228	-273	-273	-273	-272	2	-2	Condition 1
	M	1512	1410	1217	213	282	-42	-132	-79	4342	3227	-903	-955	-31	-97	-52	-36	-241	64	67	97	-43	-43	
VII	Q	524	129	-293	35	-76	-29	-20	27	-1445	-1227	-412	297	-56	46	-54	-130	92	36	19	-55	56	-56	Earthquake
14	N	-542	-497	-929	-824	-559	-535	-226	-225	-792	-702	-359	-255	-114	-39	-57	-257	-253	-255	-253	-253	-2	2	Condition 2



PUMP	
FRAME	
OUTPUT	M33
LOAD	8
CASE I	

MIN <	11>
	-.1173E+04
AT	3.75
MAX <	9>
	.4905E+04
AT	.00

SAP90

FIG 1.1.7 (a) MOMENT DIAGRAM

106

CASE I

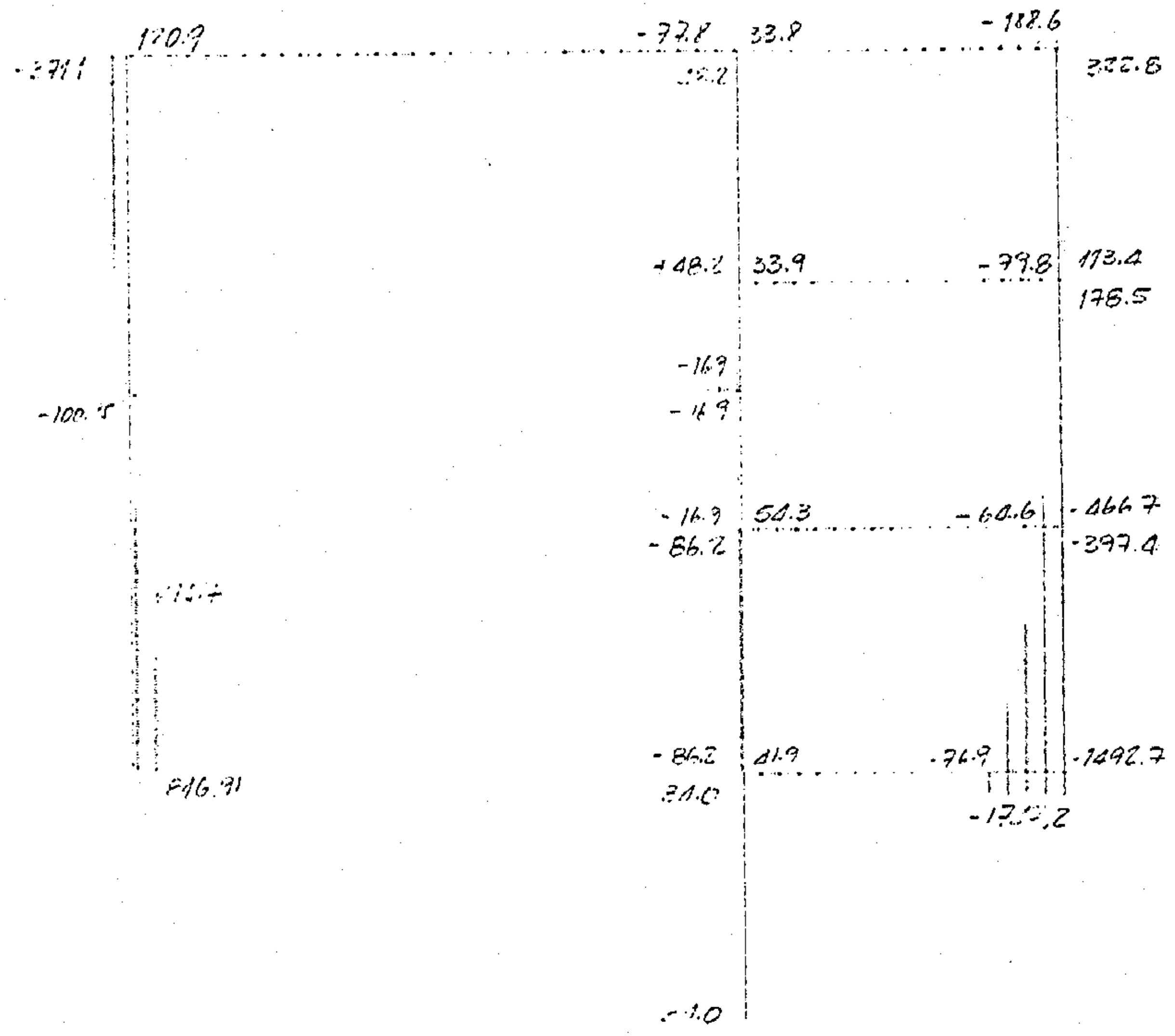
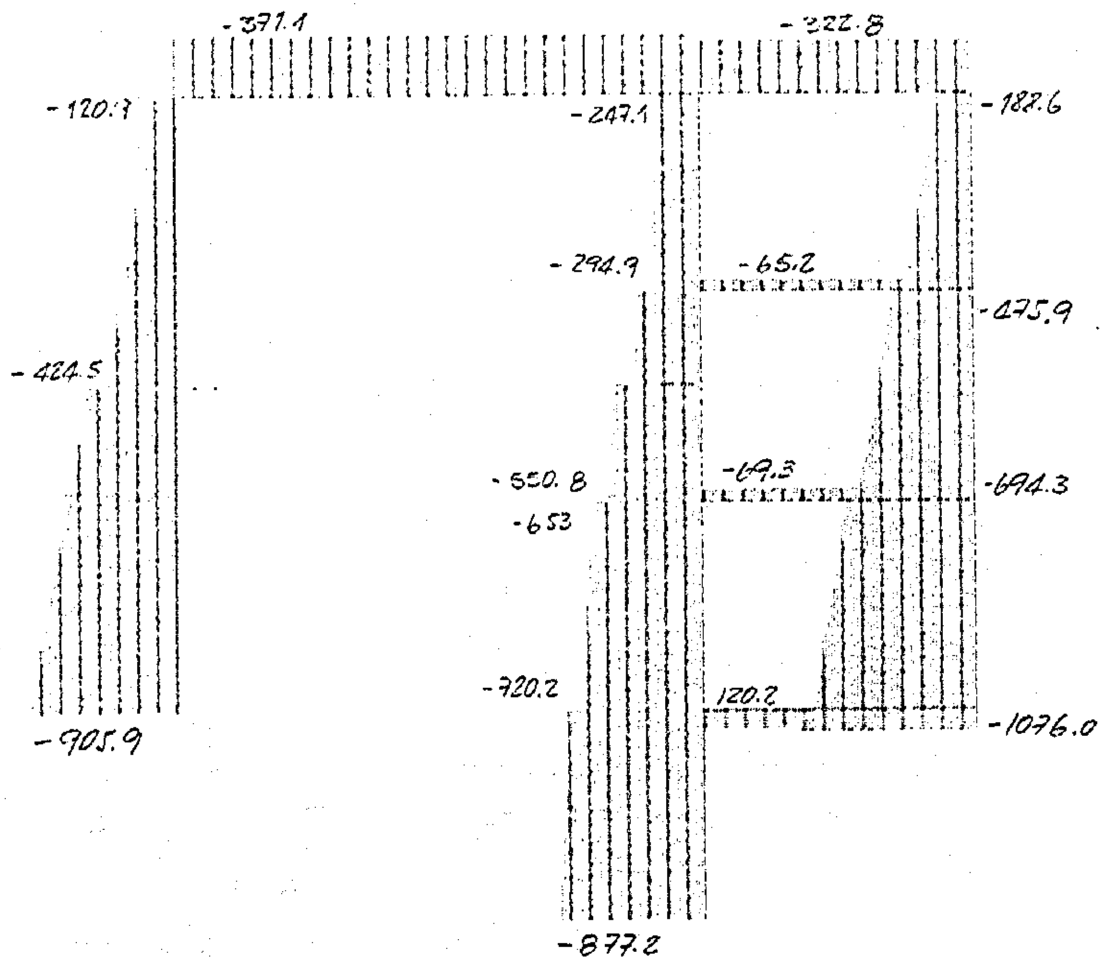


FIG 1.17 (b)

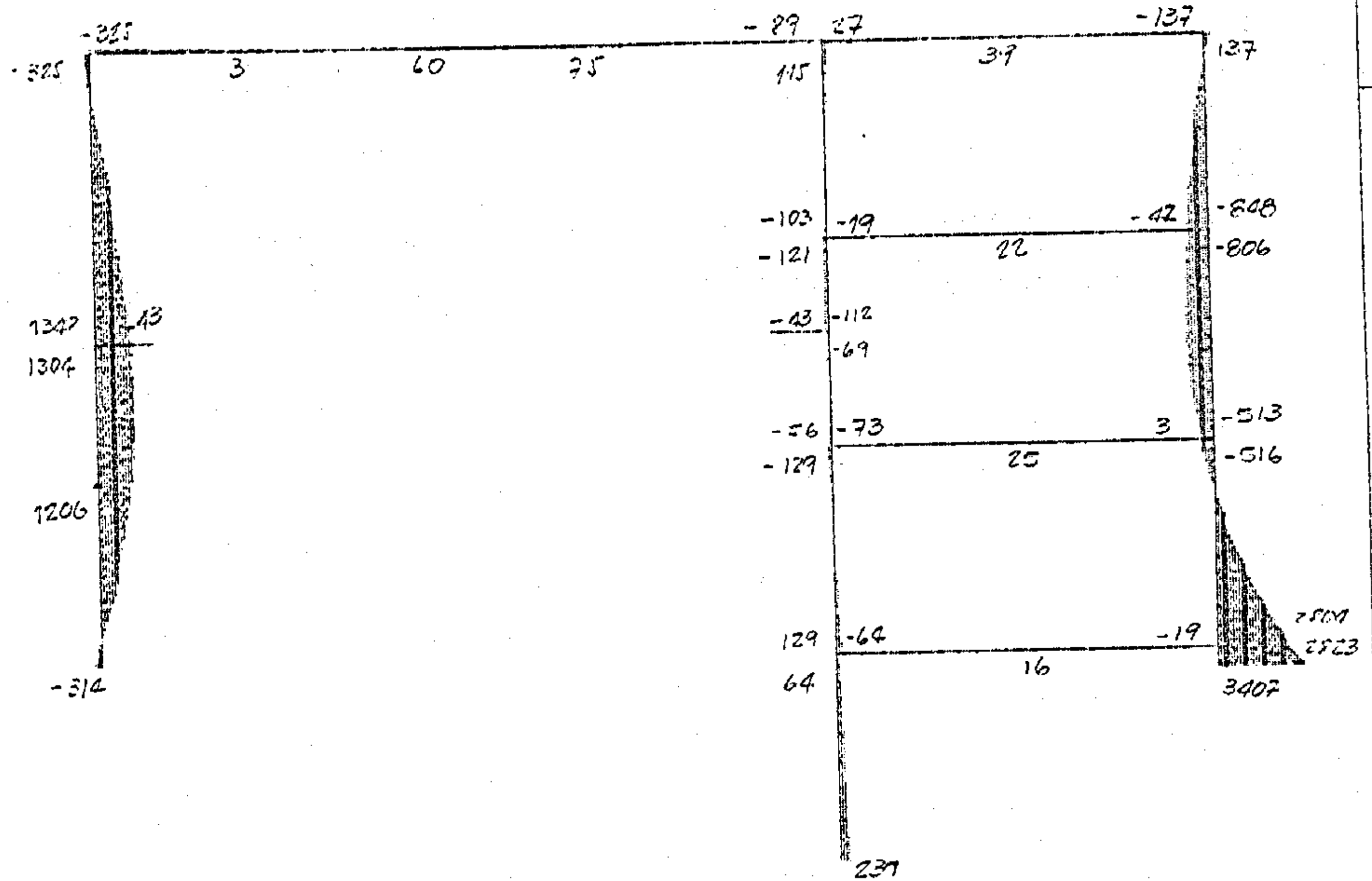
SHEAR DIAGRAM



FRAME
OUTPUT P
LOAD
CASE I
MIN
AT .00
MAX
AT .00
SAP90

FIG 1.1.7 (c) AXIAL FORCE DIAGRAM

106

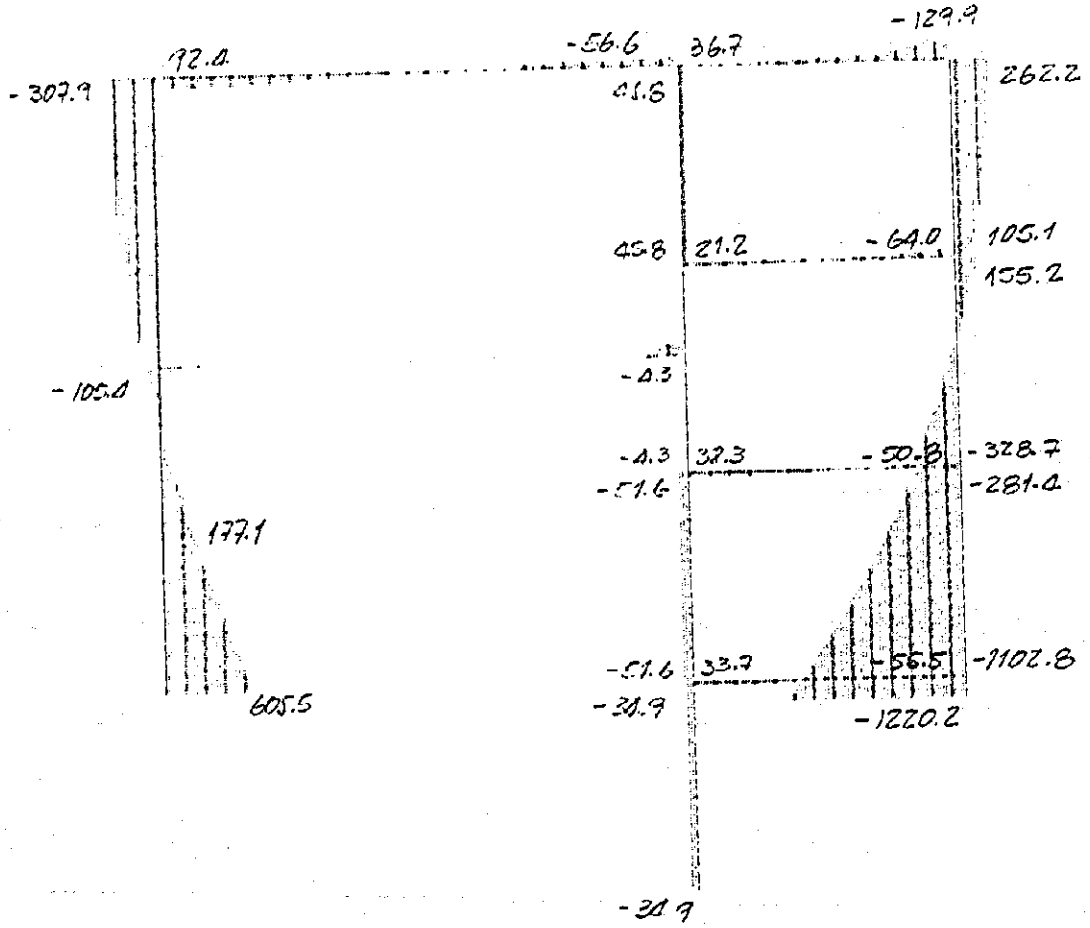


PUMP
FRAME
OUTPUT M33
LOAD 9
CASE II

MIN < 11>
-.9621E+03
AT 2.50
MAX < 9>
.3407E+04
AT .00

SAP90

FIG 1.1.R (a) MOMENT DIAGRAM

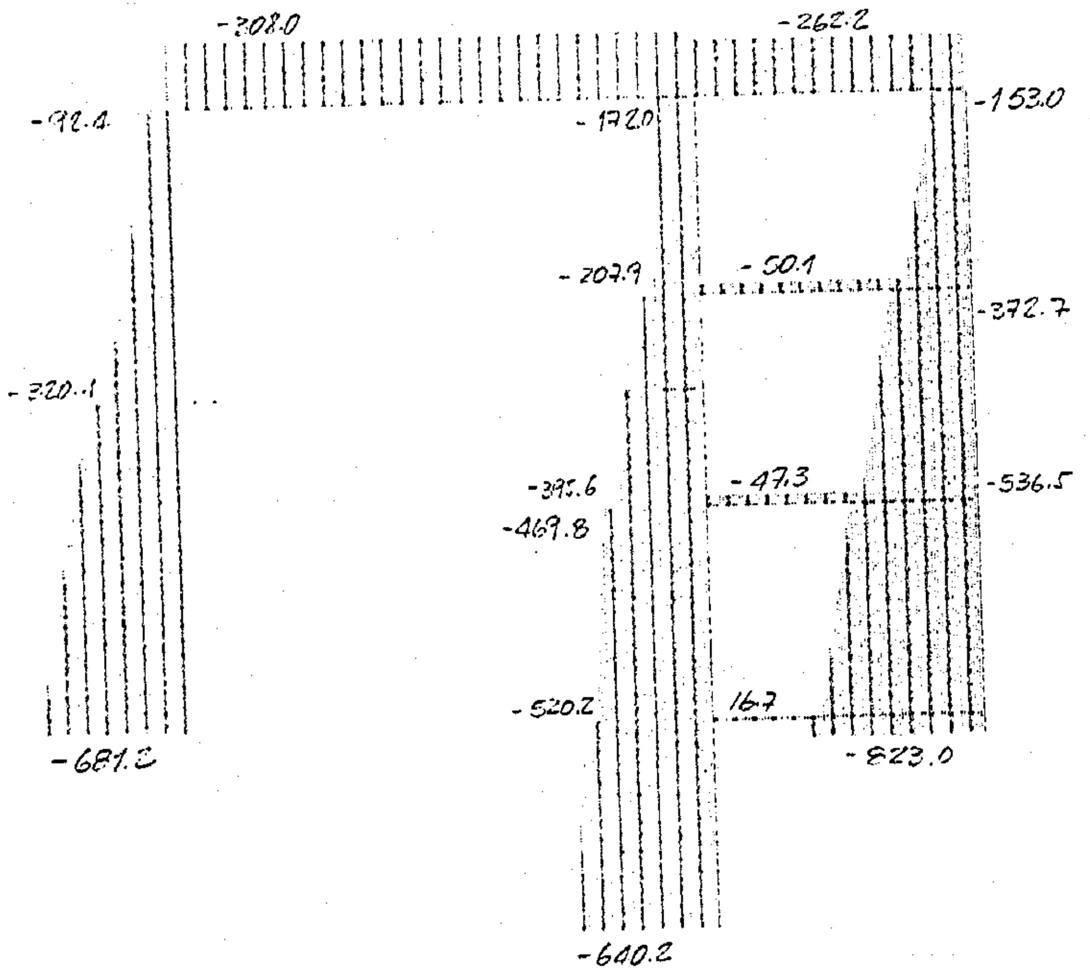


PUMP
FRAME
OUTPUT V22
LOAD 9
CASE II

MIN
AT .00
MAX
AT .00

SAP90

FIG 1.1.8 (b) SHEAR DIAGRAM.

