

### 5.3.3 Análisis Estructural

#### (1) Estructura de Entrada Conguillo

##### (A) Túnel de entrada

Caso 1: Durante la construcción

#### 1) Peso muerto del revestimiento de hormigón

$$W_c = 0,5 \times 2,4 = 1,2 \text{ tf/m}$$

#### 2) Presión vertical de la roca, presión del agua y presión del relleno del enlechado

$$P_r = 1,8 \times 10,0 + (1,8 - 1,0) \times 10,0 = 26,0 \text{ tf/m}$$

$$P_w = 1,0 \times (\text{EL}80,0 - 70,0) = 10,0 \text{ tf/m}$$

$$P_g = 15,0 \text{ tf/m}$$

#### 3) Presión lateral del agua

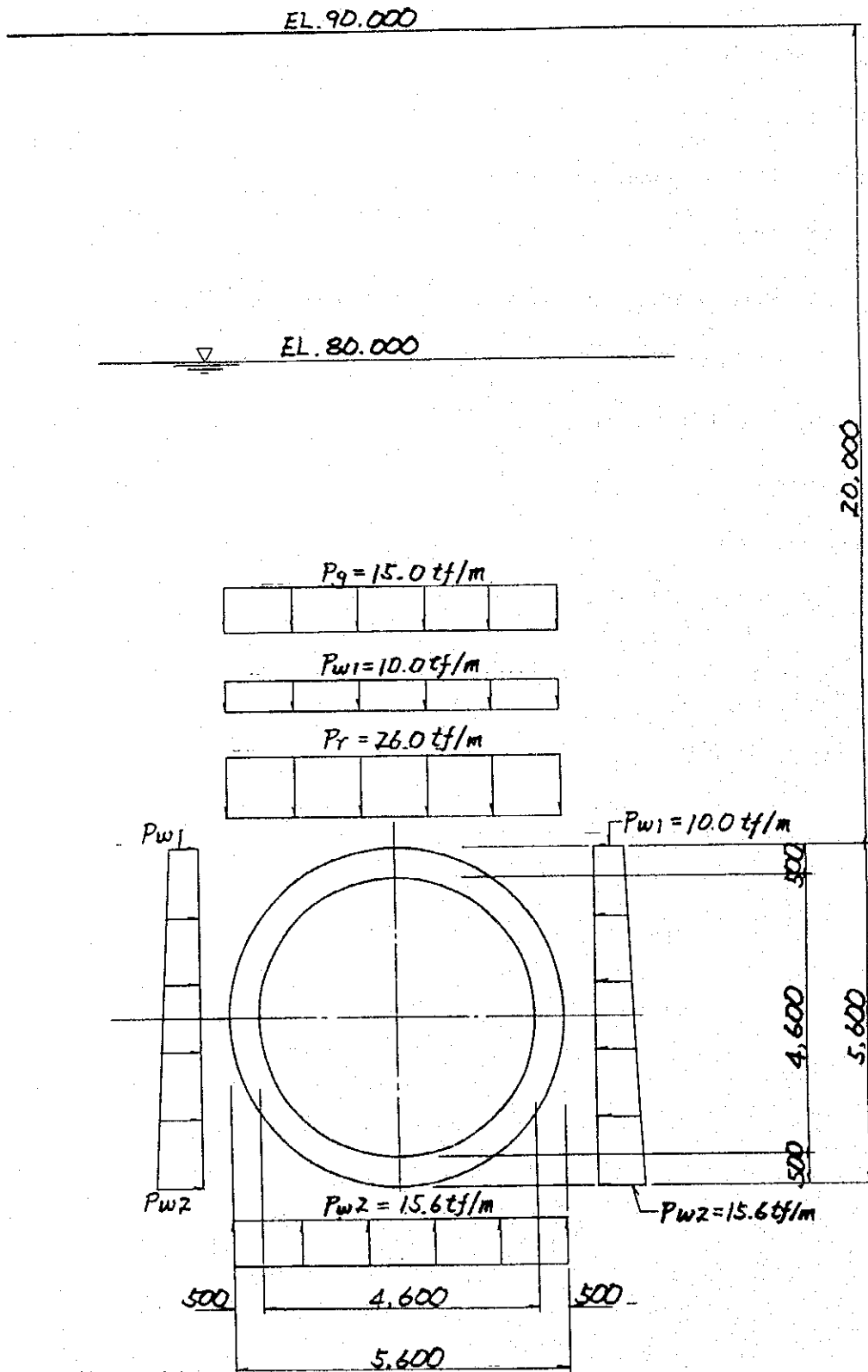
$$P_{w1} = 1,0 \times 10,0 = 10,0 \text{ tf/m}$$

$$P_{w2} = 1,0 \times 15,6 = 15,6 \text{ tf/m}$$

#### 4) Subpresión

$$P_u = 1,0 \times 15,6 = 15,6 \text{ tf/m}$$

539

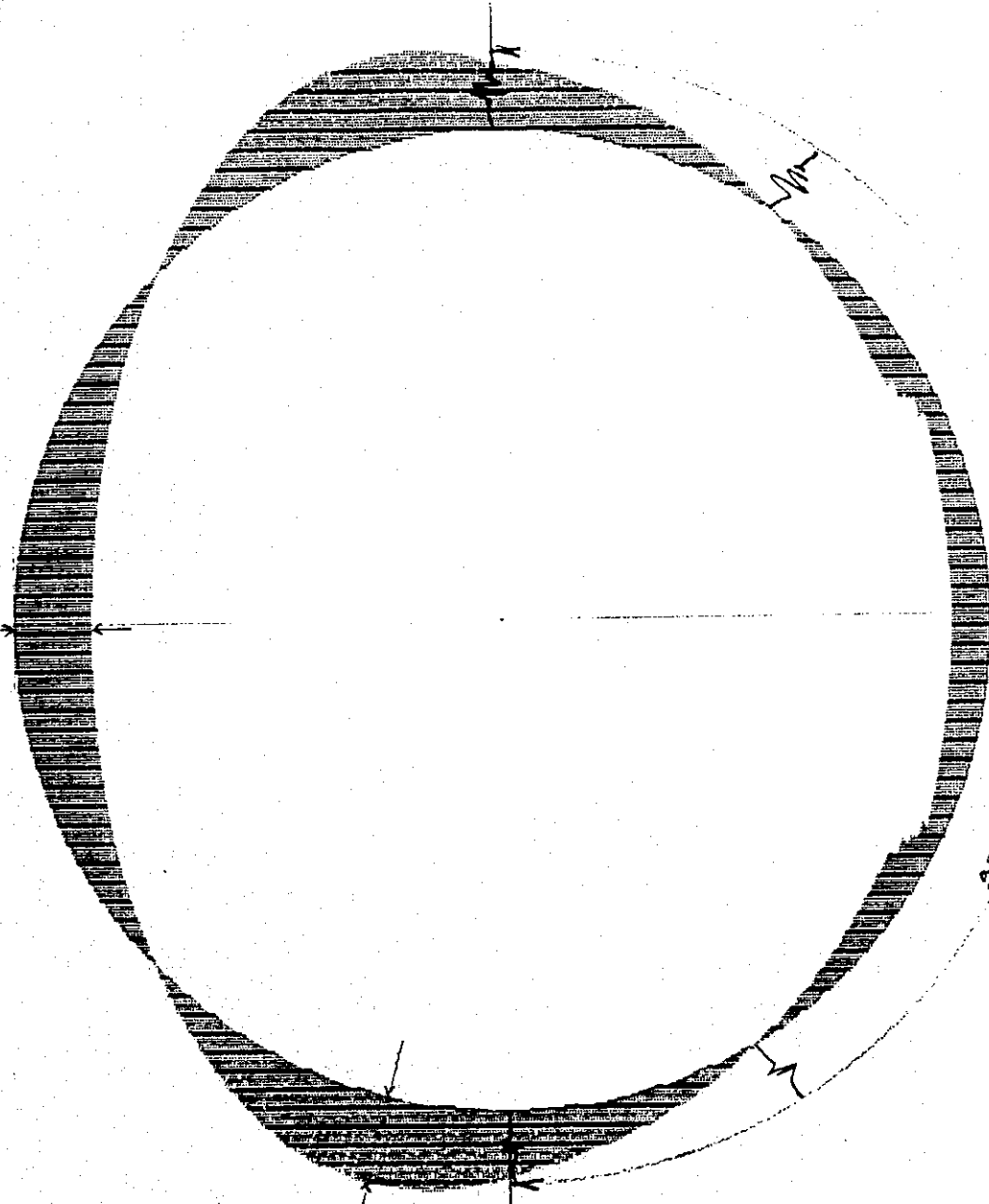


INLET TUNNEL  
 CONQUILLO INLET STRUCTURE

CONQUILLO TURNER INLET

13.01

-14.9



SPRINGS SUPPORTS X 180' E = 10,000 K/CM<sup>2</sup>  
 MOMENT DIAGRAM

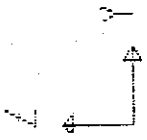
CONGT222

FRAME  
 OUTPUT M33  
 LOAD 1

MIN < 1043  
 - .1498E+02  
 AT .04  
 MAX < 1813  
 .1301E+02  
 AT .02

SAP90

5-41



CONGT222

FRAME

OUTPUT W22

LOAD 1

MIN < 241>

- .1609E+02

AT .04

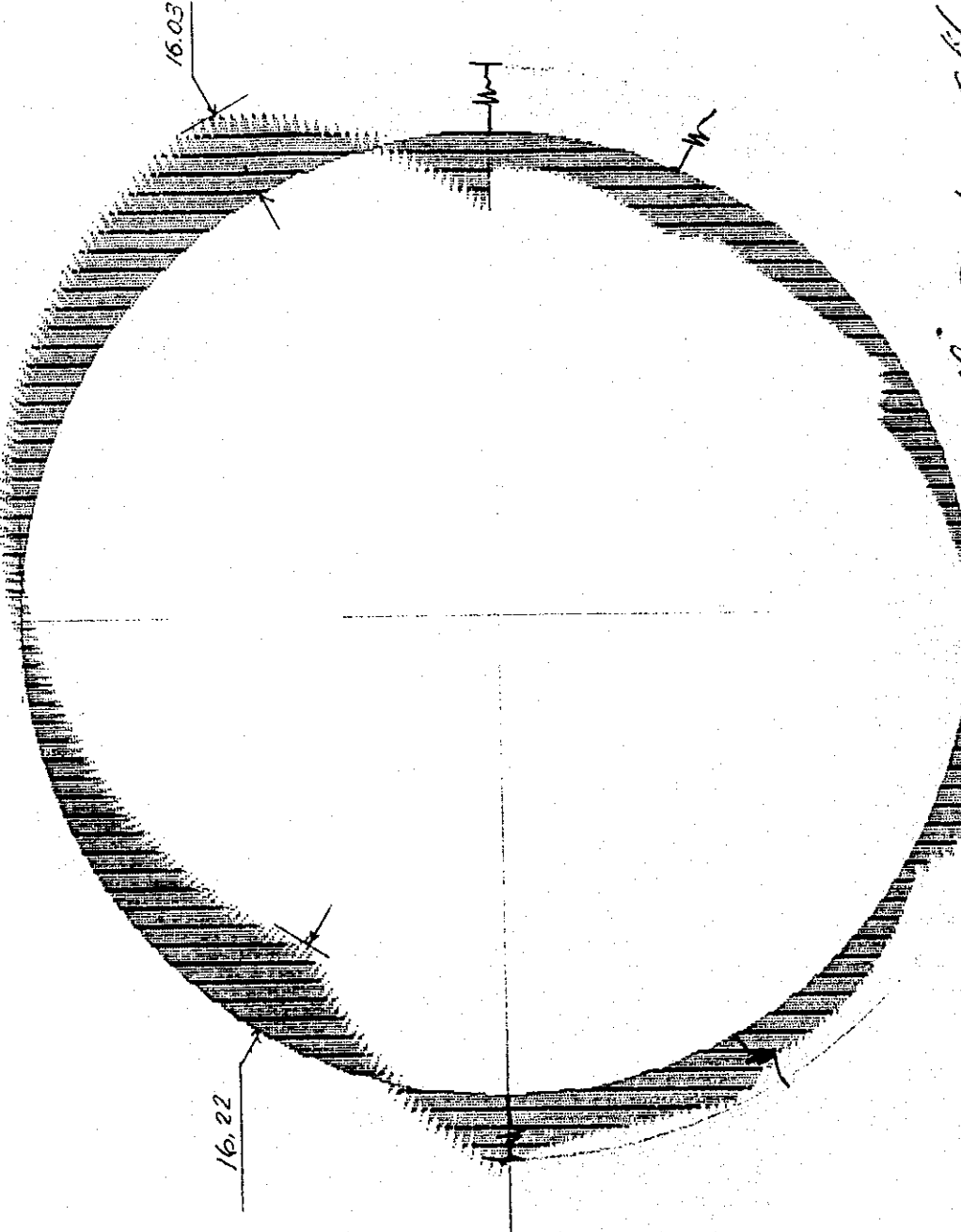
MAX < 121>

.1622E+02

AT .00

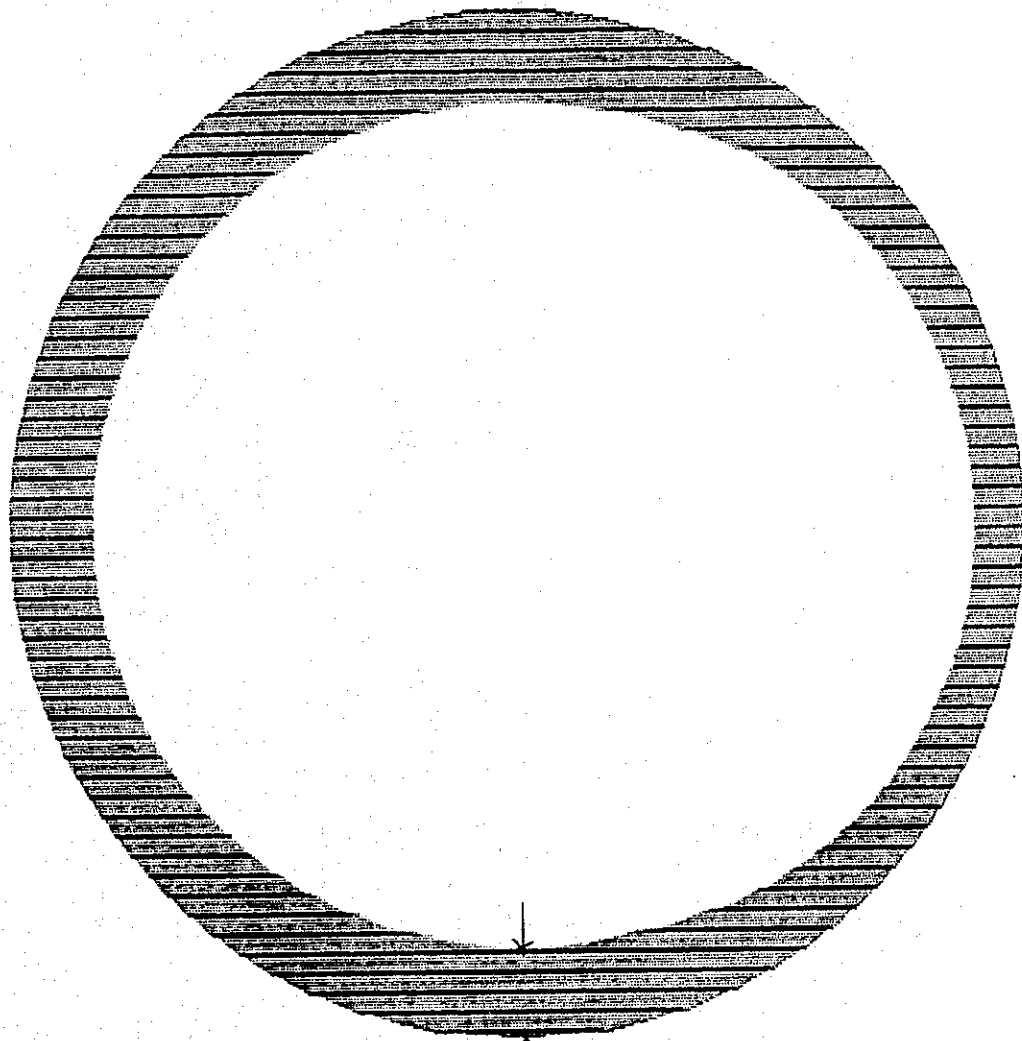
SAP90

CONGUILLO RINGLET INLET

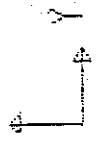


SPRING SUPPORTS  $\times 180$   $E = 10,000 \text{ N/mm}^2$   
SHEAR DIAGRAM

CONGUILLO POLET TUNNEL



AXIAL DIAGRAM



CONST222

FRAME

OUTPUT

LOAD

P

1

MIN < 952

-2.104E+03

AT .00

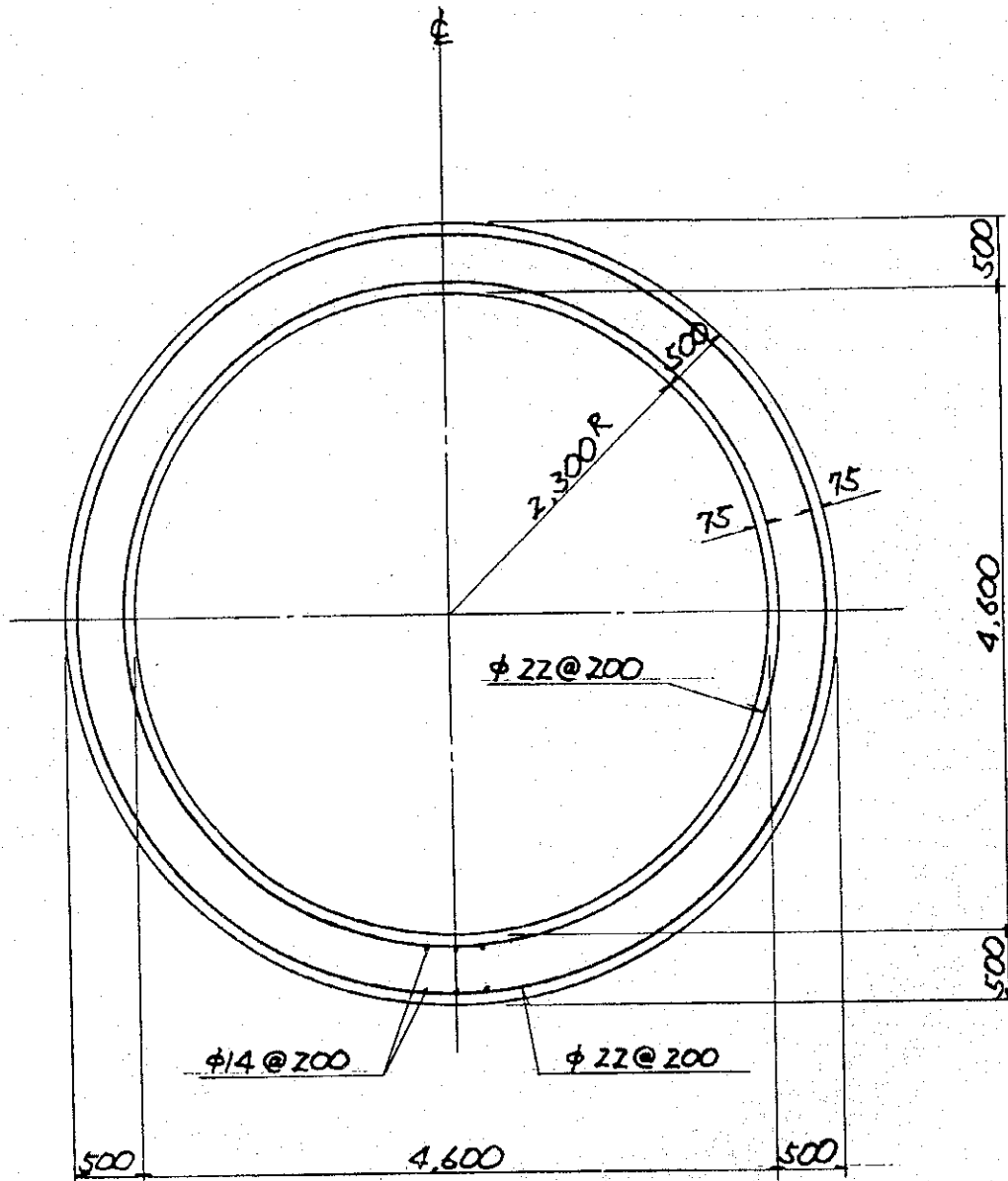
MAX < 12

-1.126E+03

AT .04

SAP90

5-43



Note;  
 $\phi 22$  means diameter of deformed bar.

INLET TUNNEL  
 CONQUILLO INLET STRUCTURE

5-44

(B) Inlet Shaft

Inlet Shaft, Section A - A

Case 1 : After construction

1) Lateral water pressure

$$P_w = 1.0 \times (El.80.0 - El.56.63) = 23.37 \text{ tf/m}$$

2) Lateral bedrock pressure

$$K_a = \tan^2(45 - 40/2) = 0.217$$
$$P_r = 0.217 \times (1.8 - 1.0) \times 8.3 = 1.44 \text{ tf/m}$$

Inlet Shaft, Section B - B

Case 1 : After construction

1) Lateral water pressure

$$P_w = 1.0 \times (El.80.0 - El.71.0) = 9.0 \text{ tf/m}$$

2) Lateral bedrock pressure

$$K_a = \tan^2(45 - 40/2) = 0.217$$
$$P_r = 0.217 \times 1.8 \times 10.00 + 0.217 \times (1.8 - 1.0) \times 9.0 = 5.468 \text{ tf/m}$$

Inlet Shaft, Section C - C

Case 1 : After construction

1) Lateral water pressure

$$P_w = 1.0 \times (El.80.0 - El.74.0) = 6.0 \text{ tf/m}$$

2) Lateral bedrock pressure

$$K_a = \tan^2(45 - 40/2) = 0.217$$
$$P_r = 0.217 \times 1.8 \times 10.0 + 0.217 \times (1.8 - 1.0) \times 6.0 = 4.948 \text{ tf/m}$$

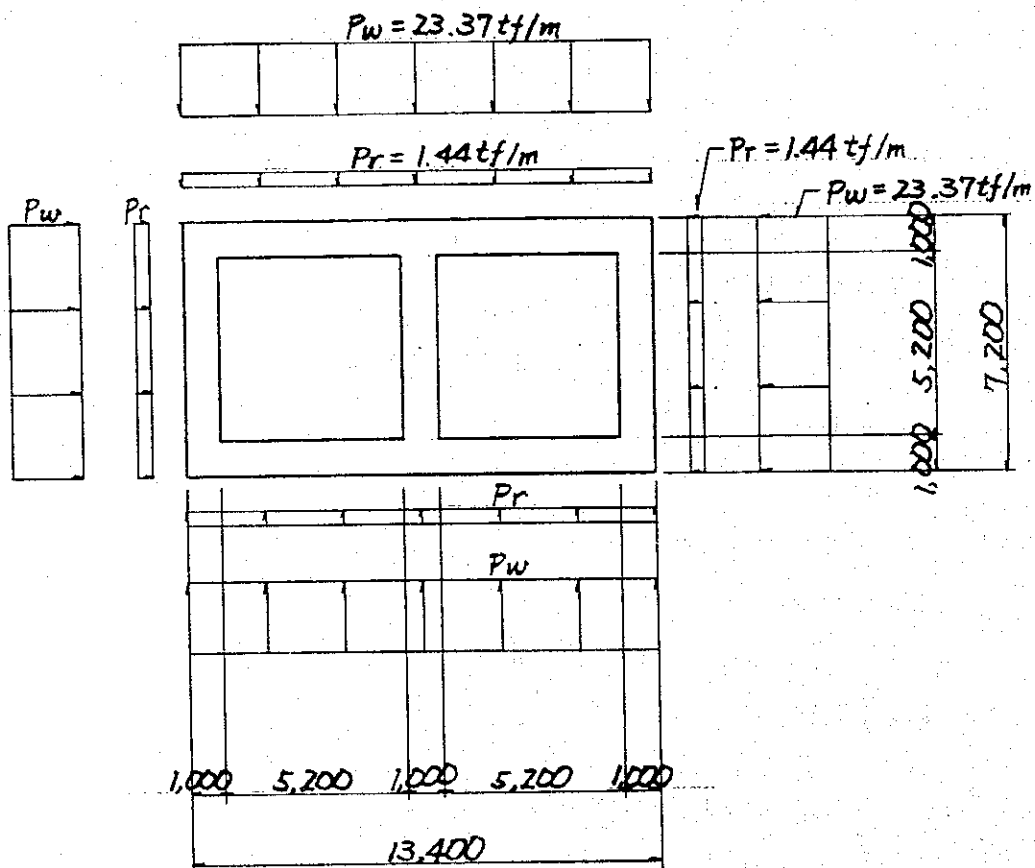
Inlet Shaft, Section D - D

Case 1 : After construction

1) Lateral bedrock pressure

$$K_a = \tan^2(45 - 40/2) = 0.217$$
$$P_r = 0.217 \times 1.8 \times 8.0 = 3.125 \text{ tf/m}$$

5-45



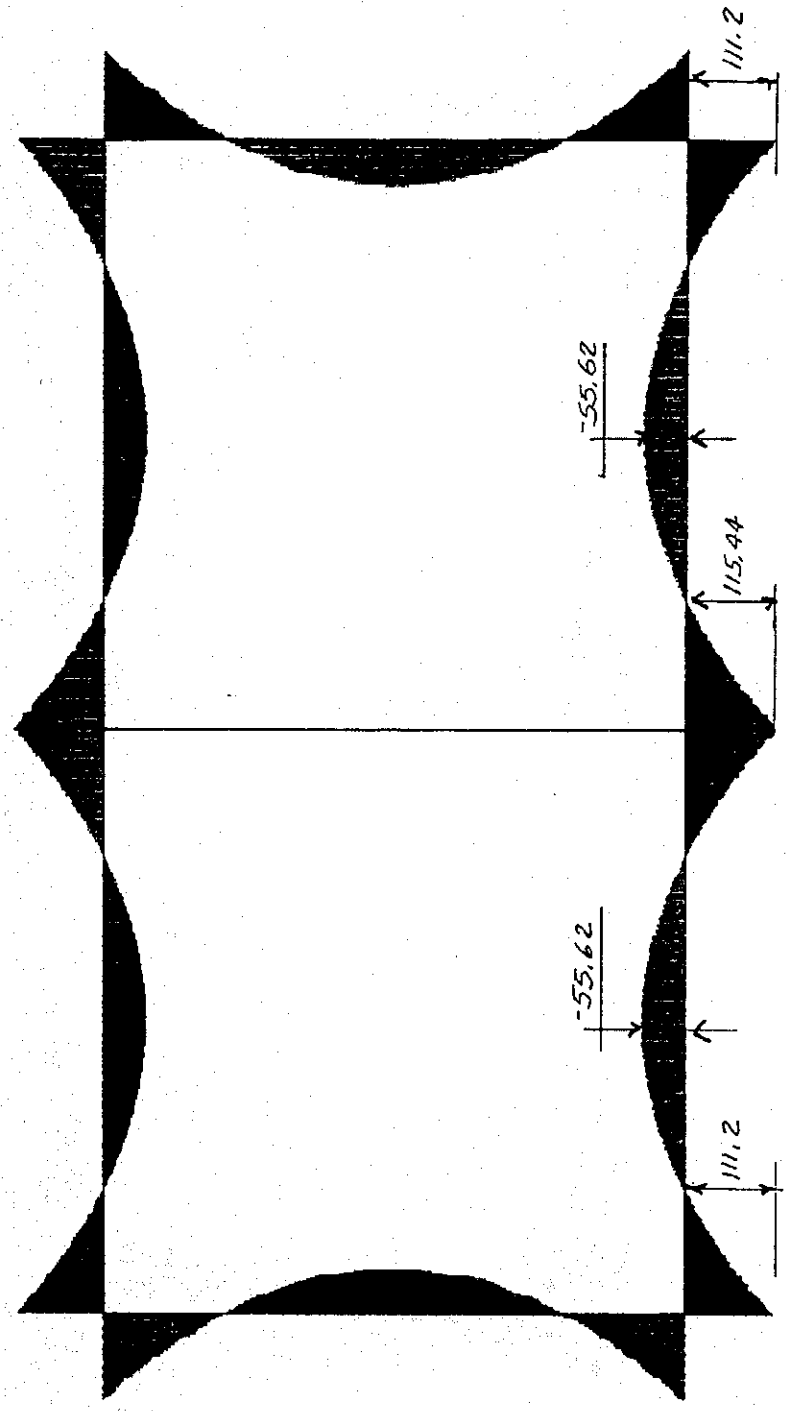
INLET SHAFT, SECTION A - A  
 CONGUILLO INLET STRUCTURE