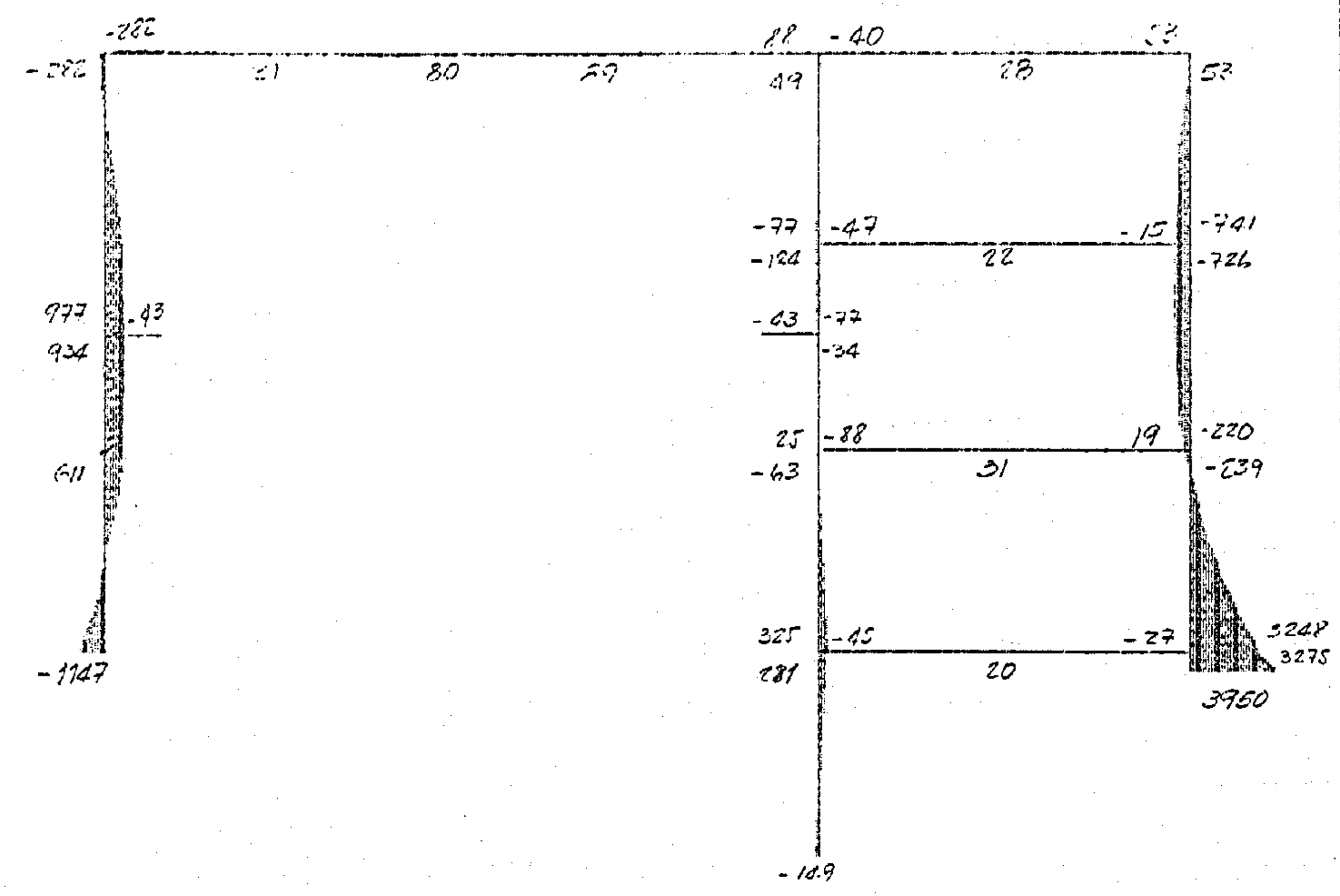


AXIAL FORCE DIAGRAM

PUMP	
FRAME	
OUTPUT	P
LOAD	9
CASE II	

MIN	9
	.823E+03
AT	.00
MAX	13
	.166E+02
AT	.00

SAP90



PUMP
FRAME
OUTPUT M33
LOAD 10
CASE III

MIN < 1>
-.1147E+04
AT .00
MAX < 9>
.3950E+04
AT .00

SAP90

FIG. 1.1.9 (a) MOMENT DIAGRAM

1-1-42

FRAME

FINAL
OUTPUT V22

LOAD 10

CASE III

SAP90

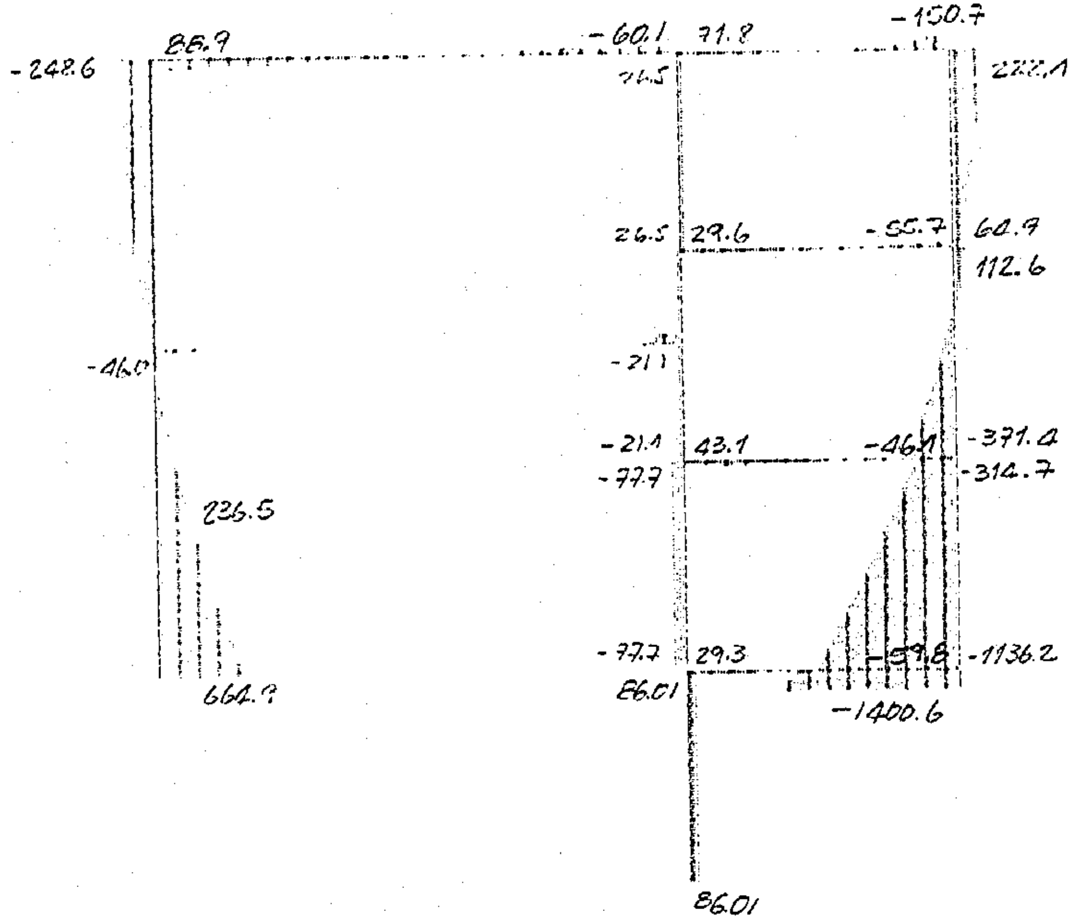


FIG. 1.1.9 (6) SHEAR DIAGRAM

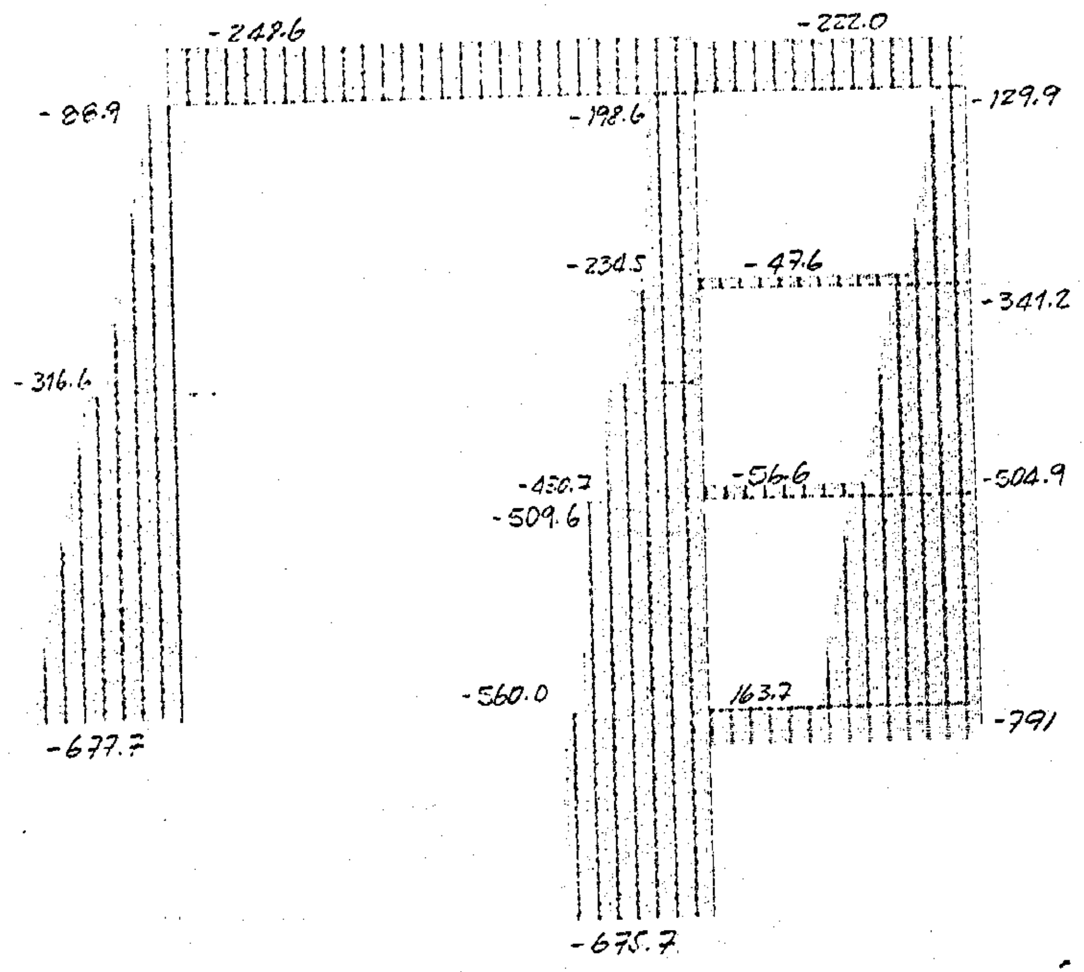


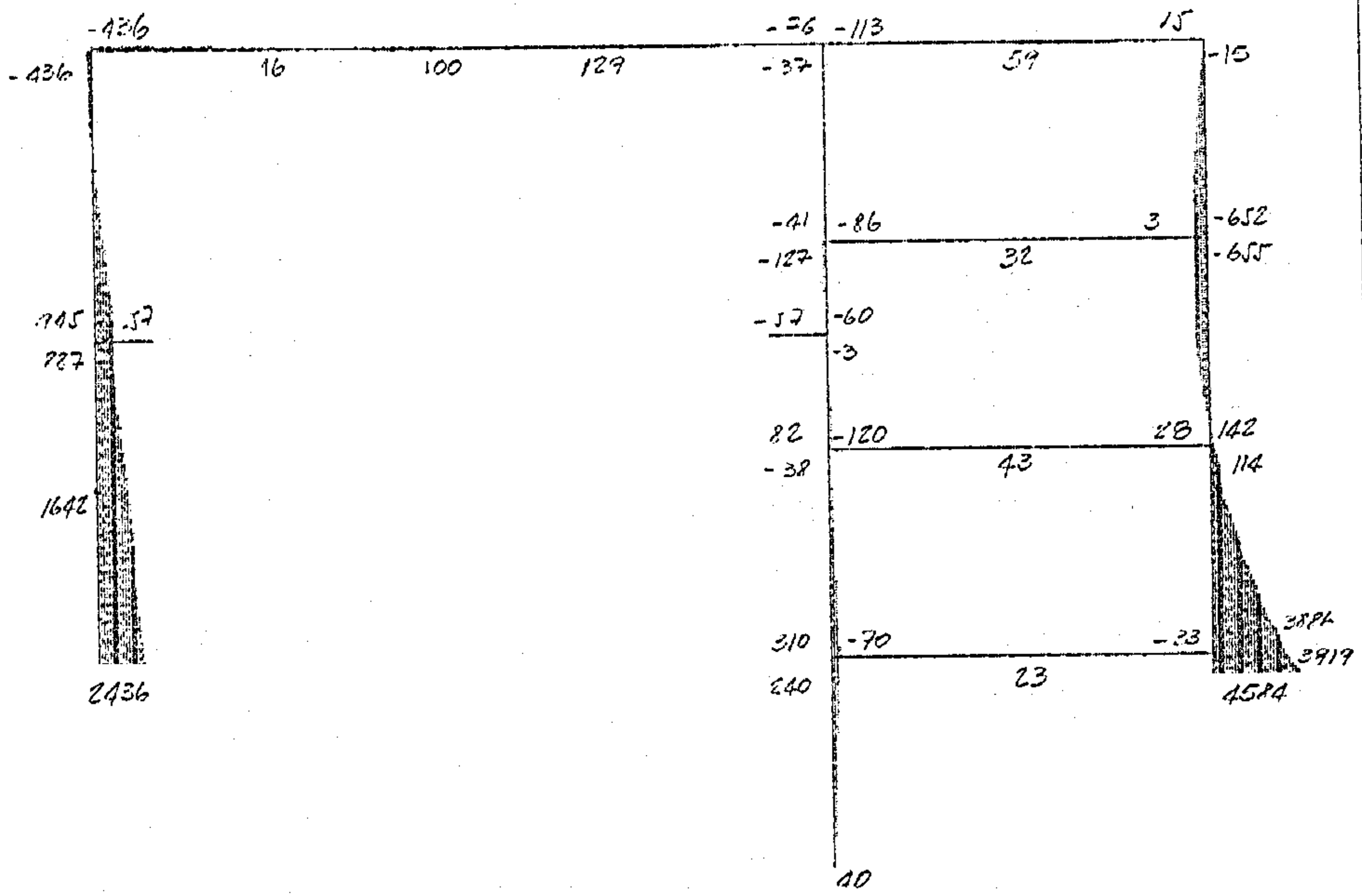
FIG. 1.1.9 (c) AXIAL FORCE DIAGRAM

PUMP	
FRAME	
OUTPUT	P
LOAD	10

CASE III

MIN :	9:
	-.7910E+03
AT	.00
MAX :	13:
	.1637E+03
AT	.00

SAP90

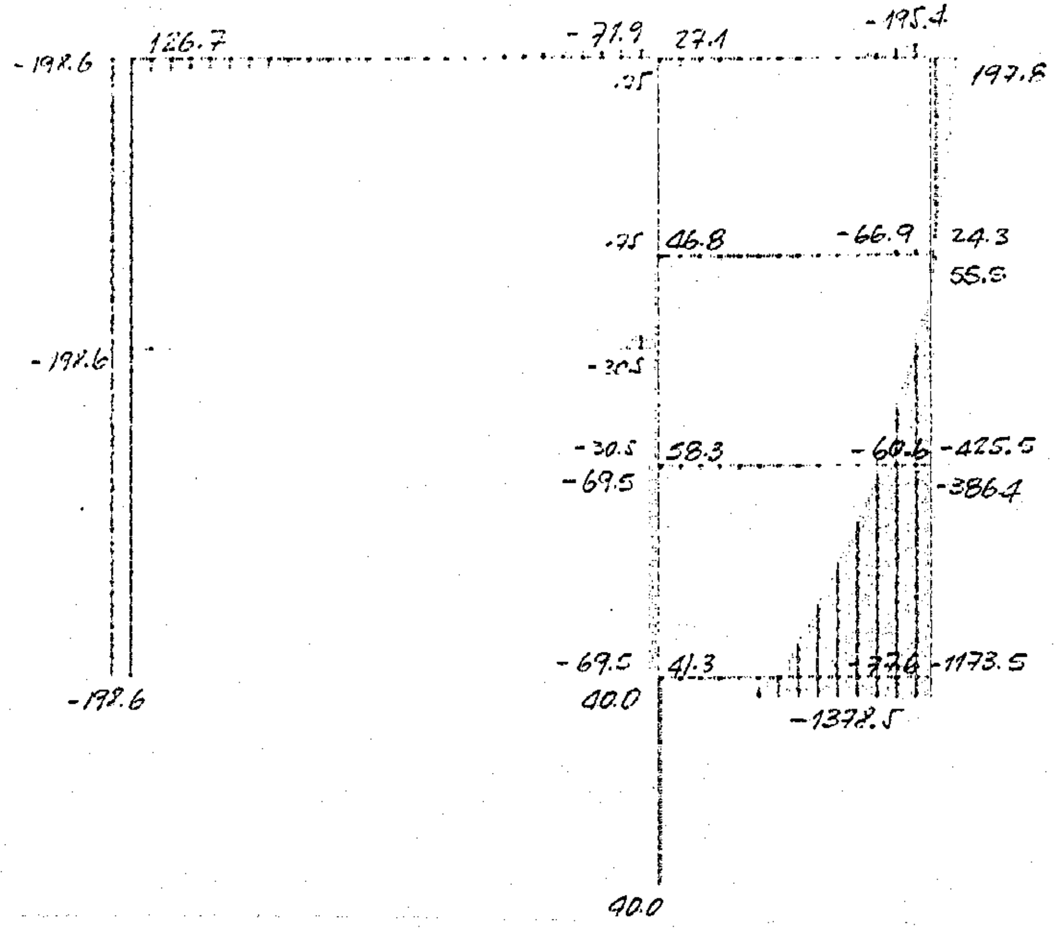


PUMP
FRAME
OUTPUT M33
LOAD 11
CASE IV

MIN < 11>
-.6695E+03
AT 3.75
MAX < 9>
.4584E+04
AT .00

SAP90

FIG. 1.1.10 (a) MOMENT DIAGRAM



PUMP
FRAME
OUTPUT V[illegible]
LOAD 11
CASE IV

MIN [illegible]
-.1379E+04
AT .00
MAX 12[illegible]
.1978E+03
AT 4.75

SAP90

FIG. 1.1.10 (b) SHEAR DIAGRAM

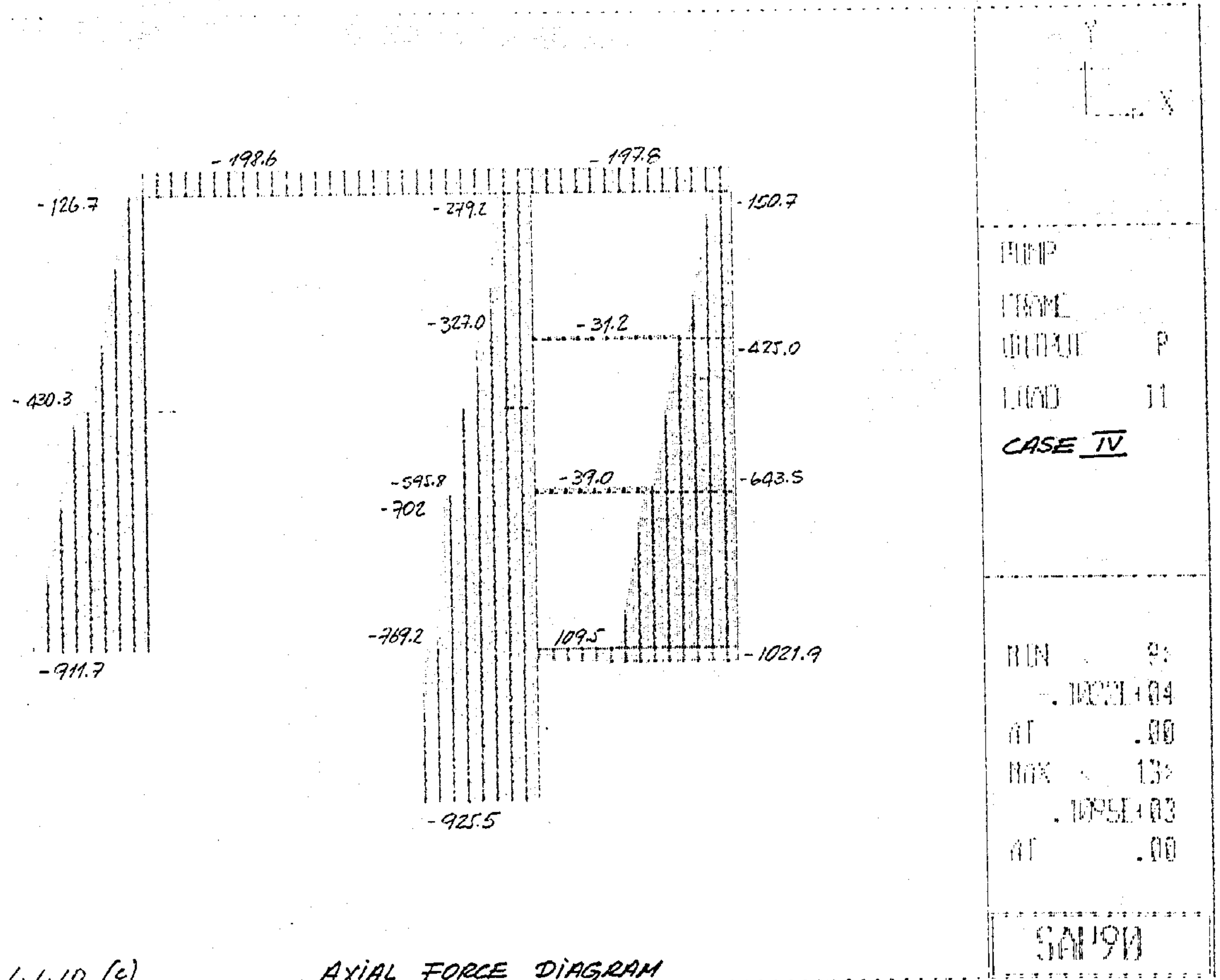
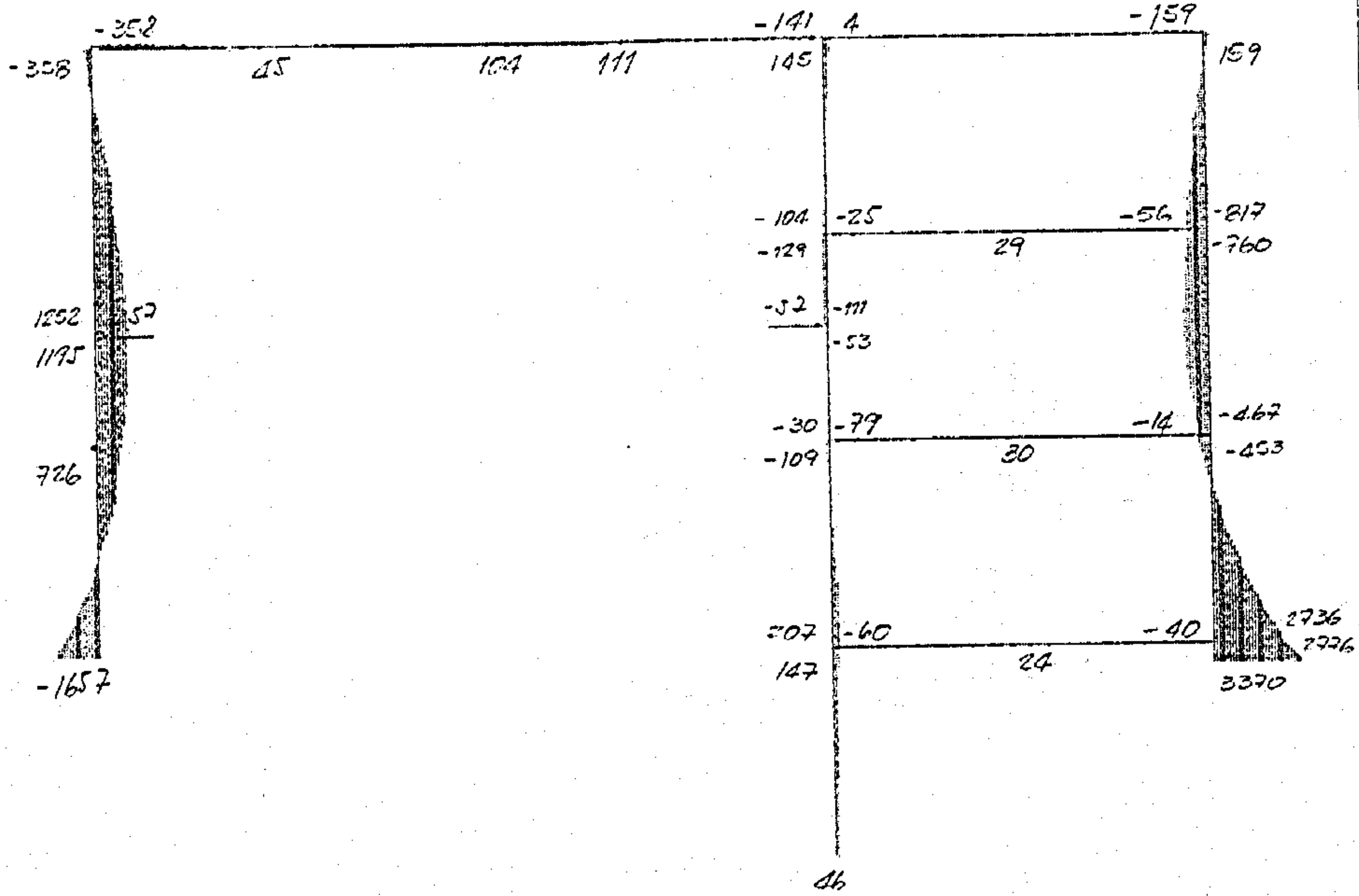


FIG. 1.1.10 (c) AXIAL FORCE DIAGRAM



PUMP
FRAME
OUTPUT M33
LOAD 12
CASE V

MIN < 1>
-.1657E+04
AT .00
MAX < 9>
.3370E+04
AT .00

SAP90

FIG. 1.1.11 (a) MOMENT DIAGRAM

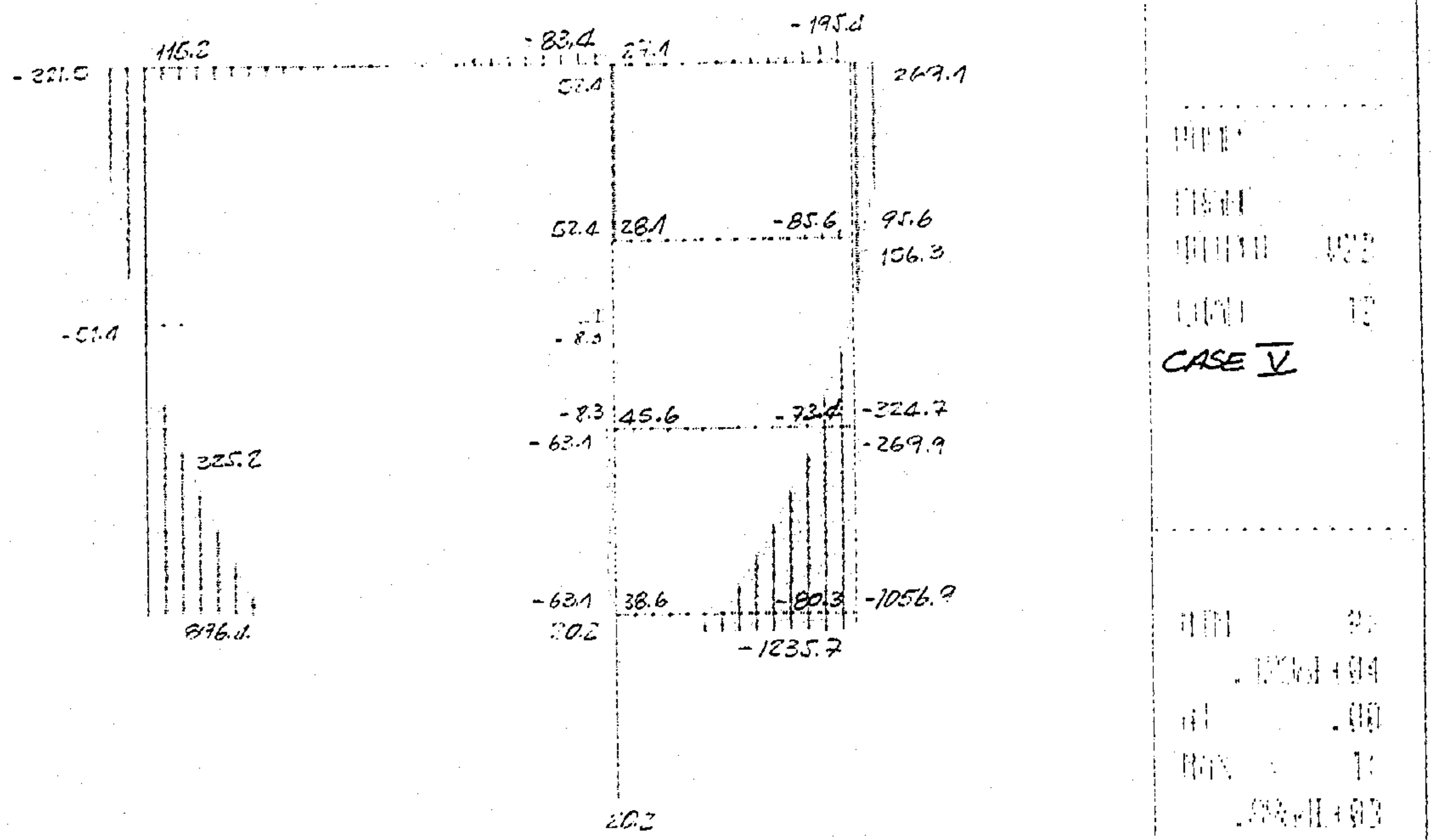
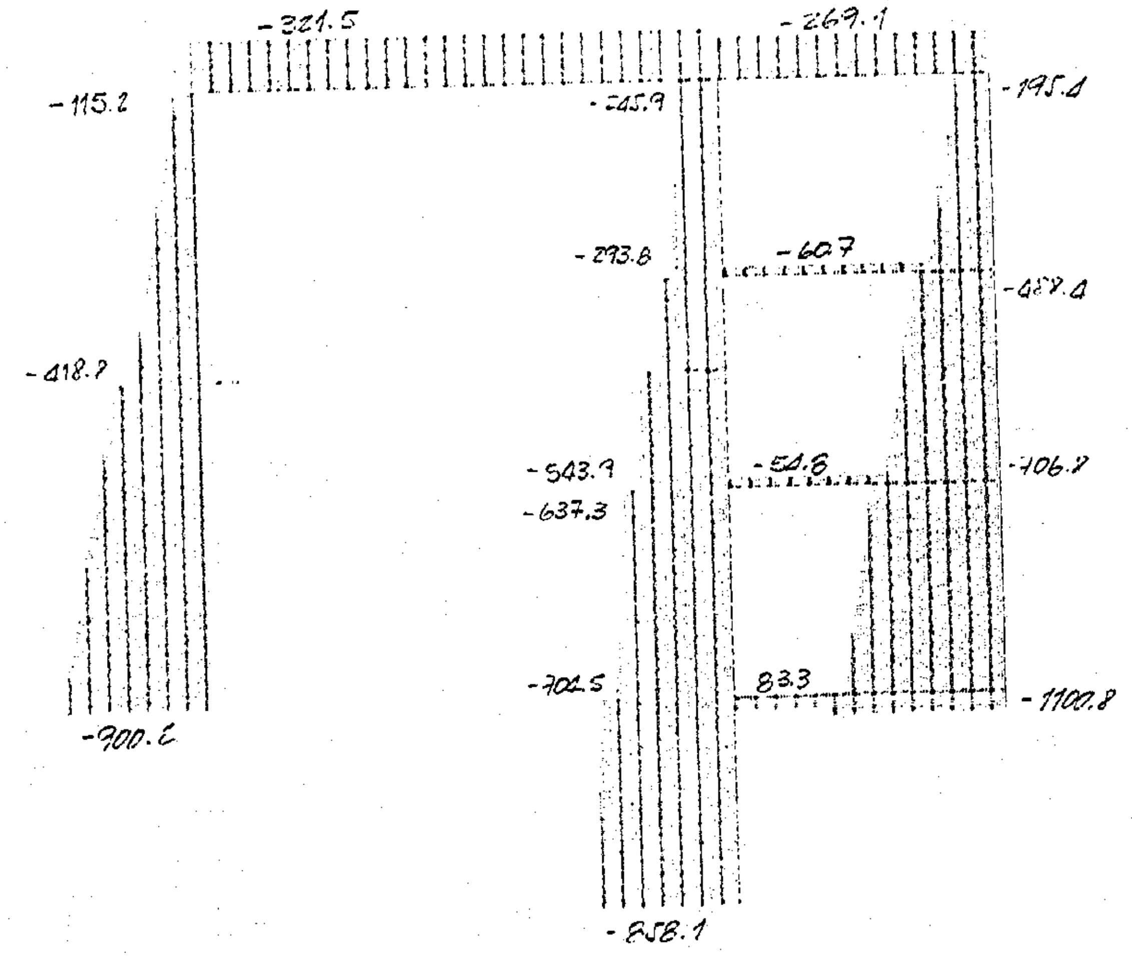
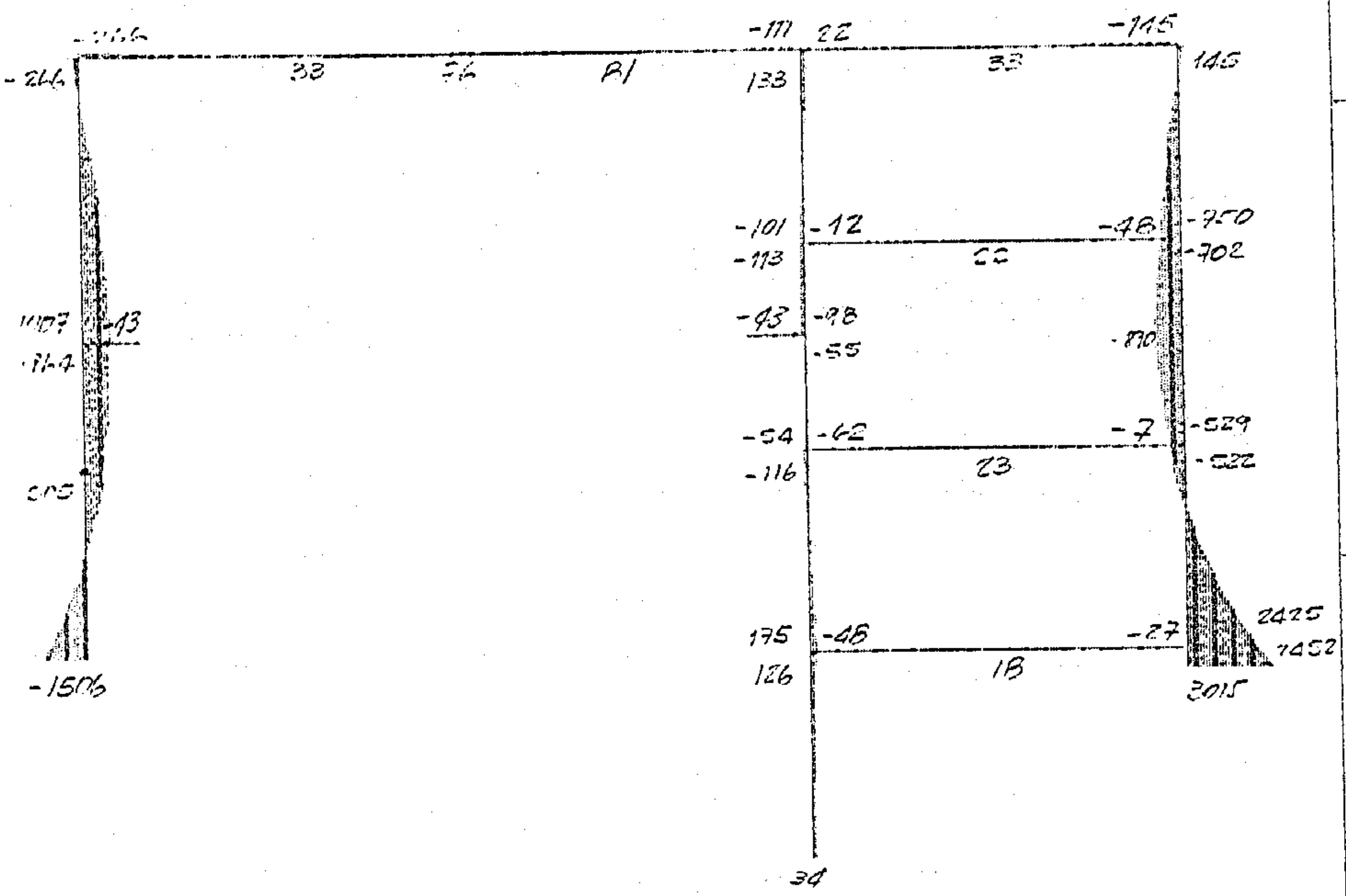


FIG. 1.1.11 (b) SHEAR DIAGRAM



CASE V

FIG. 1.1.11 (c) AXIAL FORCE DIAGRAM



PUMP	
FRAME	
OUTPUT	M33
LOAD	13
CASE VI	

MIN	<	1>
		-.1506E+04
AT		.00
MAX	<	9>
		.3015E+04
AT		.00

SAP90

Fig. 1.1.12 (a) MOMENT DIAGRAM

13-1-1

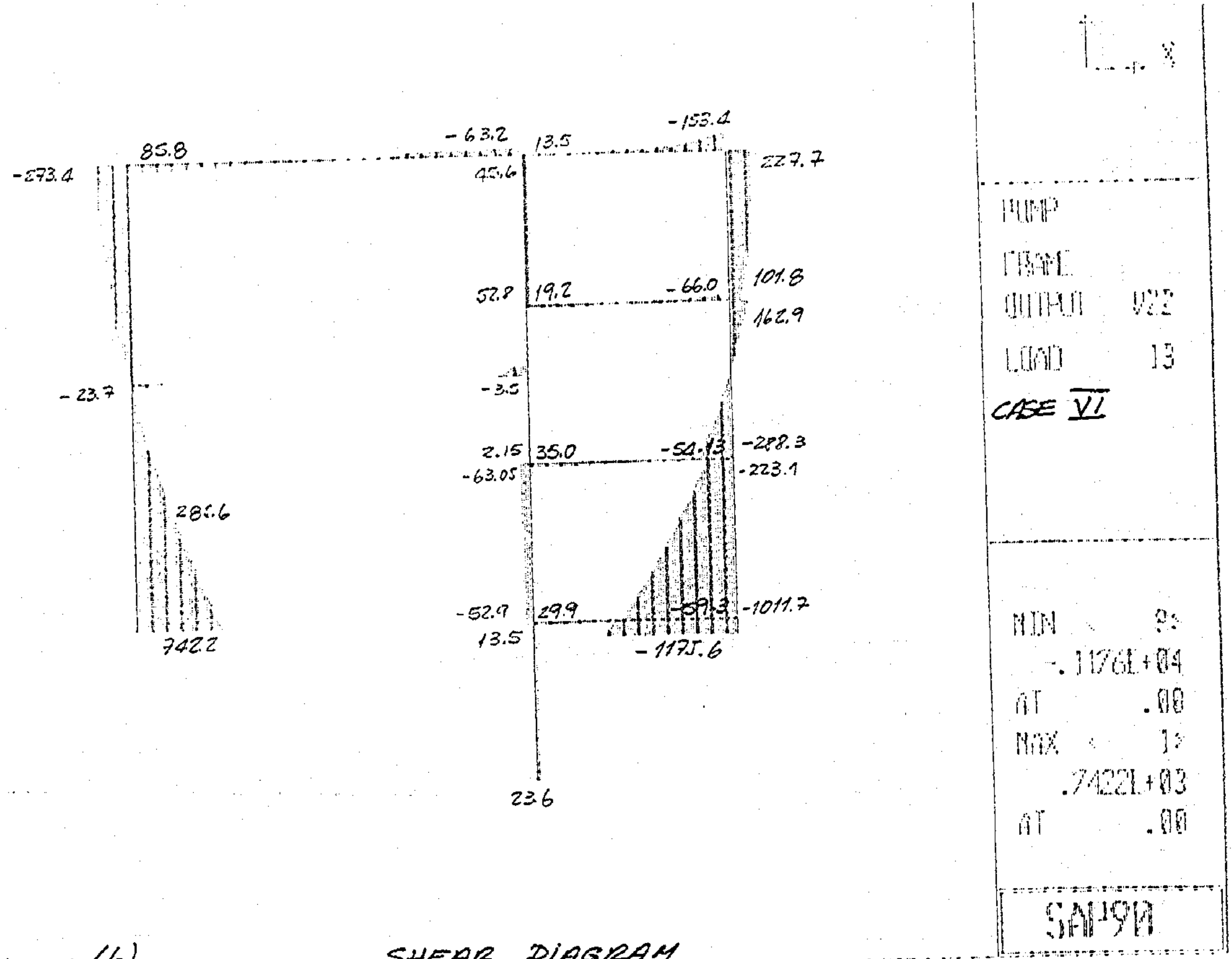


Fig. 1.1.12 (b) SHEAR DIAGRAM

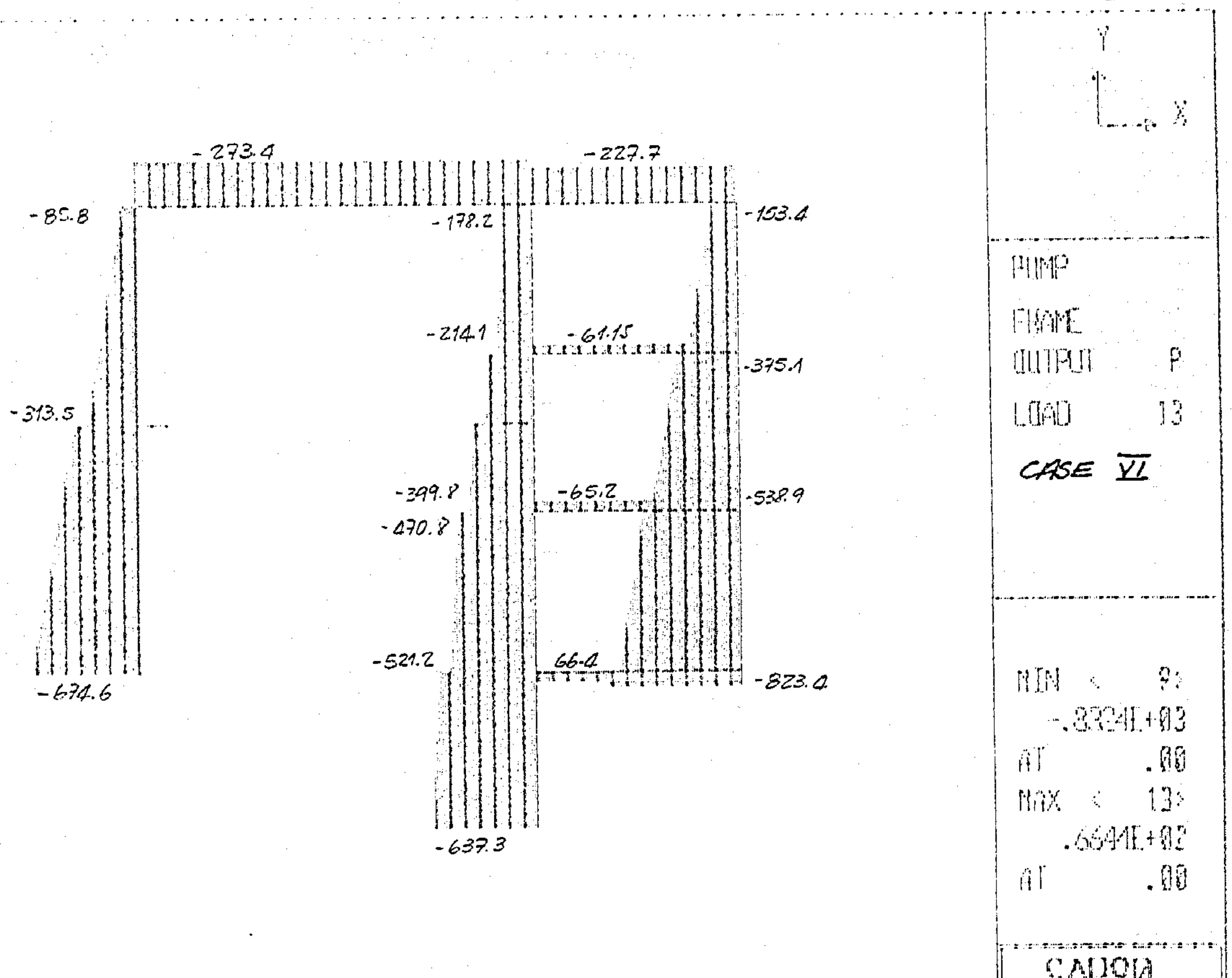
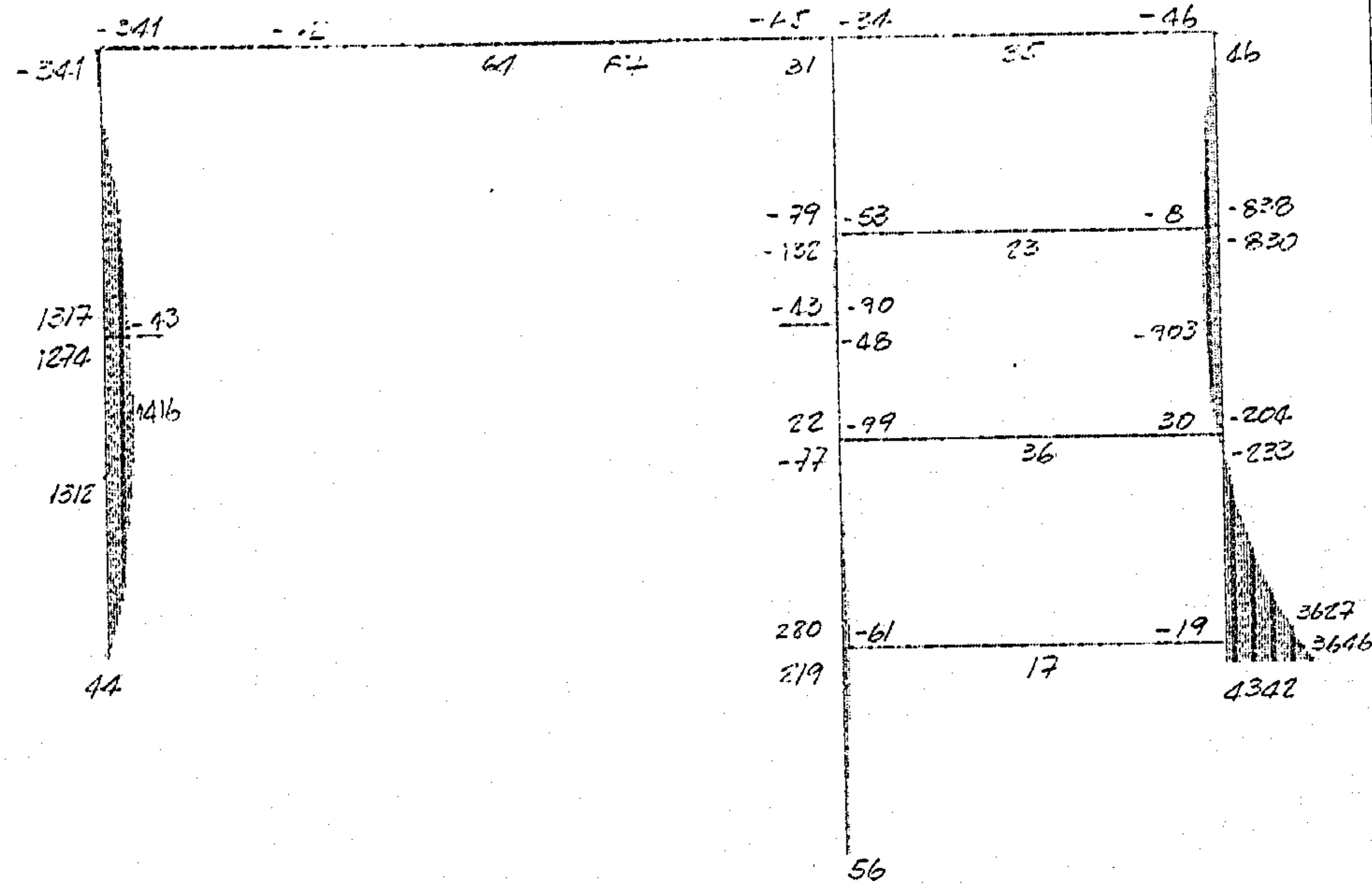


FIG. 1.1.12 (c) AXIAL FORCE DIAGRAM



PUMP
FRAME
OUTPUT M33
LOAD 14
CASE VII

MIN < 11>
-.9026E+03
AT 3.75
MAX < 9>
.4342E+04
AT .00

SAP90

FIG. 1.1.13 (a) MOMENT DIAGRAM

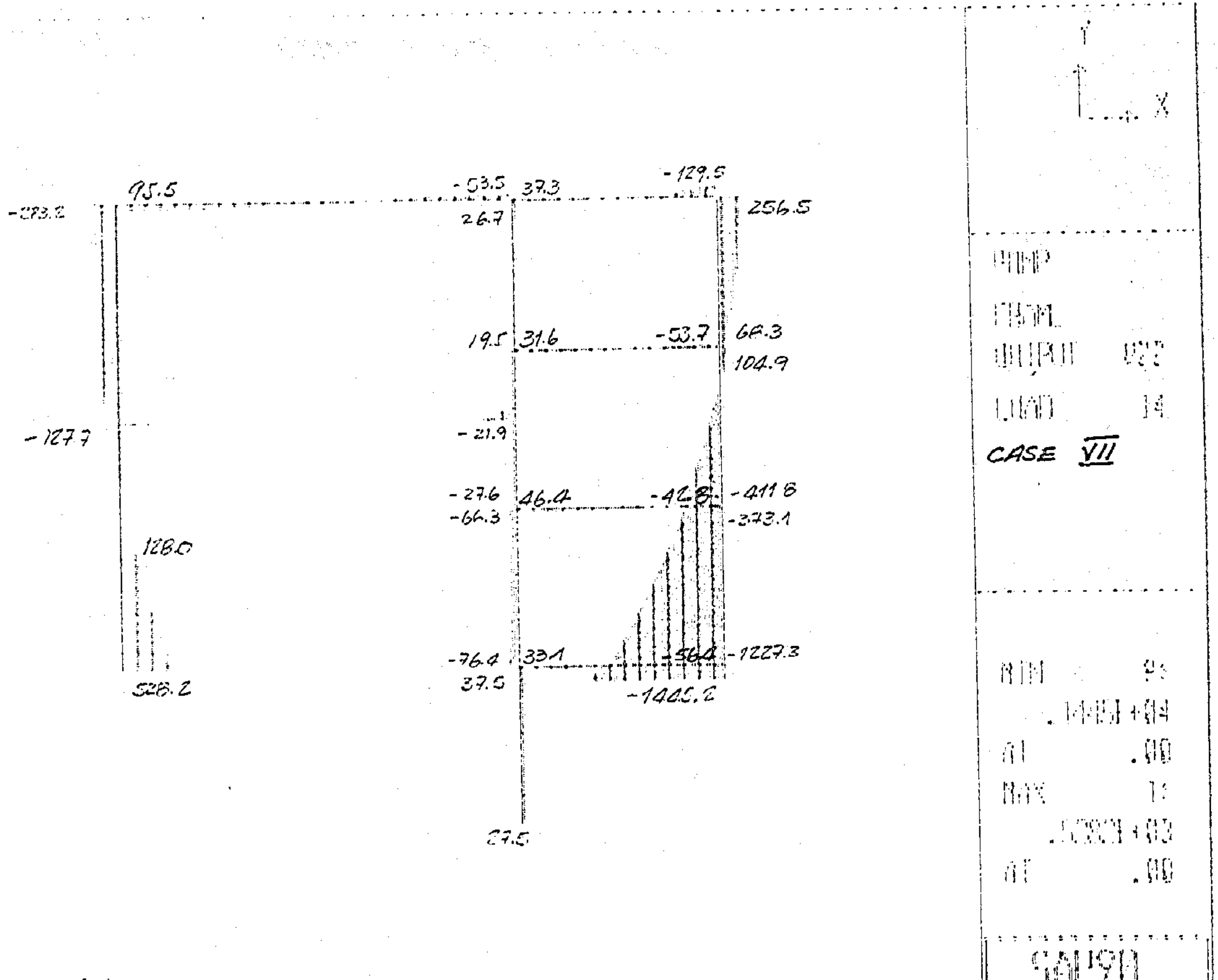
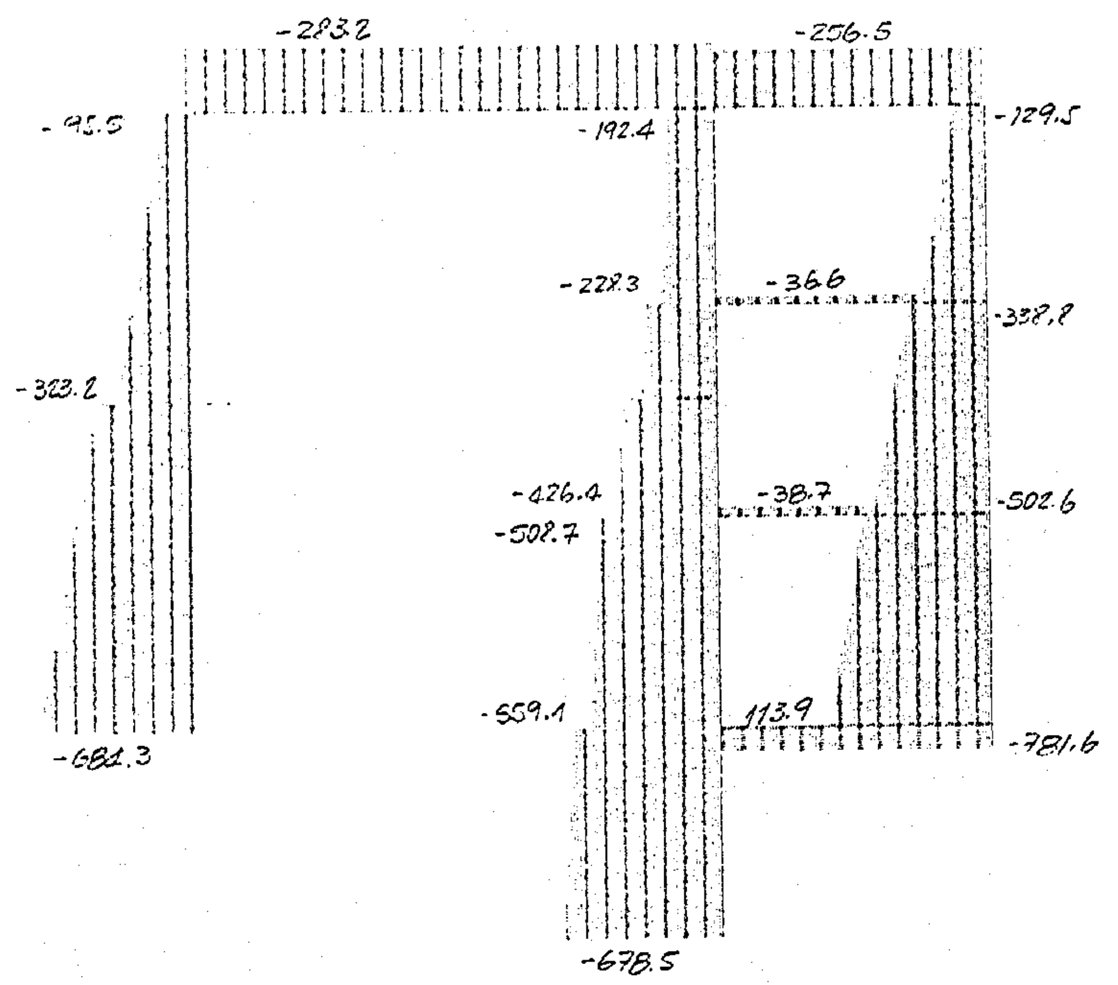


FIG. 1.1.13 (b) SHEAR DIAGRAM



PUMP
FRAME
OUTPUT P
LOAD 14
CASE VII

MIN (9)
-.7816E+03
AT .00
MAX (13)
.1139E+03
AT .00

SAP90

FIG. 1.1.13 (c) AXIAL FORCE DIAGRAM

1/12

(d) Reinforced concrete design

Calculation of required reinforcement and stress are in tabular in the following sheets .
Strength design of members shall be based in the following requirements :
The basic requirement for the strength design may be expressed as follows:

-Flexure :

Design Strength $\geqq$ Required Strength
ϕ (nominal strenght) $\geqq$ U
The design strenght in flexure of a cross section (without compression reinforcement) may be expressed as :
ϕ Mn $\geqq$ Mu
ϕMn = ϕ [As . fy (d-a/2)]
where :
As = area of nonprestressed tension reinforcement
fy = specified yield strenght of nonprestressed reinforcement
d = distance from extreme compression fiber to centroid of tension reinforcement
a = As.fy / 0.85 f'c b
ϕ = strength reduction factor

-Shear :

ϕVn $\geqq$ Vu
where :
Vu is factored shear force at section considered
Vn is nominal shear strenght computed by
Vn = Vc + Vs
where Vc is nominal shear strenght provided by concrete and Vs is nominal shear strenght provided by shear reinforcement.

For members subject to shear and flexure only
Vc = 0.53 $\sqrt{f'c}$ .bw.d
The results of calculation are shown in the following calculation sheets and bar arrangements are shown in Fig. 1 . 1 . 14

15-Oct-94

SEVERINO PUMPING STATION

FLEXURE STRENGTH DESIGN

GIVEN :

f'c =	210	Kg/cm²
fy =	4200	
r =	4.0	cm
pmax=0.75pb=	1.61	(%)
ps =	0.90	(%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(min) (cm²)	As(temp) (cm²)	As(adopt) (cm²)	As(adopt) (varillas)
13	73.00	100.0	100.0	96.0	0.22	20.64	32.00	12.50	34.36	7 ⌀ 25 @ 14 cm.
14	120.00	100.0	100.0	96.0	0.36	34.53	32.00	12.50	34.36	7 ⌀ 25 @ 14 cm.
15	86.00	100.0	100.0	96.0	0.25	24.43	32.00	12.50	34.36	7 ⌀ 25 @ 14 cm.
16	159.00	150.0	150.0	146.0	0.13	29.27	73.00	28.13	72.38	9 ⌀ 32 @ 17 cm.
17	436.00	150.0	150.0	146.0	0.38	82.69	73.00	28.13	88.44	11 ⌀ 32 @ 13 cm.
18	104.00	150.0	150.0	146.0	0.09	19.04	73.00	28.13	72.38	9 ⌀ 32 @ 17 cm.
19	129.00	150.0	150 0	146.0	0.11	23.68	73.00	28.13	72.38	9 ⌀ 32 @ 17 cm.
20	141.00	150.0	150.0	146.0	0.12	25.91	73.00	28.13	72.38	9 ⌀ 32 @ 17 cm.

15-Oct-94

SEVERINO PUMPING STATION

SHEAR STRENGTH DESIGN

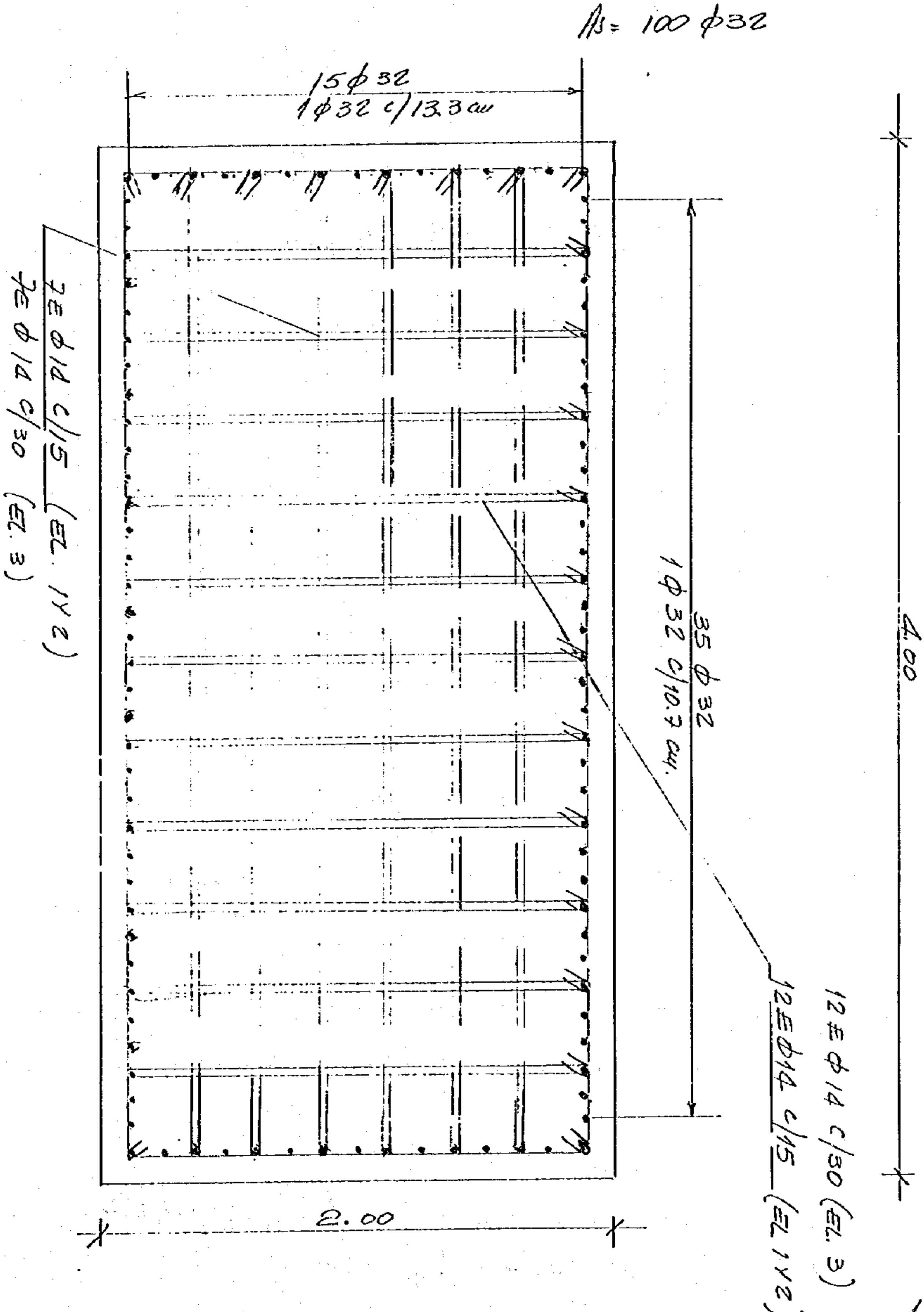
ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	ϕV_c (ton)	Vs (ton)	Av (cm^2)	S (cm)	Smax (cm)	Smax (cm)	Smax (cm)
13	80.00	100.0	122.54	100.0	96.00	62.67	20.39	3.08	60.9	37.0	48.0	24.0
14	73.00	100.0	111.82	100.0	96.00	62.67	12.15	3.08	102.2	37.0	48.0	24.0
15	86.00	100.0	131.73	100.0	96.00	62.67	27.44	3.08	45.2	37.0	48.0	24.0
16	195.00	150.0	199.13	150.0	146.00	142.97	61.21	3.08	30.9	24.6	73.0	36.5
17	127.00	150.0	129.69	150.0	146.00	142.97	-18.79	3.08	-100.5	24.6	73.0	36.5
18	48.00	150.0	49.02	150.0	146.00	142.97	-111.73	3.08	-16.9	24.6	73.0	36.5
19	25.00	150.0	25.53	150.0	146.00	142.97	-138.79	3.08	-13.6	24.6	73.0	36.5
20	83.00	150.0	84.76	150.0	146.00	142.97	-70.55	3.08	-26.8	24.6	73.0	36.5
21	115.00	200.0	88.08	150.0	146.00	190.63	-88.97	3.08	-21.2	18.5	73.0	36.5
22	115.00	200.0	88.08	150.0	146.00	190.63	-88.97	3.08	-21.2	18.5	73.0	36.5
1	896.00	200.0	686.24	400.0	396.00	517.05	445.83	36.95	137.8	221.7	198.0	99.0
2	325.00	200.0	248.91	400.0	396.00	517.05	-225.94	36.95	-272.0	221.7	198.0	99.0
3	371.00	200.0	284.14	400.0	396.00	517.05	-171.82	36.95	-357.7	221.7	198.0	99.0
9	1747.00	200.0	1338.01	350.0	346.00	451.76	1523.81	30.79	29.4	184.7	173.0	86.5
10	1493.00	200.0	1143.47	350.0	346.00	451.76	1224.98	30.79	36.5	184.7	173.0	86.5
11	467.00	200.0	357.67	350.0	346.00	451.76	17.93	30.79	2496.0	184.7	173.0	86.5
12	323.00	200.0	247.38	350.0	346.00	451.76	-151.49	3.08	-29.5	18.5	173.0	86.5

DESIGN OF MEMBERS IN COMPRESSION AND BENDING

Ref.: Design Handbook in Accordance with the Strength Design Method of ACI 318 Publication SP-17A ACI

ID ELEM	Pu (t)	Mu (t-m)	h (m)	Ag (m2)	Pu/Ag (ksi)	Mu/Ag h (ksi)	pg (%)
1	912	2436	4.0	8.0	0.16	0.11	1.0
2	724	1642	4.0	8.0	0.13	0.07	1.0
4	625	281	2.0	4.0	0.22	0.05	1.0
5	560	325	2.0	4.0	0.20	0.06	1.0
9	1076	4905	3.5	7.0	0.22	0.28	1.0
9	782	4342	3.5	7.0	0.16	0.25	1.0

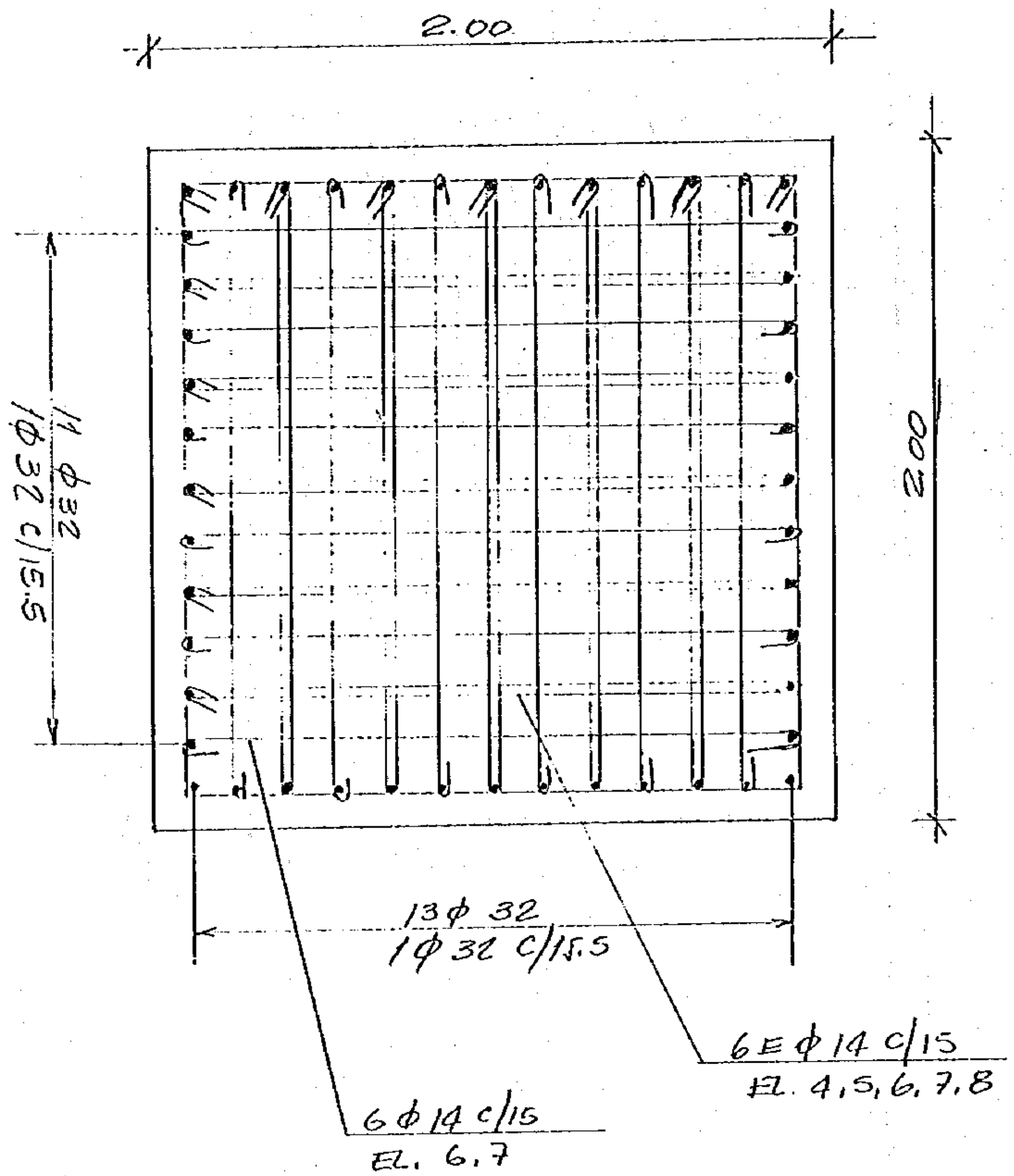
ELEMENT - 1, 2, 3
REINFORCEMENT



1-1-61

ELEMENT 4, 5, 6, 7, 8

As = 48 φ 32



ESPACIAMIENTO DEL REFUERZO

Tamaño máximo del agregado = 40 mm.

ACI 7.6 1.5 db = 1.5 (3.2) = 4.80 cm.

4 cm = 4.00 cm

3/4 l = 4.0 → l = 16/3 = 5.33 cm. ←

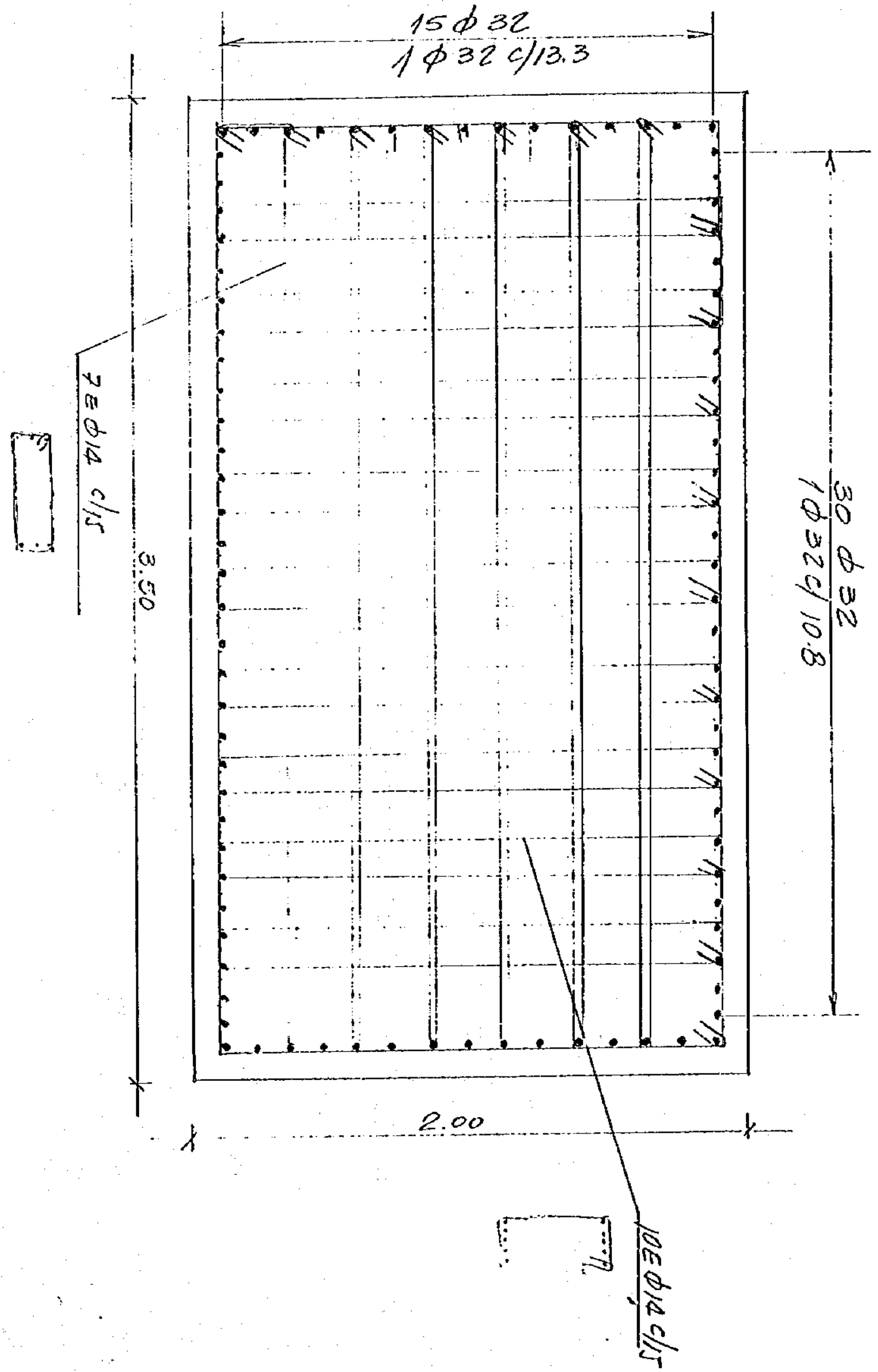
Dist. entre ejes: 5.33 + 3.20 = 8.53 cm.

130

1-1-62

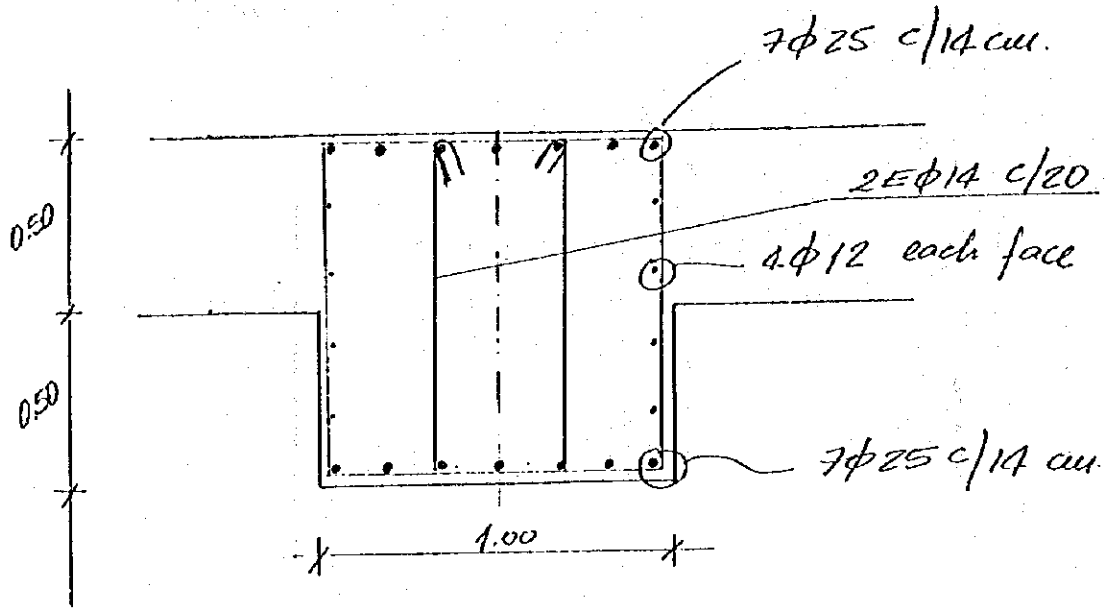
ELEMENT : 9, 10, 11, 12

As= 90 φ32

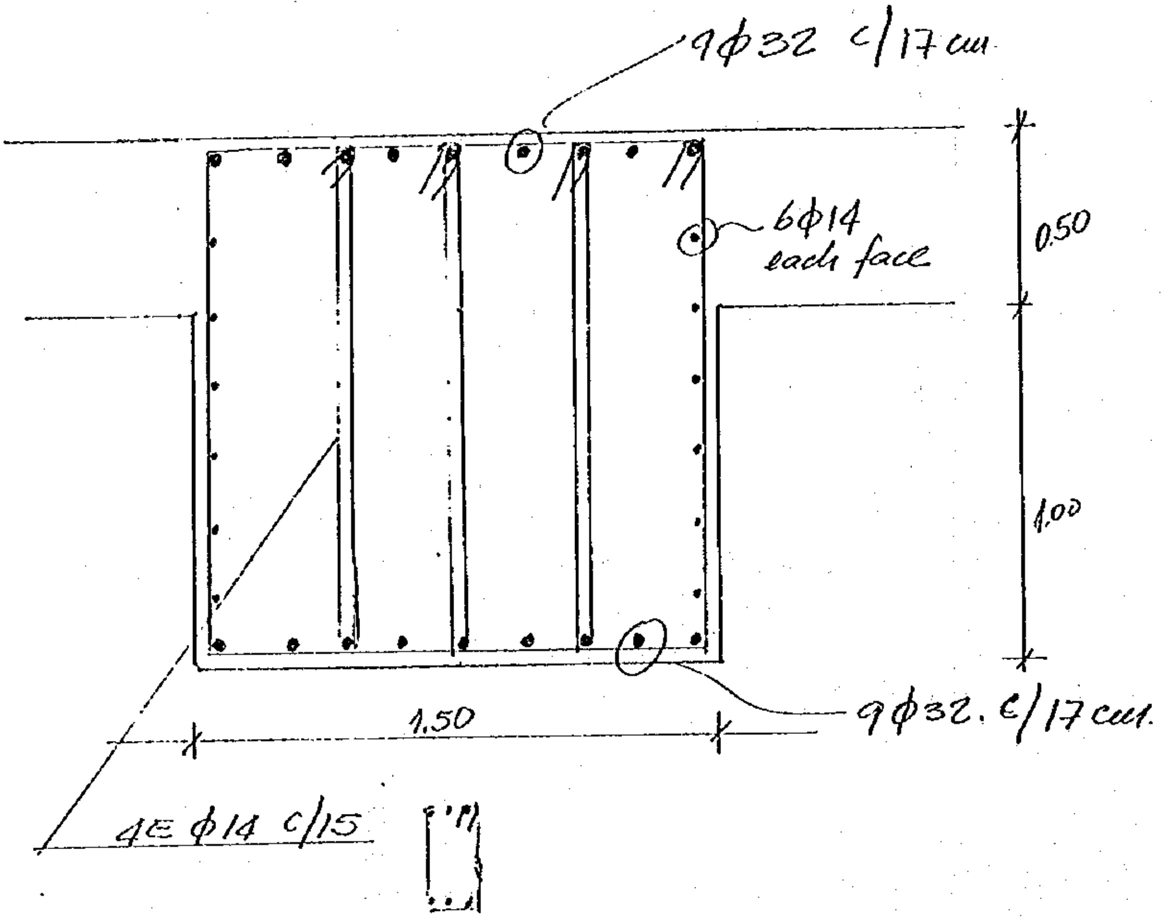


1-1-63

ELEMENT 13, 14, 15

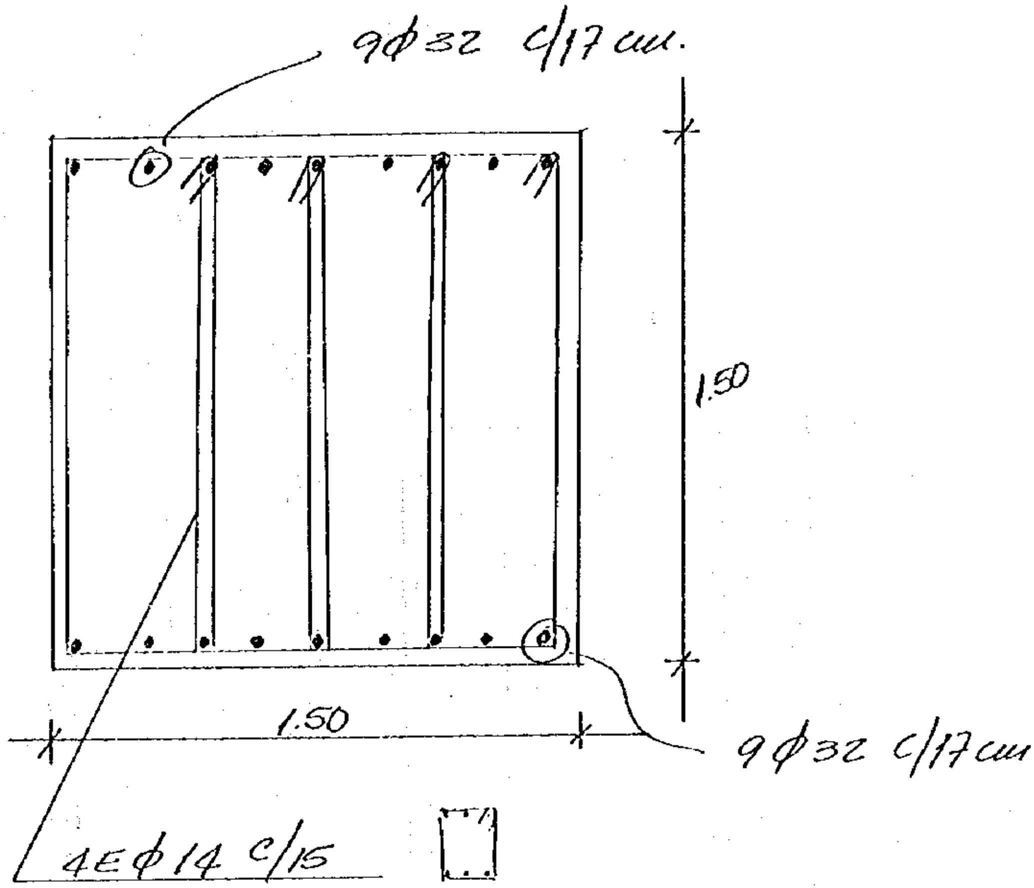


ELEMENT 16

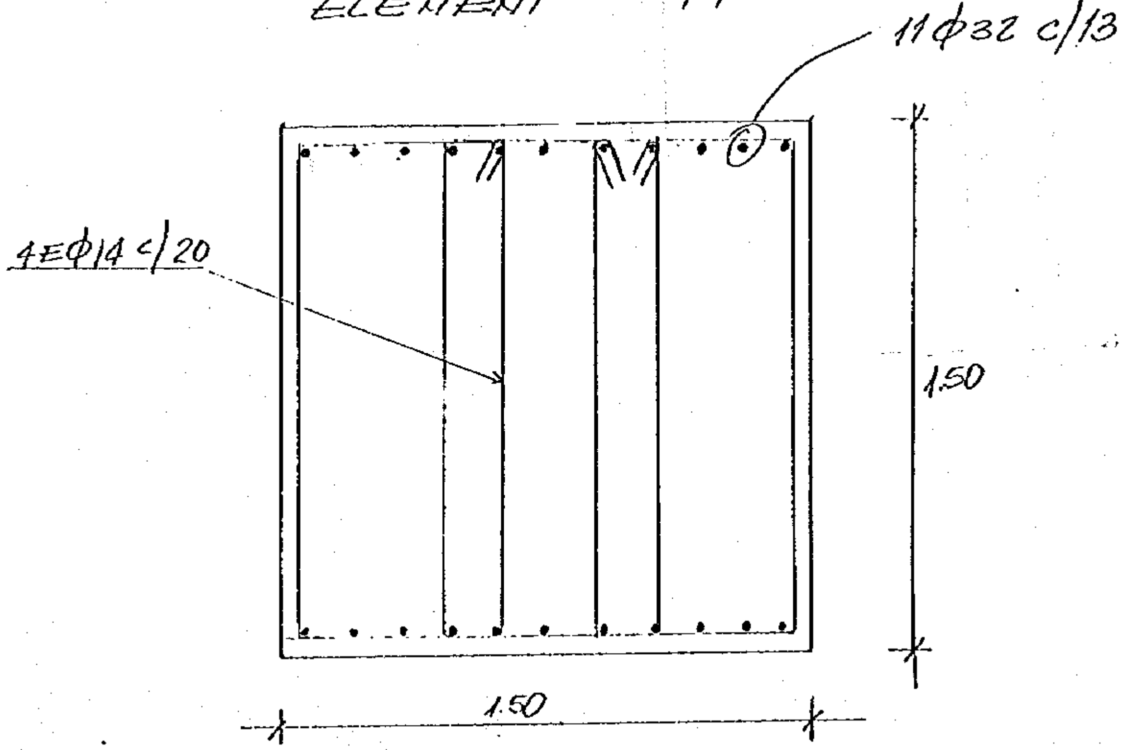


1-1-64

ELEMENT 18, 19, 20



ELEMENT 17



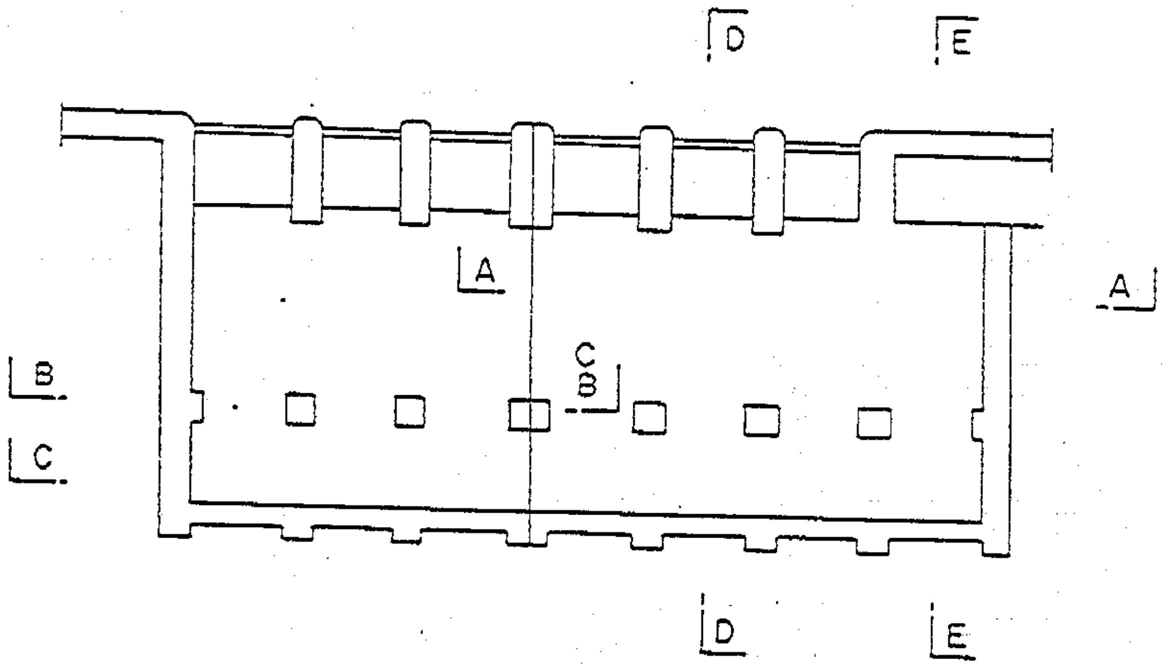


Fig. 1.1.14(a) KEY PLAN

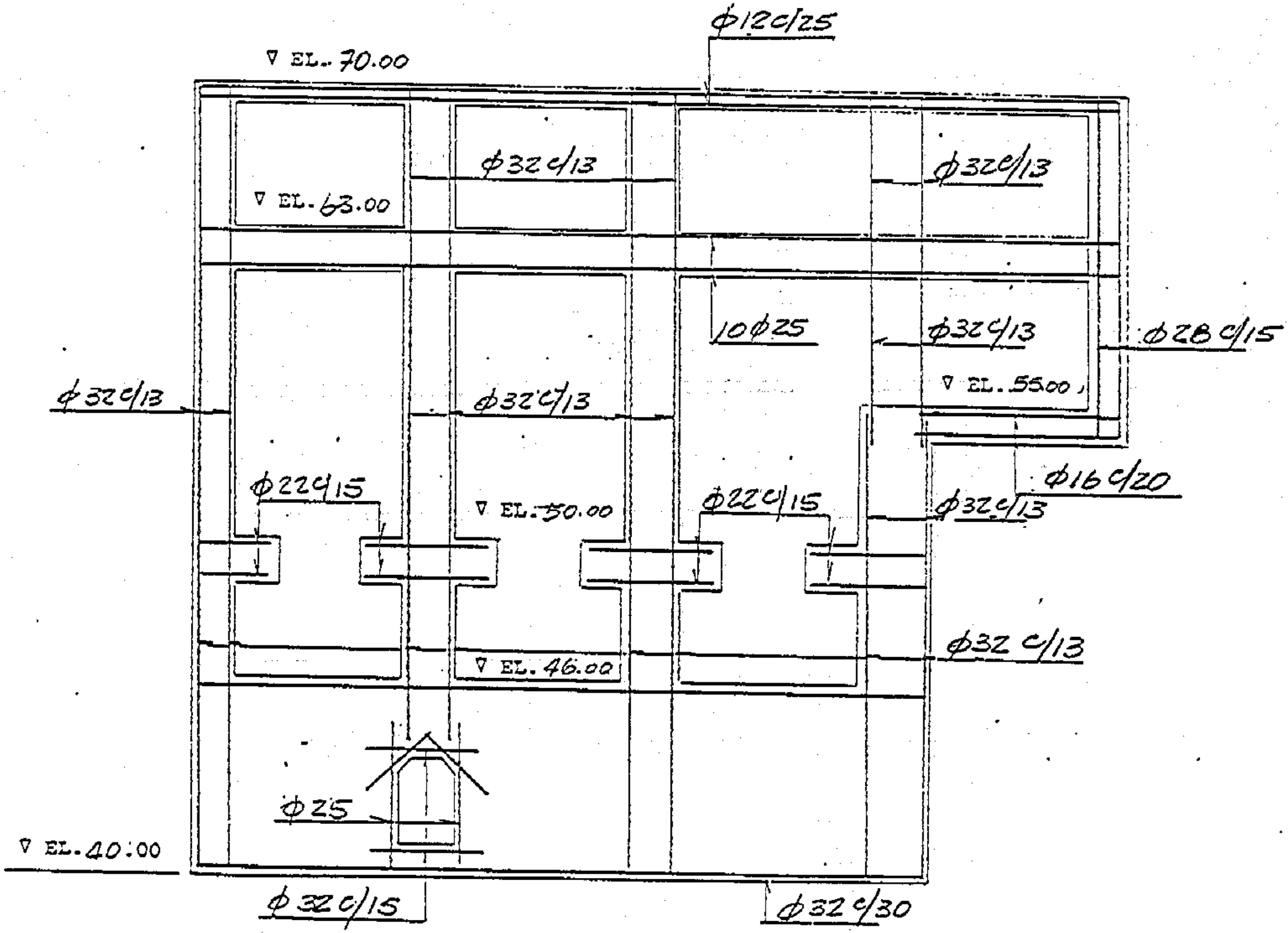


FIG 1.1.14(b)