5-46

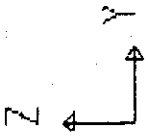


|   |   |
|---|---|
|   | CONGS260<br>FRAME      M33<br>OUTPUT<br>LOAD      1 |
| MIN < 36><br>- .1154E+03<br>AT      1.03<br>MAX < 6><br>.1154E+03<br>AT      1.03 |   |

CONQUILLO SHAFT



MOMENT DIAGRAM



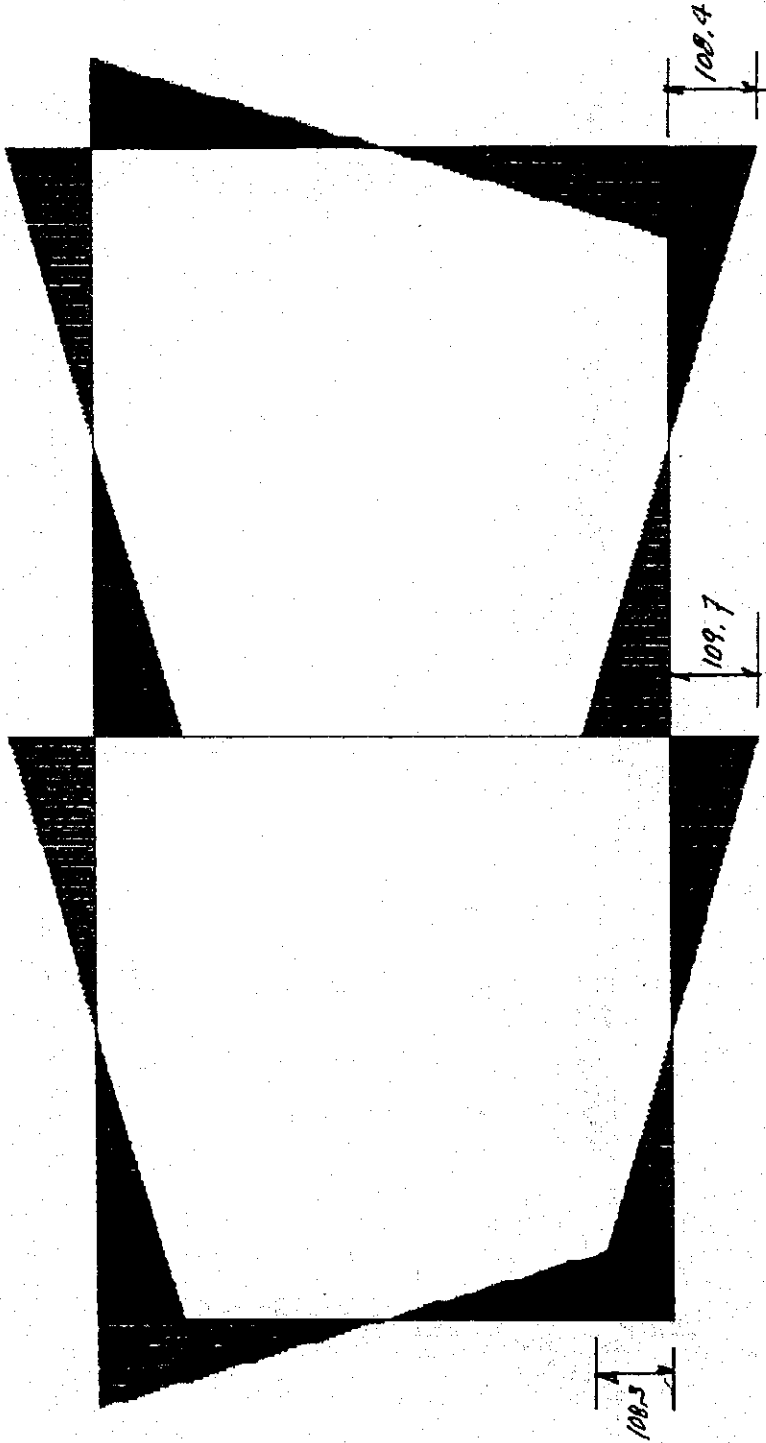
CONGS260

FRAME V22  
OUTPUT V22  
LOAD 1

MIN < 7 >  
- .1097E+03  
AT .00  
MAX < 6 >  
.1097E+03  
AT 1.03

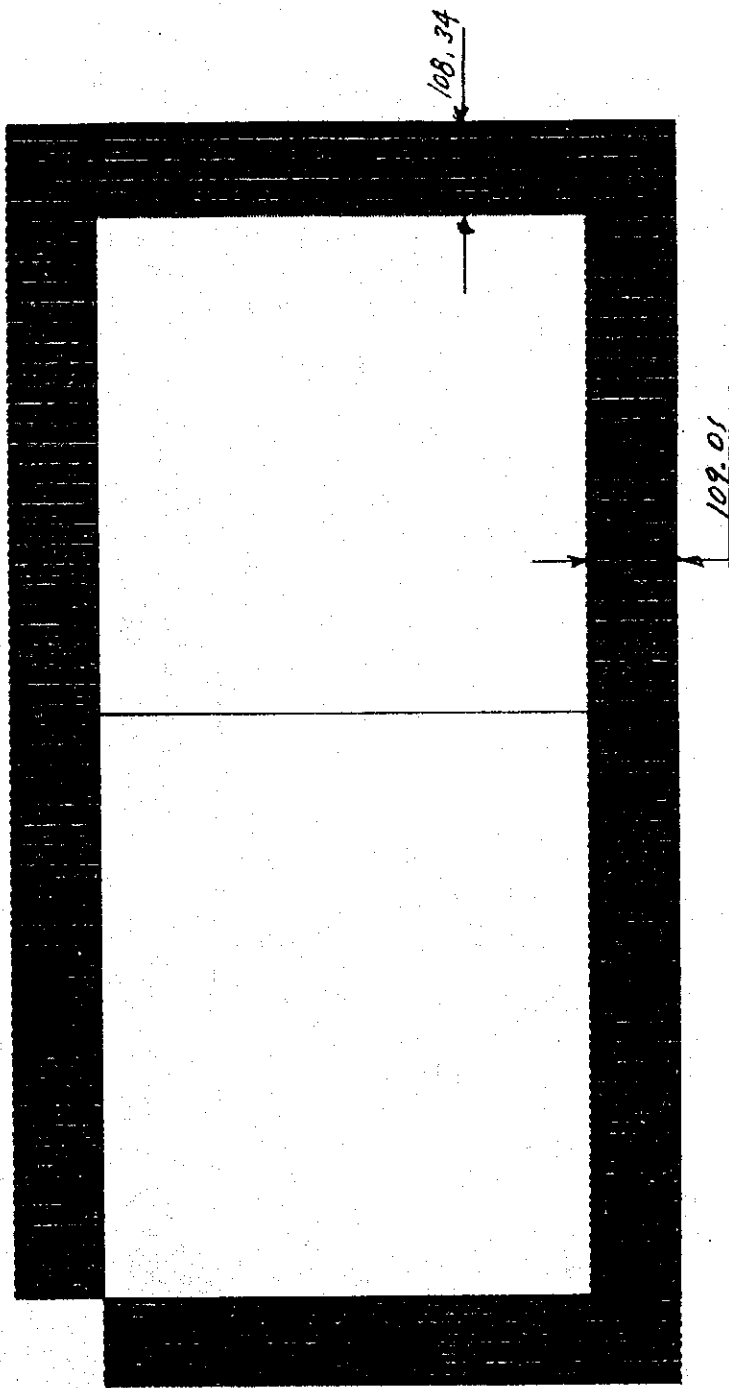
SAP90

CONGULLO SHAFT

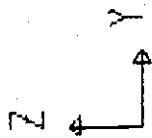


SHEAR DIAGRAM

CONQUILLO SHAFT



AXIAL FORCE

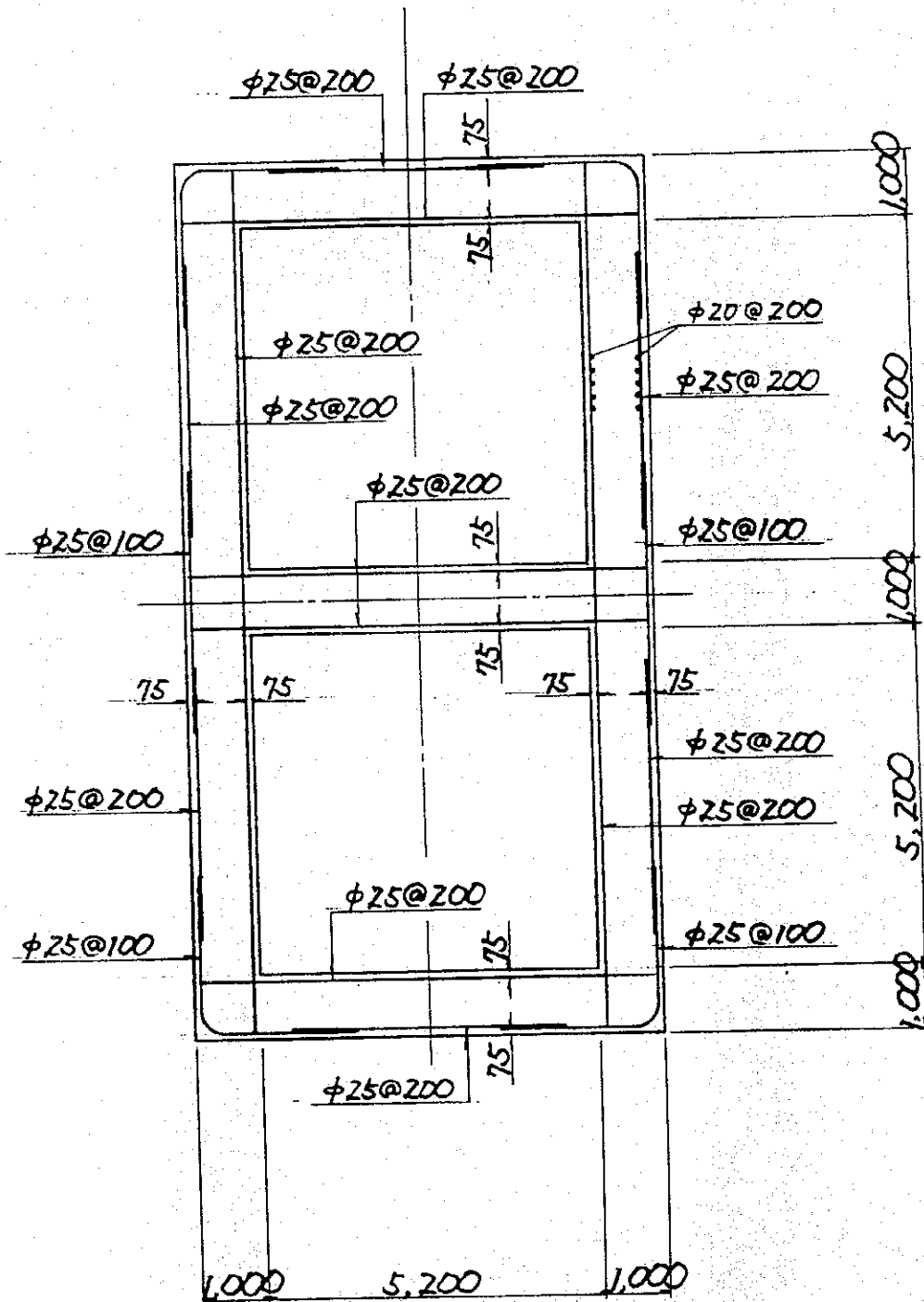


CONGS260

FRAME  
 OUTPUT P  
 LOAD 1

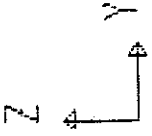
MIN < 1>  
 - .1090E+03  
 AT .00  
 MAX < 29>  
 - .2512E-23  
 AT .00

SAP90



INLET SHAFT, SECTION A - A  
 CONGUILLO INLET STRUCTURE  
 5-50



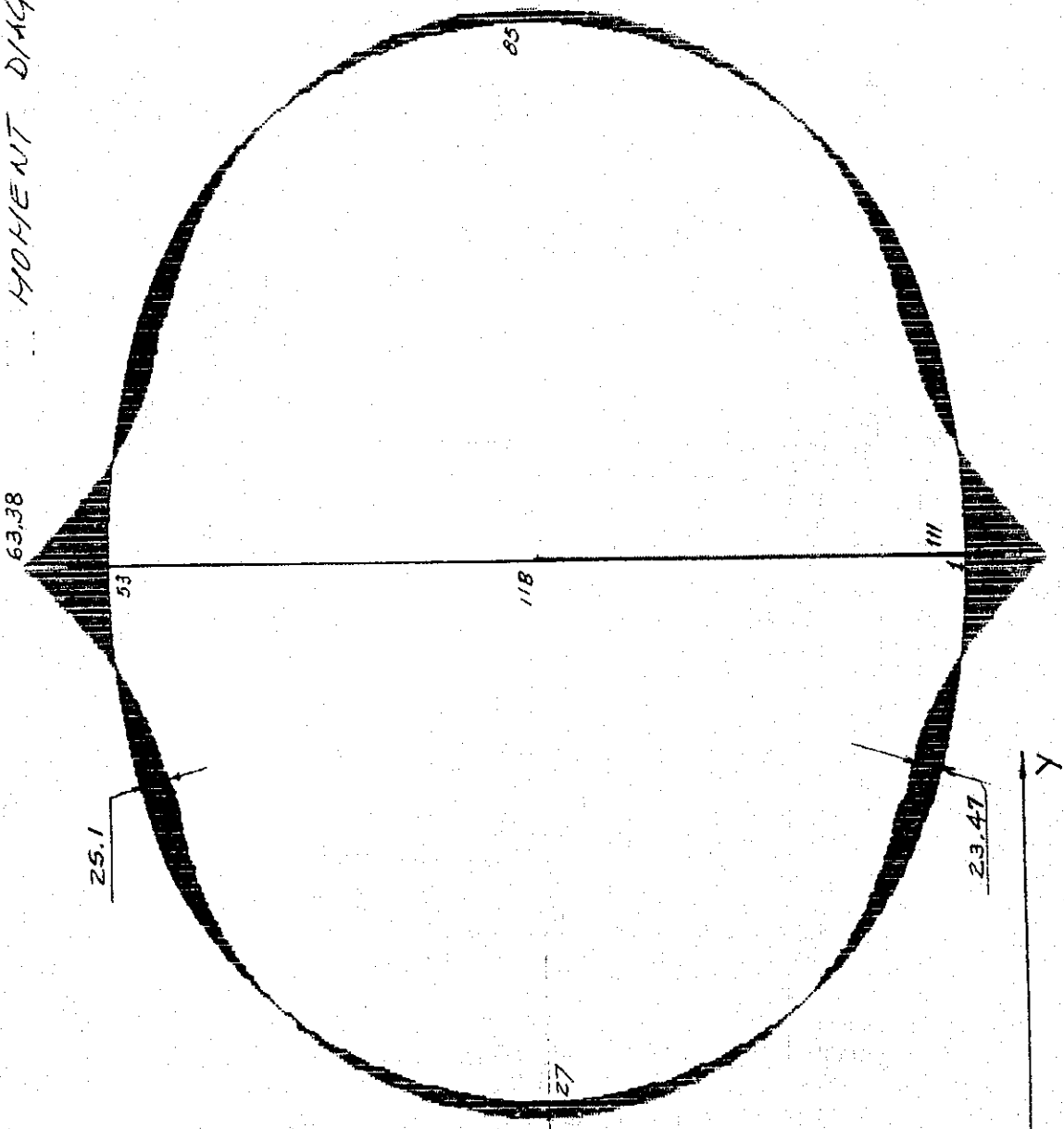


CONGSHAA  
 FRAME  
 OUTPUT M33  
 LOAD 1

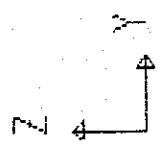
MIN < 52  
 -.6443E+02  
 AT .57  
 MAX < 45  
 .2540E+02  
 AT .16

SAP90

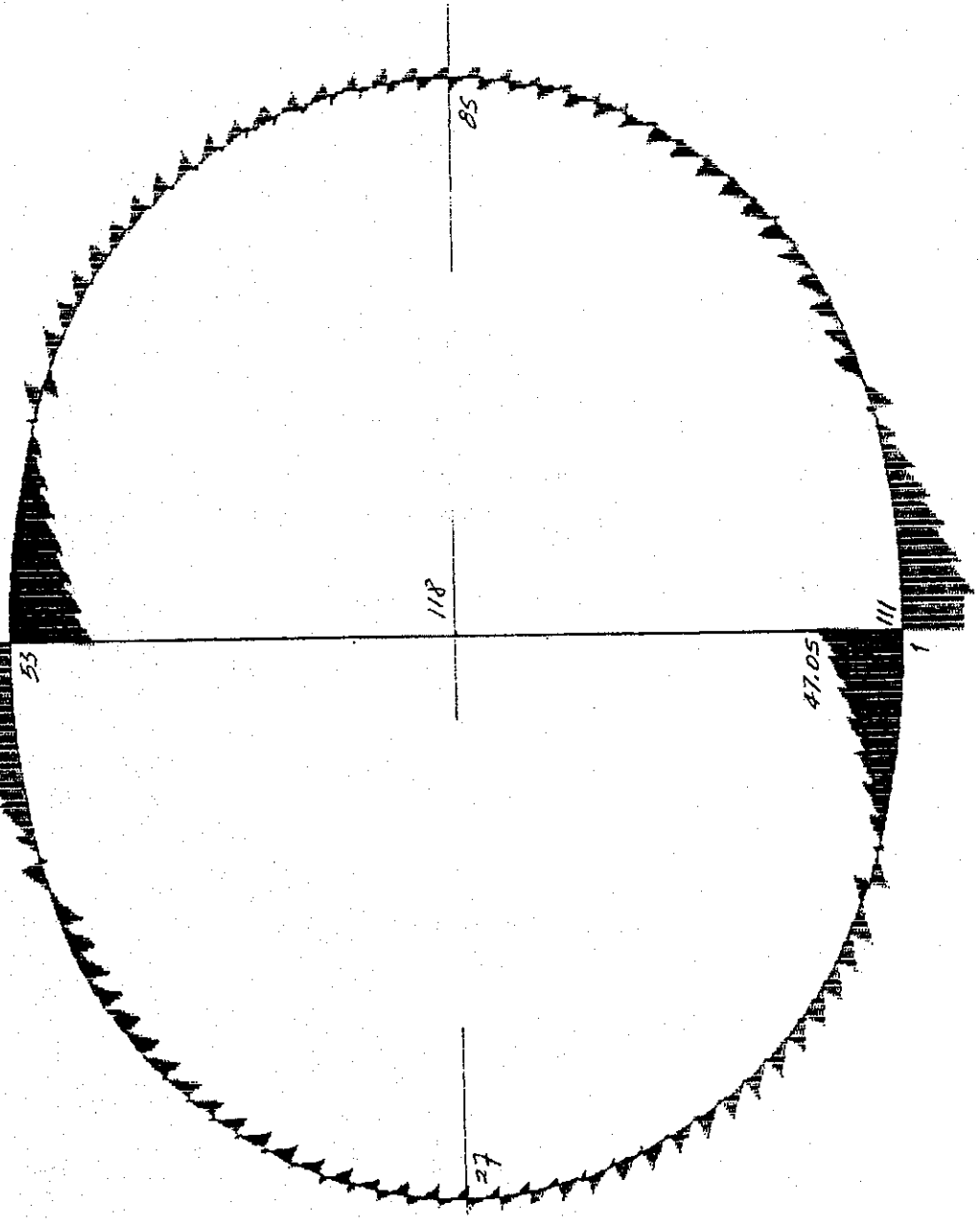
CONQUILLO SHAFT SECTION B-B MOMENT DIAG



542



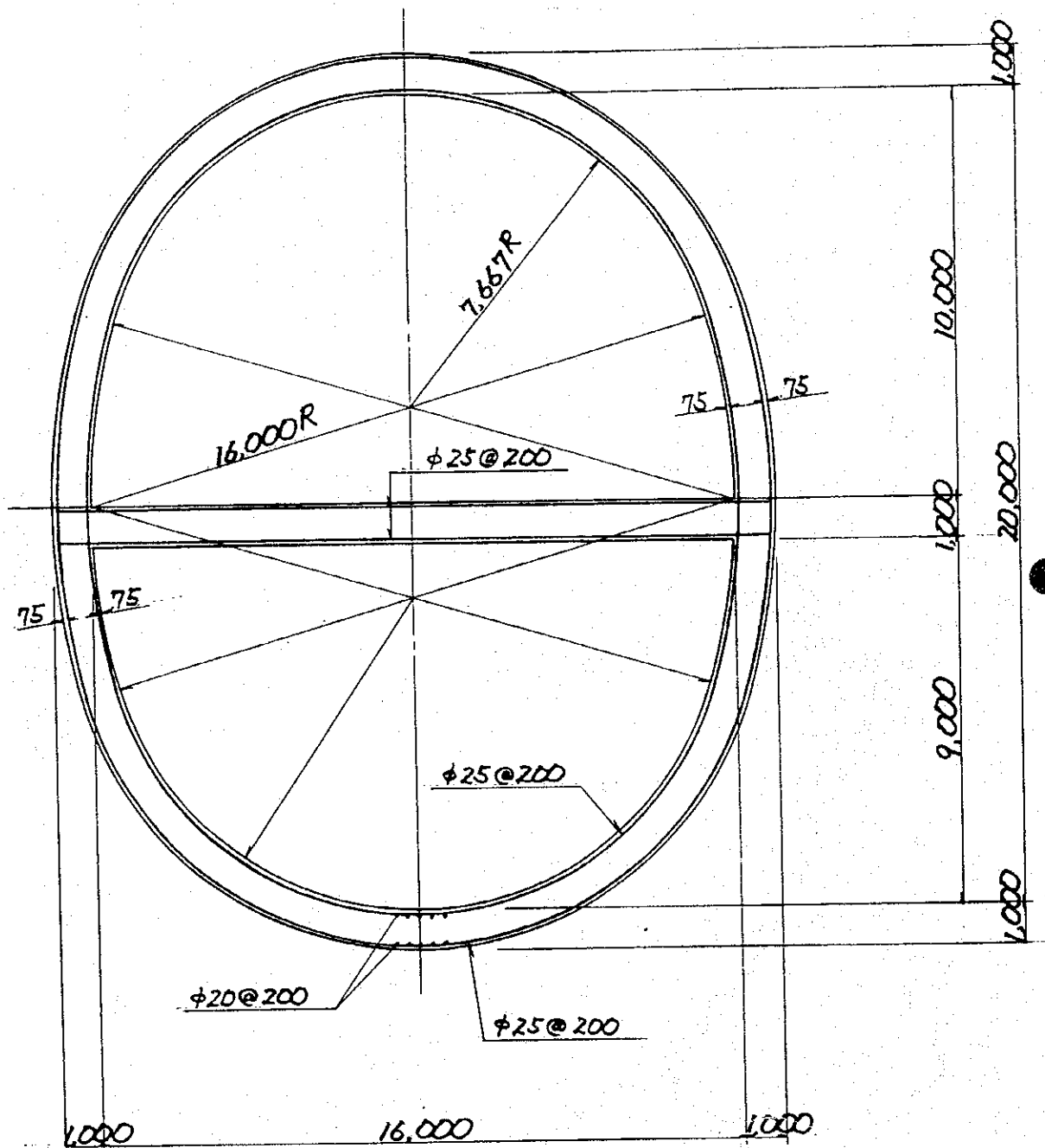
CONQUILLO SHAFT SECTION B-B  
SHEAR DIAG.