1-1-87

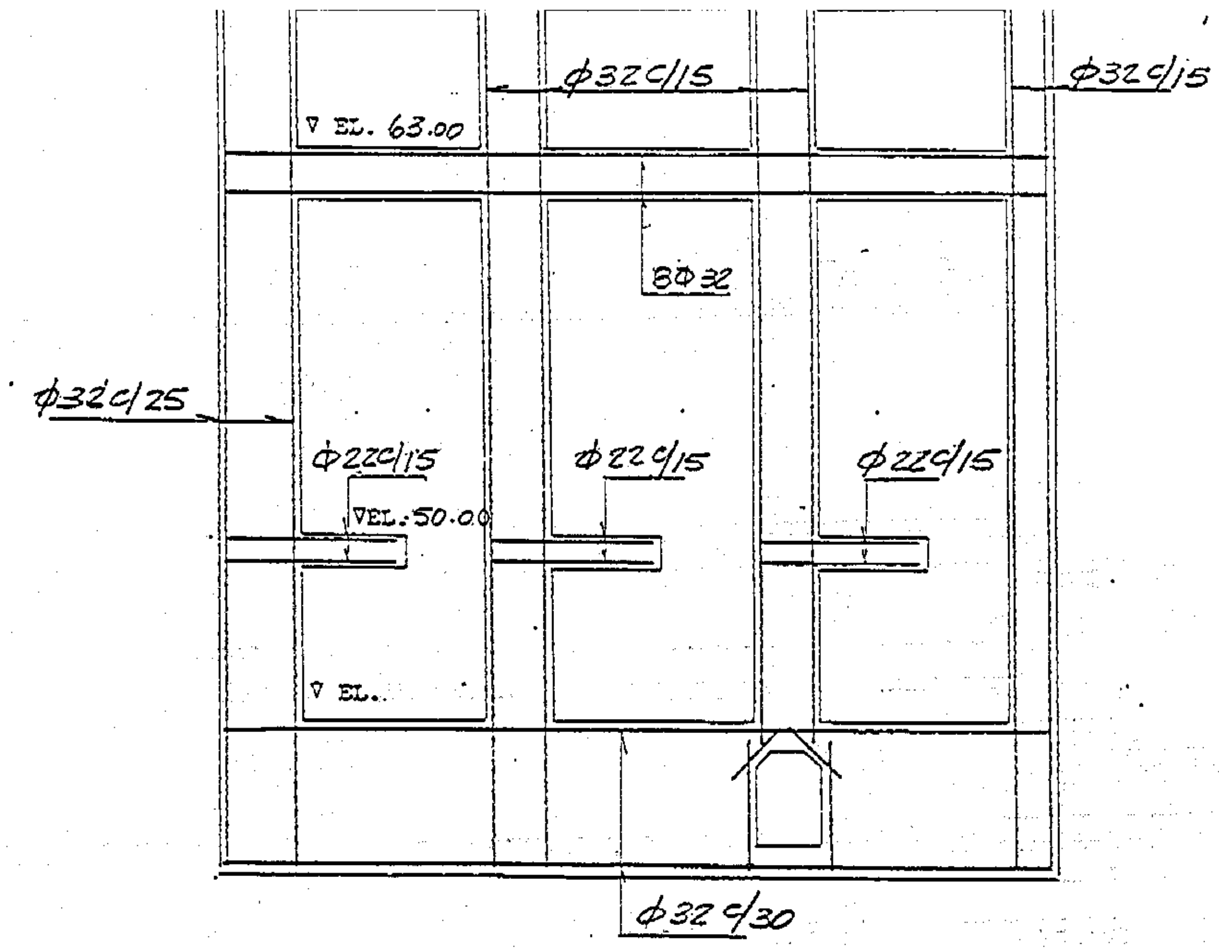
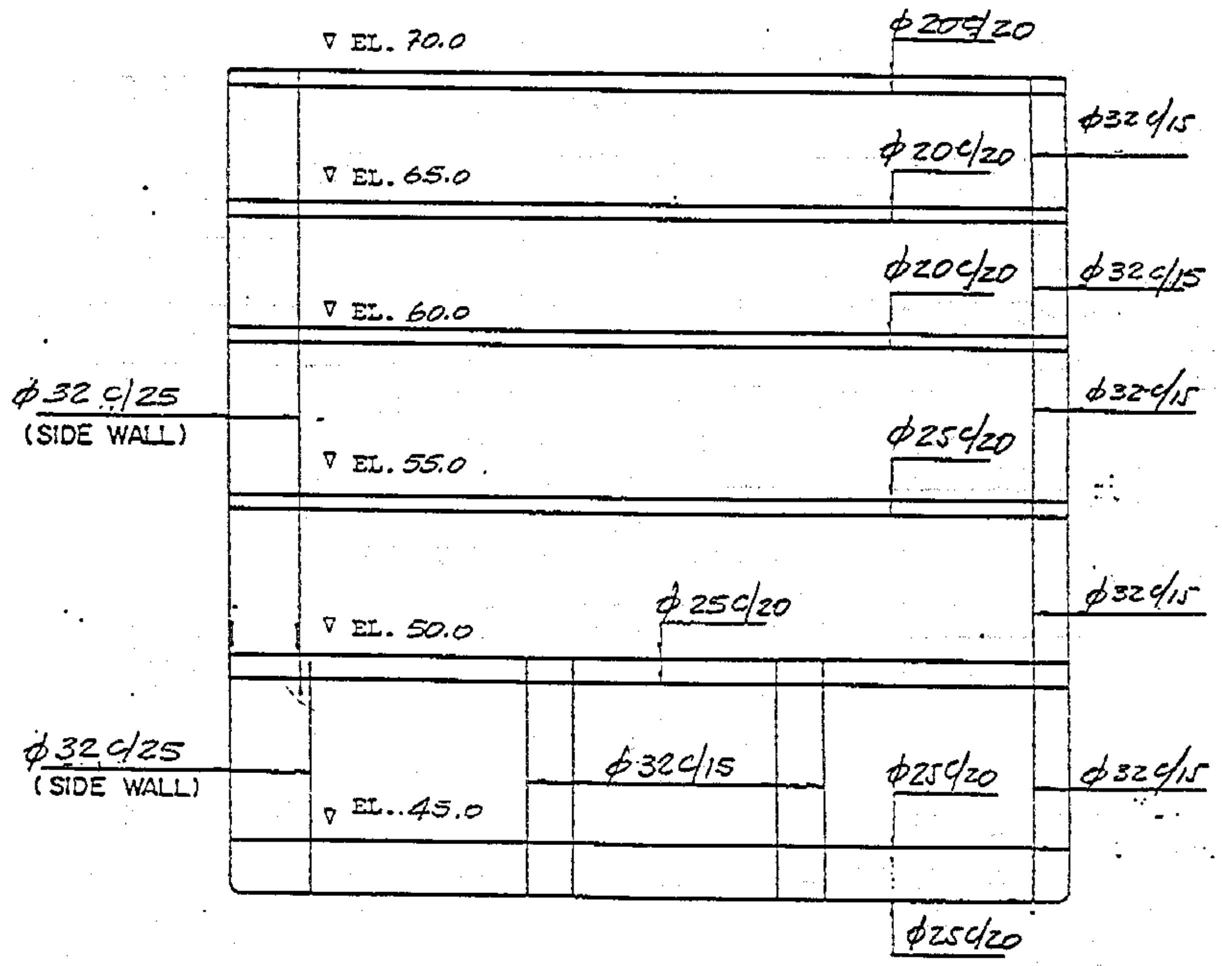


Fig. 1.1.14(c) B-B

1-1-18

136



EL. 70.0
EL. 65.0
EL. 60.0
EL. 55.0
EL. 50.0
EL..45.0
φ20c/20
φ20c/20
φ20c/20
φ25c/20
φ25c/20
φ25c/20
φ25c/20
φ32c/15
φ32c/15
φ32c/15
φ32c/15
φ32c/15
φ32c/15
φ32c/25
(SIDE WALL)
φ32c/25
(SIDE WALL)

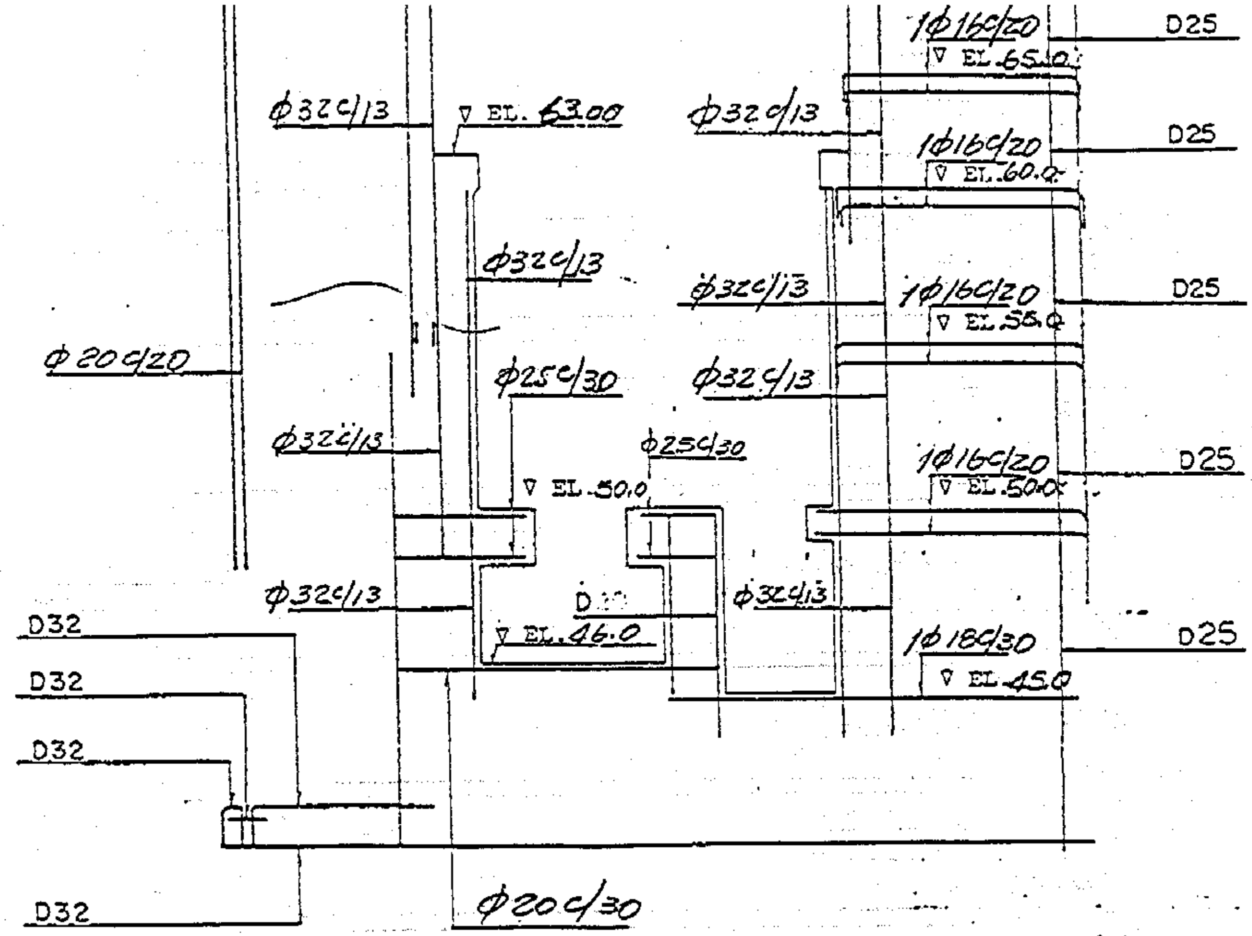


Fig. 1.1.14(e) D — D

(SLAB)

REINFORCEMENT

138

1-1-70

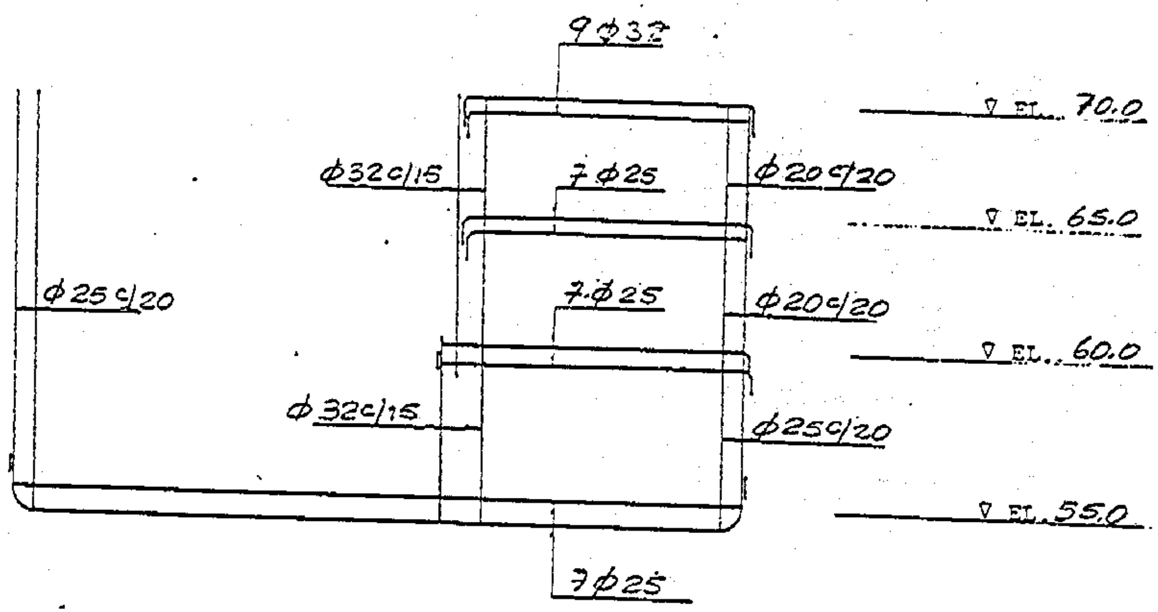


Fig. 1.1.14(f) E – E (BEAM AND COLUMN)

(B) Structural calculation of beam and slab

The floor slab and beam for i) roof and control room (EL.70.0), ii) cable gallery and laboratory (EL.65.0), iii) diesel engine room (EL.60.0), iv) cubicle room (EL.55.0), EL.42.0 to EL.45.0 for valve room are treated as the masssive concrete structure and minimum required reinforcement is provided in accordance with design criteria

Calculation model of slab and beam are shown in Fig. 1.1.5 and plan at each elevation is shown in from Fig. 1.1.16 to Fig. 1.1.20, respectively.

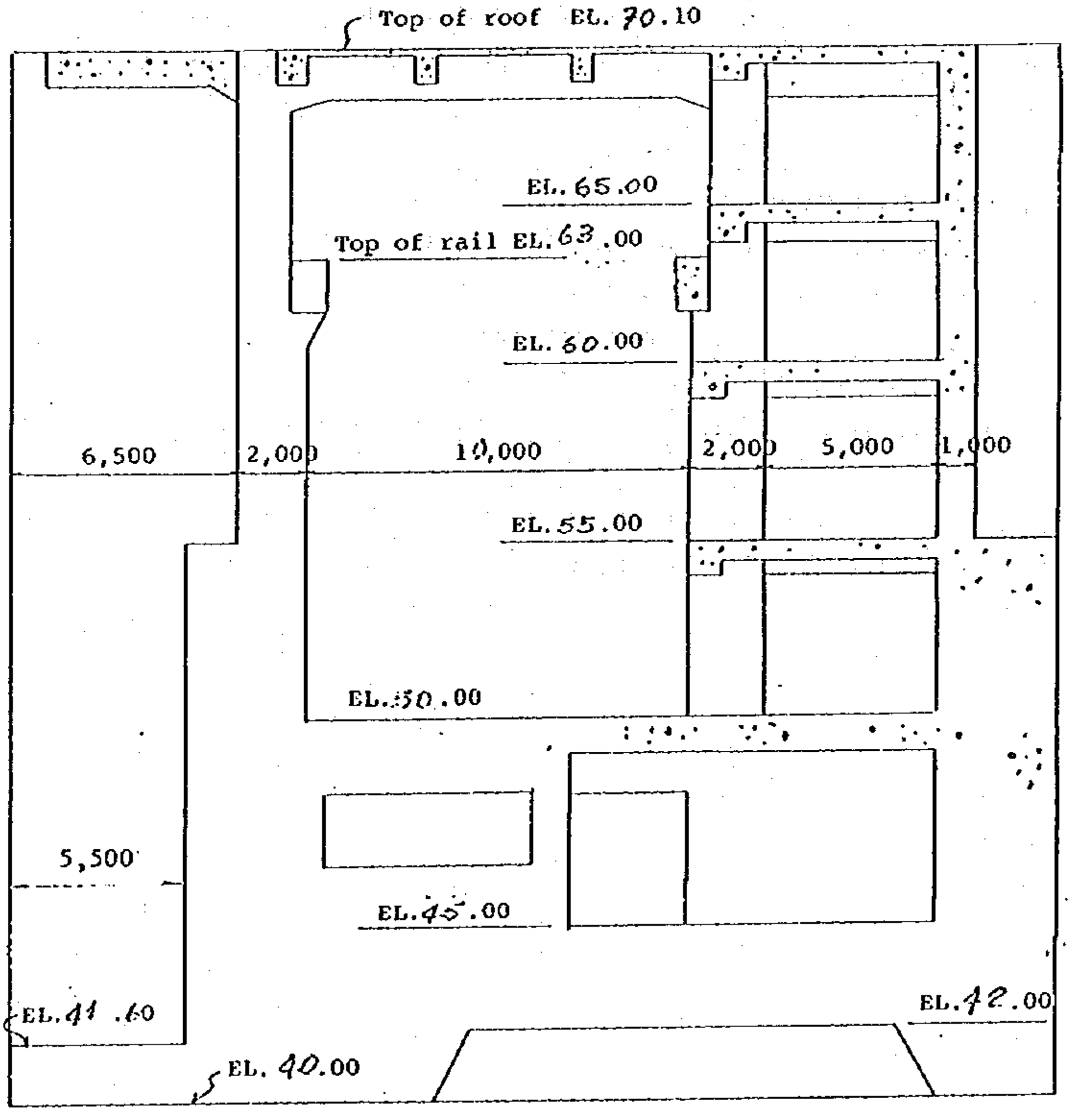


Fig.1.1.15 Structural Model of Beam & Slab

(1) Structural model of slab

The floor slabs for each elevation is categorized into following 6 types in accordance with their supporting conditions. Supporting conditions applied are designed taking into consideration of openings and pits for foundation of equipment, electric wiring and piping works, etc. The slab is designed as a two-way slab.

Type-1 : a two-way slab with four fixed ends.
Type-2 : a two-way slab with three fixed ends and one simple end.
Type-3 : a two-way slab with three fixed ends and one free end.
Type-4 : a two-way slab with two fixed ends and two simple ends.
Type-5 : a two-way slab with two fixed ends and two free ends.
Type-6 : a two-way slab with one fixed end, one free end and two simple ends.

Supporting condition and dimensions for each elevation are shown in Table
Typical diagrams of bending moment and shearing force for each type are shown in from T-1 to T-8 of 2.1.6.

SUPPORTING CONDITION AND DIMENSIONS

FLOOR	LINE	SUPPORTING CONDITION	Lx (m)	Ly (m)
EL. 70.10 (h=50 cm)	1-2	TYPE-2	5.00	7.00
	2-3	TYPE-4	6.00	6.50
	3-4,7-8	TYPE-3	2.50	7.00
	4-5,5-6,6-7	TYPE-1	6.50	7.00
EL. 65.00 (h=50 cm)	1-2	TYPE-2	5.50	6.50
	2-3,4-5,5-6,6-7	TYPE-1	8.00	6.50
	3-4,7-8	TYPE-3	8.00	2.50
EL. 60.00 (h=50 cm)	3-4,6-7,7-8	TYPE-3	5.50	7.00
	2-3,4-5,5-6	TYPE-1	8.00	7.00
	1-2	TYPE-2	7.00	7.00
EL. 55.00 (h=50 cm)	1-2	TYPE-4	4.00	6.00
	2-3	TYPE-2	5.00	7.00
	3-4,6-7,7-8	TYPE-3	7.00	2.50
	4-5	TYPE-2	7.00	4.00
	5-6	TYPE-1	8.00	7.00
EL. 50.00 (h=50 cm)	1-2,2-3,5-6,6-7	TYPE-2	7.00	10.00
	3-4,4-5	TYPE-2	7.50	10.00

1-1-75

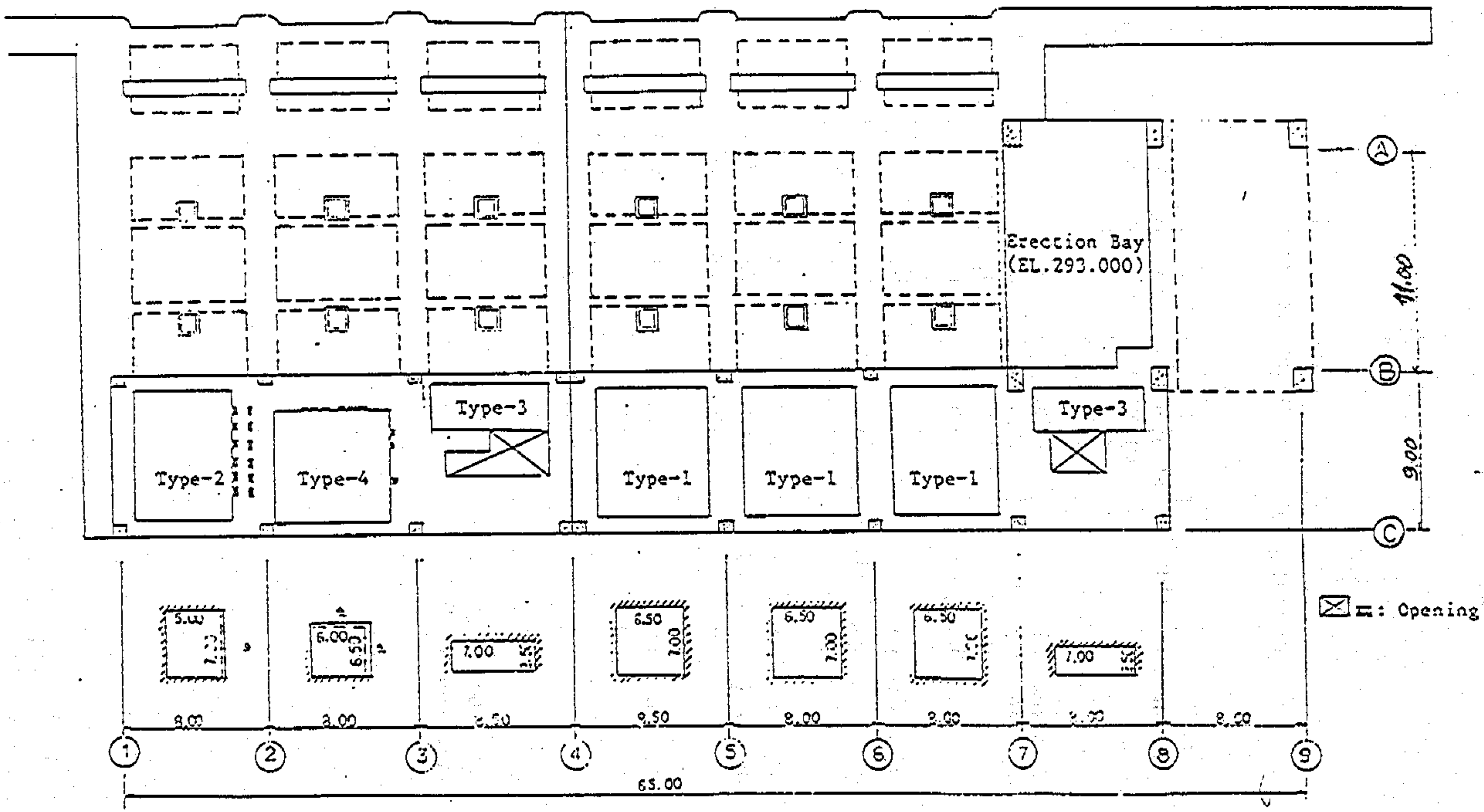


Fig. 1.1.16 PLAN (.70.10)

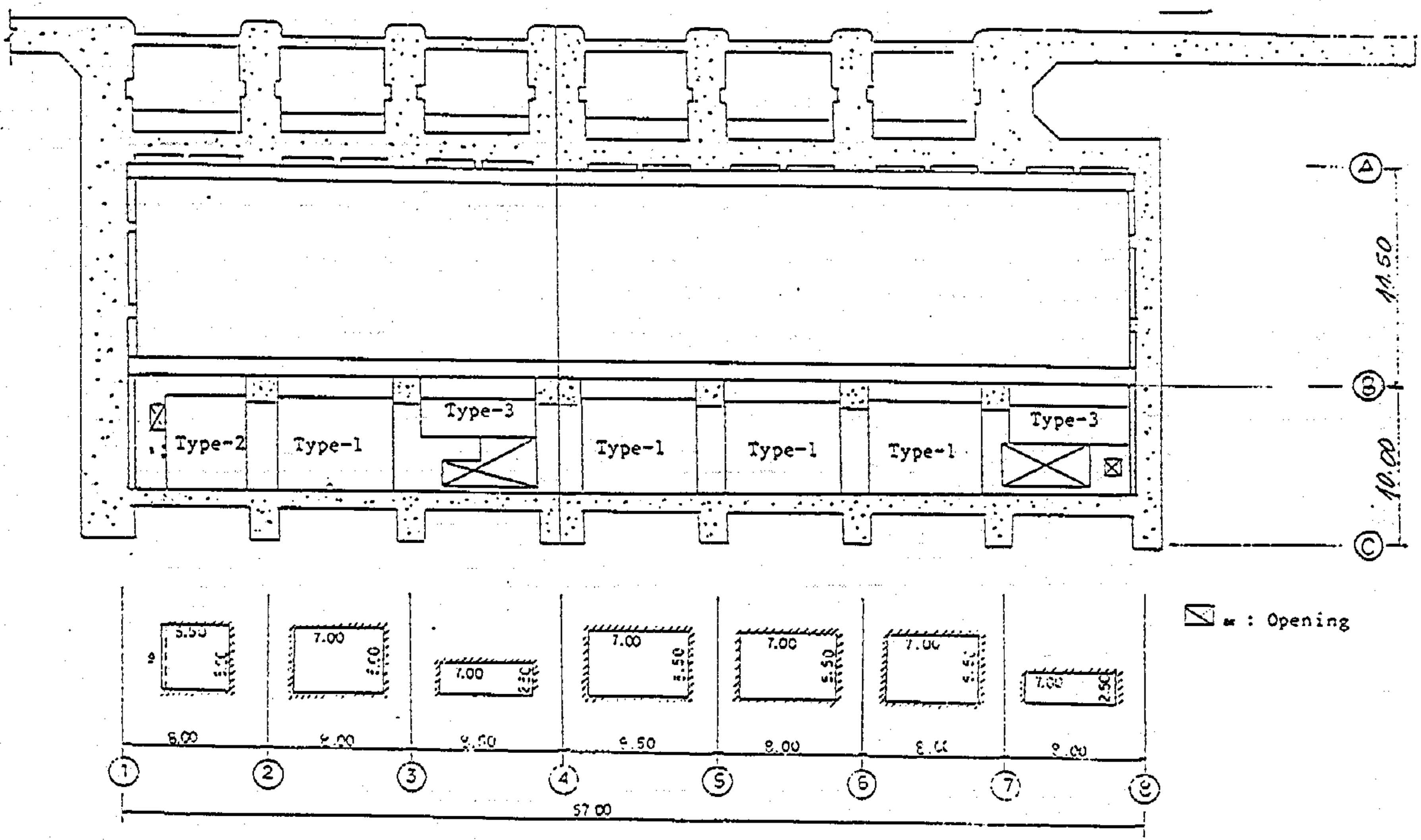


Fig. 1.1.17 PLAN (65.00)

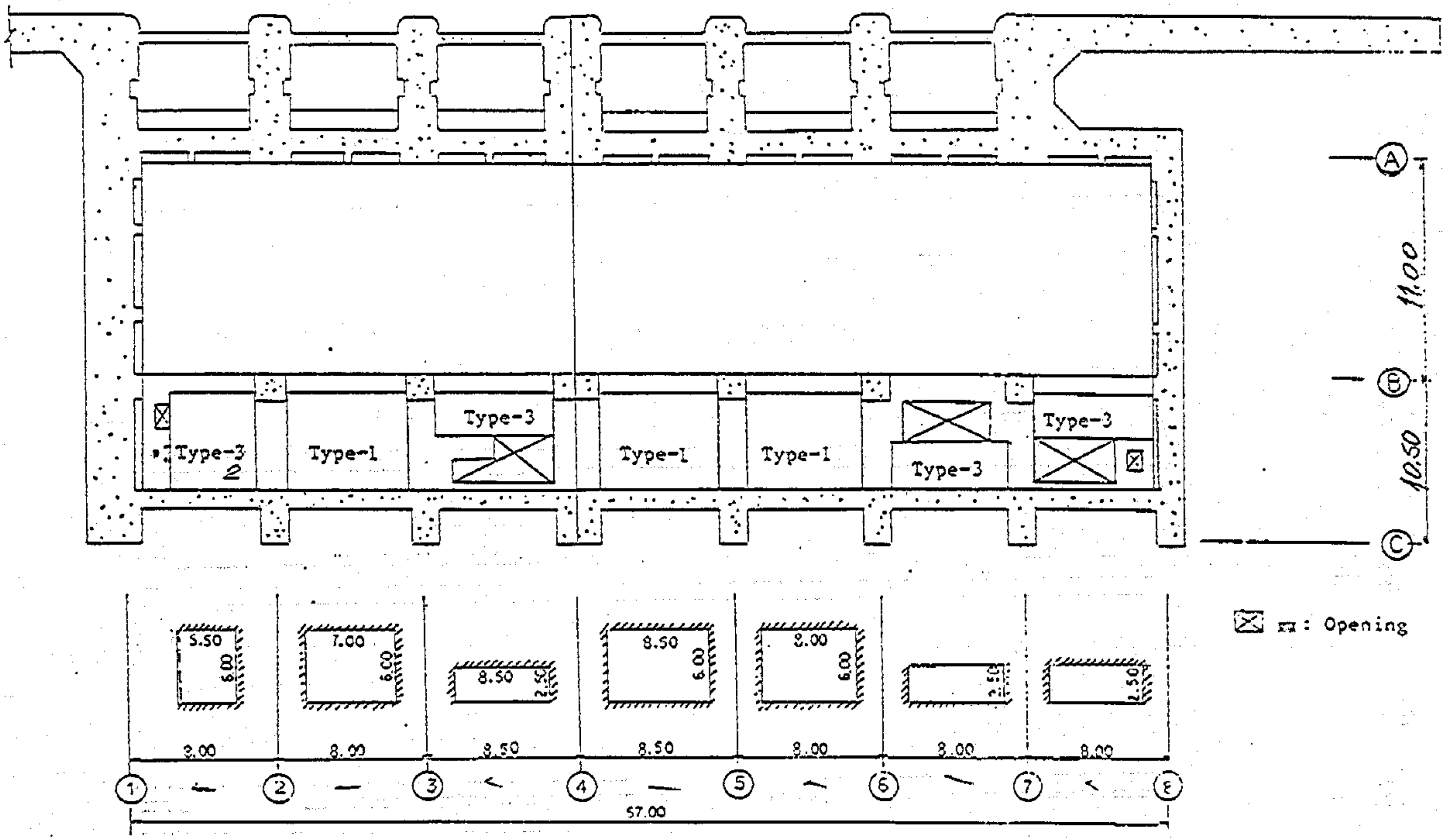


Fig. 1.1.18 PLAN (60.00)