CONGSHA  
FRAME  
OUTPUT V22  
LOAD 1

MIN < 52  
-.4706E+02  
AT .57  
MAX < 1  
.4705E+02  
AT .00

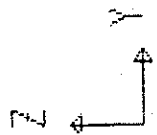
SAP90



INLET SHAFT, SECTION B - B  
 CONGUILLO INLET STRUCTURE  
 5-44





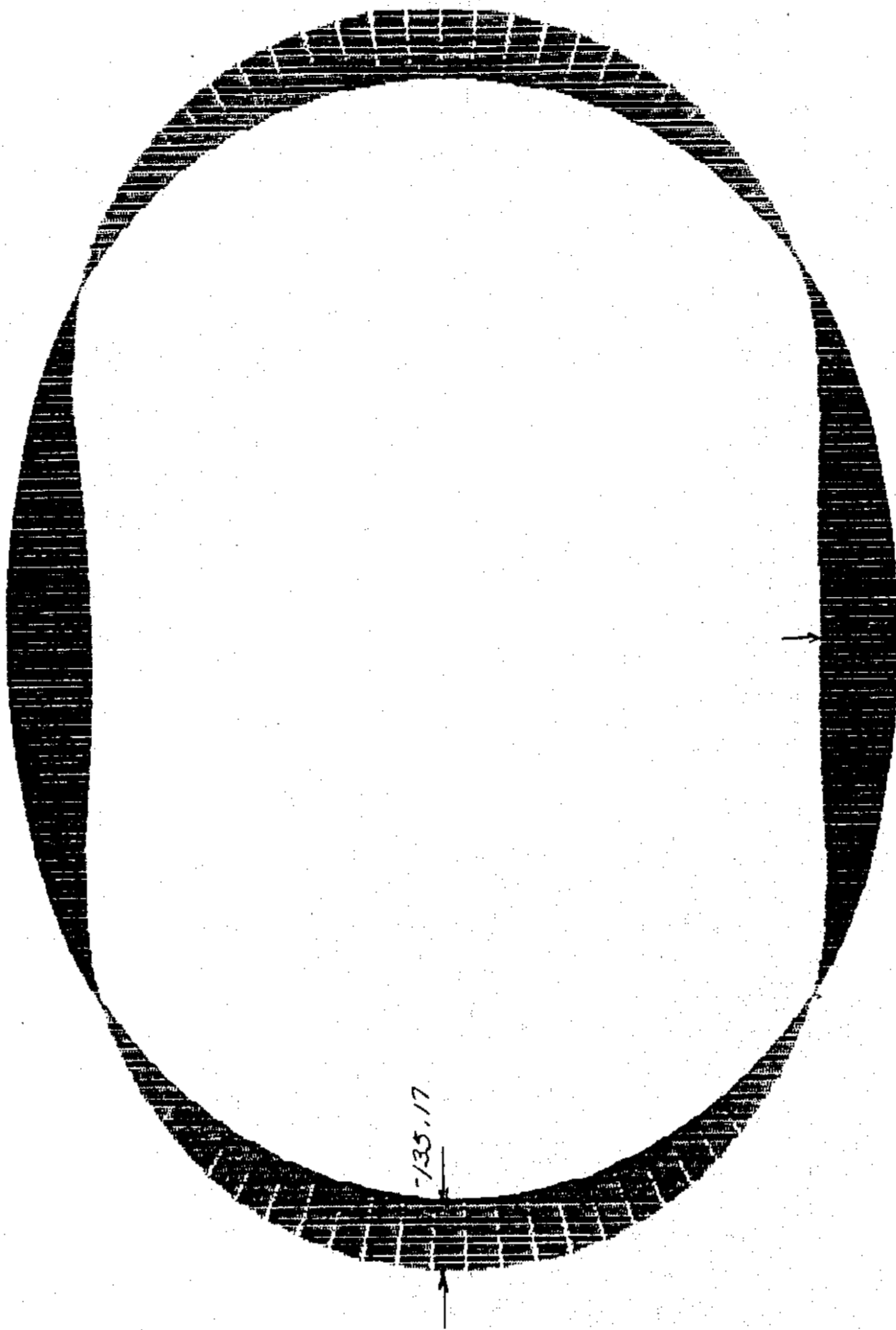


congshbt  
FRAME  
OUTPUT / M33  
LOAD 1

MIN < 27  
- .1262E+03  
AT .55  
MAX < 52  
.1523E+03  
AT .43

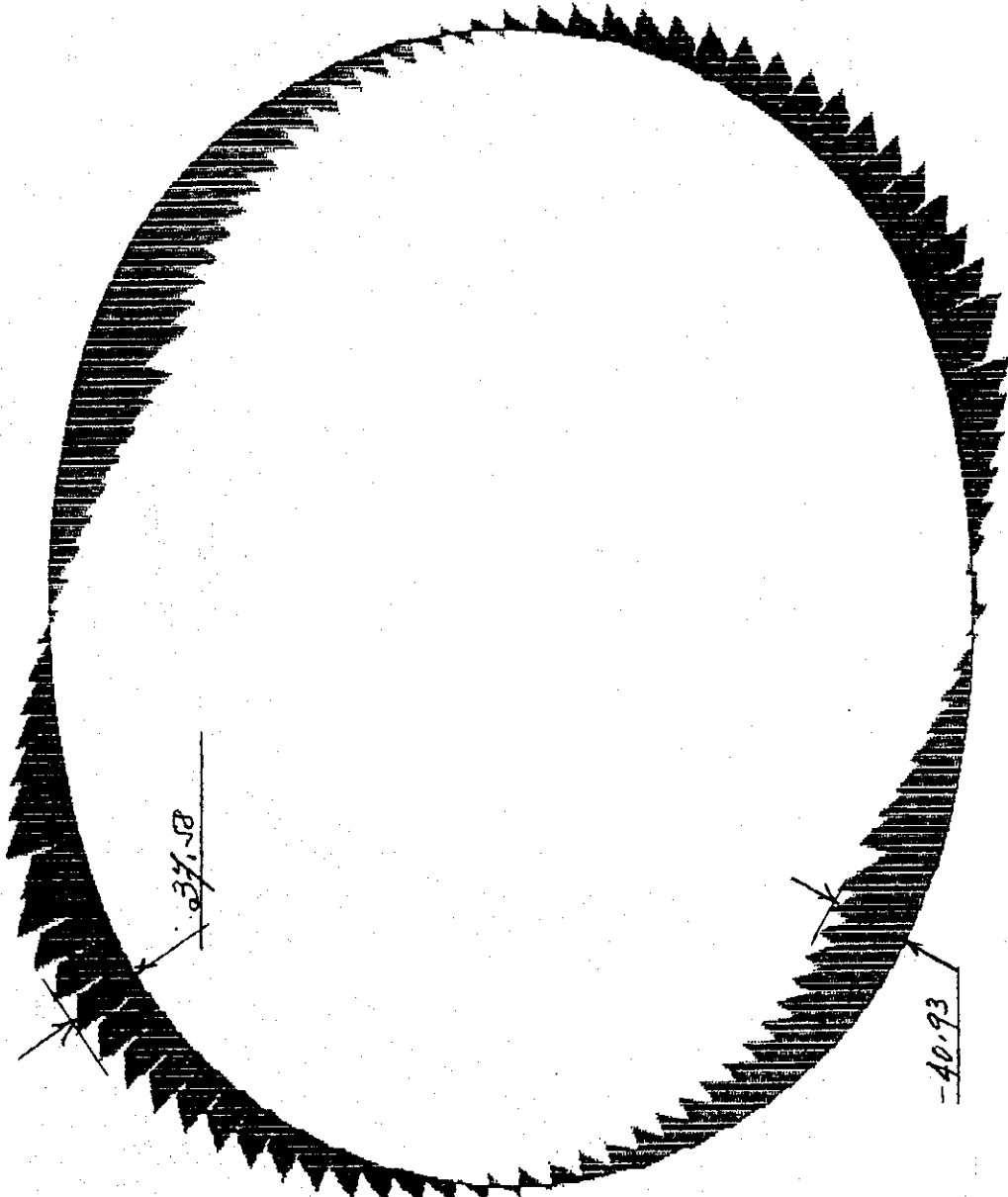
SAP90

CONQUILLO SHAFT

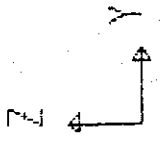


MOMENT DIAGRAM  
MODES ALL PERIMETER

CONQUILLO SHAFT



SHEAR DIAGRAM  
HORIZ ALL PERIMETER



congshbt

FRAME

OUTPUT

LOAD

V22

1

MIN < 60>

- .4059E+02

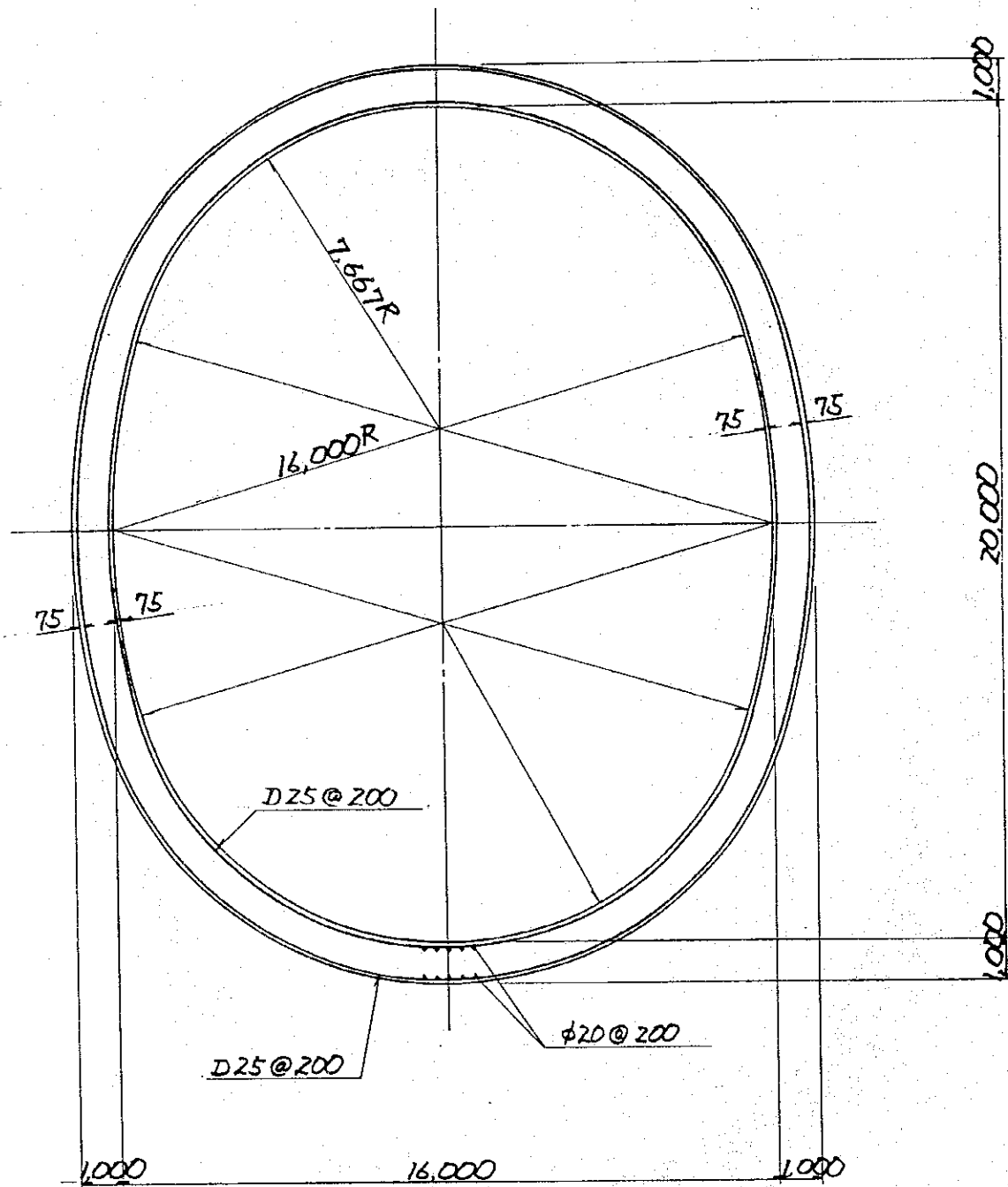
AT .57

MAX < 44>

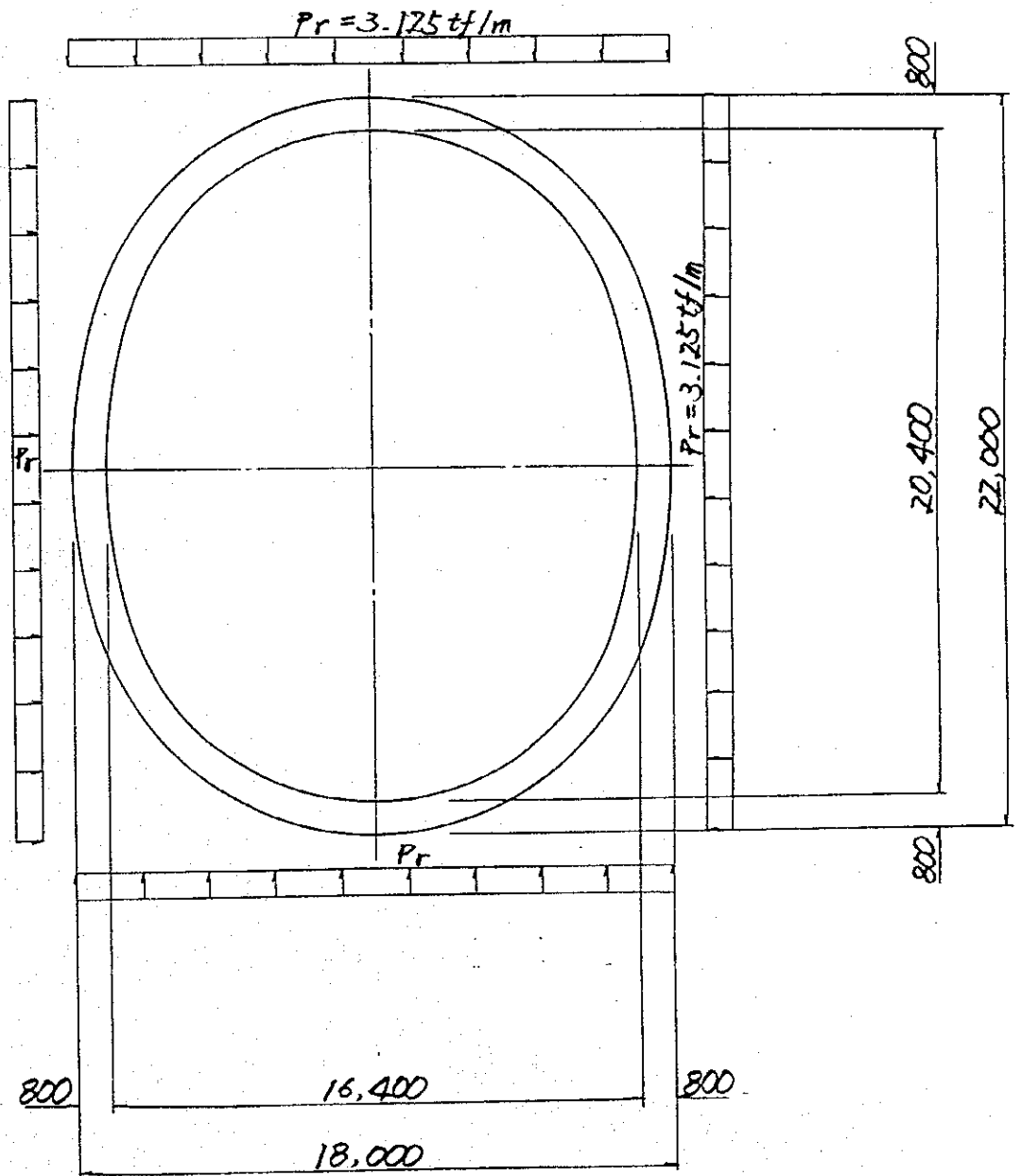
.4000E+02

AT .00

SAP90



INLET SHAFT, SECTION C-C  
 CONGUILLO INLET STRUCTURE  
 5-18

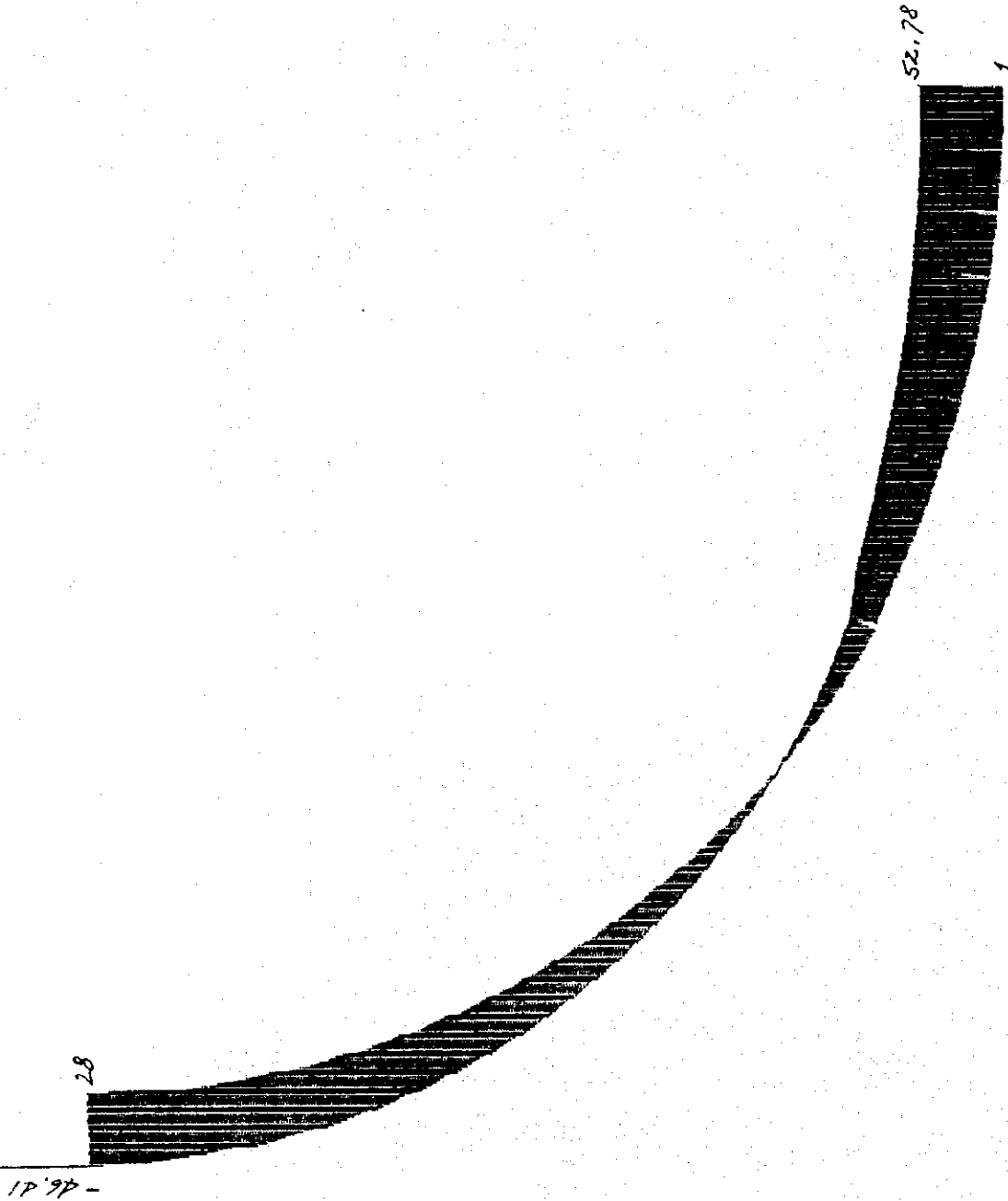


INLET SHAFT, SECTION D - D

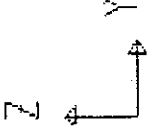
CONGUILLO INLET STRUCTURE

5-19

CONQUILLO SHAFT SEC. D-D



MOMENT DIAGRAM



CONGSHCC

FRAME

OUTPUT M33

LOAD 1

MIN < 26 >

- .4683E+02

AT .57

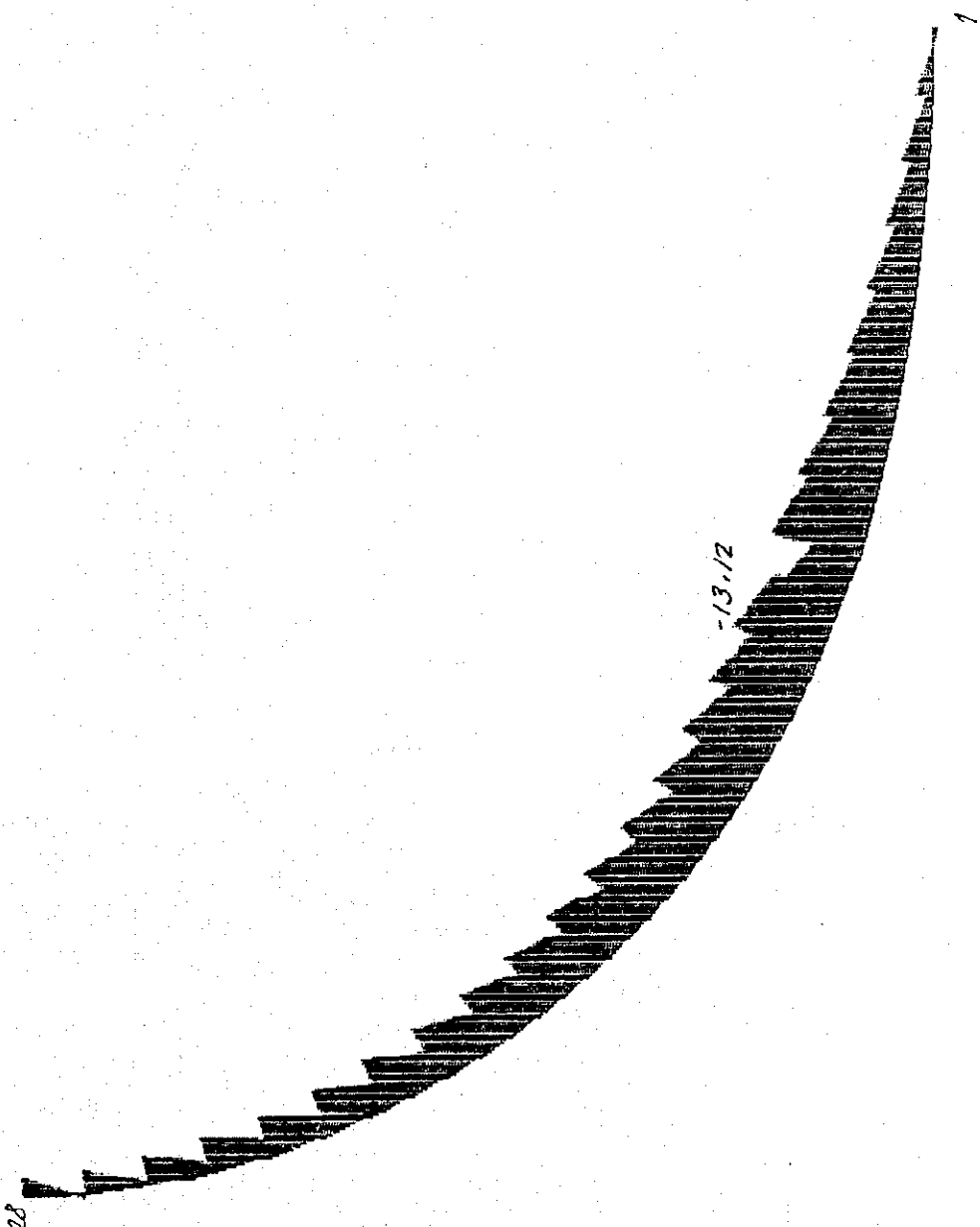
MAX < 1 >

.5656E+02

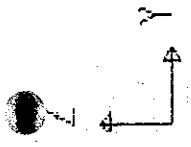
AT .15

SAP90

CONQUILLO SHAFT SECC. D-D



== SHEAR DIAGRAM.



CONGSHCC  
FRAME  
OUTPUT V22  
LOAD 1

MIN < 10>  
- .1317E+02  
AT .56  
MAX < 1>  
.7644E+00  
AT .00

SAP90

5-61





(C) Inlet Transition

Case 1 : During construction

1) Dead weight of lining concrete

$$W_c = 0.8 \times 2.4 = 1.92 \text{ tf/m}$$

2) Vertical bedrock pressure, water pressure and backfill grout pressure

$$P_r = 1.8 \times 10.0 + (1.8 - 1.0) \times 9.5 = 25.6 \text{ tf/m}$$

$$P_w = 1.0 \times (\text{El.}80.0 - \text{El.}70.5) = 9.5 \text{ tf/m}$$

$$P_g = 15.0 \text{ tf/m}$$

3) Lateral water pressure

$$P_{w1} = 1.0 \times 9.5 = 9.5 \text{ tf/m}$$

$$P_{w2} = 1.0 \times 14.8 = 14.8 \text{ tf/m}$$

4) Uplift pressure

$$P_u = 1.0 \times 14.8 = 14.8 \text{ tf/m}$$

5-63

EL. 90.0m

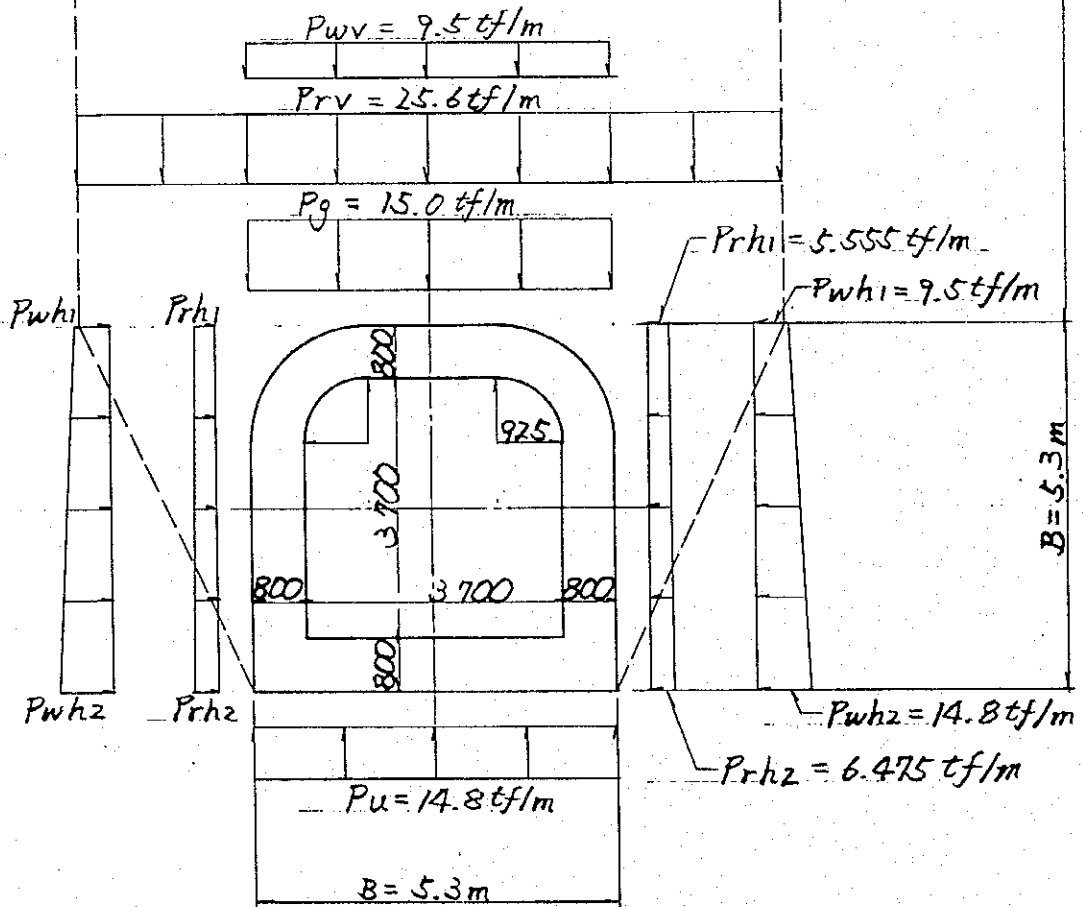
Unit weight of bedrock

$$\gamma = 1.8 \text{ tf/m}^3$$

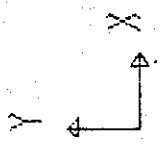
$$\phi = 40^\circ$$

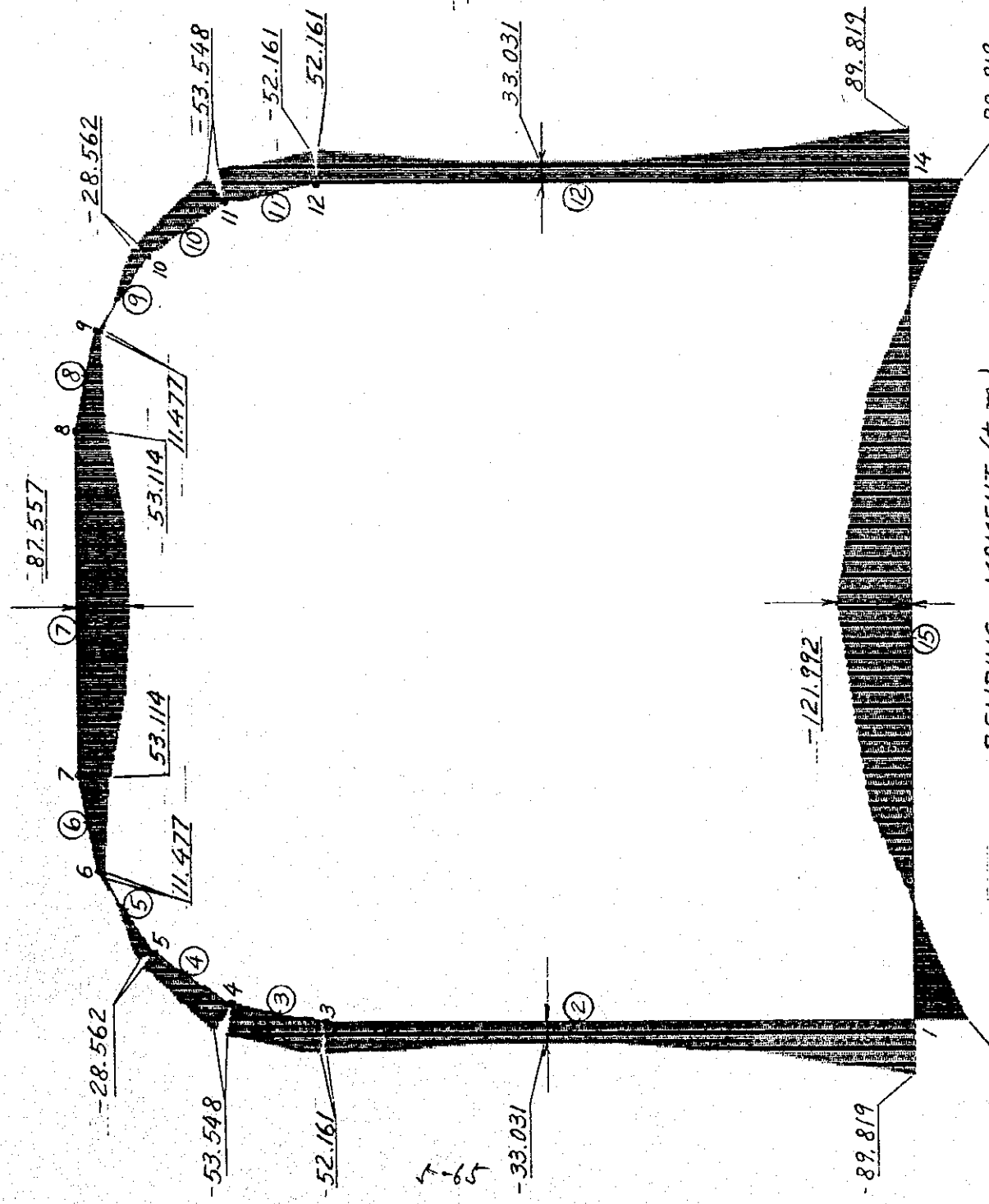
WL. 80.000

H = 19.5m



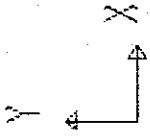
CONGUILLO INLET (TRANSITION)  
DAULE-PERIPA ~ LA ESPERANZA TUNNEL

|   |  |
|---|--|
|  | DAULEPE<br>FRAME M33<br>OUTPUT M33<br>LOAD 1 |
| CASE 2<br>DURING CONSTRUCTION   |  |
| MIN < 15<br>- .1220E+03<br>AT 2.24<br>MAX < 13<br>.8986E+02<br>AT .00             |  |



00 010

BEARING CAPACITY (4 m)



DAULEFE

FRAME

OUTPUT V22

LOAD 1

CASE 2

DURING CONSTRUCTION

MIN < 15>

- .1874E+03

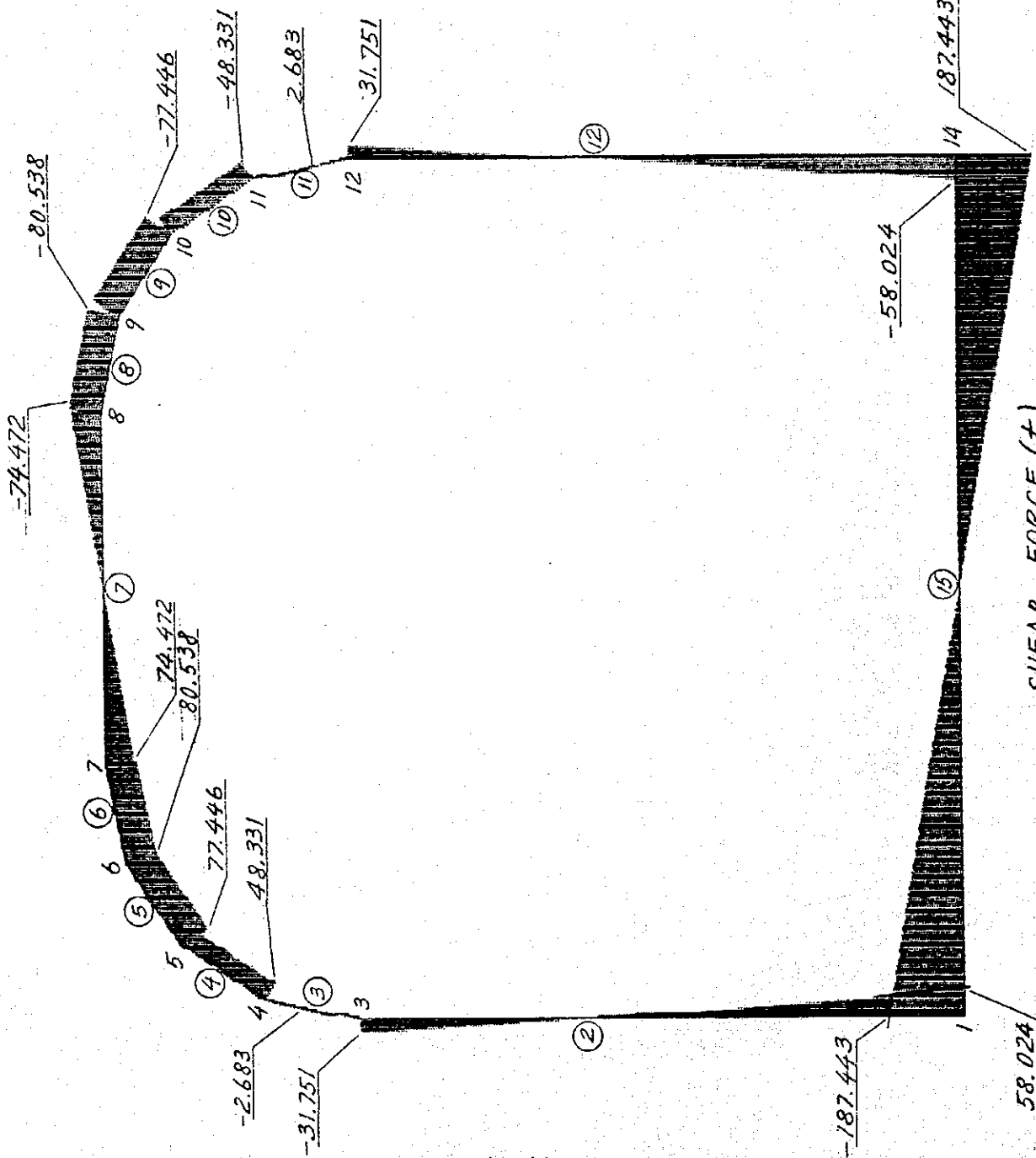
AT .00

MAX < 14>

.1875E+03

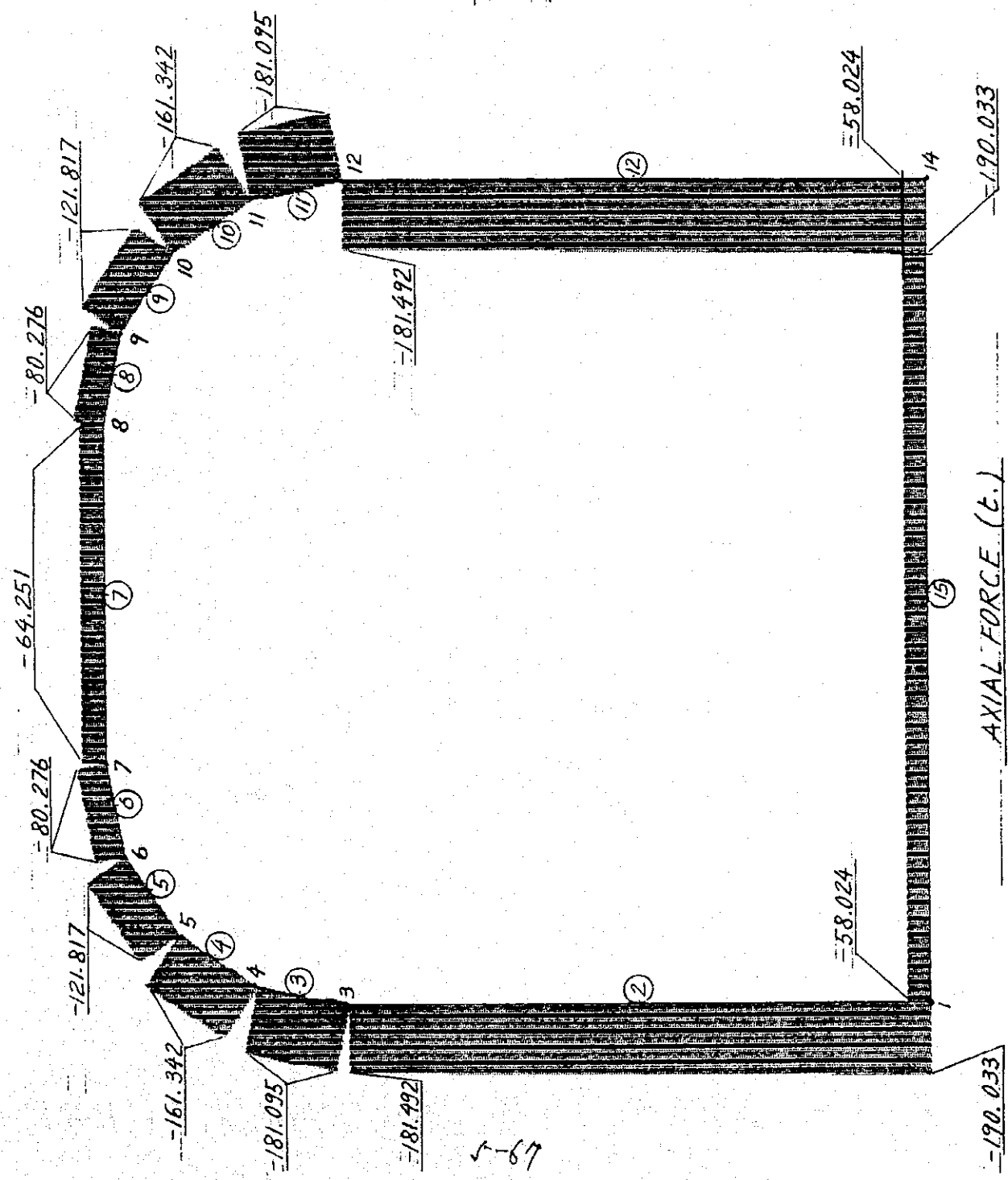
AT .00

SAP90

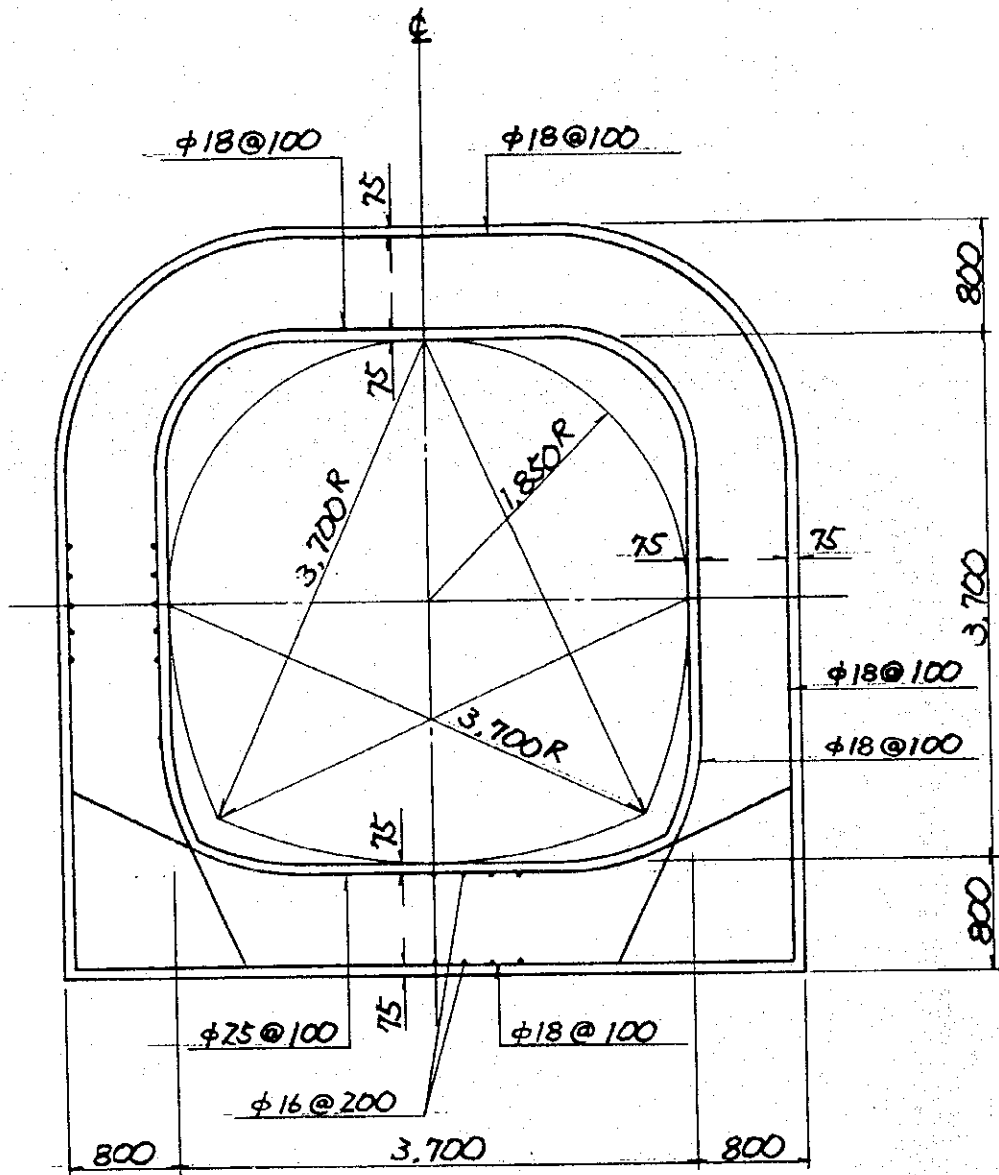


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|   |  |
|---|--|
|   | DAULEFE<br>FRAME<br>OUTPUT P<br>LOAD 1 |
| <u>CASE 2</u><br><u>DURING CONSTRUCTION</u>                               |  |
| MIN < 1 ><br>- .1901E+03<br>AT .00<br>MAX < 14 ><br>- .5805E+02<br>AT .00 |  |
| <b>SAP90</b>  |  |



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CONGUILLO INLET (TRANSITION)

DAULE - PERIPA ~ LA ESPERANZA TUNNEL

5-68

(2) Salida Membrillo

(A) Transición

Caso 1: Después de construcción

1) Peso muerto del revestimiento de hormigón

$$W_c = 0,5 \times 2,4 = 1,2 \text{ tf/m}$$

2) Presión vertical de la roca

$$P_r = 1,7 \times 5,3 = 9,01 \text{ tf/m}$$

3) Presión lateral de la roca y presión del agua

$$K_a = \tan^2(45 - 35/2) = 0,271$$

$$P_{rh1} = 0,271 \times 1,7 \times 5,3 = 2,442 \text{ tf/m}$$

$$P_{rh2} = 0,271 \times 1,7 \times 5,3 + 0,271 \times (1,7 - 1,0) \times 4,7 = 3,333 \text{ tf/m}$$

$$P_w = 1,0 \times 4,4 = 4,4 \text{ tf/m}$$

4) Subpresión

$$P_u = 1,0 \times 4,4 = 4,4 \text{ tf/m}$$

5) Reacción de la cimentación

$$P_f = (9,01 \times 4,7 + 20,079)/4,7 - 4,4 = 8,882 \text{ tf/m}$$

Caso 2 Durante la construcción

1) Peso muerto del revestimiento de hormigón

$$W_c = 0,5 \times 2,4 = 1,2 \text{ tf/m}$$

2) Presión vertical de la roca y presión de inyección de relleno

$$P_r = 1,7 \times 5,3 = 9,01 \text{ tf/m}$$

$$P_g = 15,0 \text{ tf/m}$$

3) Presión lateral de la roca

$$K_a = \tan^2(45 - 35/2) = 0,271$$

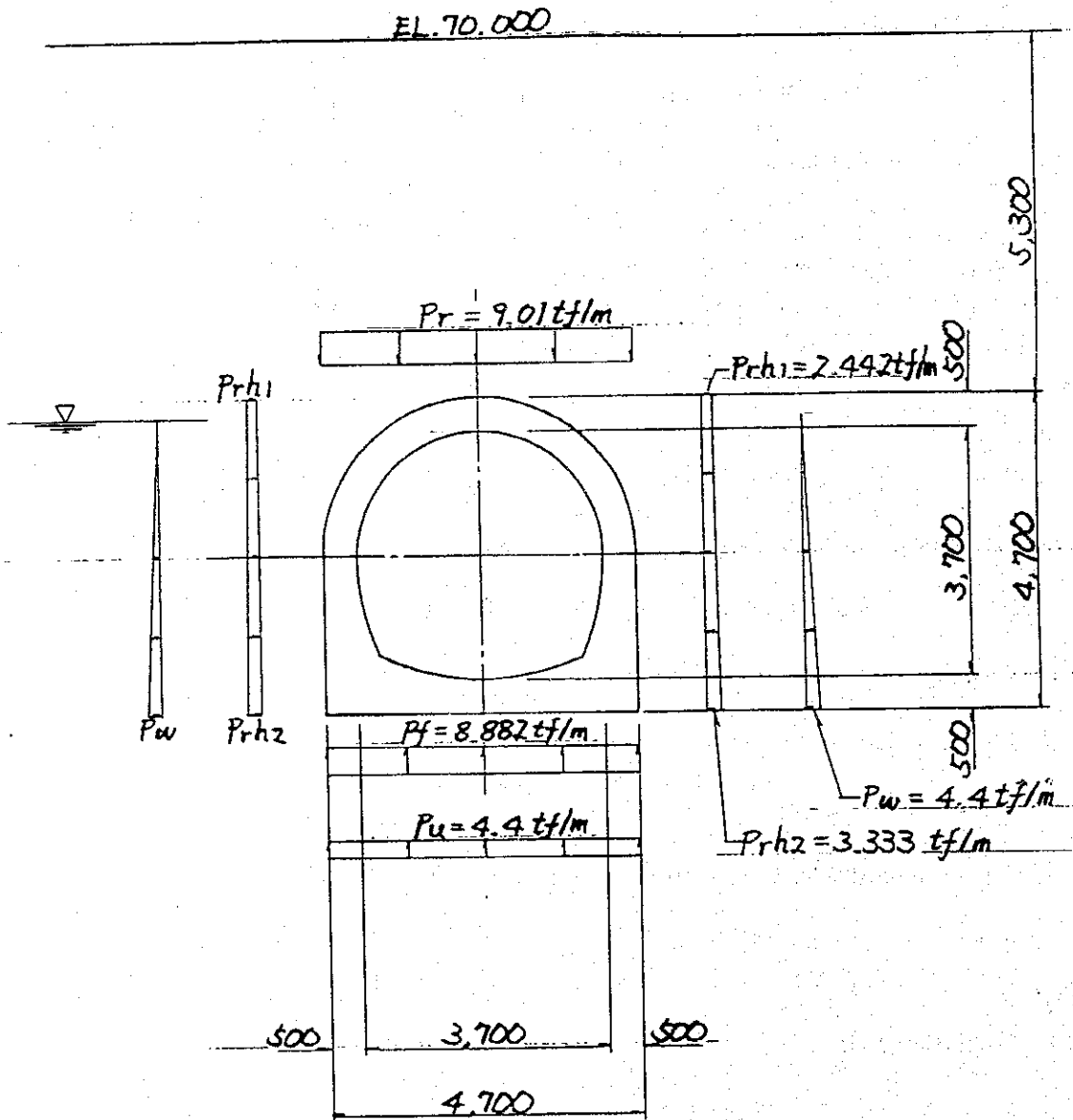
$$P_{rh1} = 0,271 \times 1,7 \times 5,3 = 2,442 \text{ tf/m}$$

$$P_{rh2} = 0,271 \times 1,7 \times 10,0 = 4,607 \text{ tf/m}$$

4) Reacción de la cimentación

$$P_f = (9,01 \times 4,7 + 15,0 \times 4,7 + 20,079)/4,7 = 28,282 \text{ tf/m}$$

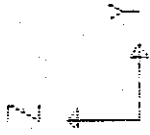
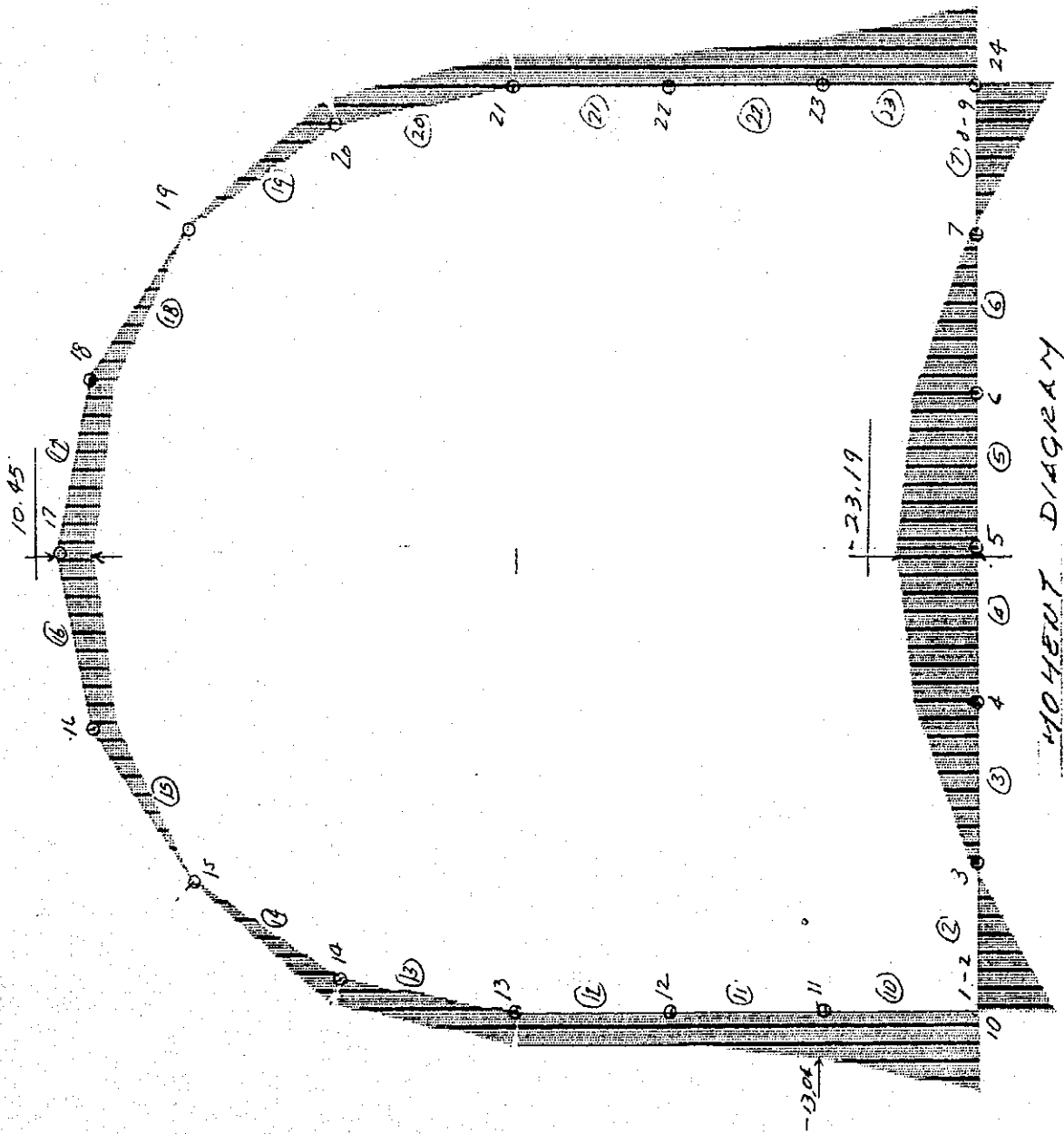
5-89



MEMBRILLO OUTLET (TRANSITION), CASE 1  
 DAULE-PERIPA ~ LA ESPERANZA TUNNEL



MEYBULLO OUTLET CASE 1



MEMBRUTE  
 FRAME M33  
 OUTPUT M33  
 LOAD 1

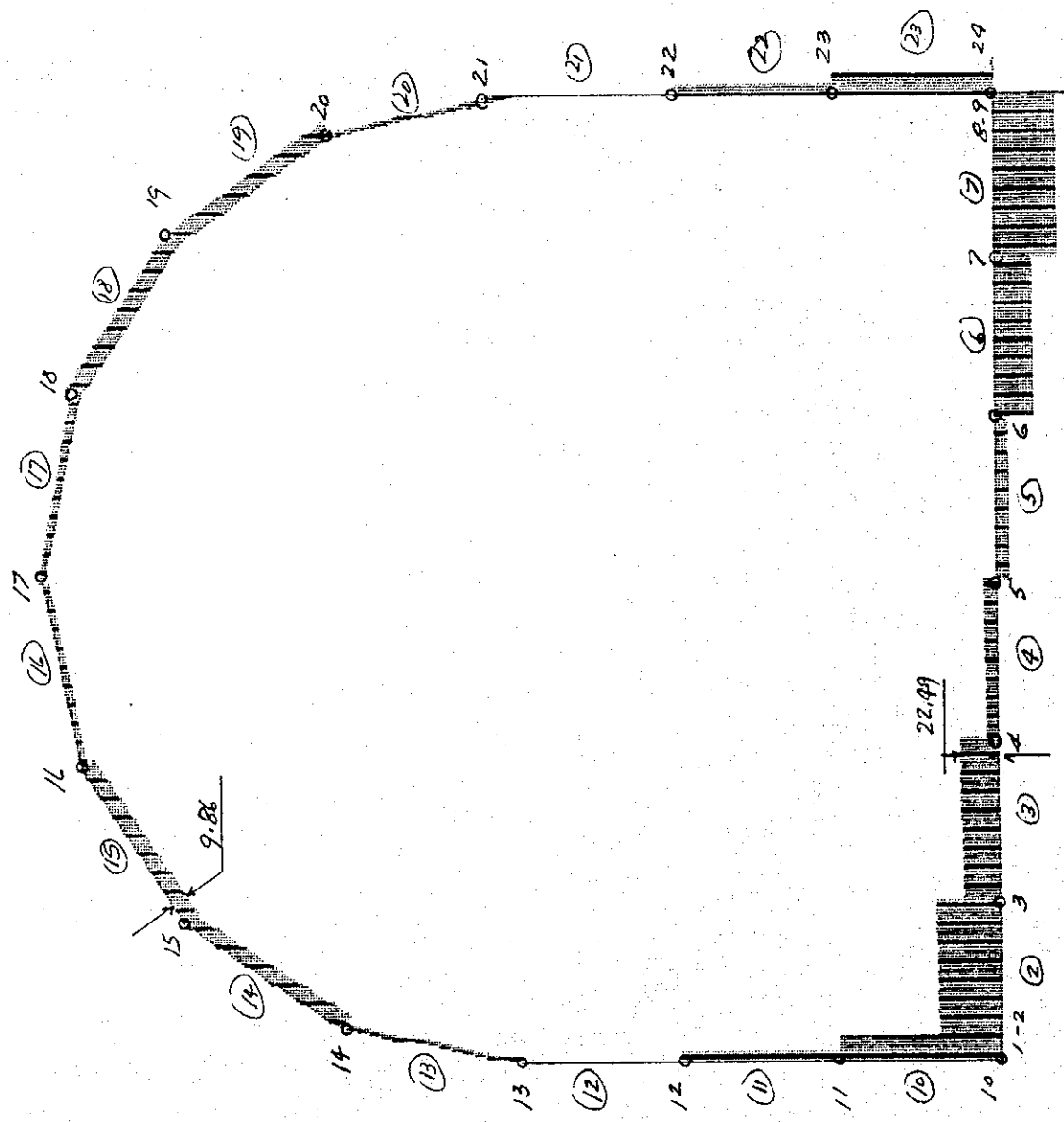
MIN < 48  
 -2319L+02  
 AT .70  
 MAX < 18  
 .2244L+02  
 AT .00

MEMBRUTE

5-71

|  |   |  |
|--|---|--|
|  | MEMBRUTE<br>FRAME    W22<br>OUTPUT    W22<br>LOAD       1 | MIN < -1<br>-4876E+02<br>AT .01<br>MAX < 8<br>4876E+02<br>AT .00 |
|--|---|--|

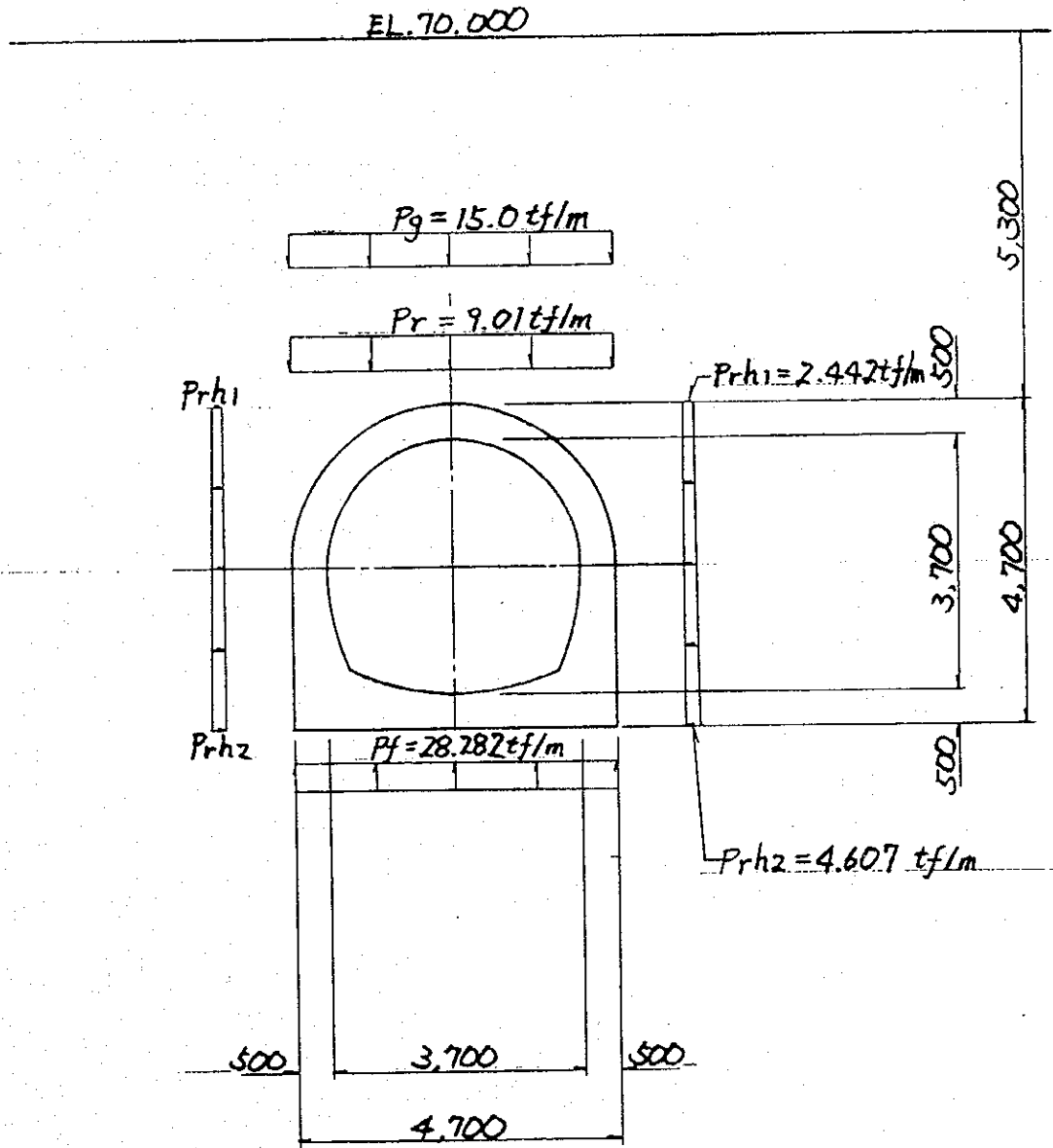
METOLLO OUTLET CASE 1



SHEAR DIAGRAM

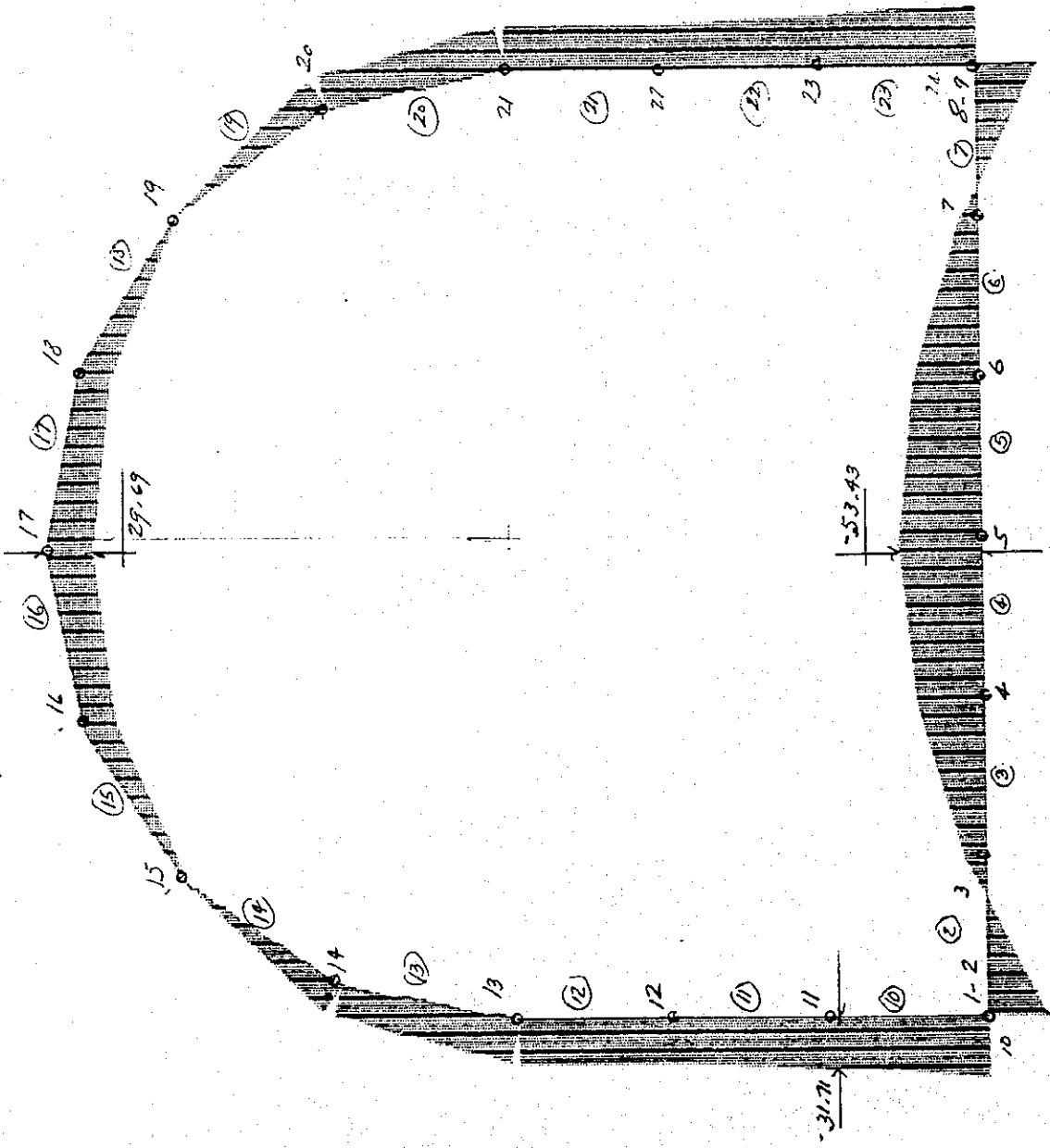
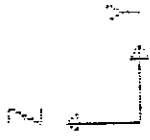
5-72