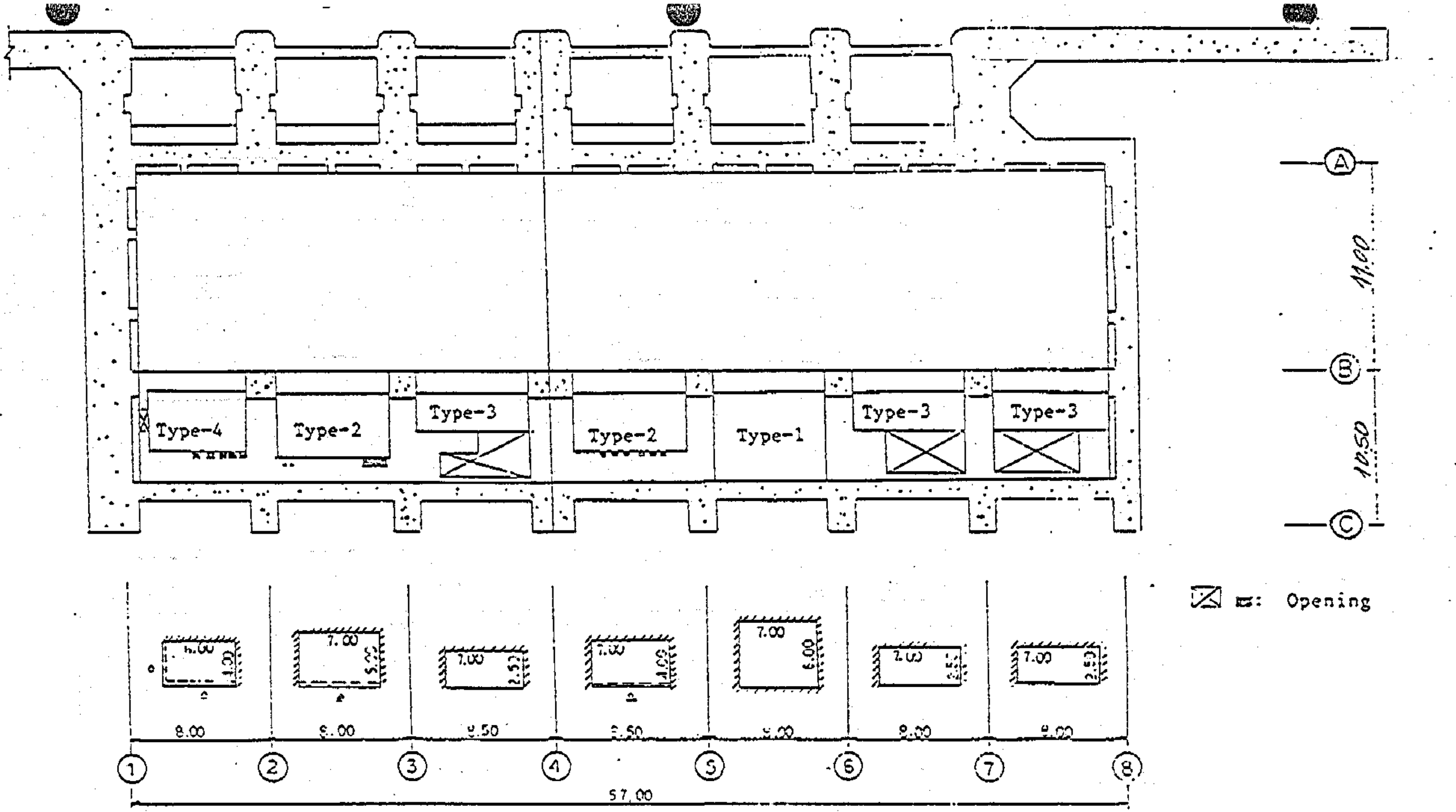


Fig. 1.1.19 PLAN (55.00)

1-1-79

147

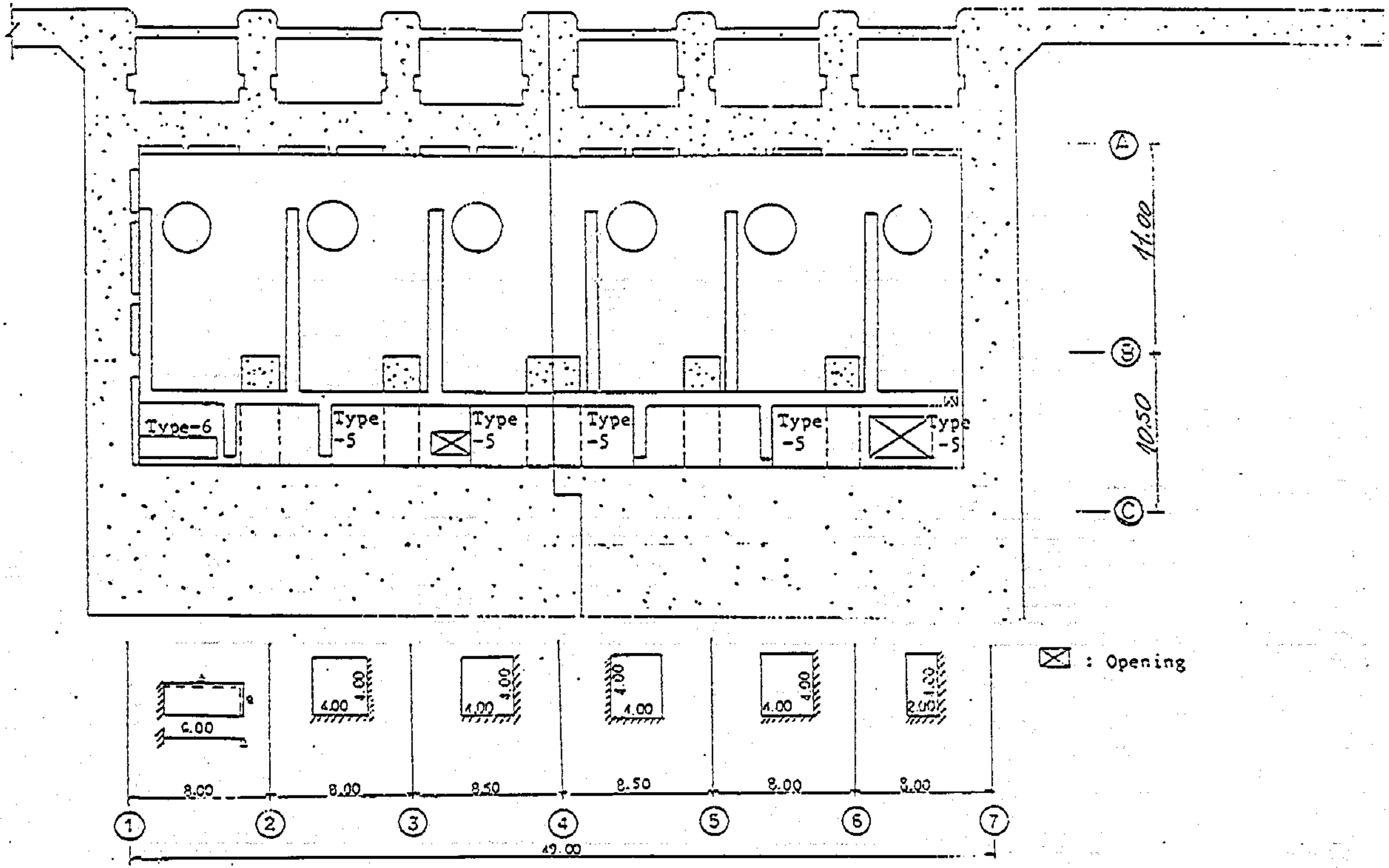
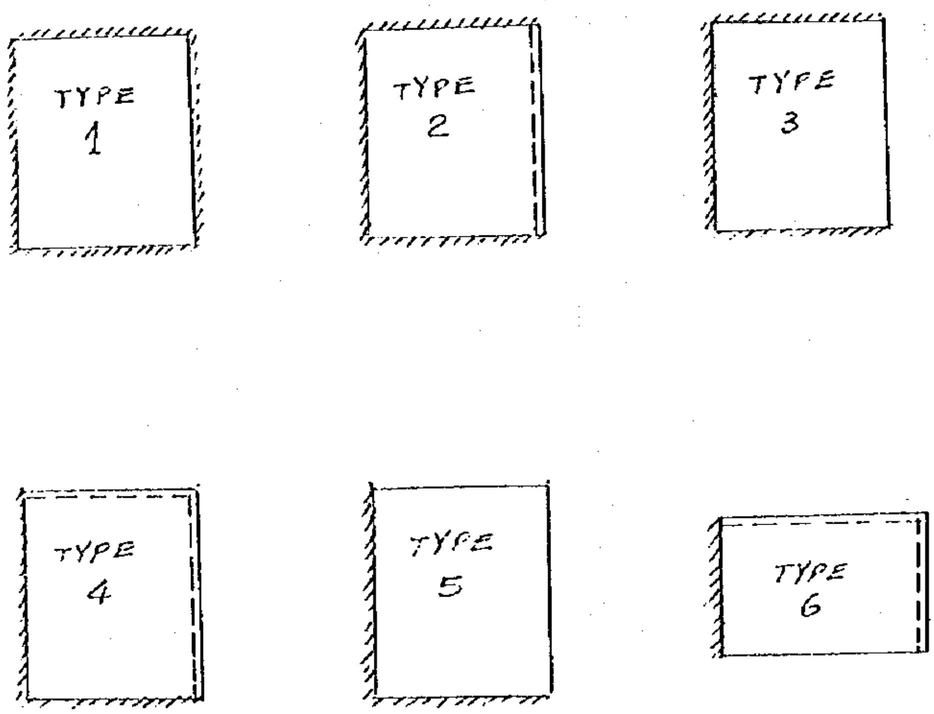


Fig. 1.1.20 PLAN (50.00)

STRUCTURAL MODEL OF SLABS

TYPE - 1 :	a two - way slab with four fixed ends
TYPE - 2 :	a two - way slab with three fixed ends and one simple end
TYPE - 3 :	a two - way slab with three fixed ends and one free end
TYPE - 4 :	a two - way slab with two fixed ends and two simple ends.
TYPE - 5 :	a two - way slab with two fixed ends and two free ends.
TYPE - 6 :	a two - way slab with one fixed end and one free end and two simple en



SLAB DESIGN

(2) **ELEVATION : 70.10**

LINE : 1 - 2 **TYPE = 2**

h =	0.50	m
DL =	1.20	t / m2
LL =	1.00	t / m2
Wu = 1.4DL + 1.7LL =	3.38	t / m2
Ly =	7.00	m
Lx =	5.00	m
Ly / Lx =	1.40	

M = c.Wu.(Lx)2
Q = c.Wu.Lx

	c			
Mx1 =	0.089	Wu.(Lx)2 =	7.52	t-m
Mx2 =	0.036	Wu.(Lx)2 =	3.04	t-m
My1 =	0.074	Wu.(Lx)2 =	6.25	t-m
My2 =	0.021	Wu.(Lx)2 =	1.77	t-m
Mymax	0.077	Wu.(Lx)2 =	6.51	t-m
Qx1 =	0.57	Wu.Lx =	9.63	t
Qx3 =	0.39	Wu.Lx =	6.59	t
Qy1 =	0.54	Wu.Lx =	9.13	t

LINE : 2 - 3 **TYPE = 4**

h =	0.50	m
DL =	1.20	t / m2
LL =	1.00	t / m2
Wu = 1.4DL + 1.7LL =	3.38	t / m2
Ly =	6.50	m
Lx =	6.00	m
Ly / Lx =	1.08	

M = c.Wu.(Lx)2
Q = c.Wu.Lx

	c			
Mx1 =	0.078	Wu.(Lx)2 =	9.49	t-m
Mx2 =	0.027	Wu.(Lx)2 =	3.29	t-m
My1 =	0.073	Wu.(Lx)2 =	8.88	t-m
My2 =	0.023	Wu.(Lx)2 =	2.80	t-m
My2max	0.025	Wu.(Lx)2 =	3.04	t-m
Qx1 =	0.55	Wu.Lx =	11.15	t
Qx3 =	0.52	Wu.Lx =	10.55	t
Qy1 =	0.37	Wu.Lx =	7.50	t
Qy3 =	0.37	Wu.Lx =	7.50	t

LINE : 3-4,7-8 **TYPE = 3**

h =	0.50	m
DL =	1.20	t / m2
LL =	1.00	t / m2
Wu = 1.4DL + 1.7LL =	3.38	t / m2
Ly =	7.00	m
Lx =	2.50	m
Ly / Lx =	2.80	

M = c.Wu.(Lx)2
Q = c.Wu.Lx

	c			
Mx1 =	0.313	Wu.(Lx)2 =	6.61	t-m
Mx2max	0.023	Wu.(Lx)2 =	0.49	t-m
My1 =	0.375	Wu.(Lx)2 =	7.92	t-m
My2 =	0.086	Wu.(Lx)2 =	1.82	t-m
My2max	0.086	Wu.(Lx)2 =	1.82	t-m
Qx1 =	1.00	Wu.Lx =	8.45	t
Qy1 =	1.05	Wu.Lx =	8.87	t

1-1-82

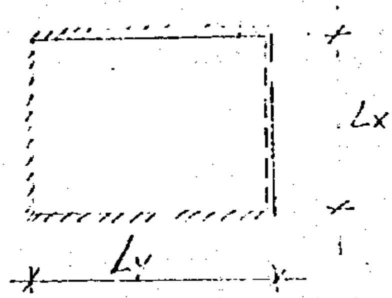
LINE :	4-5,5-6,6-7	TYPE =	1	
h =			0.50	m
DL =			1.20	t / m2
LL =			1.00	t / m2
Wu = 1.4DL + 1.7LL =			3.38	t / m2
Ly =			7.00	m
Lx =			6.50	m
Ly / Lx =			1.08	
M = c.Wu.(Lx)2				
Q = c.Wu.Lx				
	c			
Mx1 =	0.057	Wu.(Lx)2 =	8.14	t-m
Mx2max	0.021	Wu.(Lx)2 =	3.00	t-m
My1 =	0.053	Wu.(Lx)2 =	7.57	t-m
My2 =	0.017	Wu.(Lx)2 =	2.43	t-m
My2max	0.017	Wu.(Lx)2 =	2.43	t-m
Qx1 =	0.47	Wu.Lx =	10.33	t
Qy1 =	0.44	Wu.Lx =	9.67	t

SLAB DESIGN

ELEVATION : 70.10

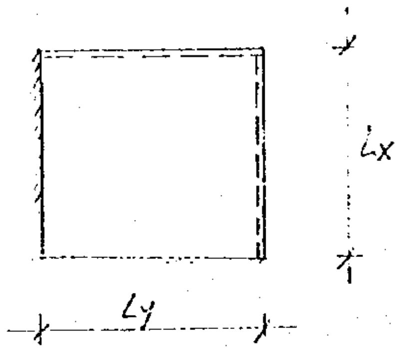
LINE : 1 - 2 **TYPE =** 2

h =			0.60	m
DL =			1.44	t / m2
LL =			1.00	t / m2
Wu = 1.4DL + 1.7LL =			3.72	t / m2
Ly =			7.00	m
Lx =			5.00	m
Ly / Lx =			1.40	
M = c.Wu.(Lx)2				
Q = c.Wu.Lx				
	c			
Mx1 =	0.089	Wu.(Lx)2 =	8.27	t-m
Mx2 =	0.036	Wu.(Lx)2 =	3.34	t-m
My1 =	0.074	Wu.(Lx)2 =	6.87	t-m
My2 =	0.021	Wu.(Lx)2 =	1.95	t-m
Mymax =	0.077	Wu.(Lx)2 =	7.15	t-m
Qx1 =	0.57	Wu.Lx =	10.59	t
Qx3 =	0.39	Wu.Lx =	7.25	t
Qy1 =	0.54	Wu.Lx =	10.03	t



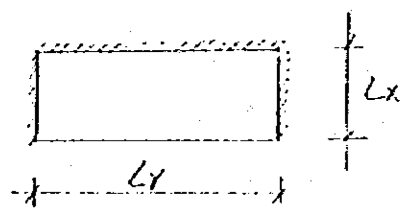
LINE : 2 - 3 **TYPE =** 4

h =			0.60	m
DL =			1.44	t / m2
LL =			1.00	t / m2
Wu = 1.4DL + 1.7LL =			3.72	t / m2
Ly =			6.50	m
Lx =			6.00	m
Ly / Lx =			1.08	
M = c.Wu.(Lx)2				
Q = c.Wu.Lx				
	c			
Mx1 =	0.078	Wu.(Lx)2 =	10.43	t-m
Mx2 =	0.027	Wu.(Lx)2 =	3.61	t-m
My1 =	0.073	Wu.(Lx)2 =	9.77	t-m
My2 =	0.023	Wu.(Lx)2 =	3.08	t-m
My2max	0.025	Wu.(Lx)2 =	3.34	t-m
Qx1 =	0.55	Wu.Lx =	12.26	t
Qx3 =	0.52	Wu.Lx =	11.59	t
Qy1 =	0.37	Wu.Lx =	8.25	t
Qy2 =	0.37	Wu.Lx =	8.25	t



LINE : 3-4,7-8 **TYPE =** 3

h =			0.60	m
DL =			1.44	t / m2
LL =			1.00	t / m2
Wu = 1.4DL + 1.7LL =			3.72	t / m2
Ly =			7.00	m
Lx =			2.50	m
Ly / Lx =			2.80	
M = c.Wu.(Lx)2				
Q = c.Wu.Lx				
	c			
Mx1 =	0.313	Wu.(Lx)2 =	7.27	t-m
Mx2max	0.023	Wu.(Lx)2 =	0.53	t-m
My1 =	0.375	Wu.(Lx)2 =	8.71	t-m
My2 =	0.086	Wu.(Lx)2 =	2.00	t-m
My2max	0.085	Wu.(Lx)2 =	2.00	t-m

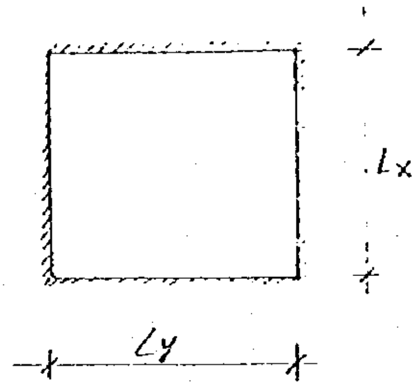


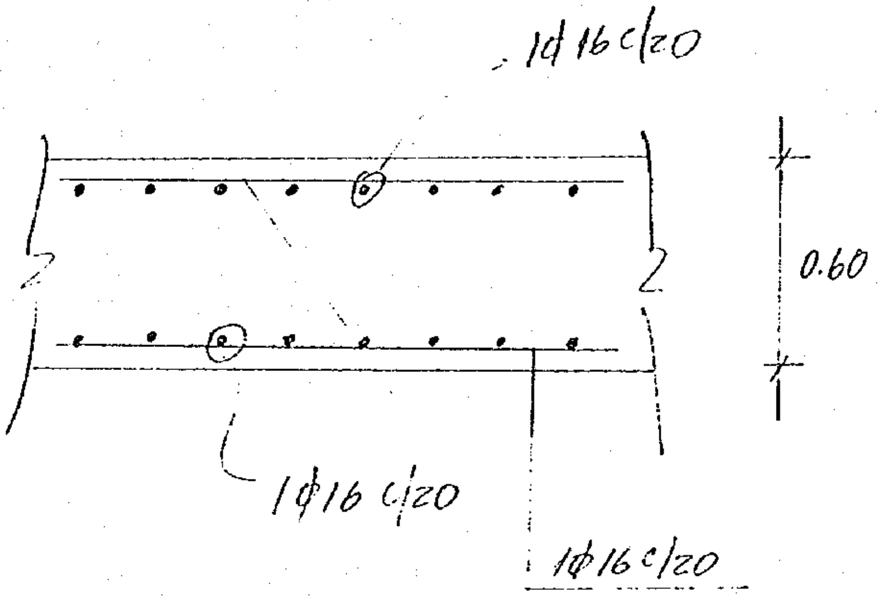
1-1-84

Qx1 =	1.00	Wu.Lx =	9.29	t
Qy1 =	1.05	Wu.Lx =	9.75	t

LINE : 4-5,5-6,6-7 **TYPE = 1**

h =			0.60	m
DL =			1.44	t / m2
LL =			1.00	t / m2
Wu = 1.4DL + 1.7LL =			3.72	t / m2
Ly =			7.00	m
Lx =			6.50	m
Ly / Lx =			1.08	
M = c.Wu.(Lx)2				
Q = c.Wu.Lx				
	c			
Mx1 =	0.067	Wu.(Lx)2 =	8.95	t-m
Mx2max	0.021	Wu.(Lx)2 =	3.30	t-m
My1 =	0.053	Wu.(Lx)2 =	8.32	t-m
My2 =	0.017	Wu.(Lx)2 =	2.67	t-m
My2max	0.017	Wu.(Lx)2 =	2.67	t-m
Qx1 =	0.47	Wu.Lx =	11.35	t
Qy1 =	0.44	Wu.Lx =	10.63	t





SLAB REINFORCEMENT EL. 70.1

1-1-85

FLEXURE STRENGTH DESIGN

ELEVATION : 70.1

GIVEN :

f'c = 210 Kg/cm²
fy = 4200 "
r = 7.5 cm
pmax=0.75pb = 1.61 (%)
ps = 0.90 (%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(temp (cm²)	As(adopt) (cm²)	As(adopt) (varillas)
Mx1	8.27	100.0	50.0	42.5	0.12	5.22	6.25	10.05	1 ø 16 @ 20 cm.
Mx2	3.34	100.0	50.0	42.5	0.05	2.09	6.25	10.05	1 ø 16 @ 20 cm.
My1	6.87	100.0	50.0	42.5	0.10	4.33	6.25	10.05	1 ø 16 @ 20 cm.
My2	1.95	100.0	50.0	42.5	0.03	1.22	6.25	10.05	1 ø 16 @ 20 cm.
Mymax	7.15	100.0	50.0	42.5	0.11	4.51	6.25	10.05	1 ø 16 @ 20 cm.
Mx1	10.43	100.0	50.0	42.5	0.16	6.62	6.25	10.05	1 ø 16 @ 20 cm.
Mx2	3.61	100.0	50.0	42.5	0.05	2.26	6.25	10.05	1 ø 16 @ 20 cm.
My1	9.77	100.0	50.0	42.5	0.15	6.19	6.25	10.05	1 ø 16 @ 20 cm.
My2	3.08	100.0	50.0	42.5	0.05	1.93	6.25	10.05	1 ø 16 @ 20 cm.
My2max	3.34	100.0	50.0	42.5	0.05	2.09	6.25	10.05	1 ø 16 @ 20 cm.
Mx1	7.27	100.0	50.0	42.5	0.11	4.58	6.25	10.05	1 ø 16 @ 20 cm.
Mx2max	0.53	100.0	50.0	42.5	0.01	0.33	6.25	10.05	1 ø 16 @ 20 cm.
My1	8.71	100.0	50.0	42.5	0.13	5.51	6.25	10.05	1 ø 16 @ 20 cm.
My2	2.00	100.0	50.0	42.5	0.03	1.25	6.25	10.05	1 ø 16 @ 20 cm.
My2max	2.00	100.0	50.0	42.5	0.03	1.25	6.25	10.05	1 ø 16 @ 20 cm.
Mx1	8.95	100.0	50.0	42.5	0.13	5.66	6.25	10.05	1 ø 16 @ 20 cm.
Mx2max	3.30	100.0	50.0	42.5	0.05	2.06	6.25	10.05	1 ø 16 @ 20 cm.
My1	8.32	100.0	50.0	42.5	0.12	5.26	6.25	10.05	1 ø 16 @ 20 cm.
My2	2.67	100.0	50.0	42.5	0.04	1.67	6.25	10.05	1 ø 16 @ 20 cm.
My2max	2.67	100.0	50.0	42.5	0.04	1.67	6.25	10.05	1 ø 16 @ 20 cm.

SHEAR STRENGTH DESIGN

ELEVATION : 70.1

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)
Qx1	10.69	100.0	16.22	50.0	42.50	27.75
Qx2	7.25	100.0	11.10	50.0	42.50	27.75
Qy1	10.03	100.0	15.37	50.0	42.50	27.75
Qx1	12.26	100.0	18.78	50.0	42.50	27.75
Qx3	11.59	100.0	17.76	50.0	42.50	27.75
Qy1	8.25	100.0	12.64	50.0	42.50	27.75
Qy3	8.25	100.0	12.64	50.0	42.50	27.75
Qx1	9.29	100.0	14.23	50.0	42.50	27.75
Qy1	9.75	100.0	14.94	50.0	42.50	27.75
Qx1	11.35	100.0	17.39	50.0	42.50	27.75
Qy1	10.63	100.0	16.28	50.0	42.50	27.75

1-1-86

SLAB DESIGN

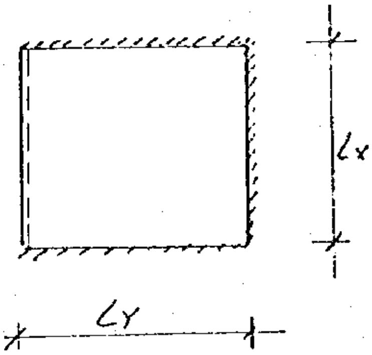
(3) **ELEVATION :** **65.00**

LINE : 1 - 2 **TYPE = 2**

h =	0.50	m
DL =	1.20	t/m2
LL =	1.00	t/m2
Wu = 1.4DL + 1.7LL =	3.38	t/m2
Ly =	6.50	m
Lx =	5.50	m
Ly / Lx =	1.18	

M = c.Wu.(Lx)2

Q = c.Wu.Lx



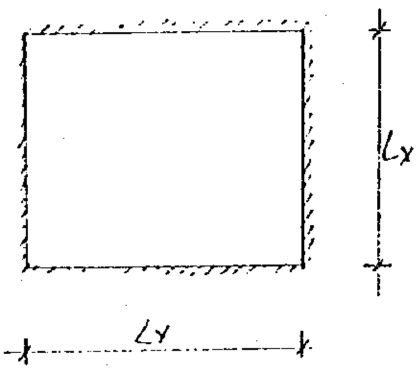
	c			
Mx1 =	0.072	Wu.(Lx)2 =	7.36	t-m
Mx2 =	0.025	Wu.(Lx)2 =	2.56	t-m
My1 =	0.068	Wu.(Lx)2 =	6.95	t-m
My2 =	0.022	Wu.(Lx)2 =	2.25	t-m
Mymax =	0.070	Wu.(Lx)2 =	7.16	t-m
Qx1 =	0.52	Wu.Lx =	9.67	t
Qx3 =	0.38	Wu.Lx =	7.06	t
Qy1 =	0.52	Wu.Lx =	9.67	t

LINE : 2-3,4-5,5-6,6-7 **TYPE = 1**

h =	0.50	m
DL =	1.20	t/m2
LL =	1.00	t/m2
Wu = 1.4DL + 1.7LL =	3.38	t/m2
Ly =	8.00	m
Lx =	6.50	m
Ly / Lx =	1.23	

M = c.Wu.(Lx)2

Q = c.Wu.Lx



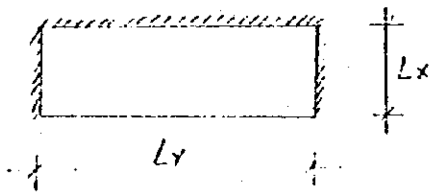
	c			
Mx1 =	0.066	Wu.(Lx)2 =	9.43	t-m
Mx2 =	0.038	Wu.(Lx)2 =	5.43	t-m
My1 =	0.056	Wu.(Lx)2 =	8.00	t-m
My2 =	0.028	Wu.(Lx)2 =	4.00	t-m
My2max	0.014	Wu.(Lx)2 =	2.00	t-m
Qx1 =	0.48	Wu.Lx =	10.55	t
Qy1 =	0.45	Wu.Lx =	9.89	t

LINE : 3-4,7-8 **TYPE = 3**

h =	0.50	m
DL =	1.20	t/m2
LL =	1.00	t/m2
Wu = 1.4DL + 1.7LL =	3.38	t/m2
Ly =	8.00	m
Lx =	2.50	m
Ly / Lx =	3.20	

M = c.Wu.(Lx)2

Q = c.Wu.Lx



	c			
Mx1 =	0.361	Wu.(Lx)2 =	7.63	t-m
Mx2max	0.020	Wu.(Lx)2 =	0.42	t-m
My1 =	0.420	Wu.(Lx)2 =	8.87	t-m
My2 =	0.080	Wu.(Lx)2 =	1.69	t-m
My2max	0.080	Wu.(Lx)2 =	1.69	t-m
Qx1 =	1.05	Wu.Lx =	8.87	t
Qy1 =	1.10	Wu.Lx =	9.30	t

1-1-87

1

FLEXURE STRENGTH DESIGN

ELEVATION : 65.0

GIVEN :

f'c = 210 Kg/cm²

fy = 4200 "

r = 7.5 cm

pmax=0.75pb = 1.61 (%)

ps = 0.90 (%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(temp) (cm²)	As(adopt) (cm²)	As(adopt) (varillas)
Mx1	7.36	100.0	50.0	42.5	0.11	4.64	6.25	10.05	1 ø 16 @ 20 cm.
Mx2	2.56	100.0	50.0	42.5	0.04	1.60	6.25	10.05	1 ø 16 @ 20 cm.
My1	6.95	100.0	50.0	42.5	0.10	4.38	6.25	10.05	1 ø 16 @ 20 cm.
My2	2.25	100.0	50.0	42.5	0.03	1.41	6.25	10.05	1 ø 16 @ 20 cm.
Mymax	7.16	100.0	50.0	42.5	0.11	4.51	6.25	10.05	1 ø 16 @ 20 cm.
Mx1	9.43	100.0	50.0	42.5	0.14	5.97	6.25	10.05	1 ø 16 @ 20 cm.
Mx2	5.43	100.0	50.0	42.5	0.08	3.41	6.25	10.05	1 ø 16 @ 20 cm.
My1	8.00	100.0	50.0	42.5	0.12	5.05	6.25	10.05	1 ø 16 @ 20 cm.
My2	4.00	100.0	50.0	42.5	0.06	2.51	6.25	10.05	1 ø 16 @ 20 cm.
My2max	2.00	100.0	50.0	42.5	0.03	1.25	6.25	10.05	1 ø 16 @ 20 cm.
Mx1	7.63	100.0	50.0	42.5	0.11	4.81	6.25	10.05	1 ø 16 @ 20 cm.
Mx2max	0.42	100.0	50.0	42.5	0.01	0.26	6.25	10.05	1 ø 16 @ 20 cm.
My1	8.67	100.0	50.0	42.5	0.13	5.61	6.25	10.05	1 ø 16 @ 20 cm.
My2	1.69	100.0	50.0	42.5	0.02	1.06	6.25	10.05	1 ø 16 @ 20 cm.
My2max	1.69	100.0	50.0	42.5	0.02	1.06	6.25	10.05	1 ø 16 @ 20 cm.

SHEAR STRENGTH DESIGN

ELEVATION : 65.0

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	φVc (ton)
Qx1	9.67	100.0	14.81	50.0	42.50	27.75
Qx3	7.06	100.0	10.82	50.0	42.50	27.75
Qy1	9.67	100.0	14.81	50.0	42.50	27.75
Qx1	10.55	100.0	16.15	50.0	42.50	27.75
Qy1	9.89	100.0	15.14	50.0	42.50	27.75
Qx1	8.87	100.0	13.59	50.0	42.50	27.75
Qy1	9.30	100.0	14.24	50.0	42.50	27.75

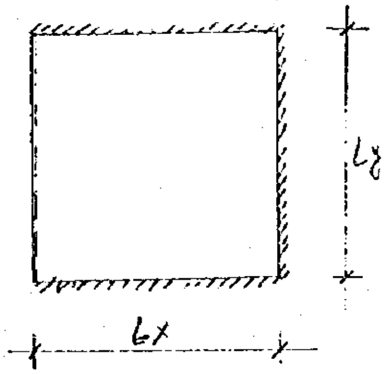
1-1-88

156

SLAB DESIGN

(4) **ELEVATION :** 60.00

LINE : 1-2 **TYPE = 2**

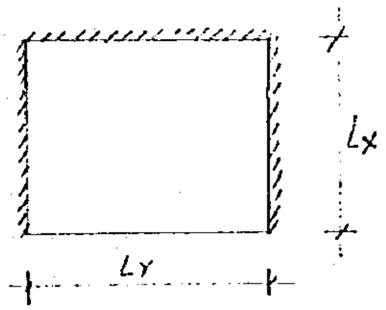


h =	0.50	m
DL =	1.20	t/m2
LL =	1.00	t/m2
Wu = 1.4DL + 1.7LL =	3.38	t/m2
Ly =	7.00	m
Lx =	7.00	m
Ly / Lx =	1.00	

M = c.Wu.(Lx)2
Q = c.Wu.Lx

	c			
Mx1 =	0.055	Wu.(Lx)2 =	9.11	t-m
Mx2 =	0.018	Wu.(Lx)2 =	2.98	t-m
My1 =	0.060	Wu.(Lx)2 =	9.94	t-m
My2 =	0.024	Wu.(Lx)2 =	3.97	t-m
Mymax =	0.061	Wu.(Lx)2 =	10.10	t-m
Qx1 =	0.45	Wu.Lx =	10.65	t
Qx3 =	0.32	Wu.Lx =	7.57	t
Qy1 =	0.44	Wu.Lx =	10.41	t

LINE : 3-4,6-7,7-8 **TYPE = 3**

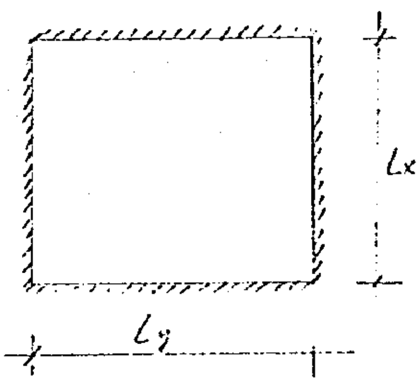


h =	0.50	m
DL =	1.20	t/m2
LL =	1.00	t/m2
Wu = 1.4DL + 1.7LL =	3.38	t/m2
Ly =	7.00	m
Lx =	5.50	m
Ly / Lx =	1.27	

M = c.Wu.(Lx)2
Q = c.Wu.Lx

	c			
Mx1 =	0.078	Wu.(Lx)2 =	7.98	t-m
Mx2 =	0.030	Wu.(Lx)2 =	3.07	t-m
My1 =	0.070	Wu.(Lx)2 =	7.16	t-m
My2 =	0.023	Wu.(Lx)2 =	2.35	t-m
Mymax =	0.074	Wu.(Lx)2 =	7.57	t-m
Qx1 =	0.55	Wu.Lx =	10.22	t
Qx3 =	0.04	Wu.Lx =	0.73	t
Qy1 =	0.54	Wu.Lx =	10.04	t

LINE : 2-3,4-5,5-6 **TYPE = 1**



h =	0.50	m
DL =	1.20	t/m2
LL =	1.00	t/m2
Wu = 1.4DL + 1.7LL =	3.38	t/m2
Ly =	8.00	m
Lx =	7.00	m
Ly / Lx =	1.14	

M = c.Wu.(Lx)2
Q = c.Wu.Lx

	c			
Mx1 =	0.062	Wu.(Lx)2 =	10.27	t-m
Mx2 =	0.024	Wu.(Lx)2 =	3.97	t-m
My1 =	0.055	Wu.(Lx)2 =	9.11	t-m
My2 =	0.016	Wu.(Lx)2 =	2.65	t-m
My2max	0.016	Wu.(Lx)2 =	2.65	t-m
Qx1 =	0.48	Wu.Lx =	11.36	t
Qy1 =	0.45	Wu.Lx =	10.65	t

1-1-89

FLEXURE STRENGTH DESIGN

ELEVATION : 60.0

GIVEN :

f'c =	210	Kg/cm²
fy =	4200	"
r =	7.5	cm
ρmax=0.75ρb =	1.61	(%)
ρs =	0.90	(%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(temp) (cm²)	As(adopt) (cm²)	As(adopt) (varillas)
Mx1	9.11	100.0	50.0	42.5	0.14	5.76	6.25	10.05	1 ø 16 @ 20 cm.
Mx2	2.98	100.0	50.0	42.5	0.04	1.87	6.25	10.05	1 ø 16 @ 20 cm.
My1	9.94	100.0	50.0	42.5	0.15	6.30	6.25	10.05	1 ø 16 @ 20 cm.
My2	3.97	100.0	50.0	42.5	0.06	2.49	6.25	10.05	1 ø 16 @ 20 cm.
Mymax	10.10	100.0	50.0	42.5	0.15	6.40	6.26	10.05	1 ø 16 @ 20 cm.
Mx1	7.99	100.0	50.0	42.5	0.12	5.03	6.25	10.05	1 ø 16 @ 20 cm.
Mx2	3.07	100.0	50.0	42.5	0.05	1.92	6.25	10.05	1 ø 16 @ 20 cm.
My1	7.16	100.0	50.0	42.5	0.11	4.51	6.25	10.05	1 ø 16 @ 20 cm.
My2	2.35	100.0	50.0	42.5	0.03	1.47	6.25	10.05	1 ø 16 @ 20 cm.
Mymax	7.57	100.0	50.0	42.5	0.11	4.77	6.25	10.05	1 ø 16 @ 20 cm.
Mx1	10.27	100.0	50.0	42.5	0.15	6.51	6.25	10.05	1 ø 16 @ 20 cm.
Mx2	3.97	100.0	50.0	42.5	0.06	2.49	6.25	10.05	1 ø 16 @ 20 cm.
My1	9.11	100.0	50.0	42.5	0.14	5.76	6.25	10.05	1 ø 16 @ 20 cm.
My2	2.65	100.0	50.0	42.5	0.04	1.66	6.25	10.05	1 ø 16 @ 20 cm.
My2max	2.65	100.0	50.0	42.5	0.04	1.66	6.25	10.05	1 ø 16 @ 20 cm.