SAP90



MEMBRILLO OUTLET (TRANSITION), CAS  
 DAULE - PERIPA ~ LA ESPERANZA TUNNEL  
 5-73

MEYBULLO OUTLET CASE 2



MOMENT DIAGRAM

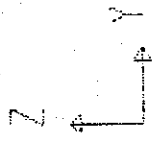
MEMBR012  
 FRAME  
 OUTPUT M33  
 LOAD 1

MIN < 43  
 -53481E+02  
 AT .70  
 MAX < 13  
 38741E+02  
 AT .00

SAP90

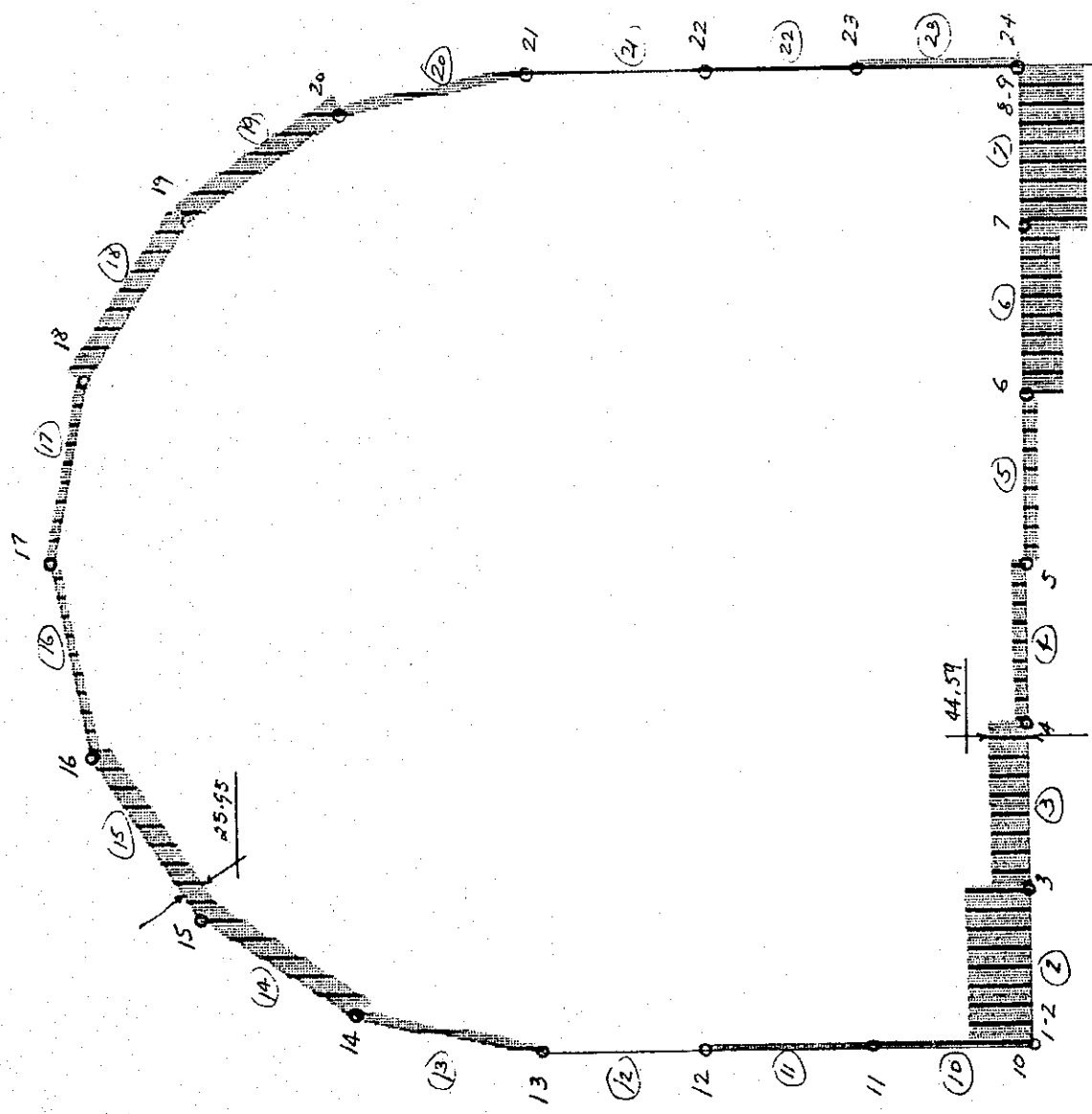
5-74

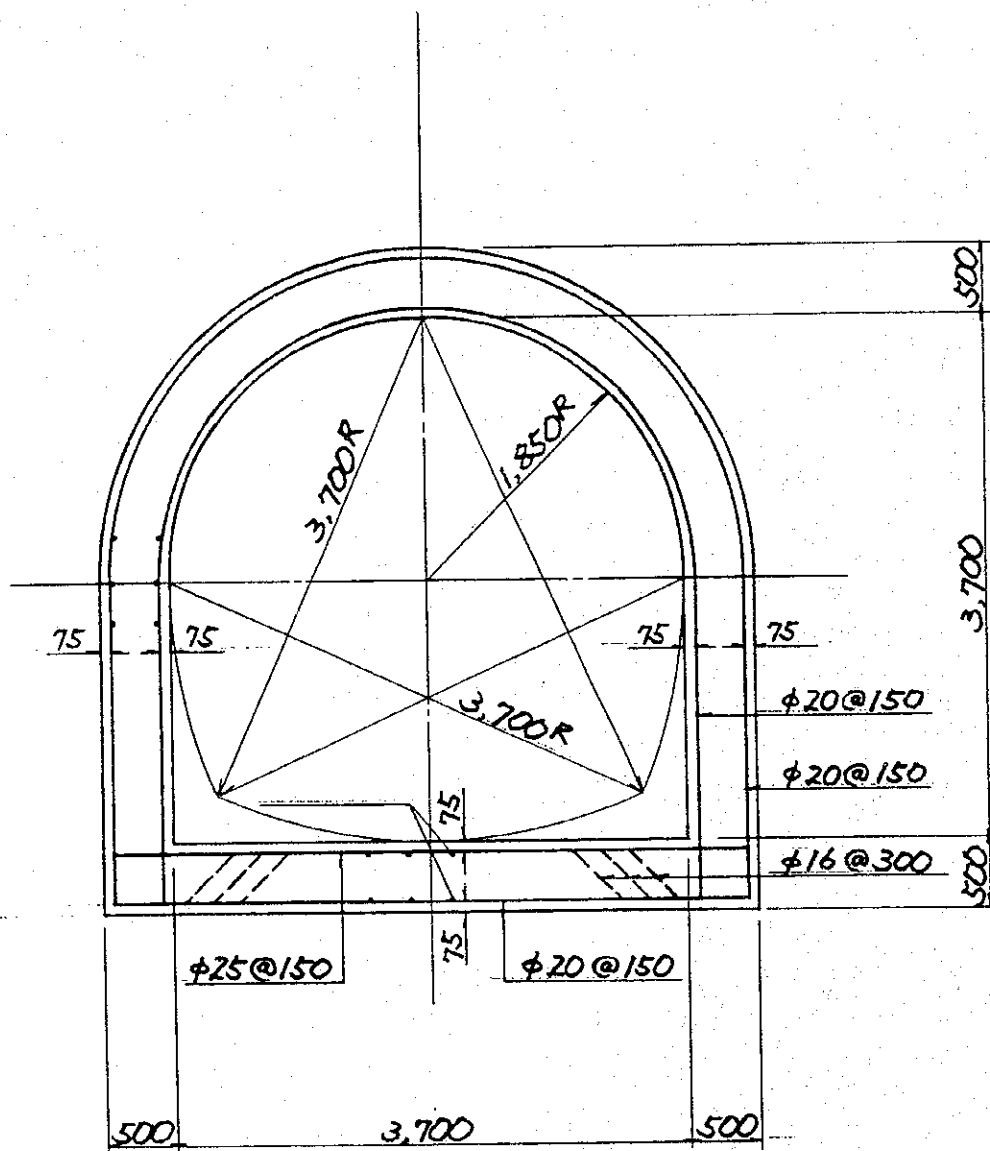
MEYRILL OUTLET CASE 2



MEMBRU2  
 FRAME V22  
 OUTPUT V22  
 LOAD 1

MIN < 1  
 - .9822E+02  
 AT  
 MAX < 83  
 .9822E+02  
 AT .00





MEMBRILLO OUTLET (TRANSITION)  
 DAULE-PERIPA ~ LA ESPERANZA TUNNEL  
 5-76

(3) Entrada Caña Dulce

(A) Estructura de Cajón

Caso 1: Condición Normal

1) Peso muerto de la estructura de cajón

$$W_{c1} = 0,50 \times 2,4 = 1,20 \text{ tf/m}$$

$$W_{c2} = 0,50 \times 2,4 = 1,20 \text{ tf/m}$$

$$W_{c3} = 0,55 \times 2,4 = 1,32 \text{ tf/m}$$

2) Presión vertical de la tierra y presión del agua

$$P_e = 1,8 \times 3,0 + (2,0 - 1,0) \times 3,65 = 9,05 \text{ tf/m}$$

$$P_w = 1,0 \times 3,65 = 3,65 \text{ tf/m}$$

3) Presión lateral de la tierra y presión del agua

$$P_{eh1} = 0,5 \times 1,8 \times 3,0 + 0,5 \times (2,0 - 1,0) \times 3,65 = 4,525 \text{ tf/m}$$

$$P_{eh2} = 0,5 \times 1,8 \times 3,0 + 0,5 \times (2,0 - 1,0) \times 8,2 = 6,80 \text{ tf/m}$$

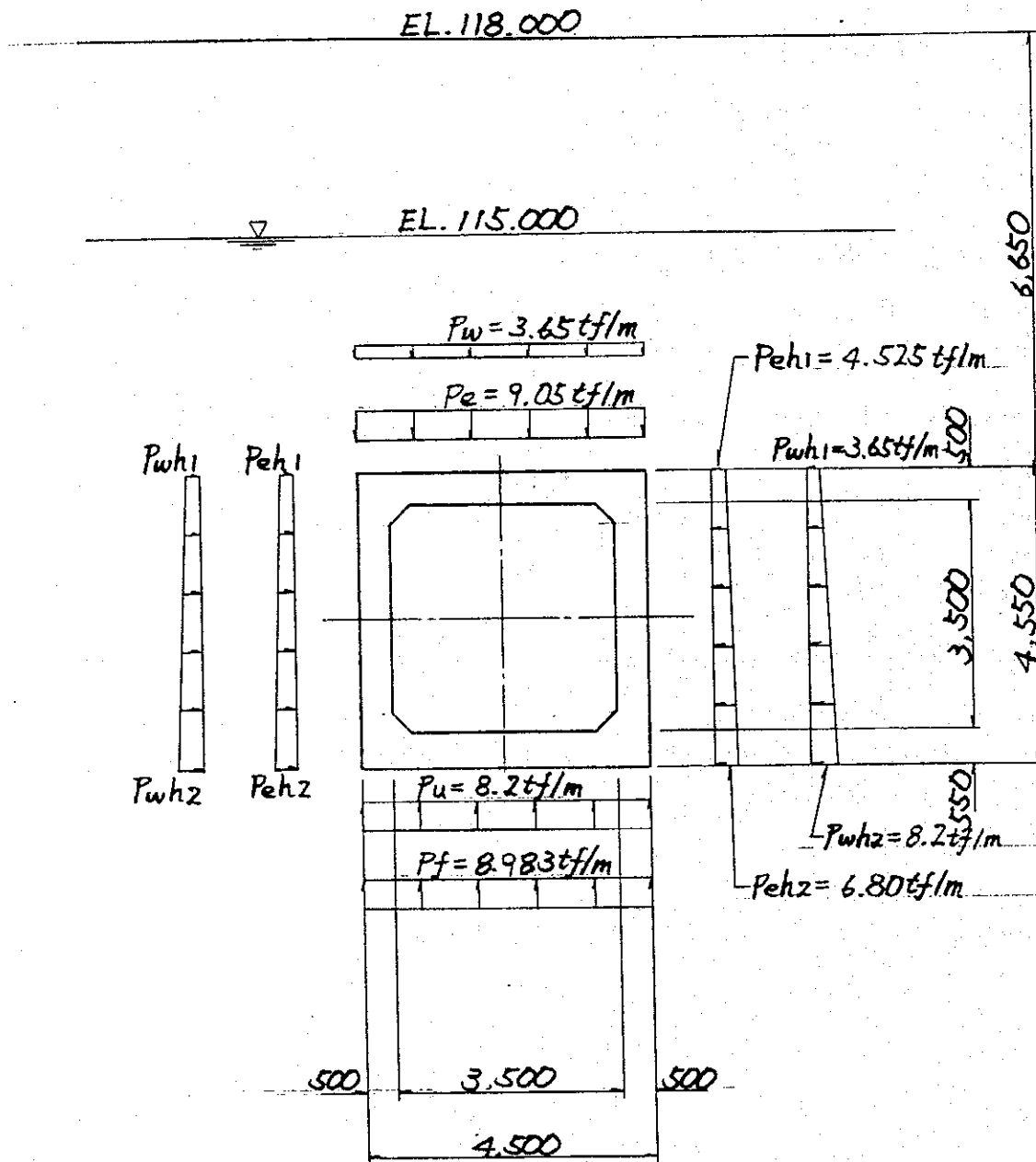
$$P_{w1} = 1,0 \times 3,65 = 3,65 \text{ tf/m}$$

$$P_{w2} = 1,0 \times 8,2 = 8,2 \text{ tf/m}$$

4) Subpresión y reacción de la cimentación

$$P_u = 1,0 \times 8,20 = 8,20 \text{ tf/m}$$

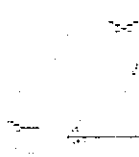
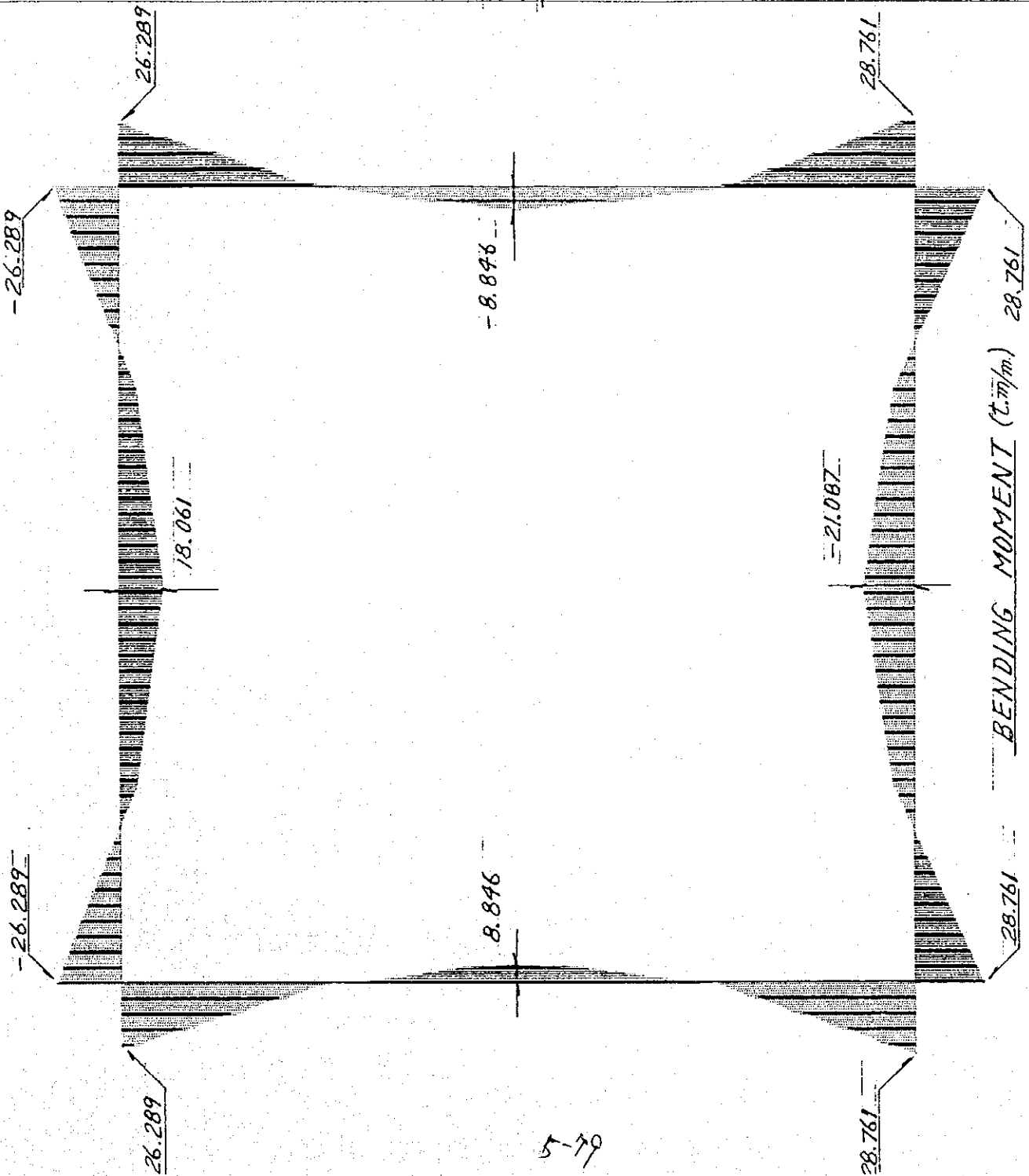
$$P_f = (9,05 \times 4,5 + 3,65 \times 4,5 + (4,55 \times 4,5 - 3,5 \times 3,5 + 0,3 \times 0,3 \times 2) \times 2,4) / 4,5 - 8,20 \\ = 8,983 \text{ tf/m}$$



CANA DULCE INLET CULVERT

5-78





EMULTEC

FRAME

OUTPUT MS3

LOAD 1

CASE 1

NORMAL CONDITION

MIN < 1

-28.761

AT .60

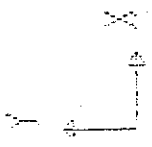
MAX < 1

28.761

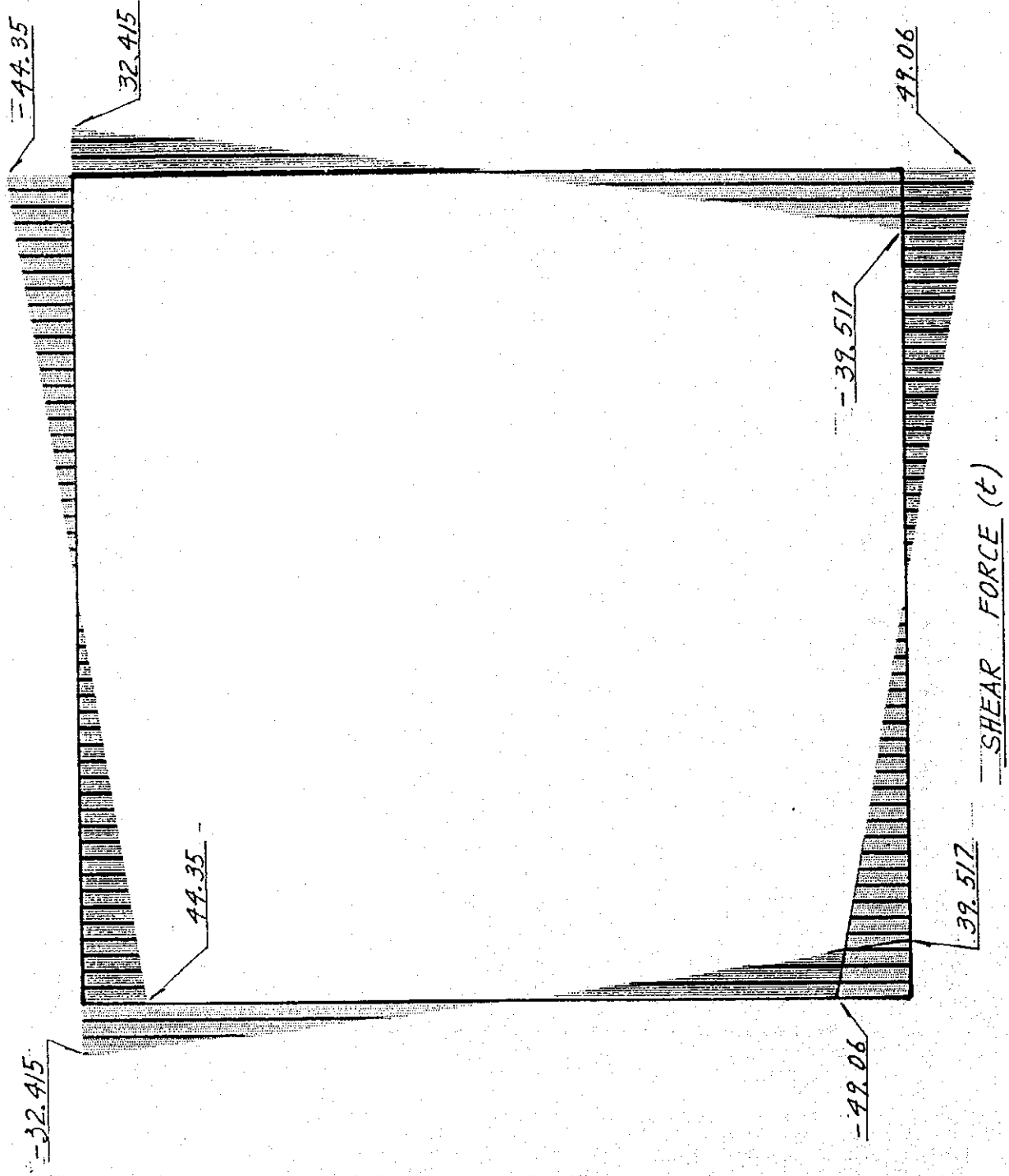
AT .60

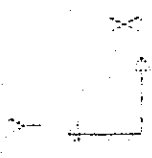
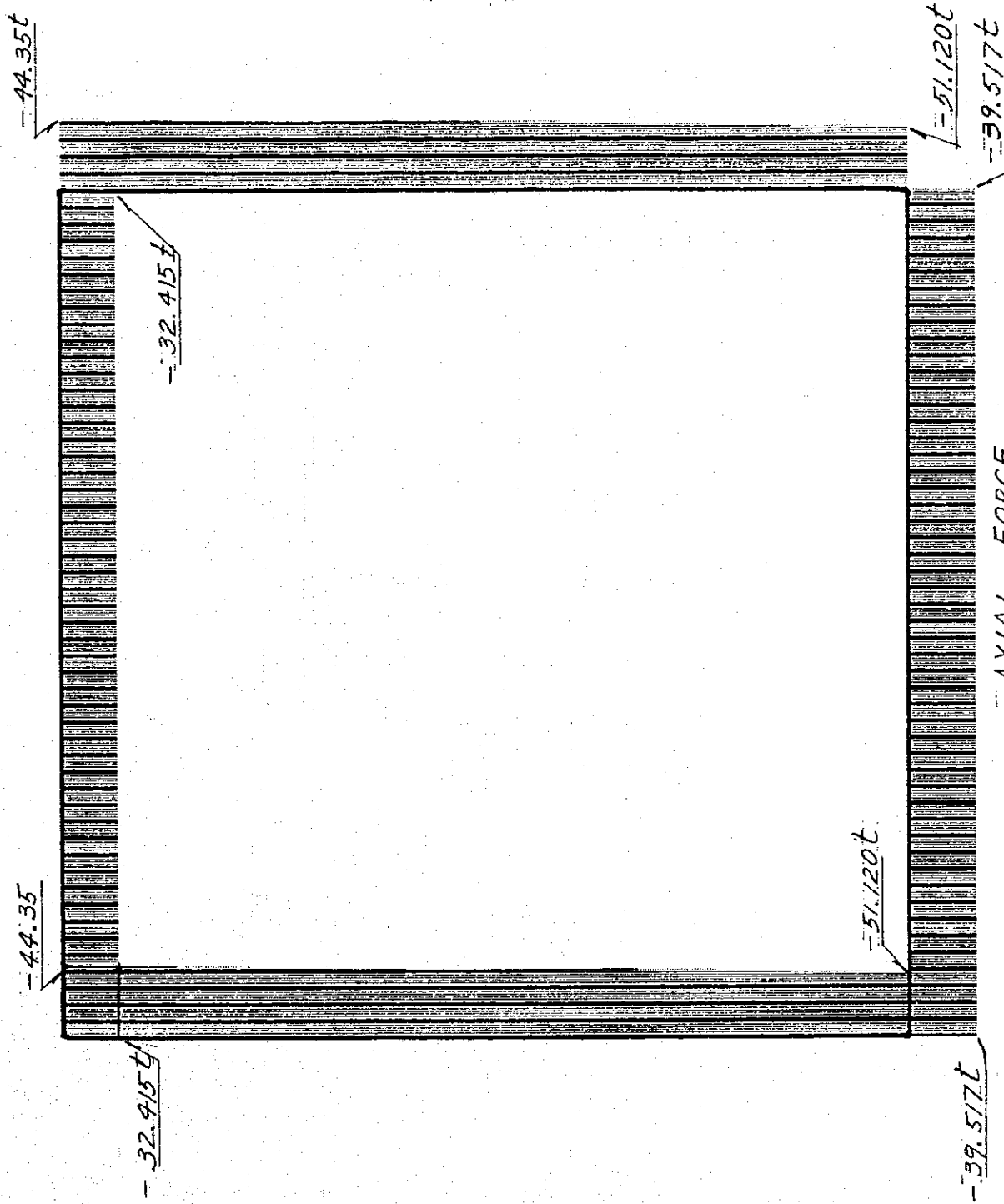
MS3

5-79

|   |  |
|---|--|
|  | INLET/DIC<br>FRAME<br>OUTPUT V22<br>LOAD 1 |
| <u>CASE 1</u>   |  |
| <u>NORMAL CONDITION</u>   |  |
| MIN   | 49.06                                      |
| AT  | .00  |
| MAX   | 49.06                                      |
| AT  | .00  |

SAP90





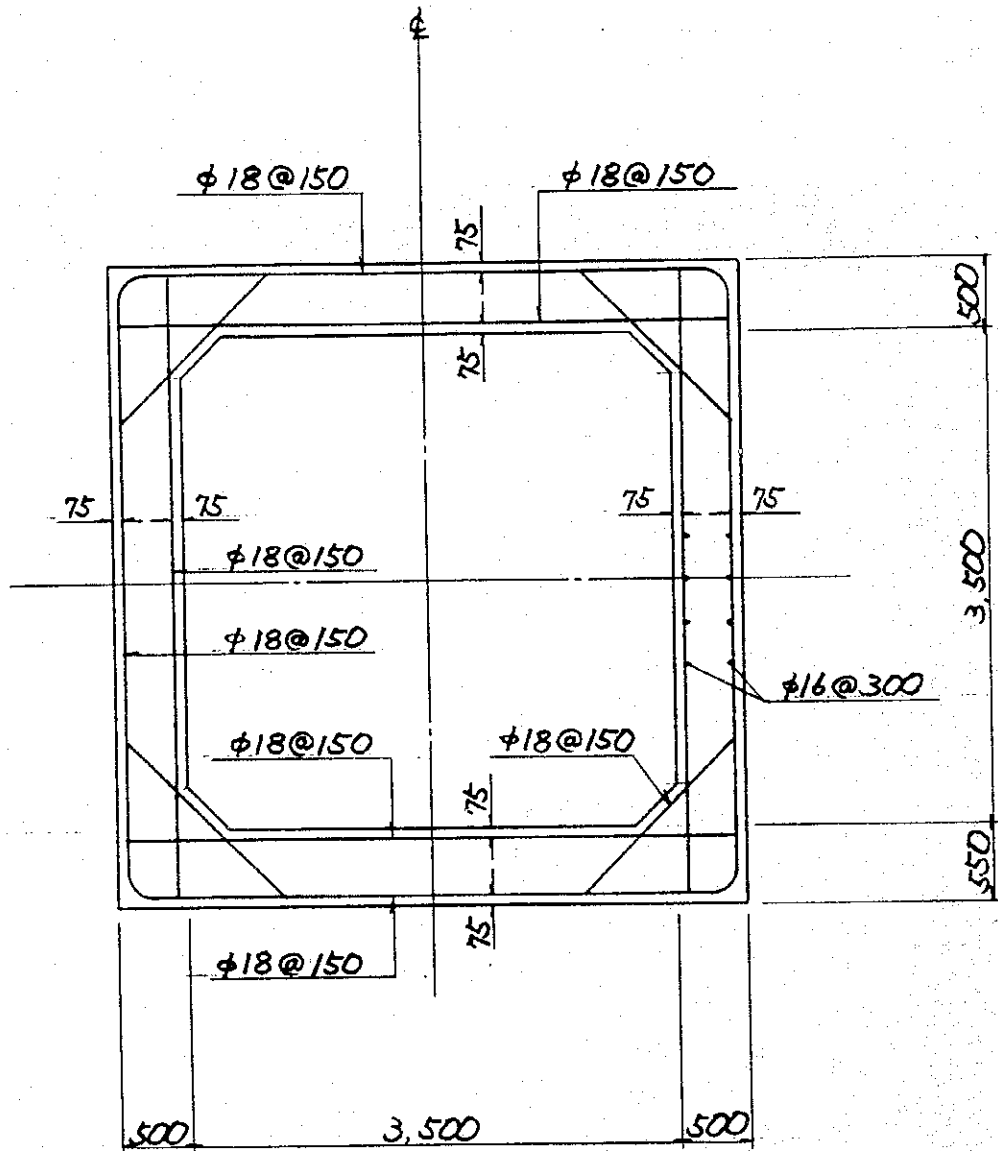
INLET  
 FRAME  
 OUTLET P  
 LOAD I

CASE 1

NORMAL CONDITION

MIN < 28  
 TEMPERATURE  
 AT .00  
 MAX < 28  
 AMBIENTURE  
 AT 4.00

SCALE



Note:

$\phi 18$  means diameter of deformed bar.