SHEAR STRENGTH DESIGN

ELEVATION : 60.0

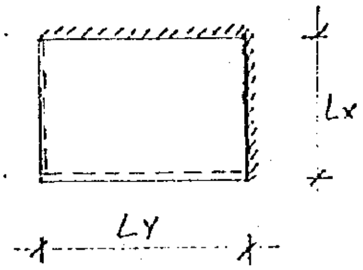
ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	φVc (ton)
Qx1	10.65	100.0	16.31	50.0	42.50	27.75
Qx3	7.57	100.0	11.60	50.0	42.50	27.75
Qy1	10.41	100.0	15.95	50.0	42.50	27.75
Qx1	10.22	100.0	15.66	50.0	42.50	27.75
Qx3	0.73	100.0	1.11	50.0	42.50	27.75
Qy1	10.04	100.0	15.38	50.0	42.50	27.75
Qx1	11.36	100.0	17.40	50.0	42.50	27.75
Qy1	10.65	100.0	16.31	50.0	42.50	27.75

1-1-90

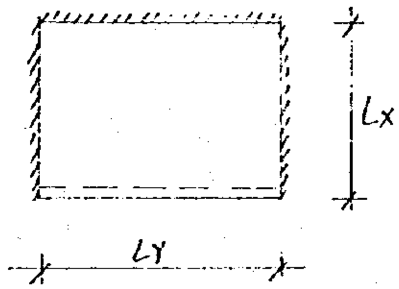
SLAB DESIGN

(5) **ELEVATION :** 65.00

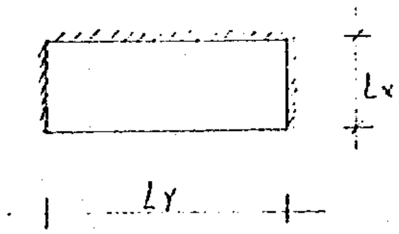
LINE :	**1-2**		**TYPE =**	**4**
h =			0.50	m
DL =			1.20	t/m2
LL =			1.00	t/m2
Wu = 1.4DL + 1.7LL =			3.38	t/m2
Ly =			6.00	m
Lx =			4.00	m
Ly / Lx =			1.50	
M = c.Wu.(Lx)2				
Q = c.Wu.Lx				
	c			
Mx1 =	0.103	Wu.(Lx)2 =	5.57	t-m
Mx2 =	0.043	Wu.(Lx)2 =	2.33	t-m
My1 =	0.080	Wu.(Lx)2 =	4.33	t-m
My2 =	0.015	Wu.(Lx)2 =	0.81	t-m
My2max	0.018	Wu.(Lx)2 =	0.97	t-m
Qx1 =	0.61	Wu.Lx =	8.25	t
Qx3 =	0.55	Wu.Lx =	7.44	t
Qy1 =	0.40	Wu.Lx =	5.41	t
Qy3 =	0.40	Wu.Lx =	5.41	t



LINE :	**2-3**		**TYPE =**	**2**
h =			0.50	m
DL =			1.20	t/m2
LL =			1.00	t/m2
Wu = 1.4DL + 1.7LL =			3.38	t/m2
Ly =			7.00	m
Lx =			5.00	m
Ly / Lx =			1.40	
M = c.Wu.(Lx)2				
Q = c.Wu.Lx				
	c			
Mx1 =	0.090	Wu.(Lx)2 =	7.61	t-m
Mx2 =	0.035	Wu.(Lx)2 =	2.96	t-m
My1 =	0.074	Wu.(Lx)2 =	6.25	t-m
My2 =	0.020	Wu.(Lx)2 =	1.69	t-m
Mymax =	0.079	Wu.(Lx)2 =	6.68	t-m
Qx1 =	0.58	Wu.Lx =	9.80	t
Qx3 =	0.40	Wu.Lx =	6.76	t
Qy1 =	0.53	Wu.Lx =	8.96	t



LINE :	**3-4,6-7,7-8**		**TYPE =**	**3**
h =			0.50	m
DL =			1.20	t/m2
LL =			1.00	t/m2
Wu = 1.4DL + 1.7LL =			3.38	t/m2
Ly =			7.00	m
Lx =			2.50	m
Ly / Lx =			2.80	
M = c.Wu.(Lx)2				
Q = c.Wu.Lx				
	c			
Mx1 =	0.310	Wu.(Lx)2 =	6.65	t-m
Mx2max	0.023	Wu.(Lx)2 =	0.49	t-m
My1 =	0.375	Wu.(Lx)2 =	7.92	t-m
My2 =	0.085	Wu.(Lx)2 =	1.80	t-m
Qx1 =	1.00	Wu.Lx =	8.45	t



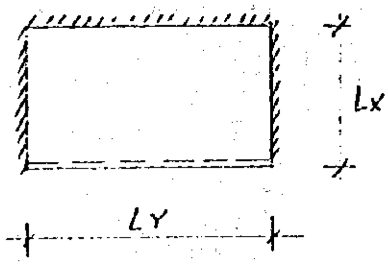
1-1-91

Qy1 = 1.10 Wu.Lx = 9.30 t

LINE : 4-5 TYPE = 2

h =		0.50	m
DL =		1.20	t/m2
LL =		1.00	t/m2
Wu = 1.4DL + 1.7LL =		3.38	t/m2
Ly =		7.00	m
Lx =		4.00	m
Ly / Lx =		1.75	

M = c.Wu.(Lx)2
Q = c.Wu.Lx

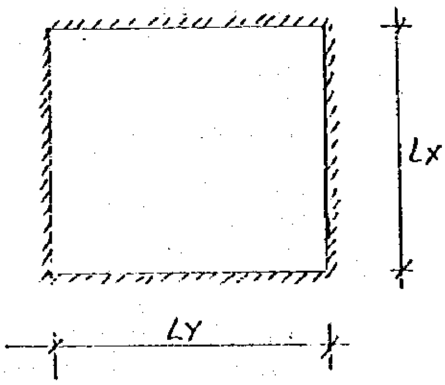


	c			
Mx1 =	0.105	Wu.(Lx)2 =	5.68	t-m
Mx2 =	0.048	Wu.(Lx)2 =	2.60	t-m
My1 =	0.079	Wu.(Lx)2 =	4.27	t-m
My2 =	0.013	Wu.(Lx)2 =	0.70	t-m
Mymax =	0.081	Wu.(Lx)2 =	4.38	t-m
Qx1 =	0.61	Wu.Lx =	8.25	t
Qx3 =	0.40	Wu.Lx =	5.41	t
Qy1 =	0.55	Wu.Lx =	7.44	t

LINE : 5-6 TYPE = 1

h =		0.60	m
DL =		1.20	t/m2
LL =		1.00	t/m2
Wu = 1.4DL + 1.7LL =		3.38	t/m2
Ly =		8.00	m
Lx =		7.00	m
Ly / Lx =		1.14	

M = c.Wu.(Lx)2
Q = c.Wu.Lx



	c			
Mx1 =	0.063	Wu.(Lx)2 =	10.43	t-m
Mx2 =	0.024	Wu.(Lx)2 =	3.97	t-m
My1 =	0.055	Wu.(Lx)2 =	9.11	t-m
My2max	0.016	Wu.(Lx)2 =	2.65	t-m
Qx1 =	0.47	Wu.Lx =	11.12	t
Qy1 =	0.45	Wu.Lx =	10.65	t

1-1-92

FLEXURE STRENGTH DESIGN

ELEVATION : 55.0

GIVEN :

f'c =	210	Kg/cm²
fy =	4200	"
r =	7.5	cm
pmax=0.75pb =	1.61	(%)
ps =	0.90	(%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(temp (cm²)	As(adopt) (cm²)	As(adopt) (varillas)
Mx1	5.57	100.0	50.0	42.5	0.08	3.50	6.25	10.05	1 ø 16 @ 20 cm.
Mx2	2.33	100.0	50.0	42.5	0.03	1.45	6.25	10.05	1 ø 16 @ 20 cm.
My1	4.33	100.0	50.0	42.5	0.06	2.71	6.25	10.05	1 ø 16 @ 20 cm.
My2	0.81	100.0	50.0	42.5	0.01	0.51	6.25	10.05	1 ø 16 @ 20 cm.
My2max	0.97	100.0	50.0	42.5	0.01	0.61	6.25	10.05	1 ø 16 @ 20 cm.
Mx1	7.61	100.0	50.0	42.5	0.11	4.80	6.25	10.05	1 ø 16 @ 20 cm.
Mx2	2.96	100.0	50.0	42.5	0.04	1.85	6.25	10.05	1 ø 16 @ 20 cm.
My1	6.25	100.0	50.0	42.5	0.09	3.94	6.25	10.05	1 ø 16 @ 20 cm.
My2	1.69	100.0	50.0	42.5	0.02	1.06	6.25	10.05	1 ø 16 @ 20 cm.
Mymax	6.68	100.0	50.0	42.5	0.10	4.20	6.25	10.05	1 ø 16 @ 20 cm.
Mx1	6.55	100.0	50.0	42.5	0.10	4.12	6.25	10.05	1 ø 16 @ 20 cm.
Mx2max	0.49	100.0	50.0	42.5	0.01	0.30	6.25	10.05	1 ø 16 @ 20 cm.
My1	7.92	100.0	50.0	42.5	0.12	5.00	6.25	10.05	1 ø 16 @ 20 cm.
My2	1.80	100.0	50.0	42.5	0.03	1.12	6.25	10.05	1 ø 16 @ 20 cm.
Mx1	5.68	100.0	50.0	42.5	0.08	3.57	6.25	10.05	1 ø 16 @ 20 cm.
Mx2	2.60	100.0	50.0	42.5	0.04	1.62	6.25	10.05	1 ø 16 @ 20 cm.
My1	4.27	100.0	50.0	42.5	0.06	2.68	6.25	10.05	1 ø 16 @ 20 cm.
My2	0.70	100.0	50.0	42.5	0.01	0.44	6.25	10.05	1 ø 16 @ 20 cm.
Mymax	4.35	100.0	50.0	42.5	0.06	2.75	6.25	10.05	1 ø 16 @ 20 cm.
Mx1	10.43	100.0	50.0	42.5	0.16	6.62	6.25	10.05	1 ø 16 @ 20 cm.
Mx2	3.97	100.0	50.0	42.5	0.06	2.49	6.25	10.05	1 ø 16 @ 20 cm.
My1	9.11	100.0	50.0	42.5	0.14	5.76	6.25	10.05	1 ø 16 @ 20 cm.
My2max	2.65	100.0	50.0	42.5	0.04	1.66	6.25	10.05	1 ø 16 @ 20 cm.
			50.0					10.05	1 ø 16 @ 20 cm.

SHEAR STRENGTH DESIGN

ELEVATION : 55.0

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)
Qx1	8.25	100.0	12.63	50.0	42.50	27.75
Qx3	7.44	100.0	11.39	50.0	42.50	27.75
Qy1	5.41	100.0	8.28	50.0	42.50	27.75
Qy1	5.41	100.0	8.28	50.0	42.50	27.75
Qy3	9.80	100.0	15.01	50.0	42.50	27.75
Qx1	6.76	100.0	10.35	50.0	42.50	27.75
Qx3	8.96	100.0	13.72	50.0	42.50	27.75
Qy1	8.45	100.0	12.94	50.0	42.50	27.75
Qx1	9.30	100.0	14.24	50.0	42.50	27.75
Qy1	8.25	100.0	12.63	50.0	42.50	27.75
Qx1	5.41	100.0	8.28	50.0	42.50	27.75
Qx3	7.44	100.0	11.39	50.0	42.50	27.75
Qy1	11.12	100.0	17.03	50.0	42.50	27.75
Qx1	10.65	100.0	16.31	50.0	42.50	27.75

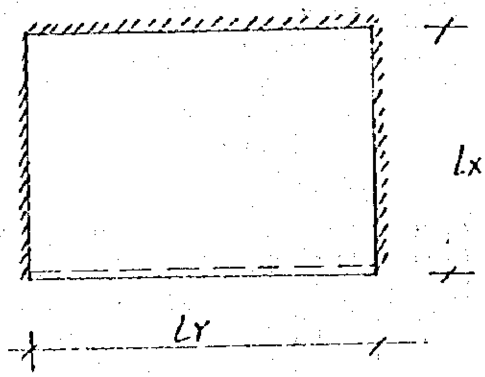
1-1-93

SLAB DESIGN

(6) ELEVATION : 60.00

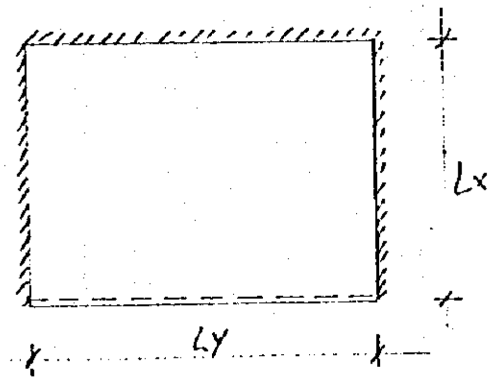
LINE : 1-2,2-3,5-6,6-7 TYPE = 2

h =			0.60	m
DL =			1.20	t/m2
LL =			1.00	t/m2
Wu = 1.4DL + 1.7LL =			3.38	t/m2
Ly =			10.00	m
Lx =			7.00	m
Ly / Lx =			1.43	
M = c.Wu.(Lx)2				
Q = c.Wu.Lx				
	c			
Mx1max	0.080	Wu.(Lx)2 =	13.25	t-m
Mx1 =	0.079	Wu.(Lx)2 =	13.08	t-m
Mx2 =	0.038	Wu.(Lx)2 =	6.29	t-m
My1 =	0.059	Wu.(Lx)2 =	9.77	t-m
My2 =	0.008	Wu.(Lx)2 =	1.32	t-m
Mymax =	0.013	Wu.(Lx)2 =	2.15	t-m
Qx1 =	0.51	Wu.Lx =	12.07	t
Qx3 =	0.38	Wu.Lx =	8.99	t
Qy1 =	0.43	Wu.Lx =	10.17	t



LINE : 3-4,4-5 TYPE = 2

h =			0.60	m
DL =			1.20	t/m2
LL =			1.00	t/m2
Wu = 1.4DL + 1.7LL =			3.38	t/m2
Ly =			10.00	m
Lx =			7.50	m
Ly / Lx =			1.33	
M = c.Wu.(Lx)2				
Q = c.Wu.Lx				
	c			
Mx1max	0.078	Wu.(Lx)2 =	14.83	t-m
Mx1 =	0.076	Wu.(Lx)2 =	14.45	t-m
Mx2 =	0.034	Wu.(Lx)2 =	6.46	t-m
My1 =	0.059	Wu.(Lx)2 =	11.22	t-m
My2 =	0.011	Wu.(Lx)2 =	2.09	t-m
Mymax =	0.013	Wu.(Lx)2 =	2.47	t-m
Qx1 =	0.52	Wu.Lx =	13.18	t
Qx3 =	0.37	Wu.Lx =	9.38	t
Qy1 =	0.48	Wu.Lx =	12.17	t



1-1-94

FLEXURE STRENGTH DESIGN
ELEVATION : 50.0
GIVEN :

f'c = 210 Kg/cm²
fy = 4200
r = 7.5 cm
ρmax=0.75ρb = 1.61 (%)
ρs = 0.90 (%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(temp (cm²)	As(adop (cm²)	As(adopt) (varillas)
Mx1max	13.25	100.0	50.0	42.5	0.20	8.45	6.25	10.05	1 ø 16 @ 20 cm.
Mx1	13.08	100.0	50.0	42.5	0.20	8.34	6.25	10.05	1 ø 16 @ 20 cm.
Mx2	6.29	100.0	50.0	42.5	0.09	3.96	6.25	10.05	1 ø 16 @ 20 cm.
My1	9.77	100.0	50.0	42.5	0.15	6.19	6.25	10.05	1 ø 16 @ 20 cm.
My2	1.32	100.0	50.0	42.5	0.02	0.83	6.25	10.05	1 ø 16 @ 20 cm.
Mymax	2.15	100.0	50.0	42.5	0.03	1.35	6.25	10.05	1 ø 16 @ 20 cm.
Mx1max	14.83	100.0	50.0	42.5	0.22	9.48	6.25	10.05	1 ø 16 @ 20 cm.
Mx1	14.45	100.0	50.0	42.5	0.22	9.23	6.25	10.05	1 ø 16 @ 20 cm.
Mx2	6.46	100.0	50.0	42.5	0.10	4.07	6.25	10.05	1 ø 16 @ 20 cm.
My1	11.22	100.0	50.0	42.5	0.17	7.12	6.25	10.05	1 ø 16 @ 20 cm.
My2	2.09	100.0	50.0	42.5	0.03	1.31	6.25	10.05	1 ø 16 @ 20 cm.
Mymax	2.47	100.0	50.0	42.5	0.04	1.55	6.25	10.05	1 ø 16 @ 20 cm.

SHEAR STRENGTH DESIGN
ELEVATION : 50.0

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)
Qx1	12.07	100.0	16.46	50.0	42.50	27.75
Qx3	8.99	100.0	13.77	50.0	42.50	27.75
Qy1	10.17	100.0	15.58	50.0	42.50	27.75
Qx1	13.18	100.0	20.19	50.0	42.50	27.75
Qx3	9.38	100.0	14.37	50.0	42.50	27.75
Qy1	12.17	100.0	18.64	50.0	42.50	27.75

(7)

SLAB DESIGN

MOTOR ROOM

ELEVATION :		50.00	(motor floor) A-B line
LINE : 1-2,3-4,5-6		TYPE =	1
h =		2.00	m
DL =		4.80	t / m2
LL =		2.00	t / m2
Wu =1.4DL + 1.7LL =		10.12	t / m2
Ly =		8.00	m
Lx =		8.00	m
Ly / Lx =		1.00	

M = c.Wu.(Lx)2

Q = c.Wu.Lx

	c			
Mx1 =	0.053	Wu.(Lx)2 =	34.33	t-m
My1 =	0.053	Wu.(Lx)2 =	34.33	t-m
Mx2 =	0.018	Wu.(Lx)2 =	11.66	t-m
My2max	0.018	Wu.(Lx)2 =	11.66	t-m
Qx1 =	0.44	Wu.Lx =	35.62	t
Qy1 =	0.44	Wu.Lx =	35.62	t

LINE : 2-3,4-5,6-7		TYPE =	3
h =		2.00	m
DL =		4.80	t / m2
LL =		2.00	t / m2
Wu =1.4DL + 1.7LL =		10.12	t / m2
Ly =		8.00	m
Lx =		6.00	m
Ly / Lx =		1.33	

M = c.Wu.(Lx)2

O = c.Wu.Lx

	c			
My2max	0.010	Wu.(Lx)2 =	3.64	t-m
Mx1 =	0.083	Wu.(Lx)2 =	30.24	t-m
Mx2 =	0.042	Wu.(Lx)2 =	15.30	t-m
My1 =	0.058	Wu.(Lx)2 =	21.13	t-m
Ox1 =	0.50	Wu.Lx =	30.36	t
Qy1 =	0.40	Wu.Lx =	24.29	t

1-1-96

FLEXURE STRENGTH DESIGN
MOTOR ROOM 50.0
GIVEN :

f'c = 210 Kg/cm²
fy = 4200 "
r = 7.5 cm
pmax=0.75pb = 1.61 (%)
ps = 0.90 (%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(temp) (cm²)	As(adopt) (cm²)	As(adopt) (varillas)
Mx1	34.33	100.0	200.0	192.5	0.02	4.73	25.00	25.34	1 ø 22 @ 15 cm.
My1	34.33	100.0	200.0	192.5	0.02	4.73	25.00	25.34	1 ø 22 @ 15 cm.
Mx2	11.66	100.0	200.0	192.5	0.01	1.60	25.00	25.34	1 ø 22 @ 15 cm.
My2max	11.66	100.0	200.0	192.5	0.01	1.60	25.00	25.34	1 ø 22 @ 15 cm.
My2max	3.64	100.0	200.0	192.5	0.00	0.50	25.00	25.34	1 ø 22 @ 15 cm.
Mx1	30.24	100.0	200.0	192.5	0.02	4.17	25.00	25.34	1 ø 22 @ 15 cm.
Mx2	15.30	100.0	200.0	192.5	0.01	2.11	25.00	25.34	1 ø 22 @ 15 cm.
My1	21.13	100.0	200.0	192.5	0.02	2.91	25.00	25.34	1 ø 22 @ 15 cm.

SHEAR STRENGTH DESIGN
MOTOR ROOM 50.0

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)
Qx1	35.62	100.0	54.57	200.0	192.50	125.67
Qy1	35.62	100.0	54.57	200.0	192.50	125.67
Qx1	30.35	100.0	46.50	200.0	192.50	125.67
Qy1	24.29	100.0	37.20	200.0	192.50	125.67

1-1-97

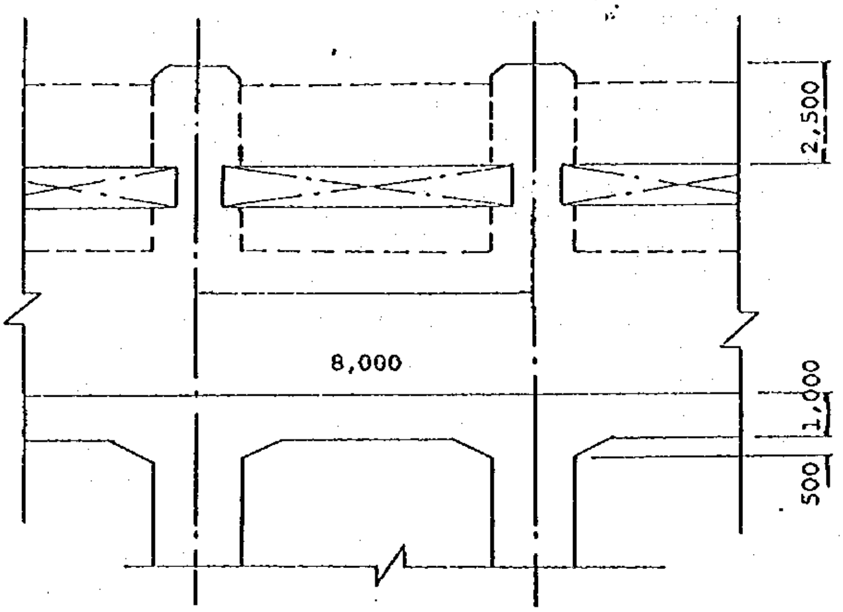
SLAB DESIGN

(B) Floor slab for gantry crane

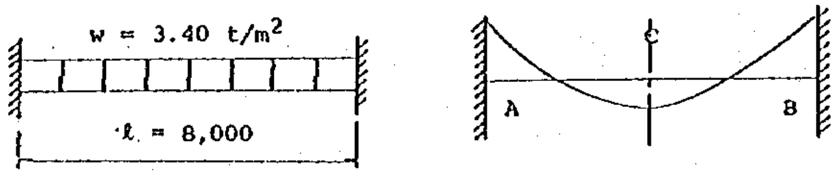
The floor is designed as a fixed beam with uniform load of 1.0 t/m2

TOTAL STATIC ULTIMATE LOAD :

h =	1.00	m
DL =	2.40	t / m2
LL =	1.00	t / m2
Wu =1.4DL + 1.7LL =	5.06	t / m2
L =	8.00	m
Mu = Wu.L²/12 =	26.99	t-m
Qu=Wu.L/2 =	20.24	ton



$W = 1.00 \times 2.40 + 1.00 = 3.40\ t/m^2$



166

1-1-98

FLEXURE STRENGTH DESIGN

Floor slab for gantry crane

GIVEN :

f'c = 210 Kg/cm²
fy = 4200 "
r = 7.5 cm
ρmax=0.75ρb= 1.61 (%)
ρs = 0.90 (%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	ρ (%)	As (cm²)	As(temp) (cm²)	As(adopt) (cm²)	As(adopt) (varillas)
Mu1	26.99	100.0	100.0	92.5	0.08	7.80	12.50	15.71	1 ø 20 @ 20 cm

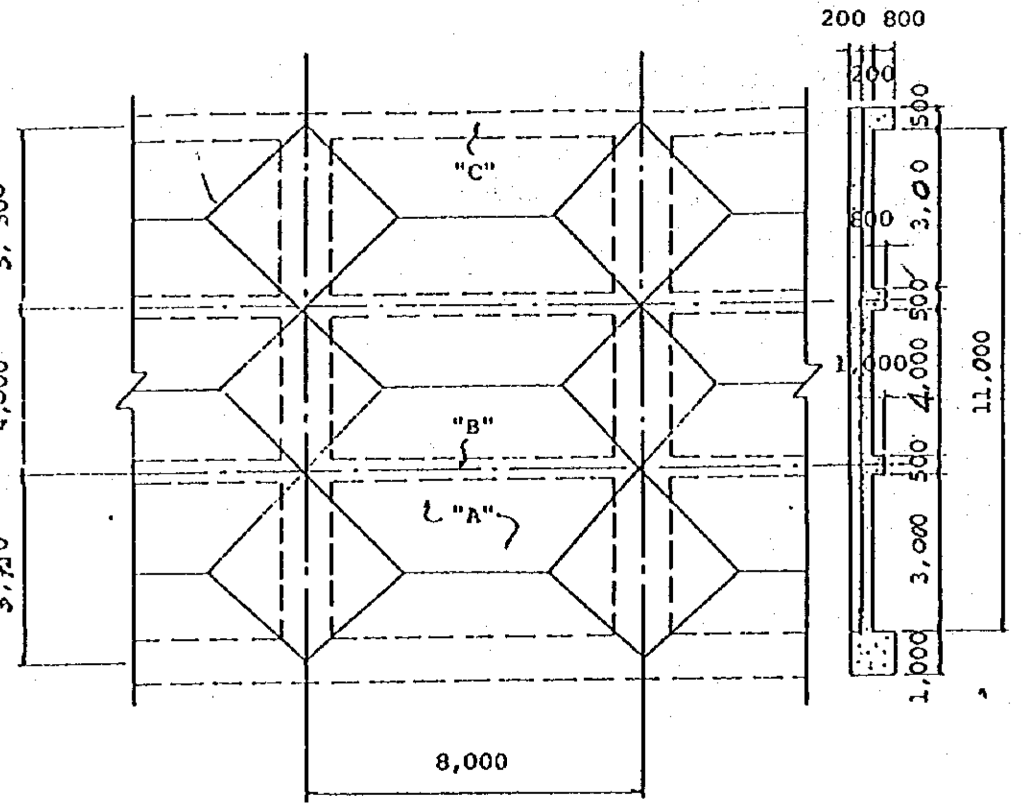
SHEAR STRENGTH DESIGN

Floor slab for gantry crane

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)
Qu1	20.24	100.0	31.00	100.0	92.50	60.39

1-1-99

(9) Roof (EL. 70.10 m)



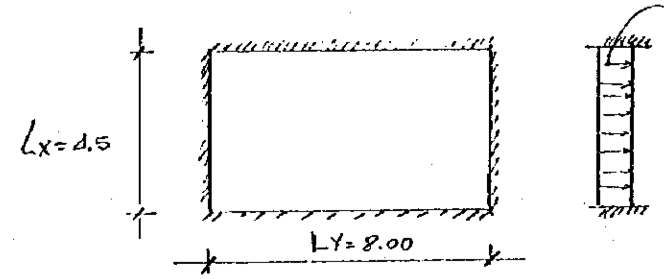
Roof (EL. 70.10).

Loads:

Self-Weight = $W_1 = 0.20 \times 2.40 = 0.48\ T/m^2$
Mortar weight = $W_2 = 0.20 \times 2.00 = 0.40\ T/m^2$
Live-load = $W_3 = 0.20\ T/m^2$

$W_u = 1.4(0.48 + 0.40) + 1.7(0.20) = 1.57\ T/m^2$

1) SLAB
The roof slab is designed as a two way slab with four fixed ends at part "A".



$W_u = 1.57\ T/m^2$.
$L_Y/L_X = 8.0/4.5 = 1.78$

$M_{X1} = 0.082 \times 1.57 \times \overline{4.5}^2 = 2.61$ T-m.
$M_{Y2} = 0.038 \times 1.57 \times \overline{4.5}^2 = 1.21$ "
$M_{Y1} = 0.057 \times 1.57 \times \overline{4.5}^2 = 1.81$ "
$M_{Y2} = 0.010 \times 1.57 \times \overline{4.5}^2 = 0.32$ "
$Q_{X1} = 0.52 \times 1.57 \times 4.5 = 3.67$ Ton.
$Q_{Y1} = 0.46 \times 1.57 \times 4.5 = 3.25$ Ton.

$M_{max} = 2.61$ T-m para $b = 100$ $d = 17$ $f'_c = 210$
$f_y = 4200$.

$\rho = 0.25\%$ $A_s = 4.18\ cm^2/m$. USAR: 1φ 12 c/25 (4.52
$A_{s\,min} = 2.50\ cm^2/m$ 1φ10 c/25

1(

ii) BEAMS

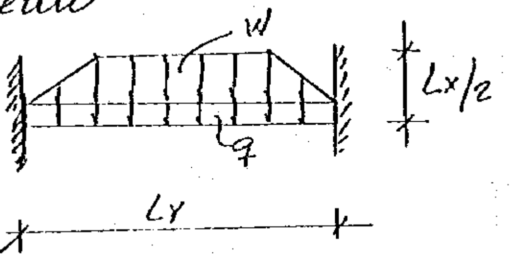
a) BEAM "B"

The beam is designed as a fixed beam.

Loads :

- Self-Weight = $W = 0.5 \times 0.8 \times 2.4 = 0.96$ T/m
- Uniform load = 1.57 T/m²

In case of floor beam, the calculation of load item (c), moment (Mo) and shearing force (Qo) are made by using the simplified equation presented below



w = uniform load of floor

q = uniform load of beam.

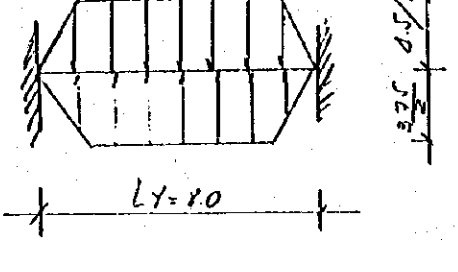
$$C = w \cdot c/w + \frac{1}{12}\, q\, L_Y^2$$

$$M_o = w \cdot M_o/w + 1/8\, q\, L_Y^2$$

$$Q_o = w \cdot Q_o/w + \frac{1}{2}\, q\, L_Y$$

In the above equation, coefficients of c/w, Mo/w, and Qo/w are determined by the ratio of long span (LY) to short span length (Lx) and graphically expressed in 2.1.6

$W_u = 1.57$ T/m² $q_u = 0.96 \times 1.4 = 1.34$ T/m



$$\lambda_1 = \frac{L_Y}{L_x} = \frac{8.00}{4.50} = 1.78$$

$$\lambda_2 = \frac{L_Y}{L_x} = \frac{8.00}{3.75} = 2.13$$

λ	L_x	C/w	M_o/w	Q_o/w
1.78	4.50	10.0	16.5	6.5
2.13	3.75	8.5	14.0	5.6

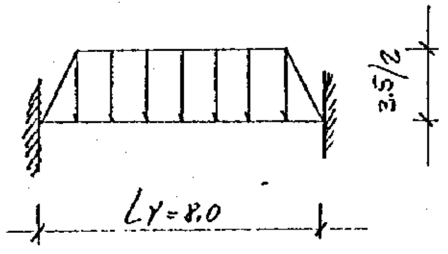
$$C = 1.57\,(10.0+8.5) + 1/12\,(1.34)\,(8.0)^2 = 36.19 \text{ T-m.}$$
$$M_o = 1.57\,(16.5+14.0) + 1/8\,(1.34)\,(8.0)^2 = 58.61 \text{ ''}$$
$$Q_o = 1.57\,(6.5+5.6) + 1/2\,(1.34)\,(8.0) = 24.36 \text{ ''}$$

End moment $= 1.2C = 43.43$ T-m.
Center moment $= M_o - 0.65C = 35.09$ T-m.

b) BEAM "C"

Loads:

- Self weight $W = 0.50 \times 0.8 \times 2.4 = 0.96$ T/m.
- Uniform load $W = 1.57$ T/m².



$\lambda = L_Y/L_x = 8.0/3.5 = 2.3$
$W_u = 1.57$ T/m²
$q_u = 1.34$ T/m.

λ	L_x	C/w	M_o/w	Q_o/w
2.3	3.50	8.9	14.0	5.5

$C = 1.57(8.9) + 1/12\,(1.34)(8.0)^2 = 21.12$ T-m.
$Mo = 1.57(14.0) + 1/8\,(1.34)(8.0)^2 = 32.70$ "
$Q_0 = 1.57(5.5) + 1/2\,(1.34)(8.0) = 14.00$ Ton.

End. Moment $1.2C = 25.34$ T-m.
Center Moment $Mo - 0.65C = 18.97$ T-m.