CANA DULCE INLET CULVERT

5-02

## Entrada del Túnel Caña Dulce

### (B) Entrada del Túnel

Caso 1: Después de construcción

- 1) Peso muerto del revestimiento de hormigón

$$W_c = 0,5 \times 2,4 = 1,2 \text{ tf/m}$$

- 2) Presión vertical de la roca y presión del agua

$$P_r = 2,0 \times 6,3 + (2,0 - 1,0) \times 3,7 = 16,3 \text{ tf/m}$$

$$P_w = 1,0 \times (\text{El. } 115,0 - \text{El. } 111,3) = 3,7 \text{ tf/m}$$

- 3) Presión lateral de la roca y presión del agua

$$K_a = \tan^2(45 - 40/2) = 0,217$$

$$P_{rh_1} = 0,217 \times 2,0 \times 6,3 + 0,217 \times (2,0 - 1,0) \times 3,7 = 3,537 \text{ tf/m}$$

$$P_{rh_2} = 0,217 \times 2,0 \times 6,3 + 0,217 \times (2,0 - 1,0) \times 8,2 = 4,514 \text{ tf/m}$$

$$P_{wh_1} = 1,0 \times 3,7 = 3,7 \text{ tf/m}$$

$$P_{wh_2} = 1,0 \times 8,2 = 8,2 \text{ tf/m}$$

- 4) Subpresión y reacción de la cimentación

$$P_u = 1,0 \times 8,2 = 8,2 \text{ tf/m}$$

$$P_f = (3,7 \times 4,5 + (4,5 \times 2,25 - 3,14 \times 4,5 \times 4,5 / 8) + 16,3 \times 4,5 + 19,003) / 4,5 - 8,2 = 16,506 \text{ tf/m}$$

Caso 2 Durante la construcción

- 1) Peso muerto del revestimiento de hormigón

$$W_c = 0,5 \times 2,4 = 1,20 \text{ tf/m}$$

- 2) Presión vertical de la roca y presión de inyección de relleno

$$P_r = 2,0 \times 10,0 = 20,0 \text{ tf/m}$$

$$P_g = 15,0 \text{ tf/m}$$

- 3) Presión lateral de la roca y presión del agua

$$K_a = \tan^2(45 - 40/2) = 0,217$$

$$P_{rh_1} = 0,217 \times 2,0 \times 10,0 = 4,34 \text{ tf/m}$$

$$P_{rh_2} = 0,217 \times 2,0 \times 12,25 + 0,217 \times (2,0 - 1,0) \times 2,25 = 5,805 \text{ tf/m}$$

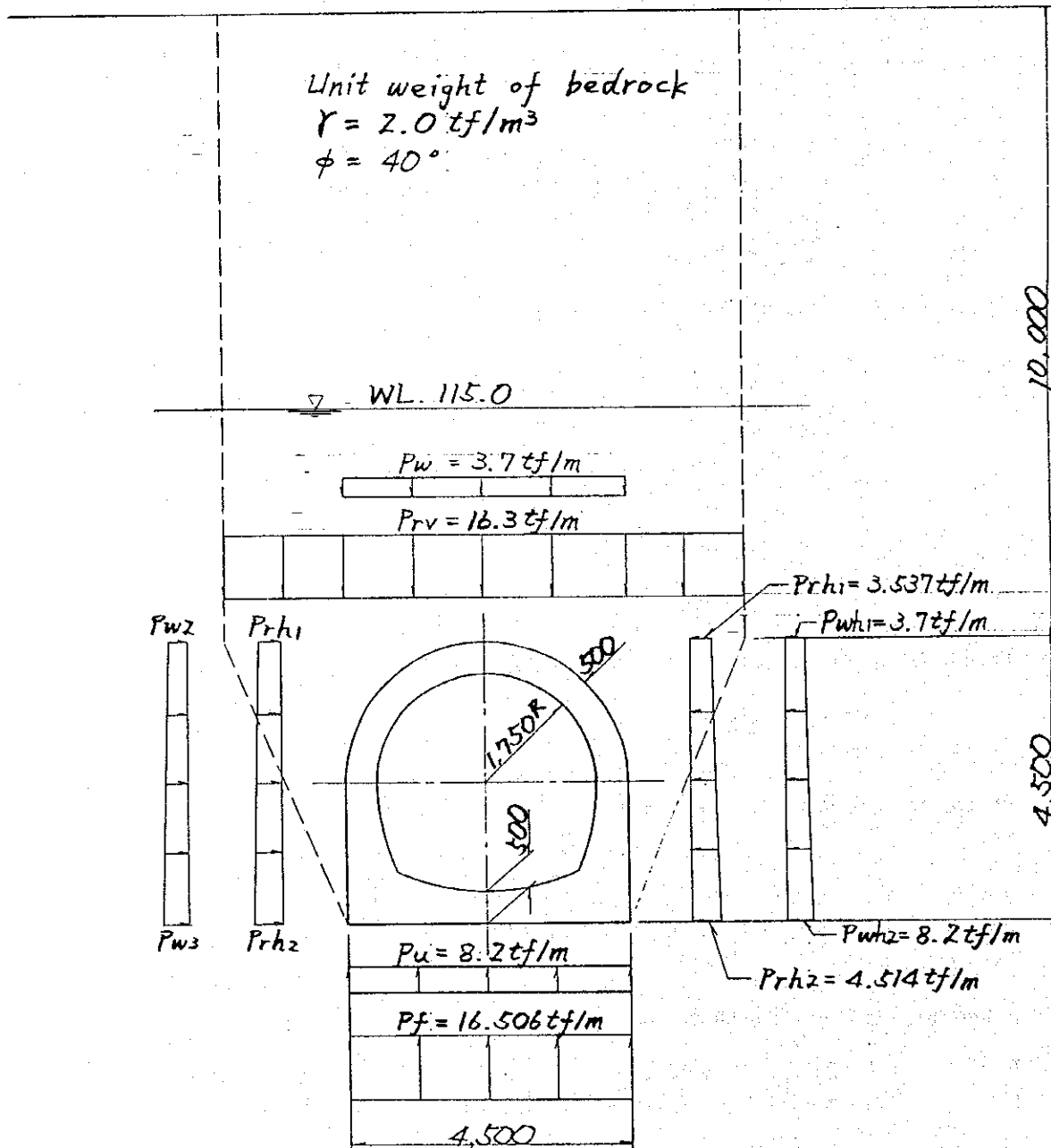
$$P_w = 1,0 \times 2,25 = 2,25 \text{ tf/m}$$

- 4) Subpresión y reacción de la cimentación

$$P_u = 1,0 \times 2,25 = 2,25 \text{ tf/m}$$

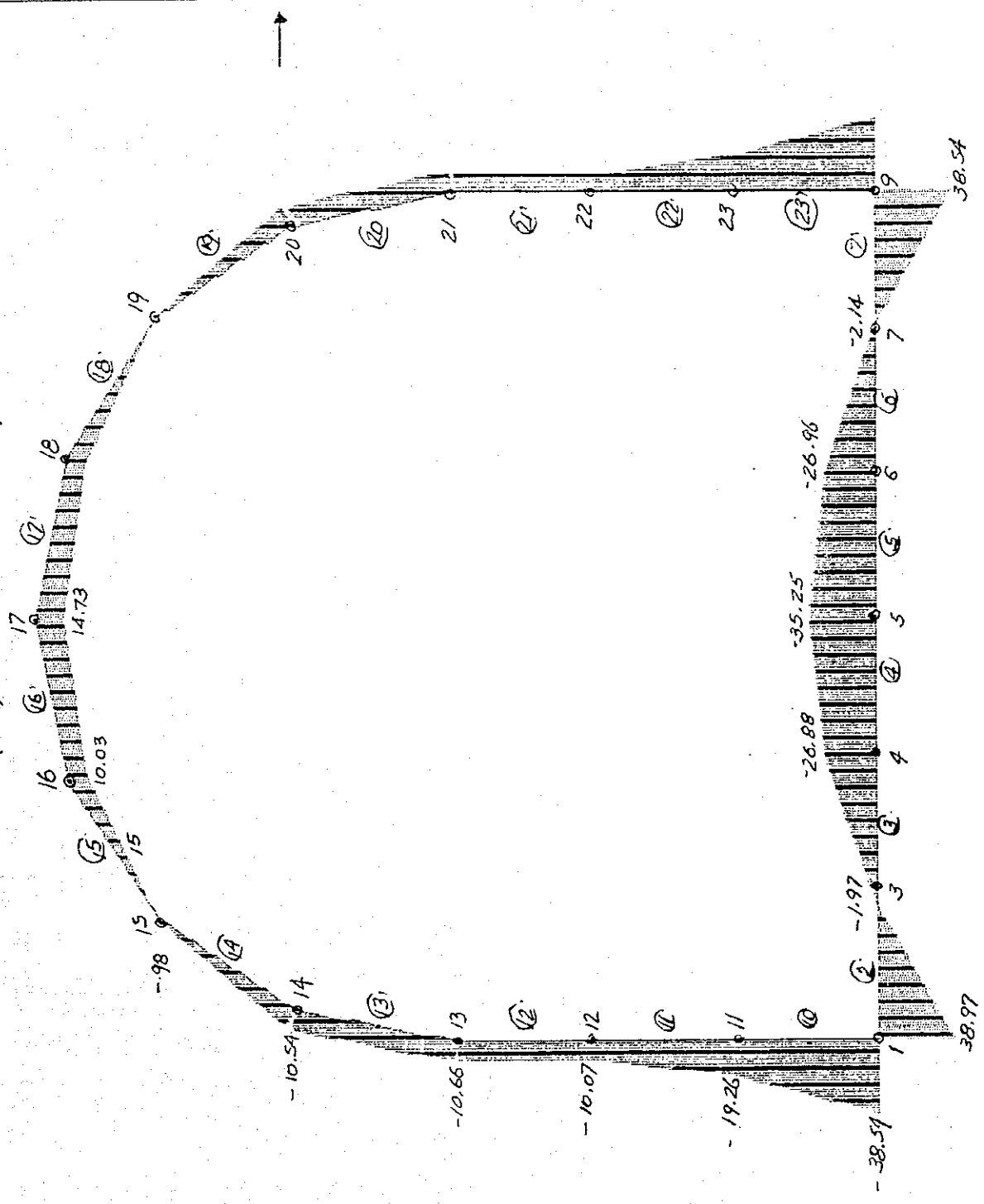
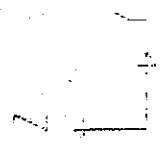
$$P_f = (20,0 \times 4,5 + 15,0 \times 4,5 + 19,003) / 4,5 - 2,25 = 36,973 \text{ tf/m}$$

5-23



CANA DULCE INLET, CASE 1  
 LA ESPERANZA ~ POZA HONDA TUNNEL

CAÑA DULCE INLET CAS. 1  
(MOMENT DIAGRAM)



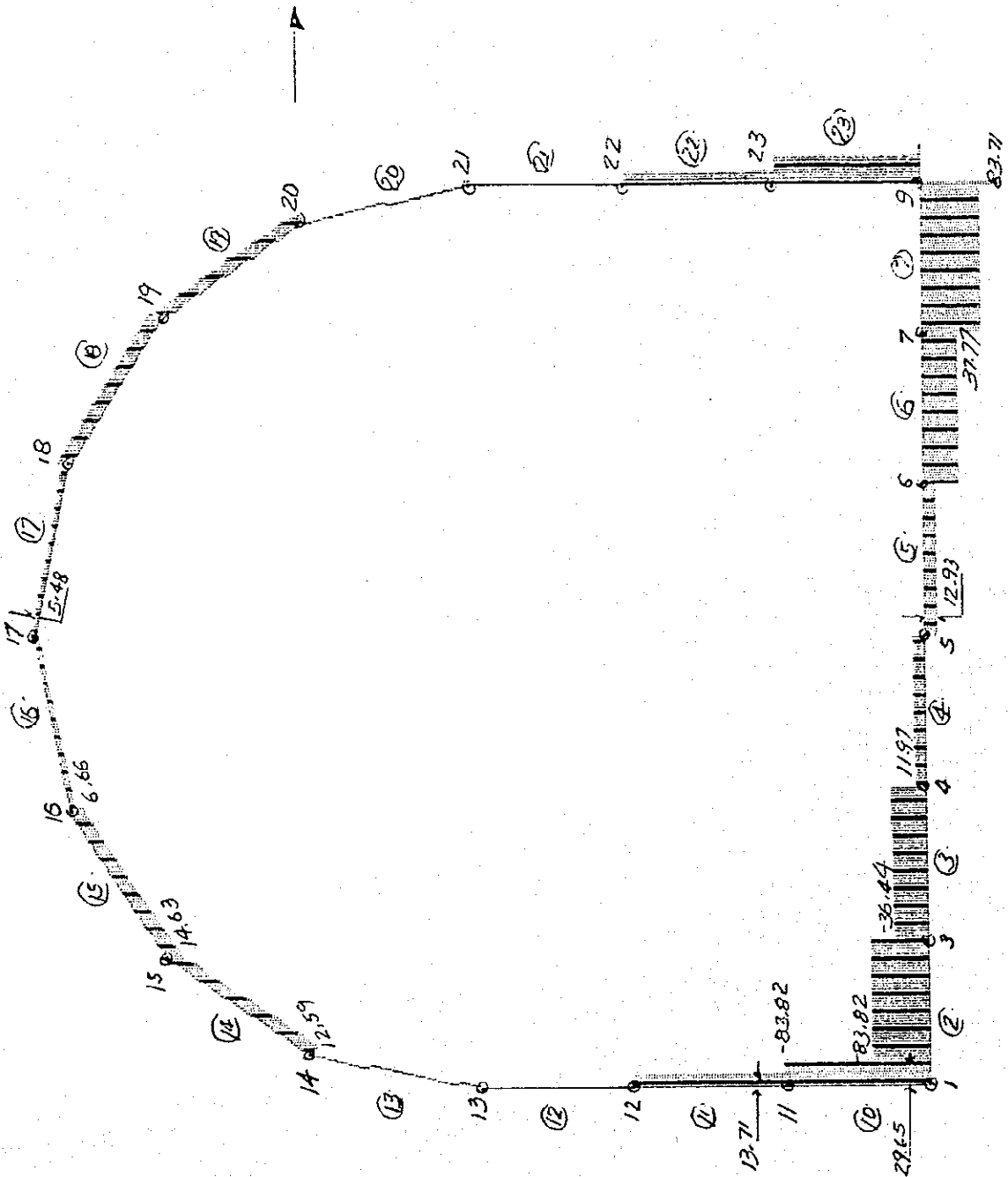
CHAIN  
FRAME  
OUTPUT HRS  
LOAD I

MIN  
MAX  
MIN  
MAX

GA191

57-27

CANA DULCE INLET CAS. 1  
— ( SHEAR DIAGRAM )



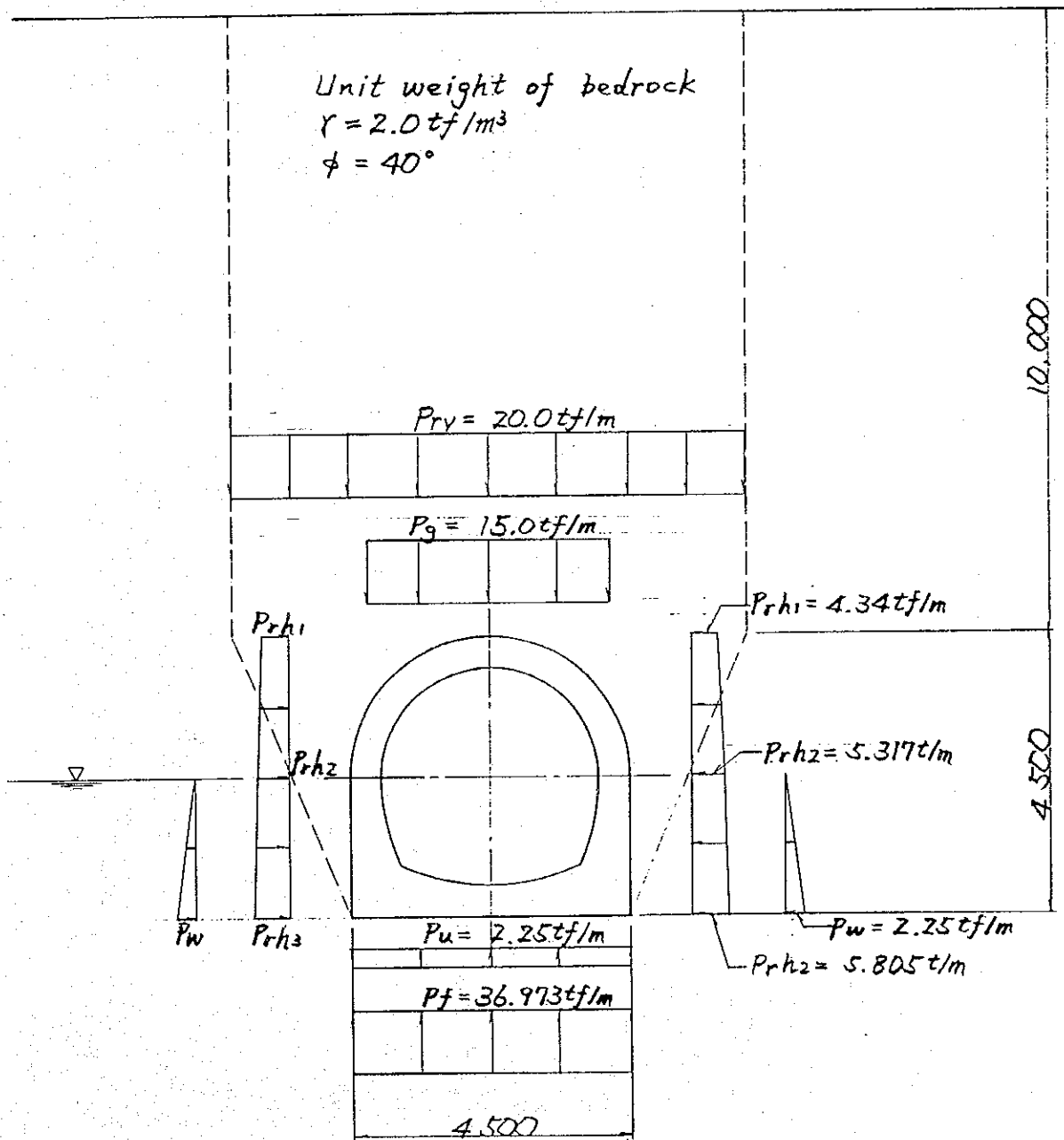
CASIN  
 FRAME  
 OUTPUT VEC  
 LOAD

MIN  
 AT  
 MAX  
 AT

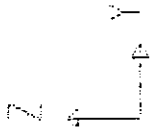
-83.711102  
 .10  
 .83741102  
 .01

541190





CANA DULCE INLET, CASE 2  
 LA ESPERANZA ~ POZA HONDA TUNNEL



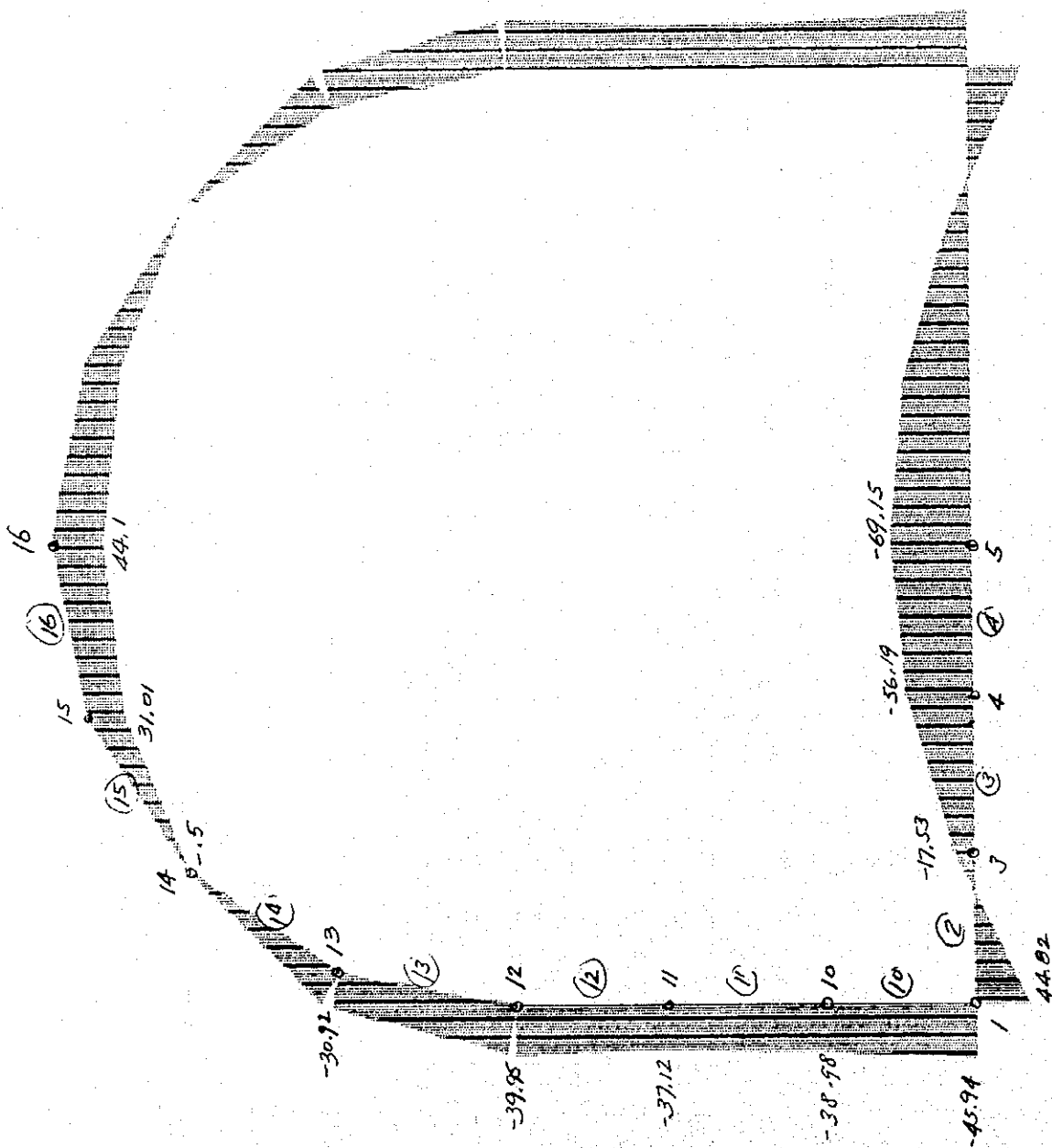
CA AINE  
 FRAME IN33  
 OUTPUT IN33  
 LOAD 1