DESIGN:
Given: $b = 50$ $d = 75$ $h = 80$.
$f'c = 210$ $fy = 4200$

FLEXURE

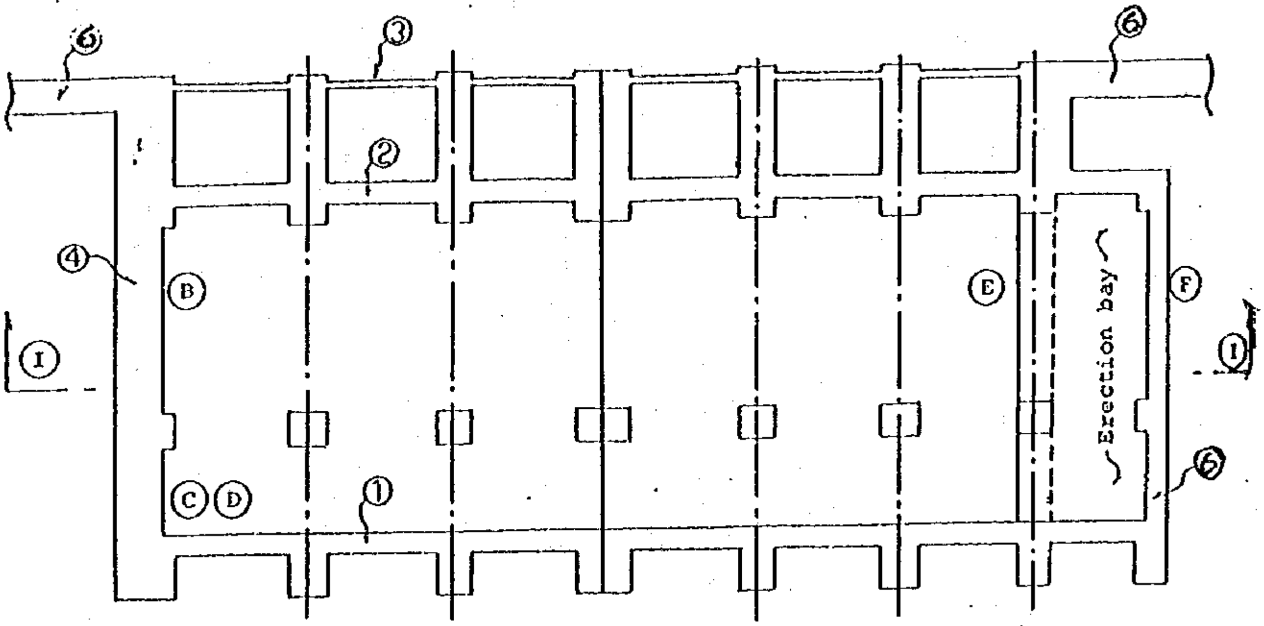
BEAM	Mu	ρ(%)	As	Asmin
"B"	43.43	0.43	16.14	12.50
	35.09	0.34	12.90	12.50
"C"	25.34	0.25	9.20	12.50
	18.97	0.18	6.84	12.50

SHEAR:
$Vu = 24.36$ Ton. $\phi Vc = 24.48$ Ton
Asmin = 2.26 cm² USAR: 1E φ12 c/30

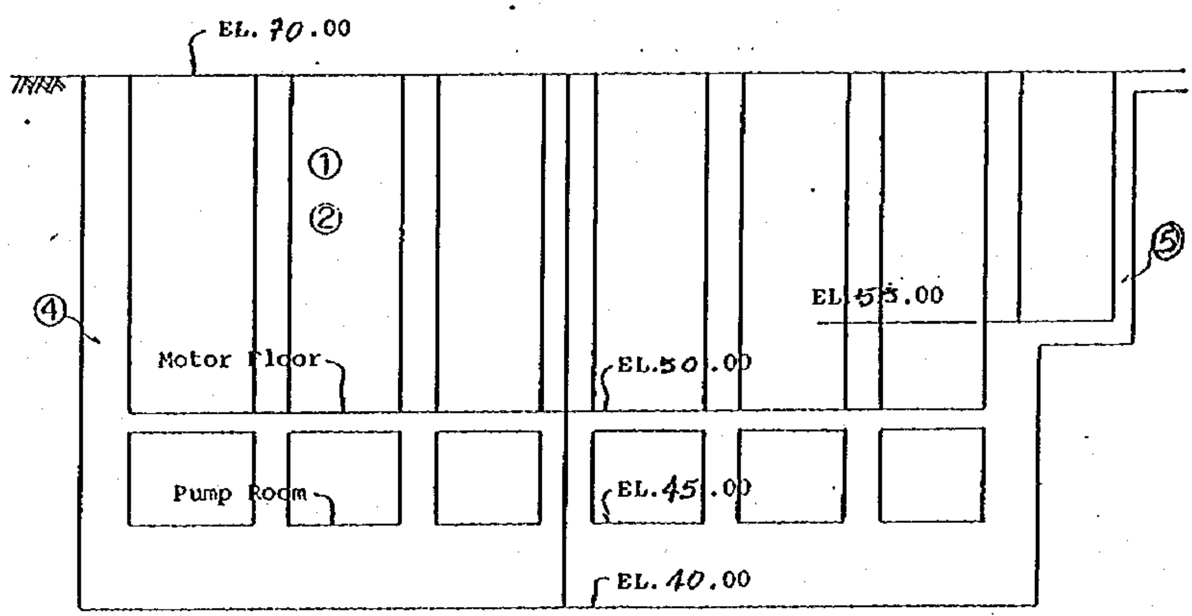
USAR: 5φ22

(C) Structural calculation of wall

Calculation model of walls are shown in Fig. 1.1.21



PLAN



SECTION I-I

Fig. 1.1.21 Structural Model of Wall

17

WALL DESIGN

(1) BACK WALL (Part 1)

The front wall is separated into two parts,namely above EL. 55.00 m and below EL. 55.00 m.
The wall below EL. 55.00 m is treated as mass concrete structure.
The wall above EL. 55.00 m is designed as a fixed beam supported by the columns.
Calculation model is shown below.

Elevation 0 : (earth pressure)	70.00 m
Elevation 0 : (water pressure)	66.00 m
Elevation 1 :	65.00 m
Elevation 2 :	60.00 m
Elevation 3 :	55.00 m

Earth Pressure :

Γ =	1.00 t/m3
Ka =	0.50
h1 =	5.00 m
Ph1= Γ.Ka.h1 =	2.50 t
h2 =	10.00 m
Ph2= Γ.Ka.h2 =	5.00 t/m²
h3 =	15.00 m
Ph3= Γ.Ka.h3 =	7.50 t/m²

Surcharge Pressure :

hs =	0.61 m
Ps= Γ.Ka.hs =	0.31 t/m²

Water Pressure :

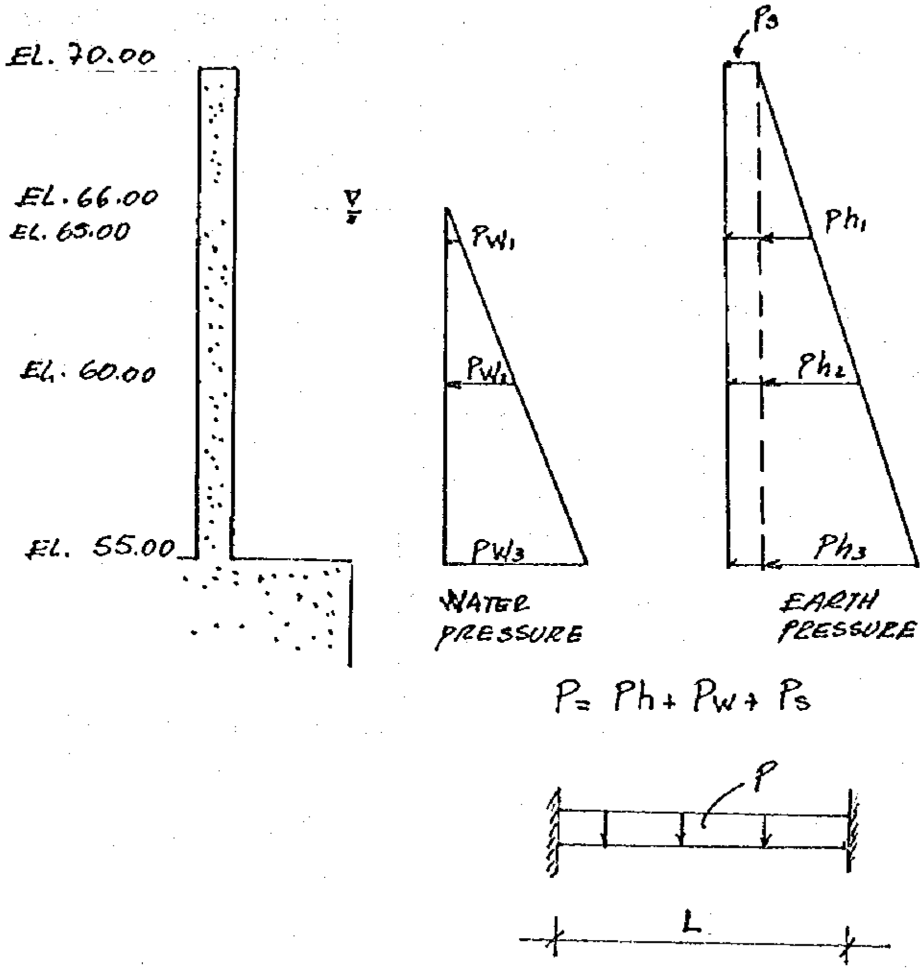
Pw1= Γw.h1 =	1.00 t/m²
Pw2= Γw.h2 =	6.00 t/m²
Pw3= Γw.h3 =	11.00 t/m²

TOTAL STATIC ULTIMATE LOAD :

ELEV.1=	65.00 m
Σ P1=Ph1+Ps+Pw1 =	3.81 t/m²
Pu1=1.4Pw+1.7(Ph+Ps) =	6.17 t/m²
L =	6.00 m
Mu1 = Pu1.L²/12 =	18.51 t-m
Qu1=Pu1.L/2 =	18.51 ton

ELEV.2=	60.00 m
Σ P2=Ph2+Ps+Pw2 =	11.31 t/m²
Pu2=1.4Pw+1.7(Ph+Ps) =	17.42 t/m²
L =	6.00 m
Mu2= Pu.L²/12 =	52.26 t-m
Qu2=Pu.L/2 =	52.26 ton

ELEV.3=	55.00 m
Σ P3=Ph3+Ps+Pw3 =	18.81 t/m²
Pu3=1.4Pw+1.7(Ph+Ps) =	28.67 t/m²
L =	6.00 m
Mu3= Pu.L²/12 =	86.01 t-m
Qu3=Pu.L/2 =	86.01 ton



FLEXURE STRENGTH DESIGN
BACK WALL (Part 1)
ELEVATION : 70.0 - 55.0
GIVEN :

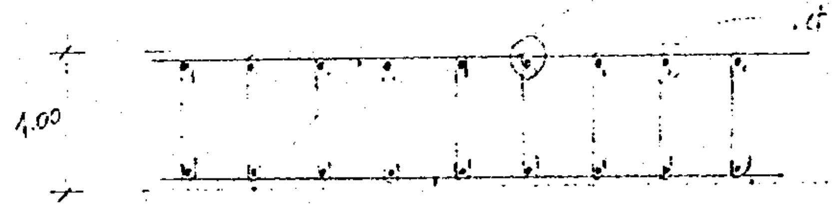
f'c = 210 Kg/cm²
fy = 4200 "
r = 7.5 cm
pmax=0.75pb= 1.61 (%)
ps = 0.90 (%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(temp (cm²)	As(adopt) (cm²)	As(adopt) (varillas)
Mu1	18.51	100.0	100.0	92.5	0.06	5.33	12.50	15.71	1 ø 20 @ 20 cm
Mu2	52.26	100.0	100.0	92.5	0.16	15.24	12.50	15.71	1 ø 20 @ 20 cm
Mu3	86.01	100.0	100.0	92.5	0.27	25.42	12.50	24.54	1 ø 25 @ 20 cm

SHEAR STRENGTH DESIGN
BACK WALL (Part 1)
ELEVATION : 70.0 - 55.0

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)	
Qu1	18.51	100.0	28.35	100.0	92.50	60.39	
Qu2	52.26	100.0	80.04	100.0	92.50	60.39	
Qu3	86.01	100.0	131.74	100.0	92.50	60.39	1 E ø 12 @ 20 cm

1φ25 c/20 (EL 55.0 - 60.0)
1φ20 c/20 (EL 65.0 - 70.0)



1φ25 c/20 (EL 55.0 - 60.0)
1φ20 c/20 (EL 60.0 - 70.0)

1E φ12 c/20
(EL 55.0 - 60.0)

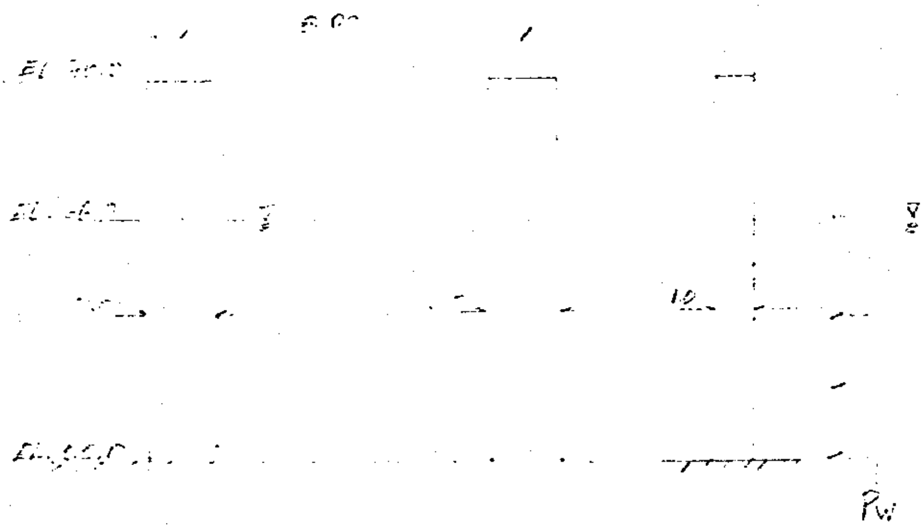
WALL DESIGN

(2) FRONT WALL (Part 2)

The front wall is separated into two parts,namely above EL. 55.00 m and below EL. 55.00 m.
The wall below EL. 55.00 m is treated as mass concrete structure.
The wall above EL. 55.00 m is designed as a two way slab with three fixed end and one free end.
Calculation model is shown below.

Elevation 0 : (water pressure)	66.00 m
Elevation 1 :	55.00 m
Water Pressure :	
Pw1= Γw . h1 =	11.00 t/m²
TOTAL STATIC ULTIMATE LOAD :	
t(thickness wall) =	1.00 m
Wu =1.4 WL =	15.40 t/m²
Ly =	14.00 m
Lx =	8.00 m
Ly/Lx =	1.75
M = c.Wu.(Lx)2	
Q = c.Wu.Lx	

Mx1 =	0.008 Wu.(Lx)2 =	7.88 t-m
Mx2 =	0.005 Wu.(Lx)2 =	4.93 t-m
Mx3 =	0.046 Wu.(Lx)2 =	45.34 t-m
My1 =	0.045 Wu.(Lx)2 =	44.35 t-m
My2 =	0.008 Wu.(Lx)2 =	7.88 t-m
Qx1 =	0.01 Wu.Lx =	1.23 t
Qx1max =	0.34 Wu.Lx =	41.89 t
Qy1 =	0.38 Wu.Lx =	46.82 t



1.

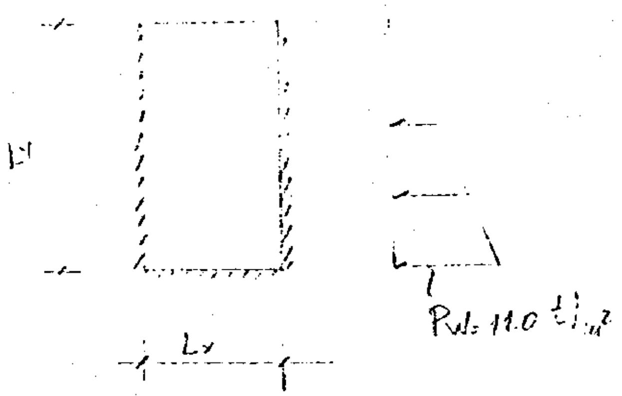
FLEXURE STRENGTH DESIGN
FRONT WALL (Part 2)
GIVEN :

f'c = 210 Kg/cm²
fy = 4200 "
r = 7.5 cm
pmax=0.75pb= 1.61 (%)
ps = 0.90 (%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(temp) (cm²)	As(adopt (cm²)	As(adopt) (varillas)
Mx1	7.68	100.0	100.0	92.5	0.02	2.26	12.50	15.71	1 ø 20 @ 20 cm
Mx2	4.93	100.0	100.0	92.5	0.02	1.41	12.50	15.71	1 ø 20 @ 20 cm
Mx3	45.34	100.0	100.0	92.5	0.14	13.19	12.50	15.71	1 ø 20 @ 20 cm
My1	44.35	100.0	100.0	92.5	0.14	12.90	12.50	15.71	1 ø 20 @ 20 cm
My2	7.68	100.0	100.0	92.5	0.02	2.26	12.50	15.71	1 ø 20 @ 20 cm

SHEAR STRENGTH DESIGN
FRONT WALL (Part 2)

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)
Qx1	1.23	100.0	1.89	100.0	92.50	60.39
Qx1max	41.89	100.0	64.16	100.0	92.50	60.39
Qy1	45.62	100.0	71.71	100.0	92.50	60.39



1-1-110

17

WALL DESIGN

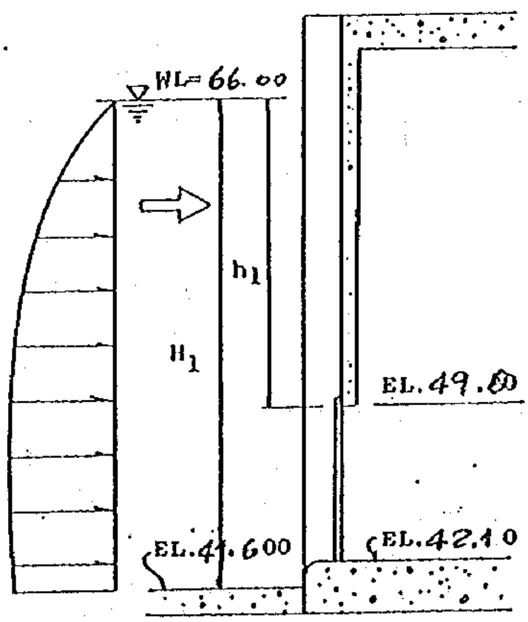
(3) PARTITION WALL OF INLET

The wall is designed for seismic forces.
The loads acting on the wall are :

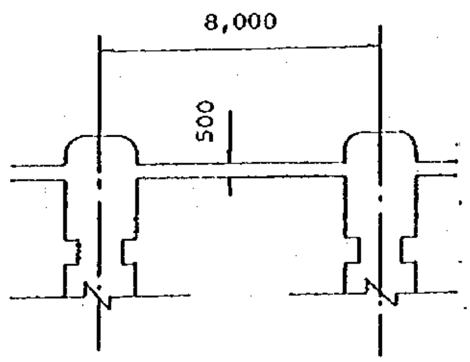
1.-) Internal forces due to seismic load and
2.-) Dynamic water pressure due seismic load.

The wall is designed as a fixed beam.

Elevation 0 : (water pressure)	66.00 m
Elevation 1 :	42.00 m
t (thickness wall) =	0.50 m
Seismic Force :	
W1=0.15 W =	0.18 t/m²
Dynamic Water Pressure :	
W2= 0.875 Wo.Kh.√ (H1.h1) =	2.63 t/m²
TOTAL STATIC ULTIMATE LOAD :	
Σ W= W1+W2 =	2.81 t/m²
Wu=1.4 (W1+W2) =	3.93 t/m²
L =	8.00 m
Mu = Wu.L²/12 =	20.95 t-m
Qu=Wu.L/2 =	15.71 ton



(Dynamic water pressure)



FLEXURE STRENGTH DESIGN

PARTITION WALL OF INLET

GIVEN :

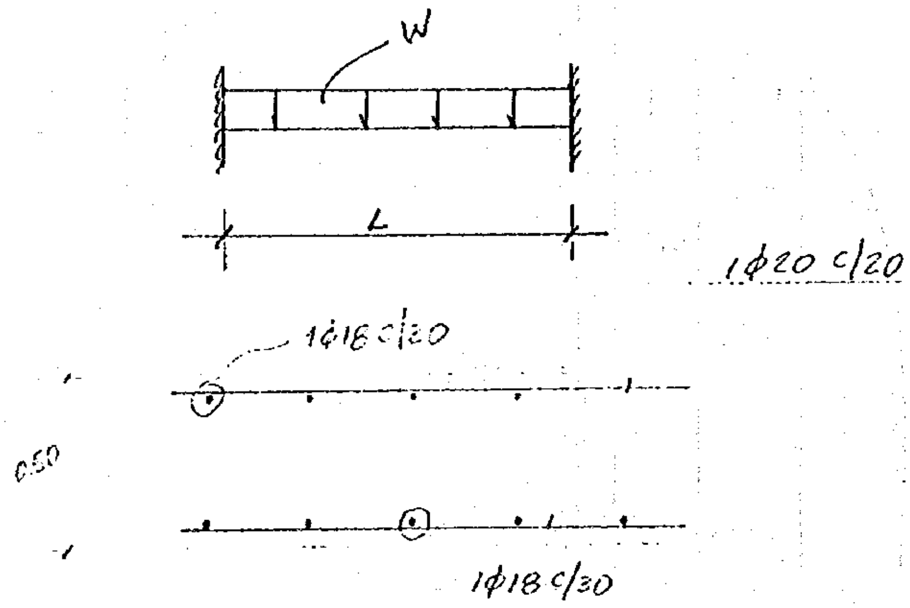
f'c =	210	Kg/cm²
fy =	4200	"
r =	7.5	cm
pmax=0.75pb=	1.61	(%)
ps =	0.90	(%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(temp) (cm²)	As(adopt) (cm²)	As(adopt) (varillas)
Mu	20.95	100.0	50.0	42.5	0.32	13.55	6.25	15.71 8.48	1 ø 20 @ 20 cm. 1 ø 18 @ 30 cm.

SHEAR STRENGTH DESIGN

PARTITION WALL OF INLET

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)
Qu	15.71	100.0	24.07	50.0	42.60	27.75



1-1-112

-188

30-Sep-94

WALL DESIGN

(4) SIDE WALL OF TRANSFORMER YARD SIDE (part 4)

The side wall of transformer yard side is separated into (4) parts as shown below

1.) Part A

Part A is designed as a fixed beam supported by wing wall of inlet.

- External load act on wall

W= qo+P = q.Ka + Γ h.Ka

The external loads at each elevation are calculated as follows :

-EL.(max) 70.10 m

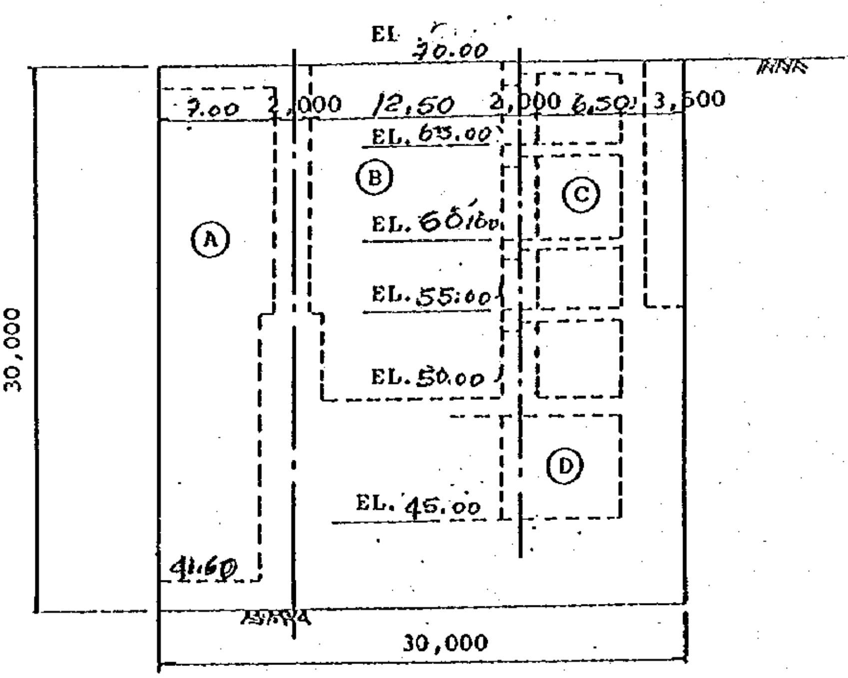
- El.1=	41.60 m		
h =	28.50 m		
Γ =	1.80 t/m3		
Ka=	0.50		
q=	1.00 t/m²		
W1= q.Ka+Γ.h.Ka =		26.15	t/m²
Wu1=1.7W =		44.45	t/m²
- El.2=	50.00 m		
h =	20.10 m		
Γ =	1.80 t/m3		
Ka=	0.50		
q=	1.00 t/m²		
W2= q.Ka+Γ.h.Ka =		18.59	t/m²
Wu2=1.7W =		31.60	t/m²
- El.3=	55.00 m		
h =	15.10 m		
Γ =	1.80 t/m3		
Ka=	0.50		
q=	1.00 t/m²		
W3= q.Ka+Γ.h.Ka =		14.09	t/m²
Wu3=1.7W =		23.95	t/m²
- El.4=	60.00 m		
h =	10.10 m		
Γ =	1.80 t/m3		
Ka=	0.50		
q=	1.00 t/m²		
W4= q.Ka+Γ.h.Ka =		9.59	t/m²
Wu4=1.7W =		16.30	t/m²
- El.5=	65.00 m		
h =	5.10 m		
Γ =	1.80 t/m3		
Ka=	0.50		
q=	1.00 t/m²		

W5= q.Ka+Γ.h.Ka = 5.09 t/m²
Wu5=1.7W = 8.65 t/m²

Bending moment and shearing force at each elevation are calculated as follows :

$Mu = Wu.L^2/12$
$Qu = Wu.L/2$
L = 7.00 m

EL. (m)	41.60	50.00	55.00	60.00	65.00
Mu (t-m)	181.52	129.05	97.81	66.57	35.33
Qu (t)	155.59	110.61	83.84	57.06	30.29



FLEXURE STRENGTH DESIGN

SIDE WALL OF TRANSFORMER YARD SIDE (part 4)

PART A

GIVEN :

f'c =	210	Kg/cm²
fy =	4200	"
r =	7.5	cm
ρmax=0.75ρb =	1.61	(%)
ρs =	0.90	(%)

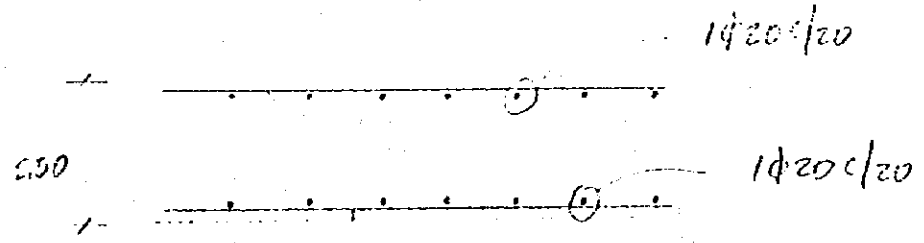
ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	ρ (%)	As (cm²)	As(temp) (cm²)	As(adopt (cm²)	As(adopt) (varillas)
Mu1	181.52	100.0	250.0	242.5	0.08	20.00	31.25	32.17	1 ø 32 @ 25 cm
Mu2	129.05	100.0	250.0	242.5	0.06	14.16	31.25	32.17	1 ø 32 @ 25 cm
Mu3	97.81	100.0	250.0	242.5	0.04	10.73	31.25	32.17	1 ø 32 @ 25 cm
Mu4	66.57	100.0	250.0	242.5	0.03	7.29	31.25	32.17	1 ø 32 @ 25 cm
Mu5	35.33	100.0	250.0	242.5	0.02	3.86	31.25	32.17	1 ø 32 @ 25 cm

SHEAR STRENGTH DESIGN

SIDE WALL OF TRANSFORMER YARD SIDE (part 4)

PART A

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)
Qu1	155.59	100.0	238.33	250.0	242.50	158.31
Qu2	110.61	100.0	169.43	250.0	242.50	158.31
Qu3	83.84	100.0	128.42	250.0	242.50	158.31
Qu4	57.06	100.0	87.40	250.0	242.50	158.31
Qu5	30.29	100.0	46.39	250.0	242.50	158.31



1φ32 c/25

1φ25 c/15

30-Sep-94

WALL DESIGN

SIDE WALL OF TRANSFORMER YARD SIDE (part 4)

The side wall of transformer yard side is separated into (4) parts as shown below

2.) Part B
Part B is designed as a two way slab with three fixed end and one free end.

EL.0 (water pressure)	66.00	m
EL.1 (earth pressure)	70.10	m
EL.2	49.50	m
hw=	16.50	m
h1=	20.60	m
q=	1.00	t/m²
Γ =	1.00	t/m3
Ka=	0.50	
qo=q.Ka=	0.50	t/m²
q1= Γ.Ka.h1+hw =	26.8	t/m²
W= qo+q1 =	27.30	t/m²
Wu1=1.7qo =	0.85	t/m²
Wu2=1.5q1 =	40.20	t/m²
t (wall thickness) =	2.50	m
Ly =	20.60	m
Lx =	12.50	m
Ly/Lx =	1.65	

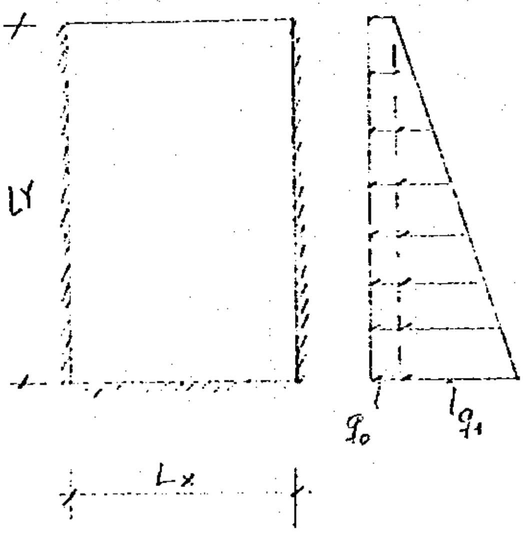
Bending moment and shearing force are calculated as follows :
M = c.Wu.(Lx)2
Q = c.Wu.Lx

TRIANGULAR LOAD

Mx1 =	0.009 Wu.(Lx)2 =	56.53	t-m
Mx2 =	0.005 Wu.(Lx)2 =	31.41	t-m
Mx3 =	0.045 Wu.(Lx)2 =	282.66	t-m
My1 =	0.044 Wu.(Lx)2 =	276.37	t-m
My2 =	0.010 Wu.(Lx)2 =	62.81	t-m
Qx1 =	0.050 Wu.Lx =	25.13	t
Qy1 =	0.380 Wu.Lx =	190.95	t
Qx1max =	0.330 Wu.Lx =	165.83	t

UNIFORM LOAD

Mx1 =	0.083 Wu.(Lx)2 =	11.02	t-m
Mx2 =	0.042 Wu.(Lx)2 =	5.58	t-m
Mx3 =	0.000 Wu.(Lx)2 =	0.00	t-m
My1 =	0.059 Wu.(Lx)2 =	7.84	t-m
My2 =	0.010 Wu.(Lx)2 =	1.33	t-m
Qx1 =	0.500 Wu.Lx =	5.31	t
Qy1 =	0.480 Wu.Lx =	5.10	t
Qx1max =	0.000 Wu.Lx =	0.00	t



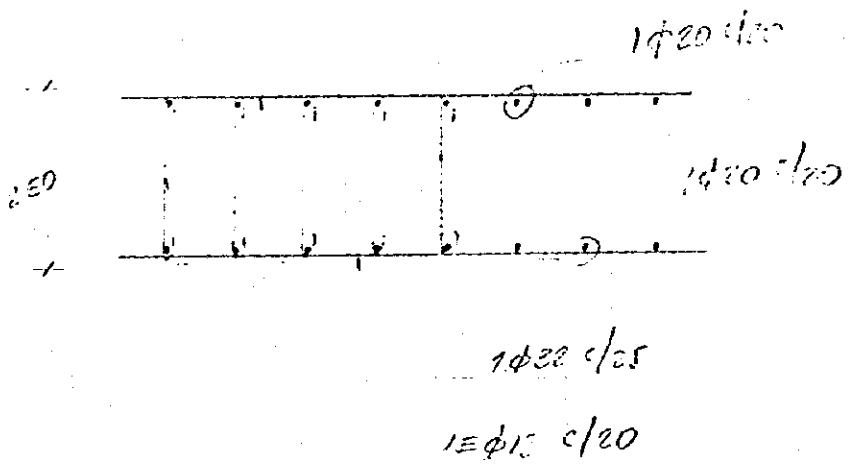
FLEXURE STRENGTH DESIGN
SIDE WALL OF TRANSFORMER YARD SIDE (part 4)
PART B
GIVEN :

f'c =	210	Kg/cm²
fy =	4200	"
r =	7.5	cm
pmax=0.75pb=	1.61	(%)
ps =	0.90	(%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(temp (cm²)	As(adopt) (cm²)	As(adopt) (varillas)
Mu1	67.55	100.0	250.0	242.5	0.03	7.40	31.25	32.17	1 ø 32 @ 25 cm
Mu2	36.98	100.0	250.0	242.5	0.02	4.04	31.25	32.17	1 ø 32 @ 25 cm
Mu3	282.66	100.0	250.0	242.5	0.13	31.31	31.25	32.17	1 ø 32 @ 25 cm
Mu4	284.21	100.0	250.0	242.5	0.13	31.49	31.25	32.17	1 ø 32 @ 25 cm
Mu5	64.14	100.0	250.0	242.5	0.03	7.02	31.25	32.17	1 ø 32 @ 25 cm

SHEAR STRENGTH DESIGN
SIDE WALL OF TRANSFORMER YARD SIDE (part 4)
PART B

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)	
Qu1	30.44	100.0	45.62	250.0	242.50	158.31	
Qu2	196.05	100.0	300.30	250.0	242.50	158.31	1 E ø 12 @ 25 cm
Qu3	165.83	100.0	264.01	250.0	242.50	158.31	1 E ø 12 @ 25 cm



WALL DESIGN

SIDE WALL OF TRANSFORMER YARD SIDE (part 4)

3.) Part C

Part C is designed as a fixed beam.
t (thickness wall) = 2.50 m

- External load act on wall

W=qo+P=q.Ka+Γs.h.Ka+hw
The external loads at each elevation are calculated as follows :

-EL.(water)=	66.00 m	
-EL.(max)=	70.10 m	

- El.1=	50.00 m	
h =	20.10 m	
hw=	16.00 m	
Γ =	1.00 t/m3	
Ka=	0.50	
q=	1.00 t/m²	
W1=q.Ka+Γs.h.Ka+hw =		26.55 t/m²
Wu1=1.7q.Ka+1.7Γs.h.Ka+1.4hw =		40.34 t/m²

- El.2=	55.00 m	
h =	15.10 m	
hw=	11.00 m	
Γ =	1.00 t/m3	
Ka=	0.50	
q=	0.61 m	
W2=q.Ka+Γs.h.Ka+hw =		19.05 t/m²
Wu2=1.7q.Ka+1.7Γs.h.Ka+1.4hw =		29.08 t/m²

- El.3=	60.00 m	
h =	10.10 m	
hw=	6.00 m	
Γ =	1.00 t/m3	
Ka=	0.50	
q=	1.00 t/m²	
W3=q.Ka+Γs.h.Ka+hw =		11.55 t/m²
Wu3=1.7q.Ka+1.7Γs.h.Ka+1.4hw =		17.83 t/m²

- El.4=	65.00 m	
h =	5.10 m	
hw=	1.00 m	
Γ =	1.00 t/m3	
Ka=	0.50	
q=	1.00 t/m²	
W4=q.Ka+Γs.h.Ka+hw =		4.05 t/m²
Wu4=1.7q.Ka+1.7Γs.h.Ka+1.4hw =		6.58 t/m²

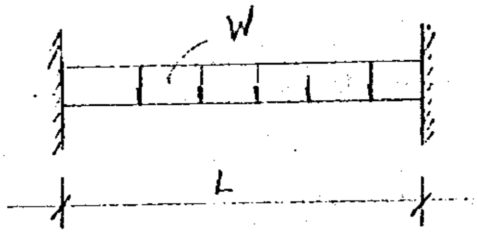
Bending moment and shearing force at each elevation are calculated as follows :

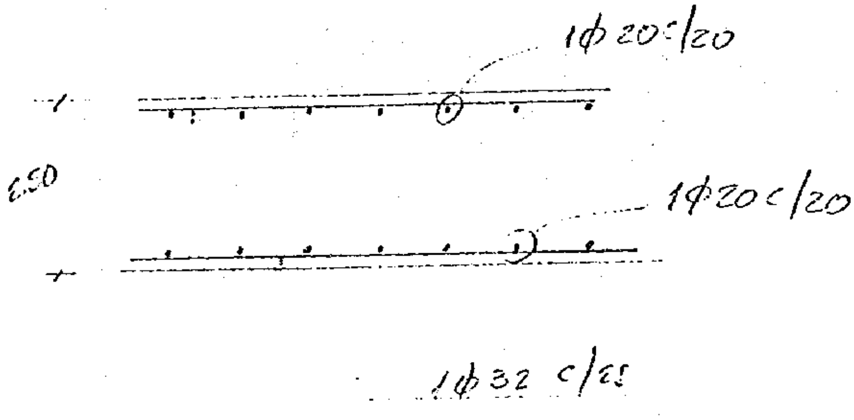
Mu = Wu.L²/12

Qu=Wu.L/2

L = 6.50 m

EL. (m)	50.00	55.00	60.00	65.00
Mu (t-m)	142.01	102.40	62.79	23.18
Qu (t)	131.09	94.53	57.96	21.40





FLEXURE STRENGTH DESIGN
SIDE WALL OF TRANSFORMER YARD SIDE (part 4)
PART C
GIVEN :

f'c =	210	Kg/cm²
fy =	4200	"
r =	7.5	cm
pmax=0.75pb=	1.61	(%)
ps =	0.90	(%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(temp (cm²)	As(adopt) (cm²)	As(adopt) (varillas)
Mu1	142.01	100.0	250.0	242.5	0.06	15.61	31.25	32.17	1 ø 32 @ 25 cm
Mu2	102.40	100.0	250.0	242.5	0.05	11.23	31.25	32.17	1 ø 32 @ 25 cm
Mu3	62.79	100.0	250.0	242.5	0.03	6.87	31.25	32.17	1 ø 32 @ 25 cm
Mu4	23.18	100.0	250.0	242.5	0.01	2.53	31.25	32.17	1 ø 32 @ 25 cm

SHEAR STRENGTH DESIGN
SIDE WALL OF TRANSFORMER YARD SIDE (part 4)
PART C

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)
Qu1	131.09	100.0	200.60	250.0	242.50	158.31
Qu2	94.53	100.0	144.79	250.0	242.50	158.31
Qu3	57.96	100.0	88.79	250.0	242.50	158.31
Qu4	21.40	100.0	32.78	250.0	242.50	158.31

1-1-120

WALL DESIGN

SIDE WALL OF TRANSFORMER YARD SIDE (part 4)

4.) Part D

Part D is designed as two way slab with four fixed end.