MIN < 4  
 AT -.62151+02  
 MAX < 13  
 AT .46121+02

SAP90

CAÑA DULCE 14 LET

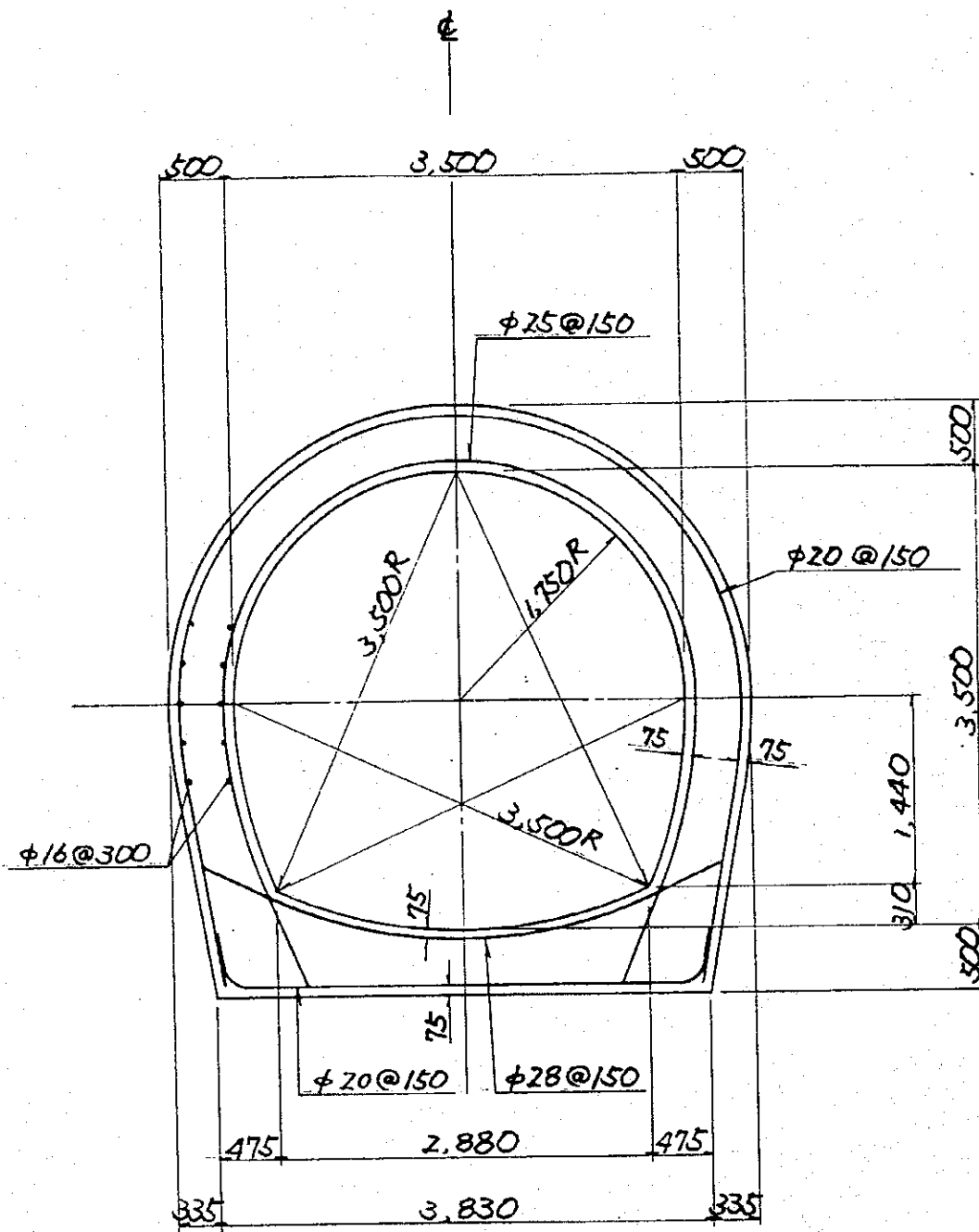
CASE 2



MOMENT DIAGRAM

88-5





CANA DULCE INLET

LA ESPERANZA - POZA HONDA TUNNEL

5-90

(4) Salida Los Cuyuyes

Caso 1: Después de la construcción

- 1) Peso muerto del revestimiento de hormigón

$$W_c = 0,5 \times 2,4 = 1,20 \text{ tf/m}$$

- 2) Presión vertical de la tierra

$$P_e = 1,8 \times 11,0 = 19,8 \text{ tf/m}$$

- 3) Presión lateral de la roca y presión del agua

$$K_a = \tan^2(45 - 35/2) = 0,271$$

$$Pr_{h1} = 0,271 \times 1,8 \times 11,0 = 5,366 \text{ tf/m}$$

$$Pr_{h2} = 0,271 \times 1,8 \times 11,0 + 0,271 \times (1,8 - 1,0) \times 4,5 = 6,341 \text{ tf/m}$$

$$P_w = 1,0 \times 4,2 = 4,2 \text{ tf/m}$$

- 4) Subpresión y reacción de la cimentación

$$P_u = 1,0 \times 4,2 = 4,2 \text{ tf/m}$$

$$P_f = (19,8 \times 4,5 + 19,003) / 4,5 - 4,2 = 19,823 \text{ tf/m}$$

Case 2: Durante la construcción

- 1) Peso muerto del revestimiento de hormigón

$$W_c = 0,5 \times 2,4 = 1,2 \text{ tf/m}$$

- 2) Presión vertical de la roca y presión de la inyección de relleno

$$P_r = 1,8 \times 11,0 = 19,8 \text{ tf/m}$$

$$P_g = 15,0 \text{ tf/m}$$

- 3) Presión lateral de la roca

$$K_a = \tan^2(45 - 35/2) = 0,271$$

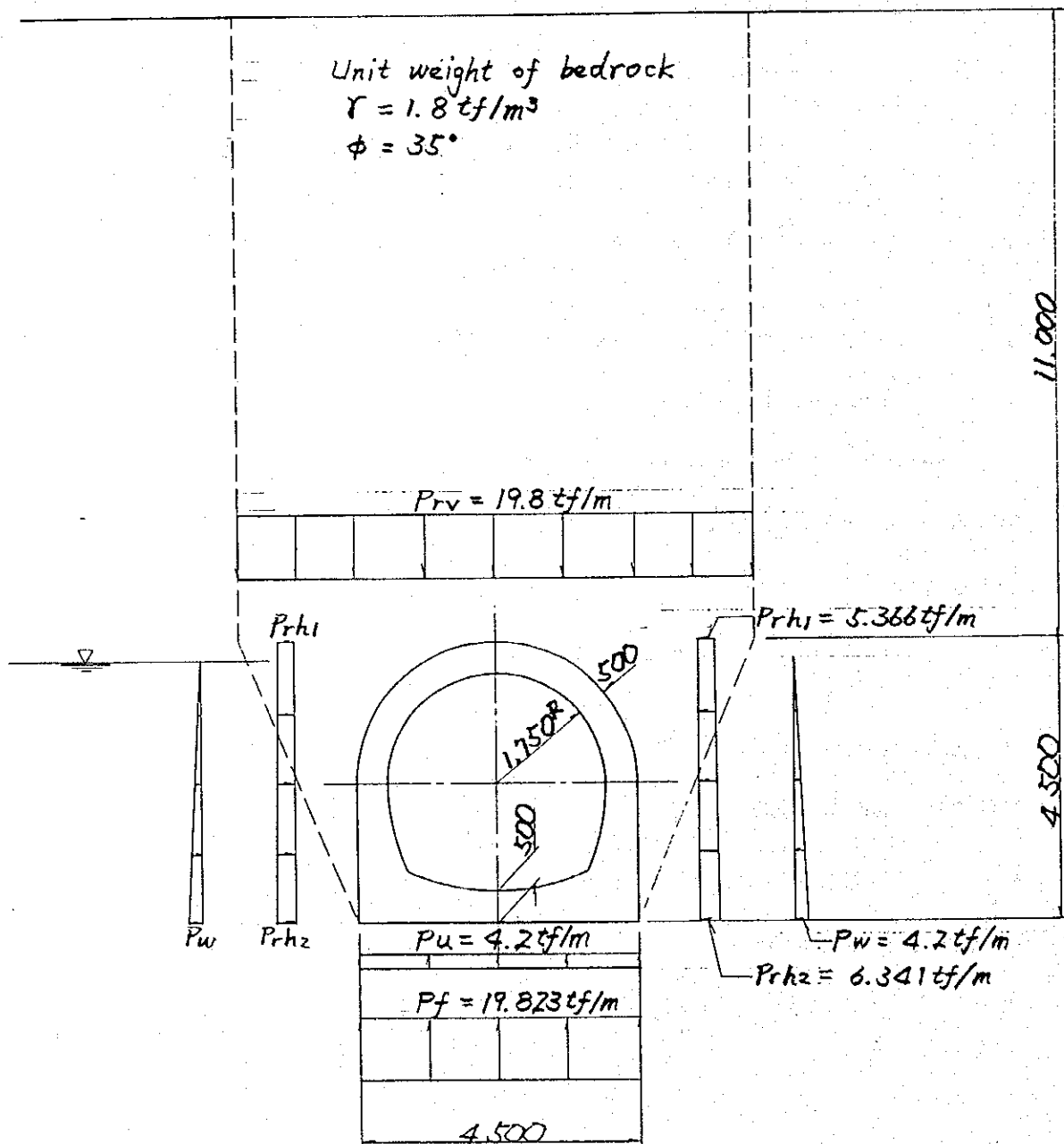
$$Pr_{h1} = 0,271 \times 1,8 \times 11,0 = 5,366 \text{ tf/m}$$

$$Pr_{h2} = 0,271 \times 1,8 \times 15,5 = 7,561 \text{ tf/m}$$

- 4) Reacción de la cimentación

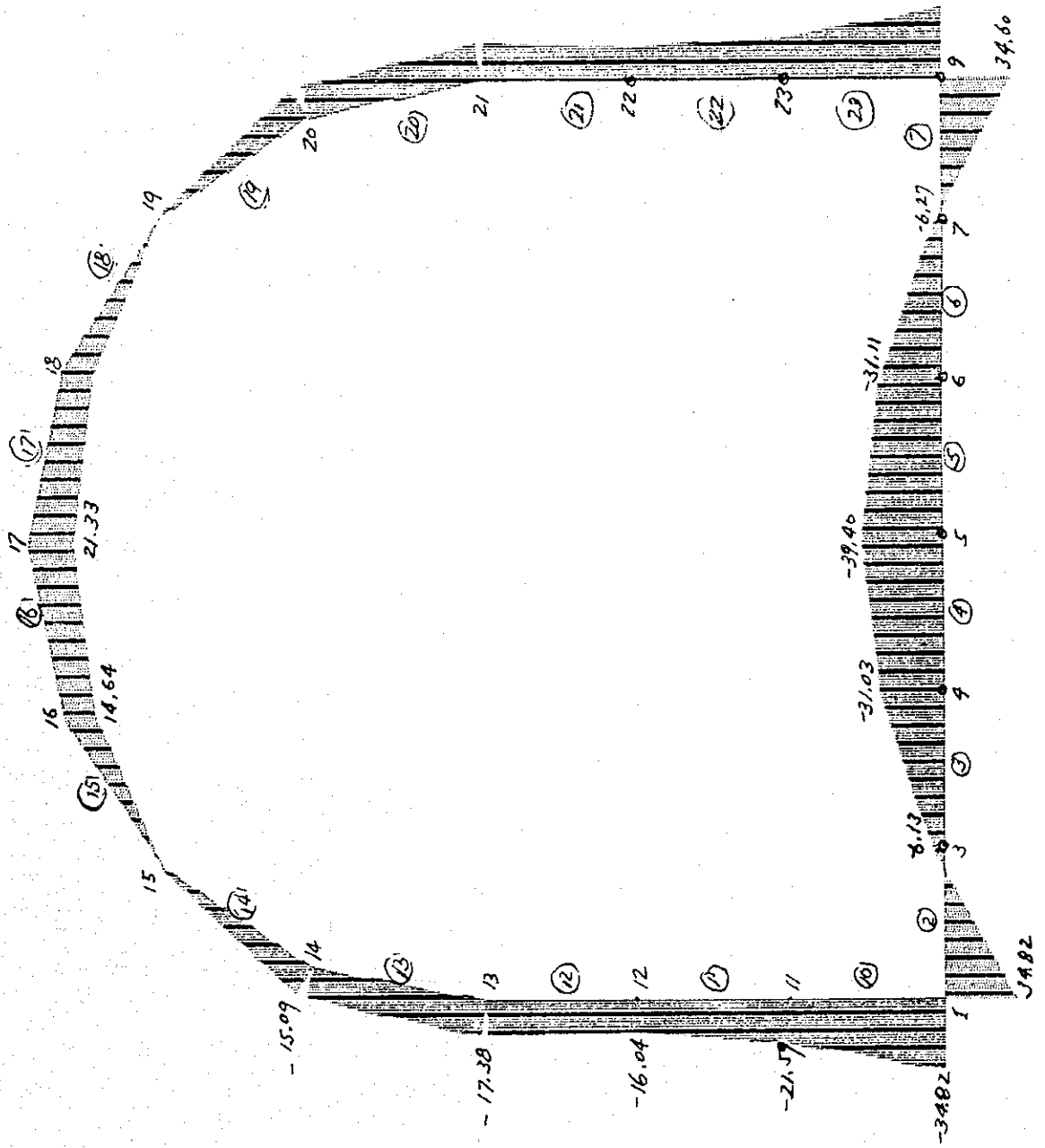
$$P_f = (19,8 \times 4,5 + 15,0 \times 4,5 + 19,003) / 4,5 = 39,023 \text{ tf/m}$$

5-8/



LOS CUYUYES OUTLET, CASE 1  
 1 A ESPERANZA - POZA HONDA TUNNEL

LOS CUYUYES OUTLET CAS. I  
(MOMENT DIAGRAM)

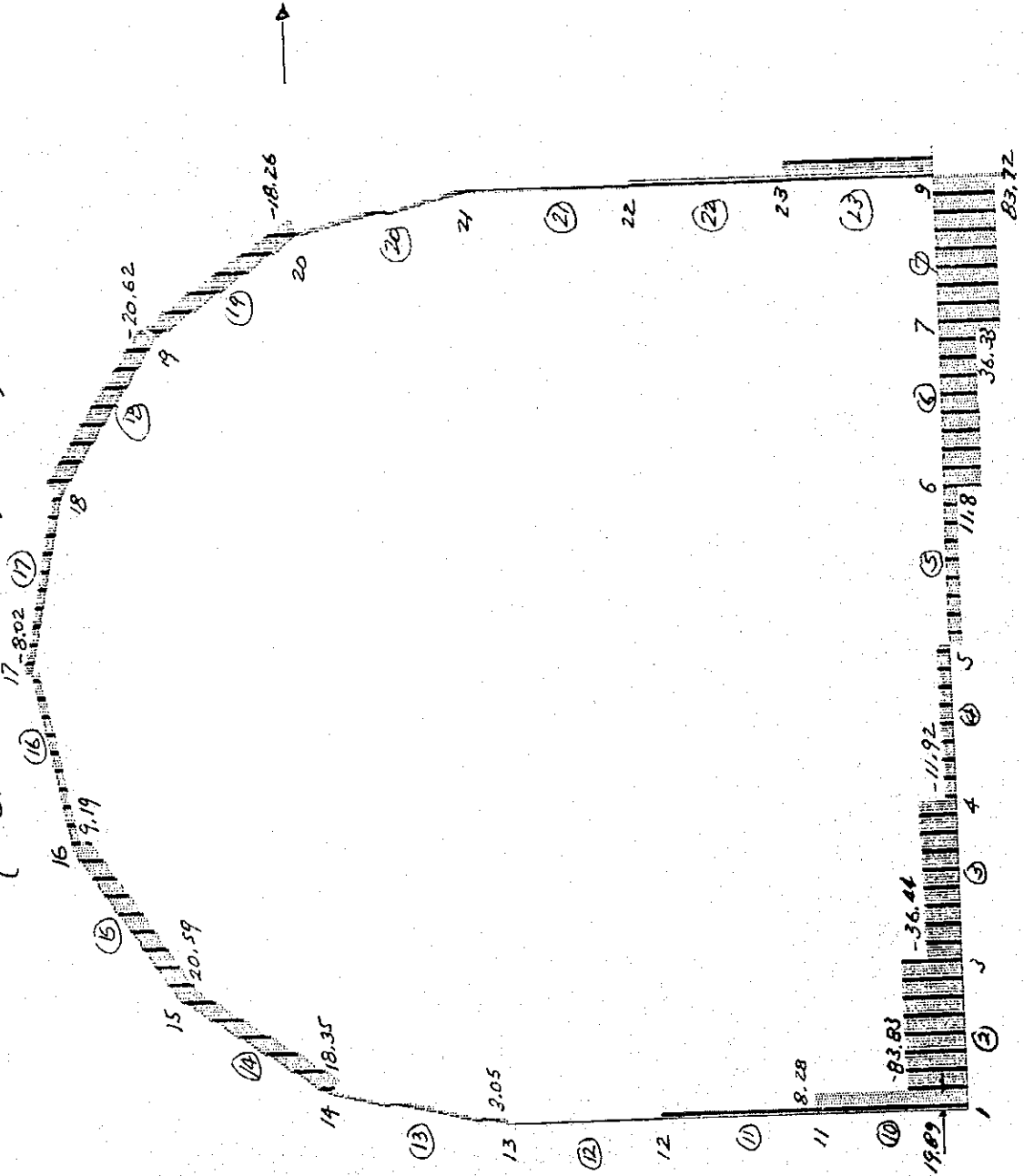


CUYUYES  
FRAME  
OUTPUT  
LOAD

MIN < 10  
MAX < 100  
MIN < 100  
MAX < 100

Output

LOS CUYUYES OUTLET CAS. 1  
( SHEAR DIAGRAM )

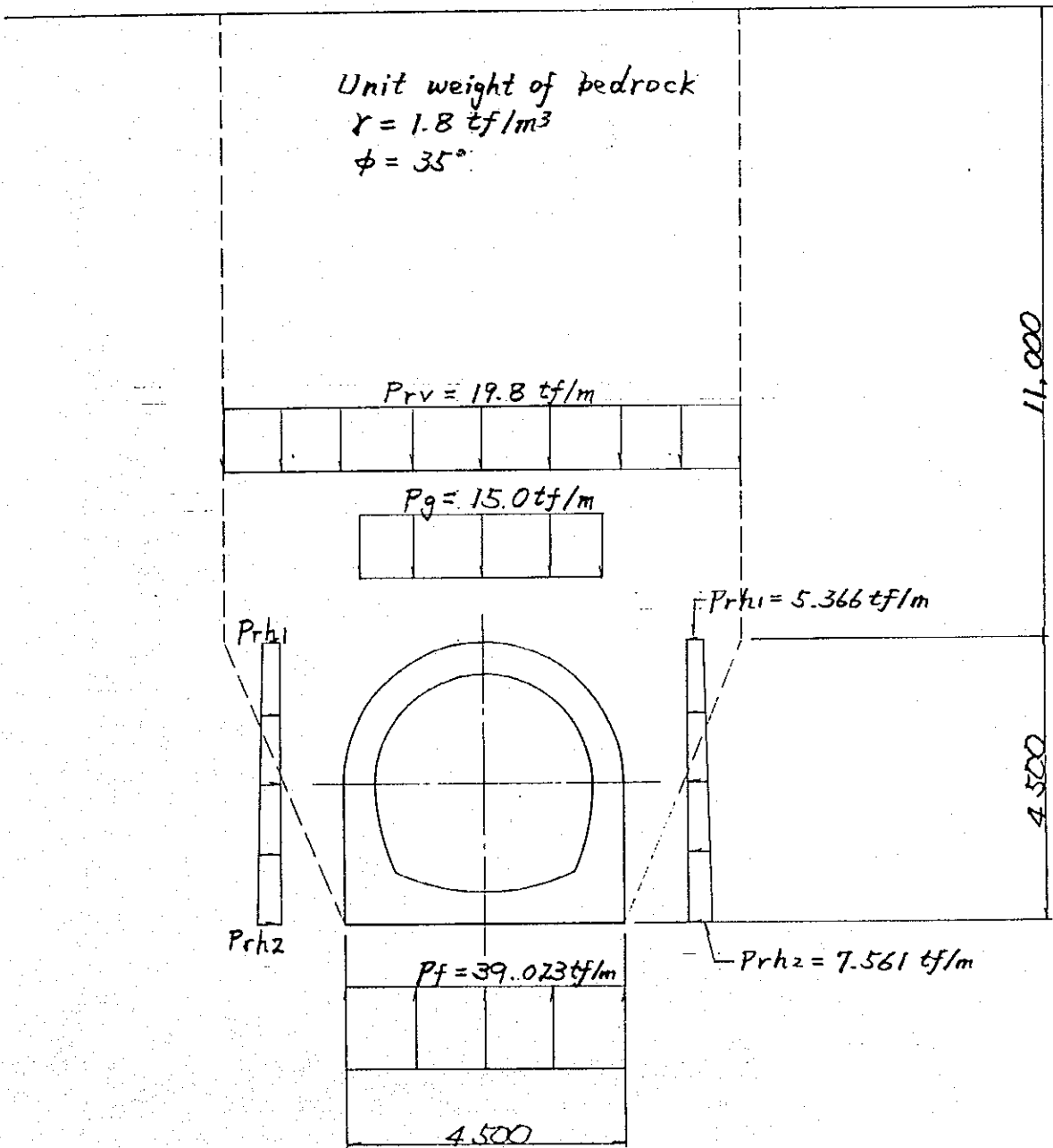


COLUMN  
FRAME  
OUTPUT U22  
LOAD 1

MIN 8:  
-83.8102  
AT .00  
MAX 15:  
83.7202  
AT .01

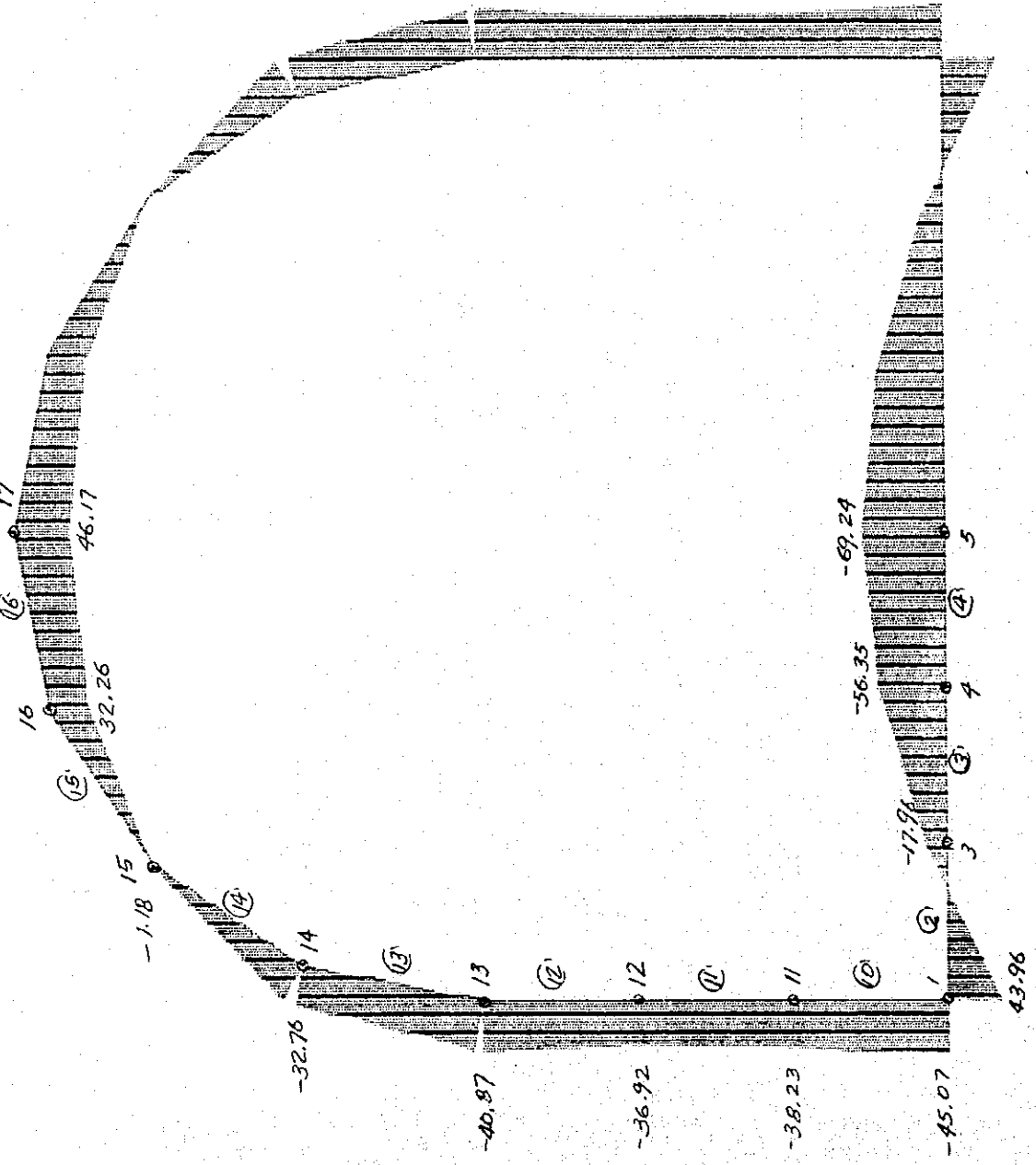
SCALE



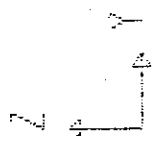


LOS CUYUYES OUTLET, CASE 2  
 LA ESPERANZA ~ POZA HONDA TUNNEL

LOS CUYUYES OUTLET (CAS. 2)  
(MOMENT DIAGRAM)



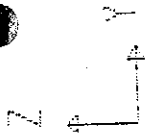
5-96



CUYUYE  
FRAME  
OUTPUT M33  
LOAD 1

MIN < 4?  
- .6924E+02  
AT .67  
MAX < 16?  
.4617E+02  
AT .78

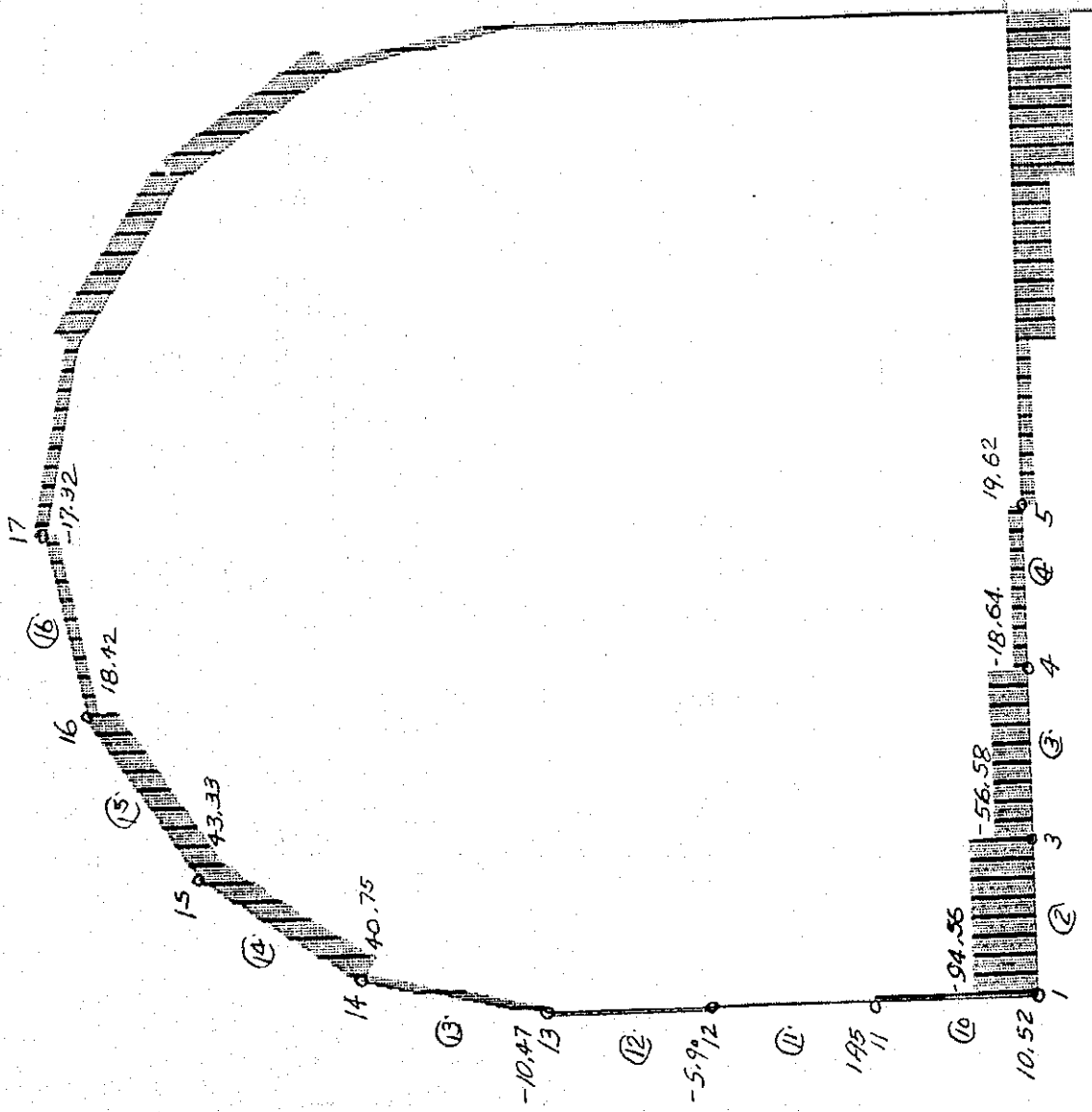
SAP90



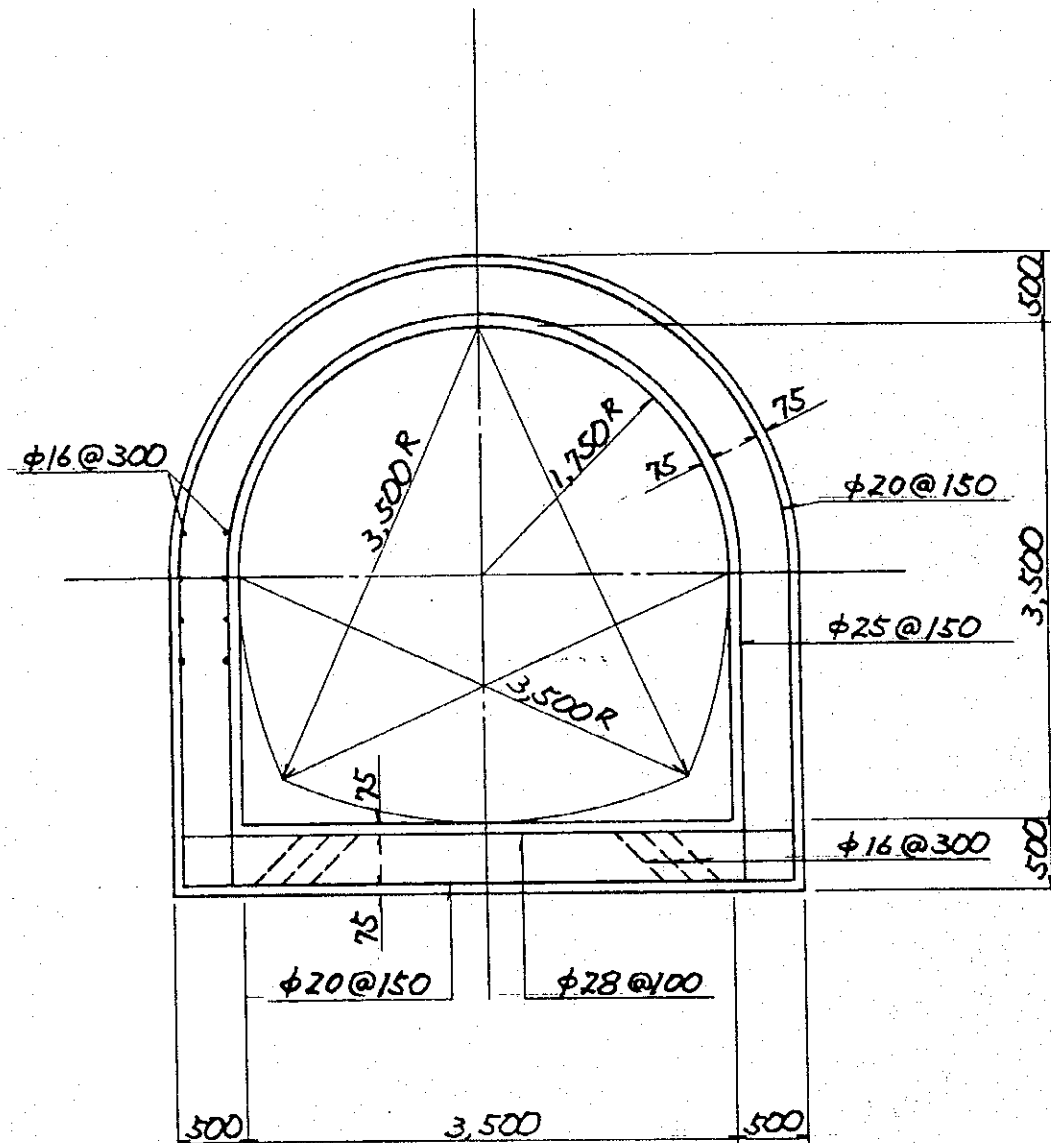
CUYDPC  
 FRAME          VZ2  
 OUTPUT  
 LOAD          1