EL.0 (water pressure)	65.00	m
EL.1 (earth pressure)	70.10	m
EL.2	49.00	m
EL.3	44.00	m
hw1=	17.00	m
hw2=	22.00	m
h1=	21.10	m
h2 =	26.10	m
h3 =	0.61	m
Γ =	1.00	t/m3
Ka=	0.50	

q_1= h3.Ka + Γs.h1.Ka + hw1 = 27.86 t/m²

q2= h3.Ka + Γs.h2.Ka + hw2 = 35.36 t/m²

Wu1=1.7 q.Ka + 1.7 Γs.h.Ka + 1.4 hw = 42.25 t/m²

Wu2=1.7 q.Ka + 1.7 Γs.h.Ka + 1.4 hw = 53.50 t/m²

w.average = (w1+w2) / 2 = 47.85 t/m²

t (wall thickness) =	2.50	m
Lx =	9.50	m
Ly =	5.00	m
Ly / Lx =	1.90	

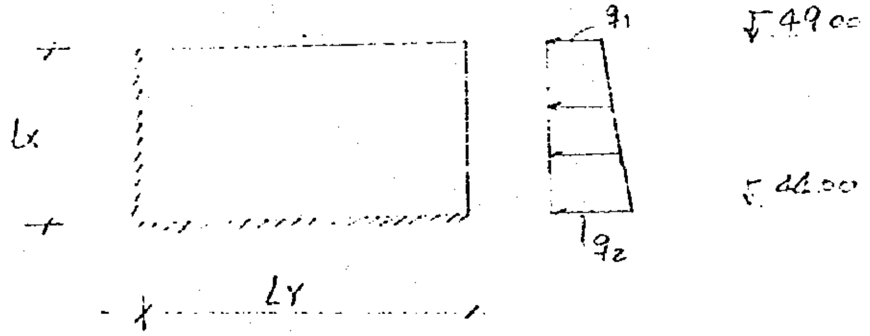
Bending moment and shearing force at each elevation are calculated as following

M = c.Wu.(Lx)2

Q = c.Wu.Lx

UNIFORM LOAD

Mx1 =	0.083 Wu.(Lx)2	99.35 t-m
Mx2 =	0.039 Wu.(Lx)2	46.68 t-m
My1 =	0.057 Wu.(Lx)2	68.22 t-m
My2 =	0.010 Wu.(Lx)2	11.97 t-m
Q1 =	0.520 Wu.Lx =	124.48 t
Q2 =	0.460 Wu.Lx =	110.22 t



1-1-121

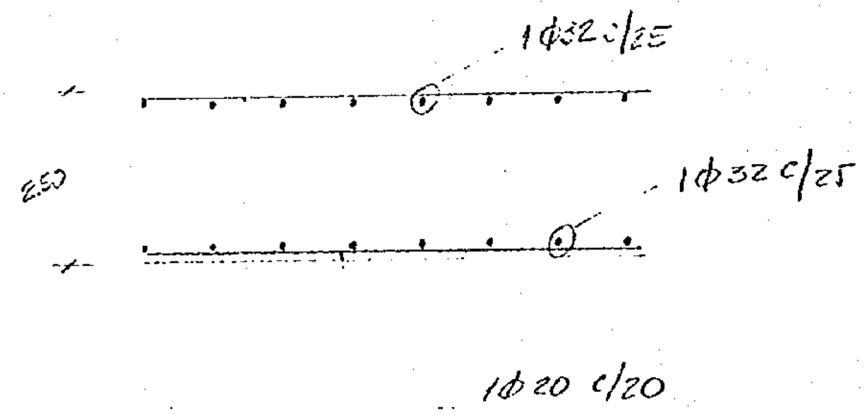
FLEXURE STRENGTH DESIGN
SIDE WALL OF TRANSFORMER YARD SIDE (part 4)
PART D
GIVEN :

f'c =	210	Kg/cm²
fy =	4200	"
r =	7.5	cm
pmax=0.75pb =	1.61	(%)
ps =	0.90	(%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(temp) (cm²)	As(adopt) (cm²)	As(adopt) (varillas)
Mu1	99.35	100.0	250.0	242.5	0.04	10.90	31.25	32.17	1 ø 32 @ 25 cm
Mu2	46.68	100.0	250.0	242.5	0.02	5.11	31.25	32.17	1 ø 32 @ 25 cm
Mu3	68.23	100.0	250.0	242.5	0.03	7.47	31.25	32.17	1 ø 32 @ 25 cm
Mu4	11.97	100.0	250.0	242.5	0.01	1.31	31.25	32.17	1 ø 32 @ 25 cm

SHEAR STRENGTH DESIGN
SIDE WALL OF TRANSFORMER YARD SIDE (part 4)
PART D

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)
Qu1	124.48	100.0	190.68	250.0	242.50	158.31
Qu2	110.12	100.0	168.68	250.0	242.50	158.31



WALL DESIGN

(5) SIDE WALL OF ERECTION BY SIDE (part 5)

Part 5

The wall is designed as a two way slab with three fixed end and one free end.

EL.0 (water pressure)	70.00 m	
EL.1 (earth pressure)	70.00 m	
EL.2	54.50 m	
hw=	15.50 m	
h1=	15.50 m	
q=	1.00 t/m²	
Γ =	1.00 t/m3	
Ka=	0.50	
qo=q.ka =		0.50 t/m²
Wu1=1.7qo =		0.85 t/m²
q2= Γs.h1.Ka + hw =		23.25 t/m²
Wu2= 1.7 Γs.h.Ka + 1.4 hw =		34.88 t/m²
t (wall thickness) =	1.50 m	
Ly =	15.50 m	
Lx =	12.50 m	
Ly/Lx =	1.24	

Bending moment and shearing force are calculated as follows :

M = c.Wu.(Lx)2

Q = c.Wu.Lx

TRIANGULAR LOAD

Mx1 =	0.011 Wu2.(Lx)2 =	59.94 t-m
Mx2 =	0.008 Wu2.(Lx)2 =	43.59 t-m
Mx3max =	0.040 Wu2.(Lx)2 =	217.97 t-m
My1 =	0.038 Wu2.(Lx)2 =	207.07 t-m
My2max =	0.009 Wu2.(Lx)2 =	49.04 t-m
Qx1 =	0.050 Wu2.Lx =	21.80 t
Qx1max =	0.280 Wu2.Lx =	122.06 t
Qy1 =	0.350 Wu2.Lx =	152.58 t

UNIFORM LOAD

Mx1 =	0.085 Wu1.(Lx)2 =	11.29 t-m
Mx2 =	0.040 Wu1.(Lx)2 =	5.31 t-m
My1 =	0.058 Wu1.(Lx)2 =	7.70 t-m
My2max =	0.010 Wu1.(Lx)2 =	1.33 t-m
Qx1 =	0.510 Wu1.Lx =	5.42 t
Qy1 =	0.400 Wu1.Lx =	4.25 t

1

FLEXURE STRENGTH DESIGN

SIDE WALL OF ERECTION BAY SIDE (part 5)

GIVEN :

f'c =	210	Kg/cm²
fy =	4200	"
r =	7.5	cm
pmax=0.75pb=	1.61	(%)
ps =	0.90	(%)

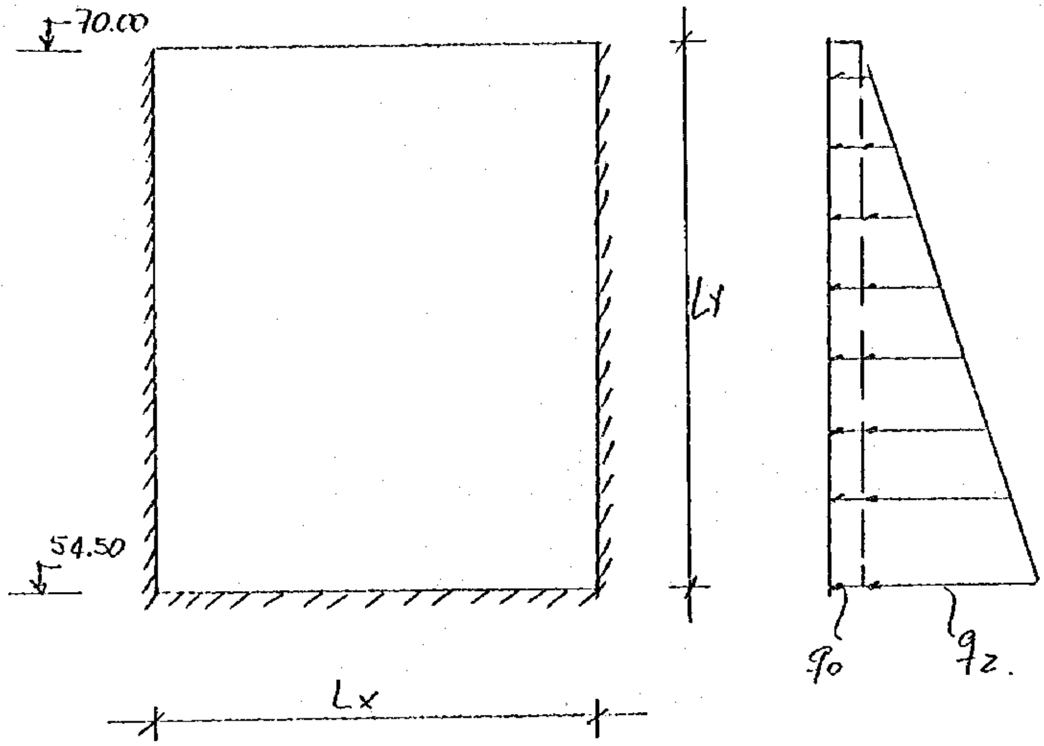
ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(temp) (cm²)	As(adopt) (cm²)	As(adopt) (varillas)
Mu1	71.23	100.0	150.0	142.5	0.09	13.37	18.75	19.63	1 ø 25 @ 25 cm
Mu2	48.91	100.0	150.0	142.5	0.06	9.15	18.75	19.63	1 ø 25 @ 25 cm
Mu3	217.97	100.0	150.0	142.5	0.29	41.92	18.75	41.05	1 ø 28 @ 15 cm
Mu4	214.77	100.0	150.0	142.5	0.29	41.28	18.75	41.05	1 ø 28 @ 15 cm
Mu5	50.37	100.0	150.0	142.5	0.07	9.42	18.75	19.63	1 ø 25 @ 25 cm

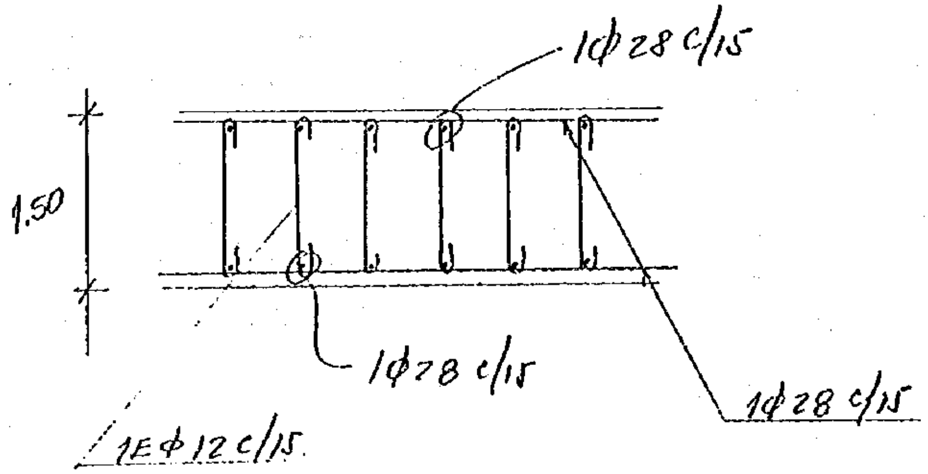
SHEAR STRENGTH DESIGN

SIDE WALL OF ERECTION BAY SIDE (part 5)

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)	
Qu1	27.22	100.0	41.69	150.0	142.50	93.03	
Qu2	122.06	100.0	166.97	150.0	142.50	93.03	1 E ø 14 @ 25 cm
Qu3	155.83	100.0	240.23	150.0	142.50	93.03	1 E ø 14 @ 25 cm

SIDE WALL OF ERECTION BY SIDE
(PART 5).





WALL DESIGN

(6) WING WALL (Part 6)

Wing wall is designed as a one way slab with one fixed and one simple end supported by side wall and rock.
Calculation is made at five sections.
Calculation model is shown below.

1.) External load act on wing wall.

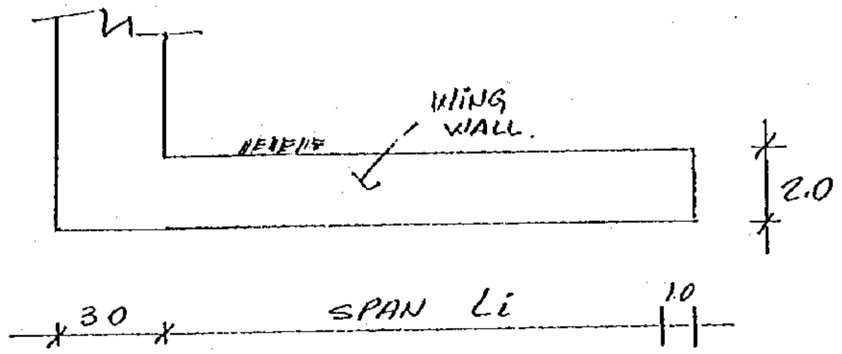
W=(q+Γt.h).Ka

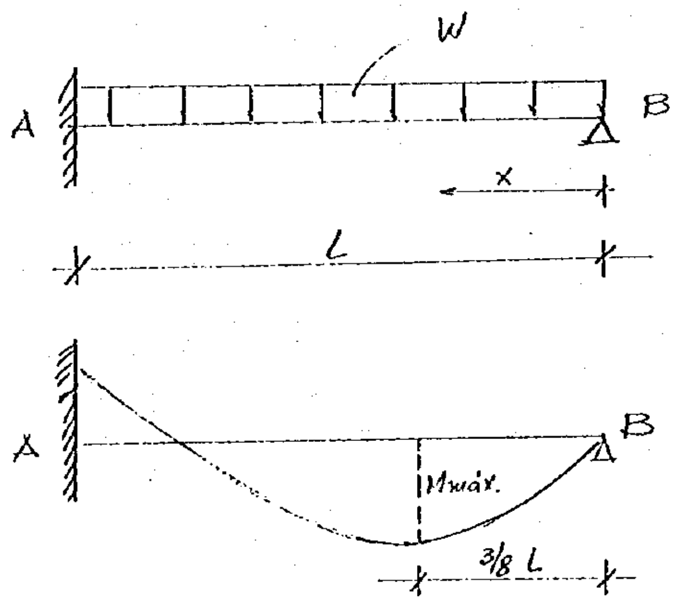
EL.1=	70.00 m
EL.2=	60.00 m
EL.3=	50.00 m
EL.4=	40.00 m

h1=	5.00 m
h2=	10.00 m
h3=	15.00 m
h4=	20.00 m
h5=	25.00 m
Γ =	2.00 t/m3
Ka=	0.50
q=	1.00 t/m²
t (thickness wall)=	200 cm

Wua=1.7(q+Γt.h).Ka=	9.35 t/m²
Wub=1.7(q+Γt.h).Ka=	17.85 t/m²
Wuc=1.7(q+Γt.h).Ka=	26.35 t/m²
Wud=1.7(q+Γt.h).Ka=	34.85 t/m²
Wue=1.7(q+Γt.h).Ka=	43.35 t/m²

WALL DESIGN
WING WALL (PART 6)





$M_A = \frac{1}{8} wL^2$

$M_{máx} = \frac{9}{128} wL^2$

$Q_A = \frac{5}{8} wL \qquad Q_B = \frac{3}{8} wL.$

Moment and shearing force are calculated at three points :
X=L   X=3/8L   X=0

SECTION	SPAN	LOAD	MOMENT & SHEARING			
	(m) L	(t/m²) W	ITEM	X=0	X=3/8L	X=L
A	21.00	9.35	X (m)	0.00	7.88	21.00
			M (t-m)	0.00	289.92	515.42
			Q (t)	73.63	0.00	122.72
B	16.50	17.85	X (m)	0.00	6.19	16.50
			M (t-m)	0.00	341.70	607.46
			Q (t)	110.45	0.00	184.08
C	11.50	26.35	X (m)	0.00	4.31	11.50
			M (t-m)	0.00	245.02	435.60
			Q (t)	113.63	0.00	189.39
D	8.50	34.85	X (m)	0.00	3.19	8.50
			M (t-m)	0.00	177.04	314.74
			Q (t)	111.08	0.00	185.14
E	3.50	43.35	X (m)	0.00	1.31	3.50
			M (t-m)	0.00	37.34	66.38
			Q (t)	56.90	0.00	94.83

FLEXURE STRENGTH DESIGN

WING WALL

GIVEN :

f'c =	210	Kg/cm²
fy =	4200	"
r =	7.5	cm
ρmax=0.75ρb =	1.61	(%)
ρs =	0.90	(%)

ID ELEM	Mu (t-m)	b (cm)	h (cm)	d (cm)	p (%)	As (cm²)	As(temp) (cm²)	As(adopt) (cm²)	As(adopt) (varillas)
Mu1	269.92	100.0	200.0	192.5	0.21	40.67	25.00	53.62	1 ø 32 @ 15 cm.
Mu2(-)	515.42	100.0	200.0	192.5	0.39	74.21	25.00	73.11	1 ø 32 @ 11 cm.
Mu3	341.70	100.0	200.0	192.5	0.25	48.39	25.00	53.62	1 ø 32 @ 15 cm.
Mu4(-)	607.46	100.0	200.0	192.5	0.46	88.26	25.00	89.36	1 ø 32 @ 9 cm.
Mu5	245.02	100.0	200.0	192.5	0.18	34.40	25.00	40.21	1 ø 32 @ 20 cm.
Mu6(-)	435.60	100.0	200.0	192.5	0.32	62.24	25.00	61.87	1 ø 32 @ 13 cm.
Mu7	177.04	100.0	200.0	192.5	0.13	24.70	25.00	26.81	1 ø 32 @ 30 cm.
Mu8(-)	314.74	100.0	200.0	192.5	0.23	44.47	25.00	53.62	1 ø 32 @ 15 cm.
Mu9	37.24	100.0	200.0	192.5	0.03	5.16	25.00	26.81	1 ø 32 @ 30 cm.
Mu10(-)	66.38	100.0	200.0	192.5	0.05	9.17	25.00	26.81	1 ø 32 @ 30 cm.

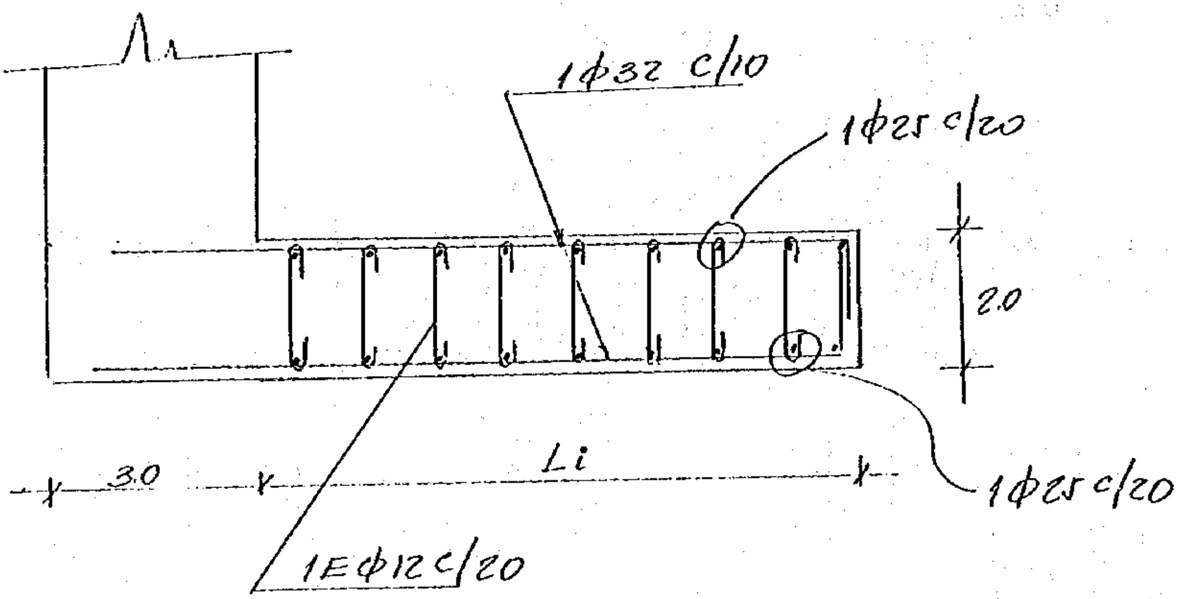
SHEAR STRENGTH DESIGN

WING WALL

ID ELEM	Vu (ton)	bw (cm)	dn (cm)	h (cm)	d(adopt) (cm)	øVc (ton)	
Qu1	72.62	100.0	112.79	200.0	192.50	125.67	
Qu2	122.72	100.0	187.93	200.0	192.50	125.67	
Qu3	110.45	100.0	169.18	200.0	192.50	125.67	
Qu4	184.09	100.0	281.97	200.0	192.50	125.67	1 E ø 14 @ 30 cm.
Qu5	113.69	100.0	174.06	200.0	192.50	125.67	
Qu6	189.39	100.0	290.10	200.0	192.50	125.67	1 E ø 14 @ 30 cm.
Qu7	111.09	100.0	170.16	200.0	192.50	125.67	
Qu8	185.14	100.0	283.59	200.0	192.50	125.67	1 E ø 14 @ 30 cm.
Qu9	56.90	100.0	87.15	200.0	192.50	125.67	
Qu10	94.83	100.0	145.26	200.0	192.50	125.67	

WALL DESIGN

WING WALL (PART 6)

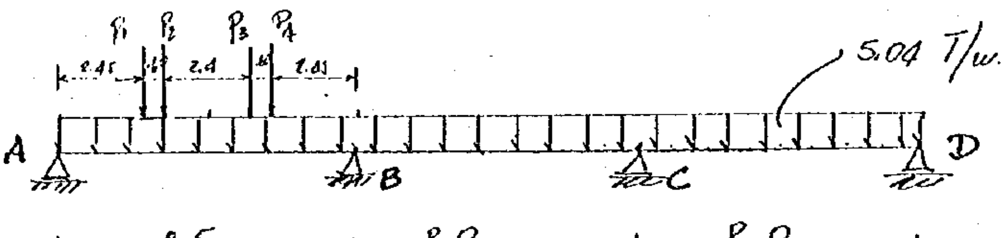


In order to seek max. bending moment and max. shearing force at nodal points or certain points on a beam, structural calculation is made in following load conditions:

i) Max. shearing force on a nodal point occurs when the vertical force P1 is on the nodal point A.

ii) Max. bending moment on a nodal point occurs when the center of the wheels is on the center of the A-B beam.

iii) Max. bending moment on a beam occurs when the center of the wheels is on the center of the A-B beam.



$P_1 = P_2 = P_3 = P_4 = 22.44$ Ton.

$W_u = 5.04$ T/m.

****

ROGRAMA PARA DETERMINAR LOS MOMENTOS EN LOS APOYOS DE UNA VIGA CONTINUA

POR MATRICES

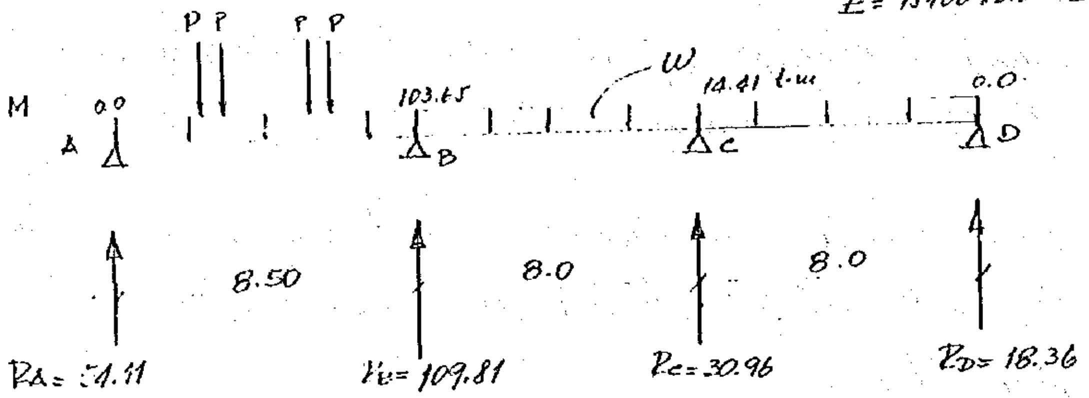
****

MOMENTOS FINALES EN LOS MIEMBROS

TRAMO	LONGITUD	CARGA REPARTIDA	M.IZQUIERDA	M.DERECHA
1	8.50	5.040	-0.00	103.65
2	8.00	5.040	-103.65	14.41
3	8.00	5.040	-14.41	-0.00

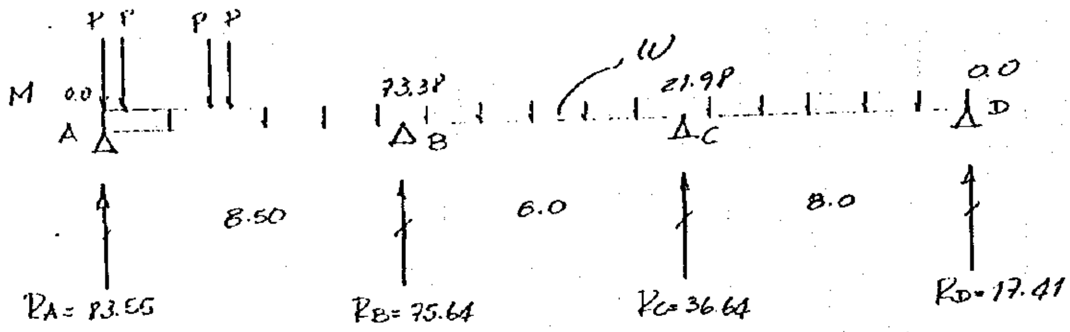
I = 2812.50 dm⁴

$E = 15100\sqrt{210} = 218\,819.8$ Kg/cm²



$M^+ = 128.10$

$x = 3.05$

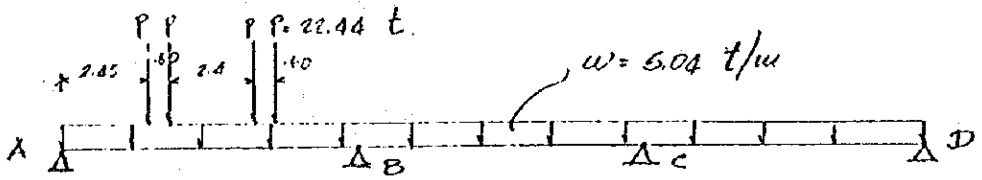


$M^+ = 106.9$

$x = 3.22$

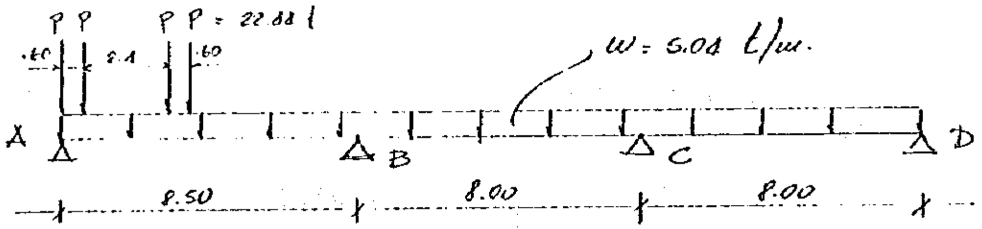
BEAM ANALYSIS:

CASE 1.-



V_I	↑66.3	66.3 ↑	↑20.16	20.16 ↑	↑20.16	20.16 ↑
V_H	↓12.19	12.19 ↑	↑11.16	11.16 ↓	↑1.80	1.80 ↓
V_T	↑54.11	78.49 ↑	↑31.32	9.00 ↑	↑21.96	18.36 ↑

CASE 2.-



V_I	↑62.18	40.42 ↑	↑20.16	20.16 ↑	↑20.16	20.16 ↑
V_H	↓8.63	8.63 ↑	↑6.43	6.43 ↓	↑2.75	2.75 ↓
V_T	↑53.55	49.05 ↑	↑26.59	13.73 ↑	↑22.91	17.41 ↑

BEAM DESIGN.

a) FLEXURE

$b = 100$ $h = 150$ $d = 145$ $f'c = 210$ $fy = 4200$

$Mu_{máx} = 128.10$ t-m.

$p = 0.16\%$ $P_{min} = 0.33\%$ $As_{min} = 48.33$ cm^2

USE : 10 ϕ 25 (49.09 cm^2)

1-1-133

b) Shear

$b = 100 \quad d = 145 \quad f'_c = 210 \quad f_y = 4200$

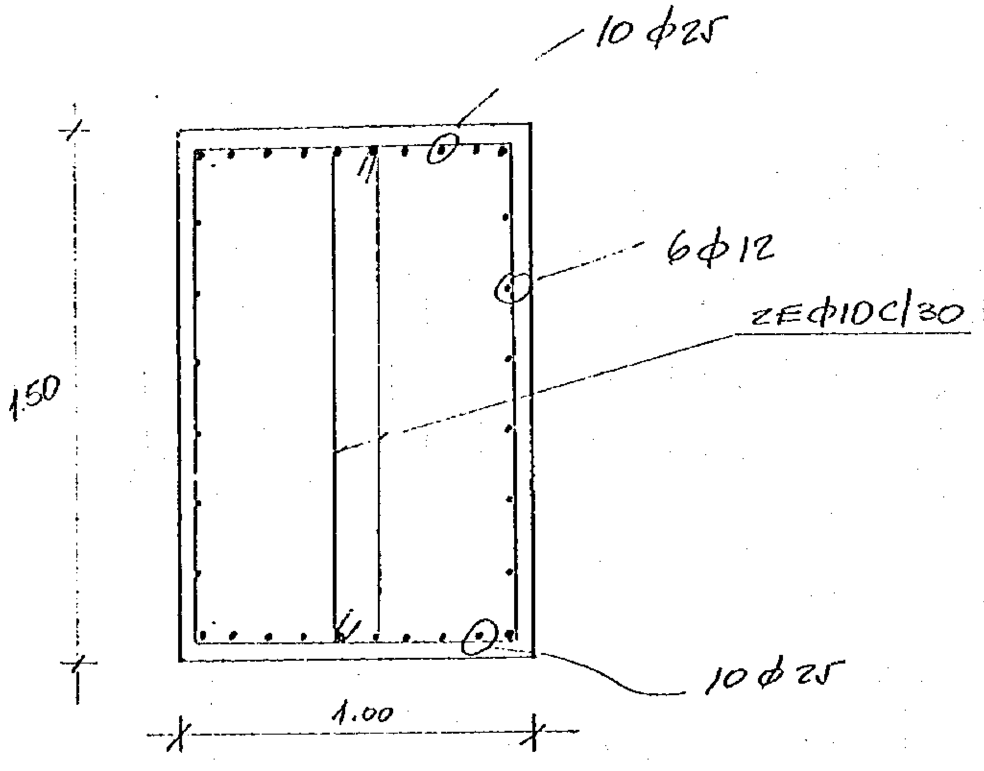
$V_{u\,max} = 83.55\ t. \qquad \phi V_c = 94.66\ t$

$\phi V_c > V_u$

$A_v = 2E\phi 10 = 3.14\ cm^2 \qquad S_{max} = 35\ cm.$

USE: $2E\phi 10\ c/30$

$A_{sTEM} = 1\phi 12\ c/20$ each face



REINFORCEMENT
CRANE GIRDER

1-1-134