MIN < 13  
 - .12921+03  
 AT .01  
 MAX < 83  
 .12901+03  
 AT .00

SAP90



5-97



LOS CUYUYES OUTLET

LA ESPERANZA ~ POZA HONDA TUNNEL

5-90

(5) Entrada Poza Honda

(A) Estructura de Cajón de Entrada

Caso 1: Condición Normal

1) Peso muerto de la estructura de cajón

$$W_{c1} = 0,5 \times 2,4 = 1,20 \text{ tf/m}$$

$$W_{c2} = 0,5 \times 2,4 = 1,20 \text{ tf/m}$$

$$W_{c3} = 0,5 \times 2,4 = 1,20 \text{ tf/m}$$

2) Presión vertical de la tierra

$$P_e = 1,8 \times 2,7 = 4,86 \text{ tf/m}$$

3) Presión lateral de la tierra y presión del agua

$$P_{eh1} = 0,5 \times 1,8 \times 2,7 = 2,43 \text{ tf/m}$$

$$P_{eh2} = 0,5 \times 1,8 \times 2,7 + 0,5 \times (1,8 - 1,0) \times 3,5 = 3,83 \text{ tf/m}$$

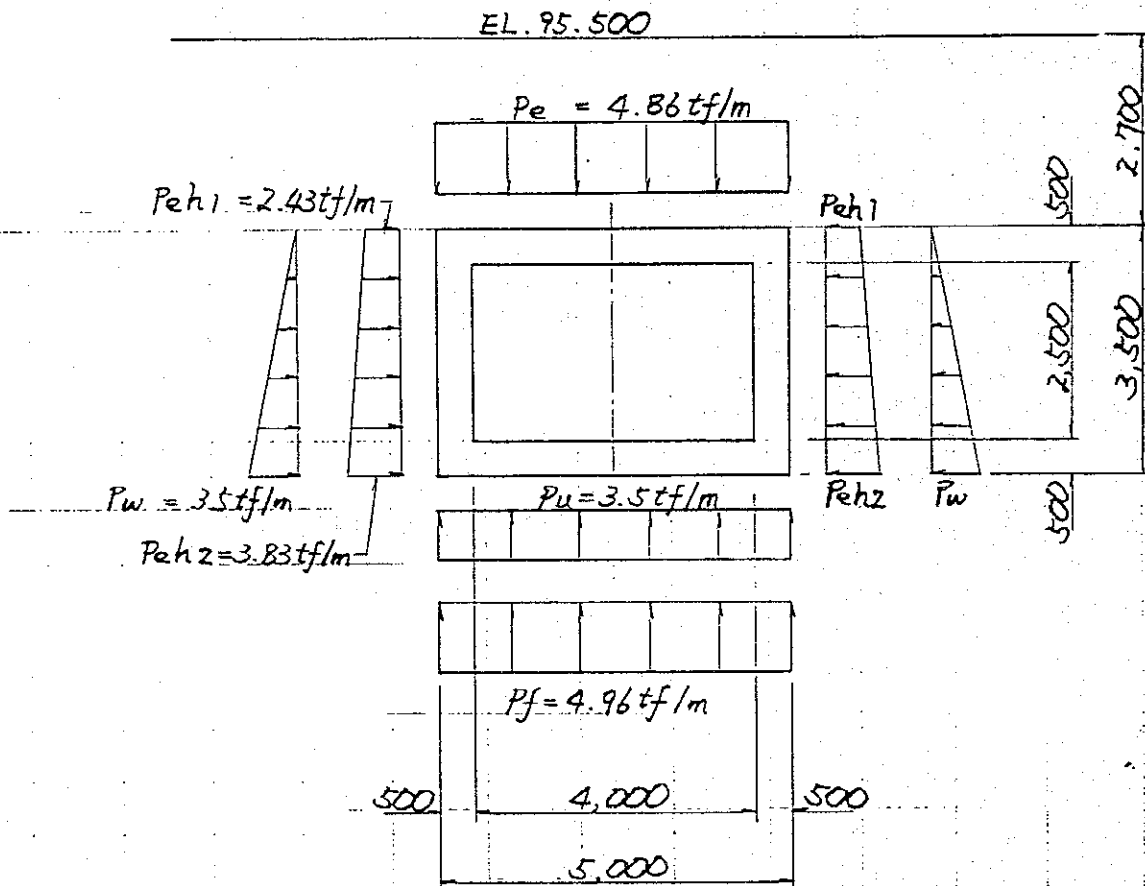
$$P_w = 1,0 \times 3,5 = 3,5 \text{ tf/m}$$

4) Subpresión y reacción de la cimentación

$$P_u = 1,0 \times 3,5 = 3,5 \text{ tf/m}$$

$$P_f = (1,2 \times 5,0 + 1,2 \times 2,5 \times 2 + 1,2 \times 5,0 + 4,86 \times 5,0) / 5,0 - 3,5 = 4,96 \text{ tf/m}$$

5-88

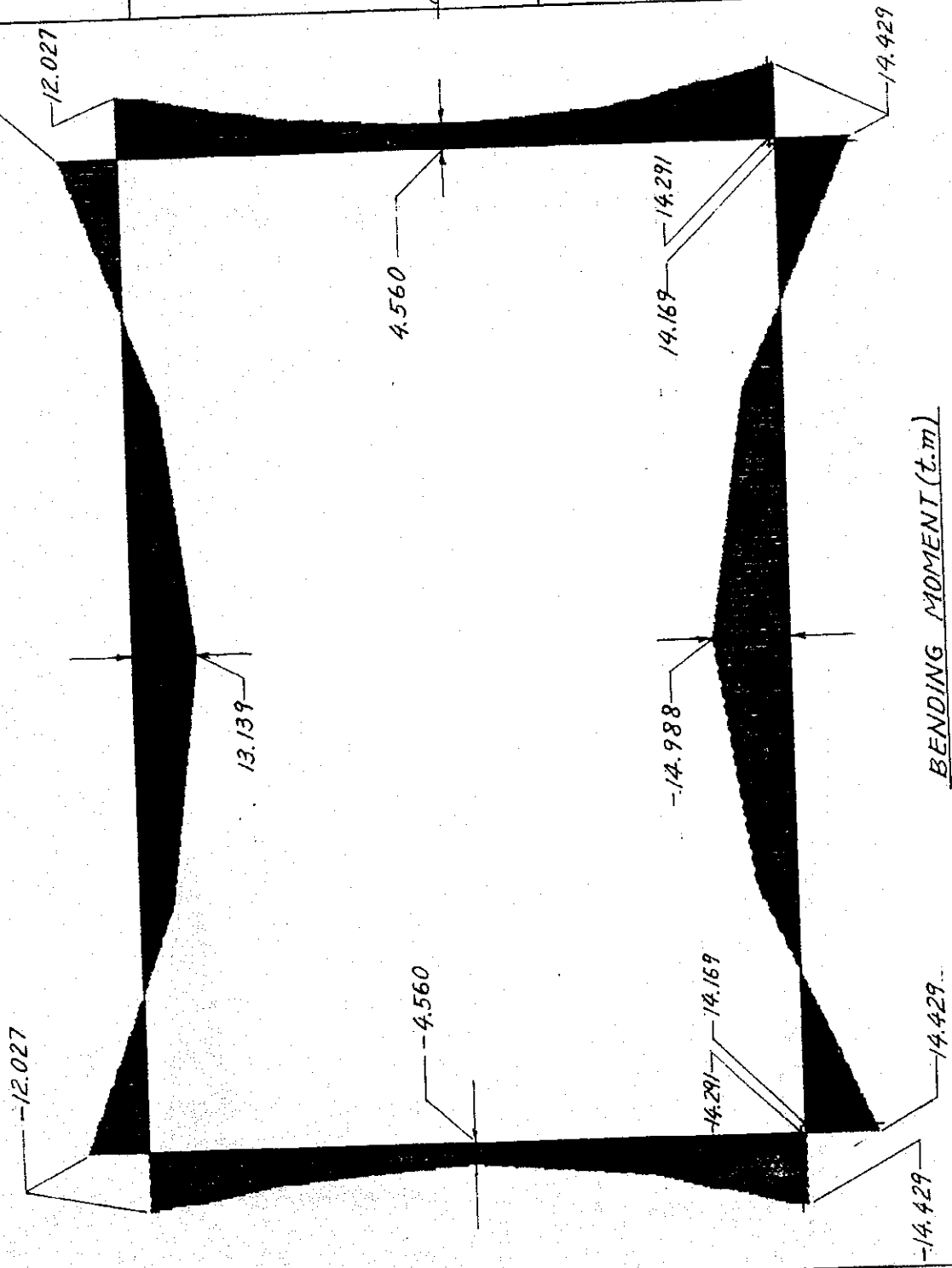


INLET CULVERT

POZA HONDA INLET STRUCTURE



POZA HONDA INLET CULVERT



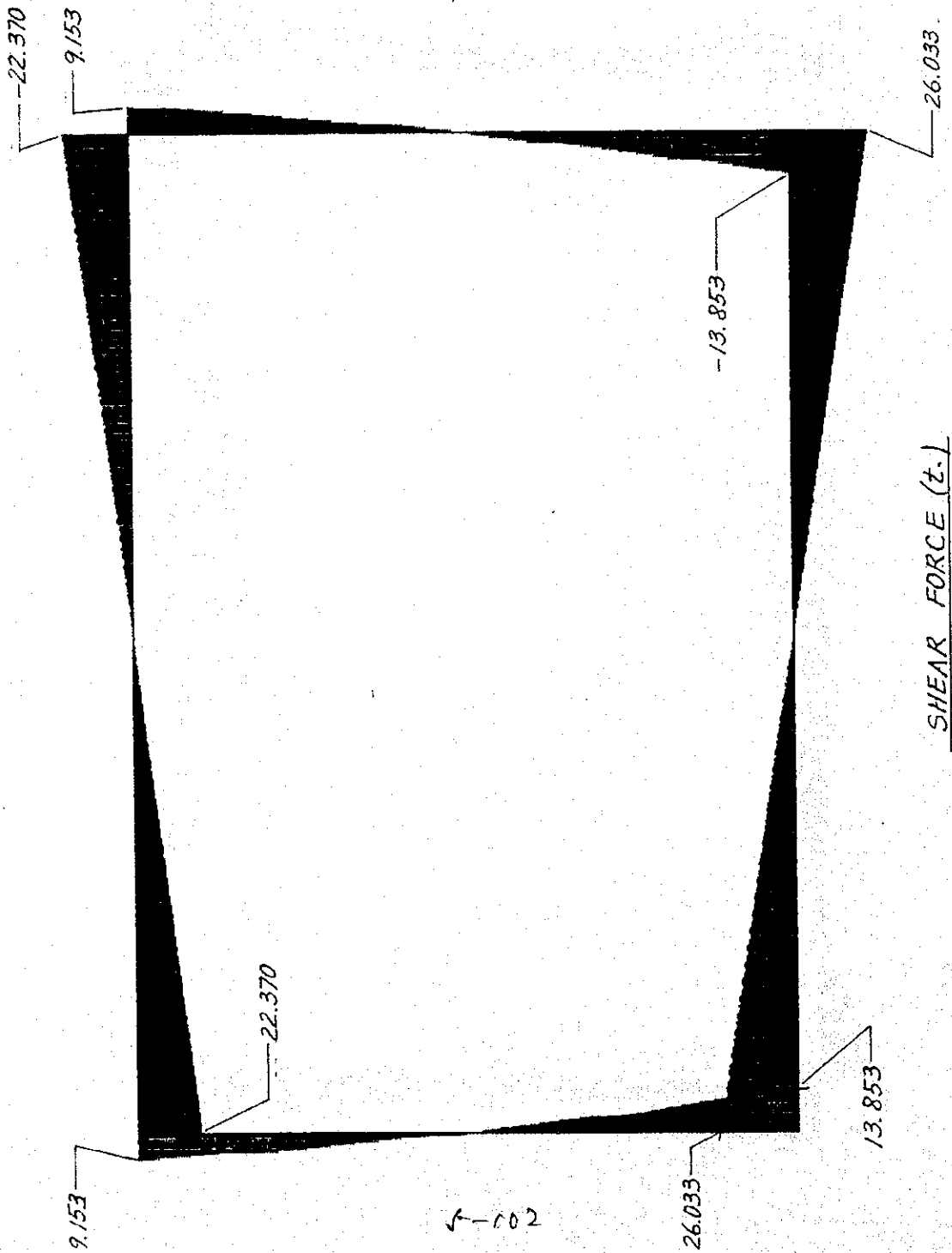
PHCULVERT  
 FRAME M33  
 OUTPUT M33  
 LOAD 1

FACTORED LOADS

NIN < 3>  
 - .1499E+02  
 AT 2.24  
 MAX < 5>  
 .1443E+02  
 AT .00

SAP90

POZA HONDA INLET CULVERT



5-102

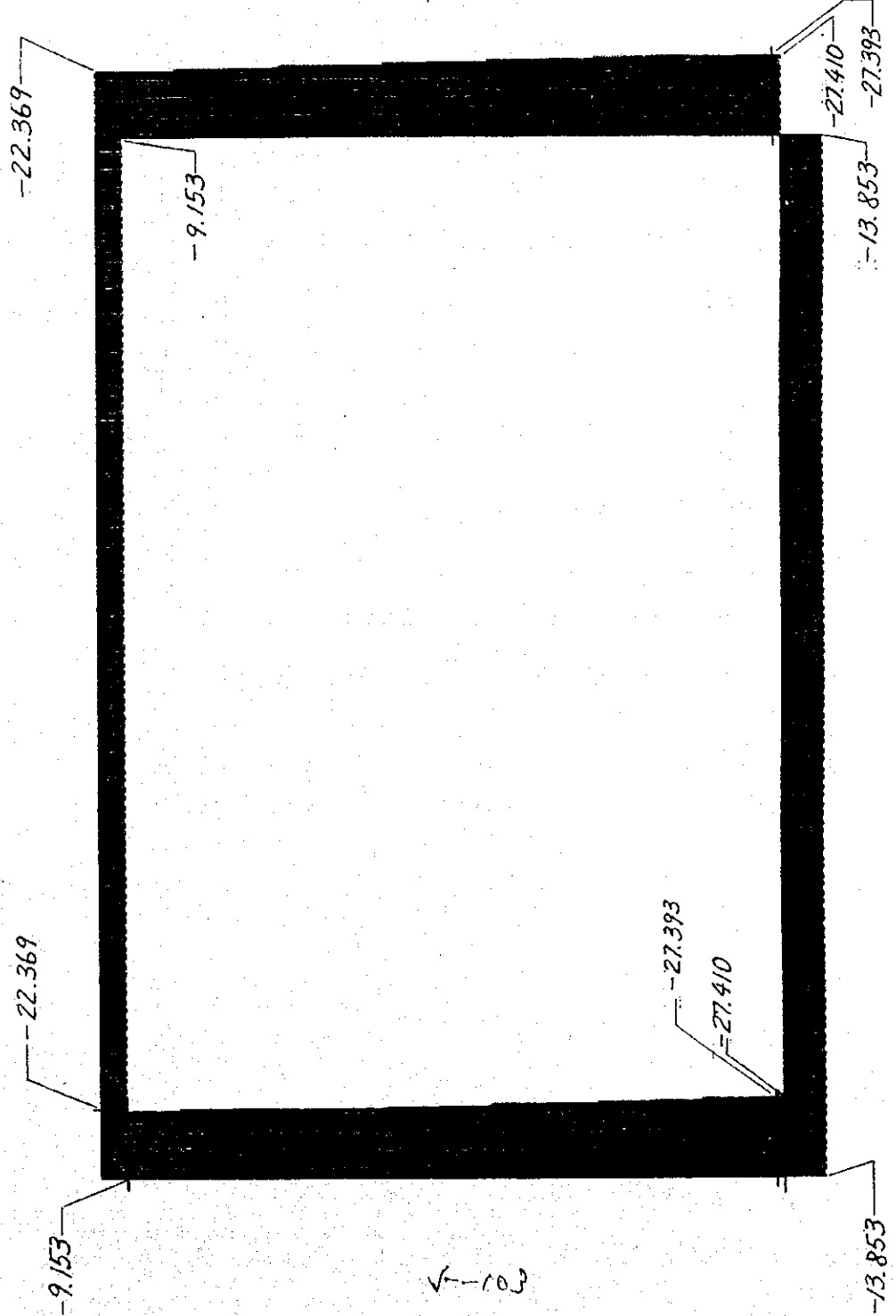
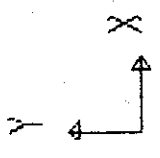


|                  |
|------------------|
| PHCULVERT        |
| FRAME OUTPUT V22 |
| LOAD 1           |
| FACTORED LOADS   |
| MIN < 3>         |
| AT -.2603E+02    |
| MAX < 6>         |
| AT .2603E+02     |
| AT .00           |
| AT .00           |

SAP90



POZA HONDA INLET CULVERT



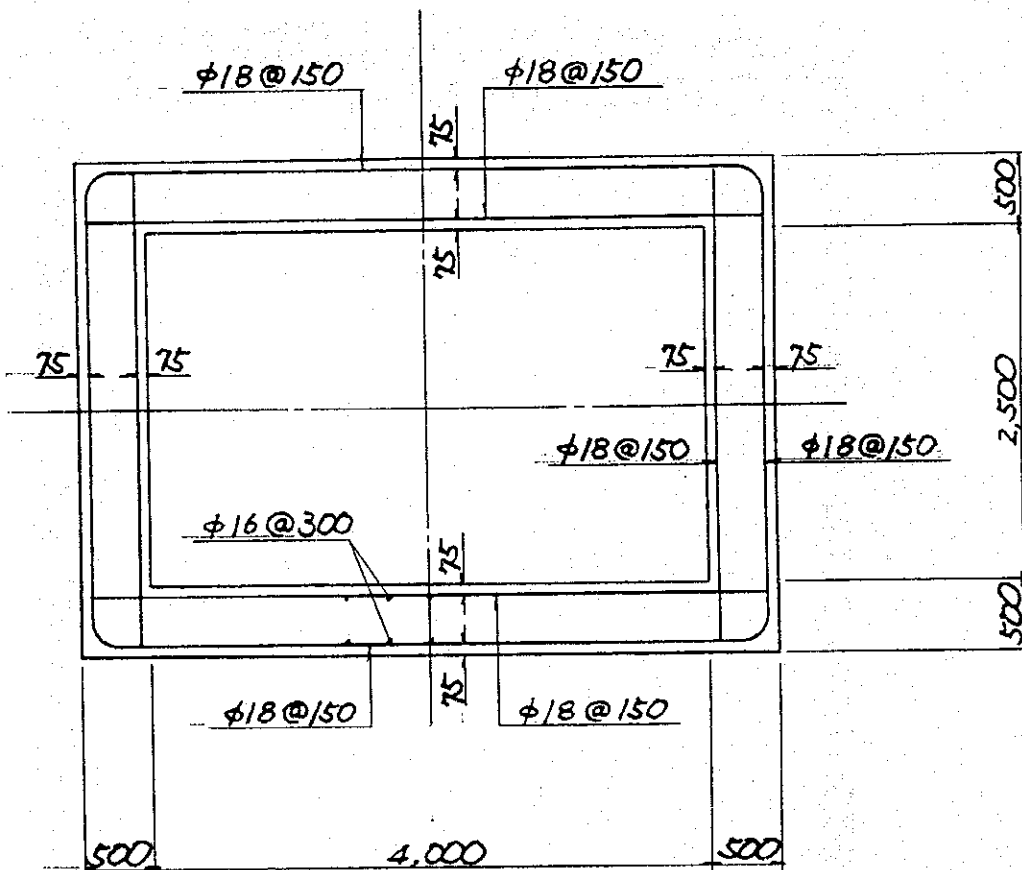
AXIAL FORCE (t)

PHCULVERT  
 FRAME P  
 OUTPUT P  
 LOAD 1

FACTORED LOADS

MIN < 1>  
 -.2741E+02  
 AT .00  
 MAX < 3>  
 -.9153E+01  
 AT .00

SAP90



INLET CULVERT

POZA HONDA INLET STRUCTURE

✓ 104

(B) Túnel de Entrada

Caso 1: Después de la construcción

- 1) Peso muerto del revestimiento de hormigón

$$W_c = 0,5 \times 2,4 = 1,2 \text{ tf/m}$$

- 2) Presión vertical de la roca y presión del agua

$$P_r = 1,8 \times 10,3 + (1,8 - 1,0) \times 8,95 = 25,7 \text{ tf/m}$$

$$P_w = 1,0 \times (\text{El. } 102,0 - \text{El. } 93,05) = 8,95 \text{ tf/m}$$

- 3) Presión lateral de la roca y presión del agua

$$K_a = \tan^2(45 - 30/2) = 0,333$$

$$P_{rh_1} = 0,333 \times 1,8 \times 10,3 + 0,333 \times (1,8 - 1,0) \times 8,95 = 8,558 \text{ tf/m}$$

$$P_{rh_2} = 0,333 \times 1,8 \times 10,3 + 0,333 \times (1,8 - 1,0) \times 12,45 = 9,49 \text{ tf/m}$$

$$P_{wh_1} = 1,0 \times 8,95 = 8,95 \text{ tf/m}$$

$$P_{wh_2} = 1,0 \times 12,45 = 12,45 \text{ tf/m}$$

- 4) Subpresión y reacción de la cimentación

$$P_u = 1,0 \times 12,45 \text{ tf/m}$$

$$P_f = (8,95 \times 3,5 + 25,7 \times 3,5 + 14,616)/3,5 - 12,45 = 26,376 \text{ tf/m}$$

Caso 2: Durante la construcción

- 1) Peso muerto del revestimiento de hormigón

$$W_c = 0,5 \times 2,4 = 1,2 \text{ tf/m}$$

- 2) Presión vertical de la roca y presión de inyección

$$P_r = 1,8 \times 19,25 = 36,65 \text{ tf/m}$$

$$P_g = 15,0 \text{ tf/m}$$

- 3) Presión lateral de la roca y presión del agua

$$K_a = \tan^2(45 - 30/2) = 0,333$$

$$P_{rh_1} = 0,333 \times 1,8 \times 19,5 = 11,538 \text{ tf/m}$$

$$P_{rh_2} = 0,333 \times 1,8 \times 19,5 + 0,333 \times (1,8 - 1,0) \times 3,5 = 12,47 \text{ tf/m}$$

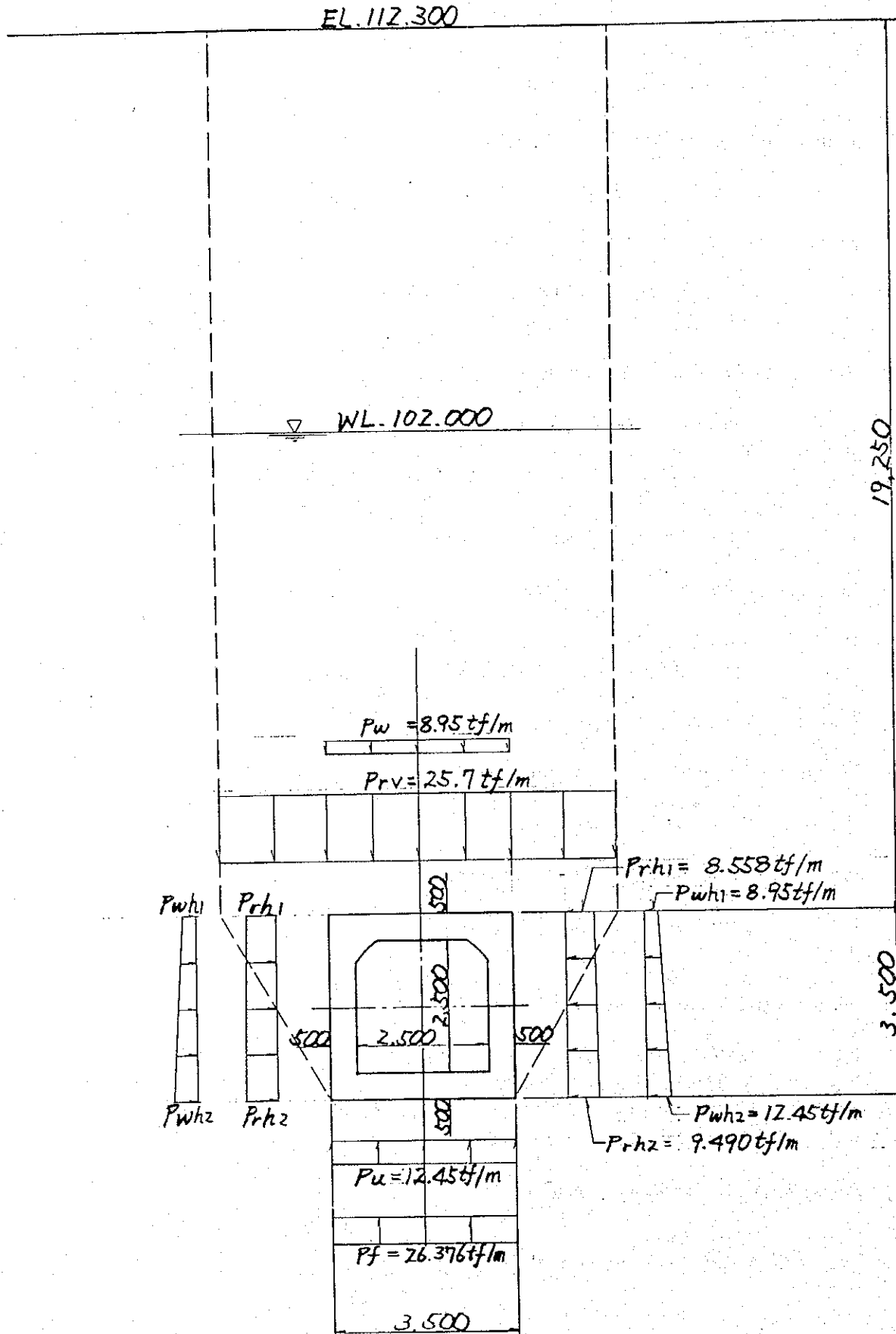
$$P_w = 1,0 \times 3,5 = 3,5 \text{ tf/m}$$

- 4) Subpresión y reacción de la cimentación

$$P_u = 1,0 \times 3,5 \text{ tf/m}$$

$$P_f = (36,45 \times 3,5 + 15,0 \times 3,5 + 14,616)/3,5 - 3,5 = 50,326 \text{ tf/m}$$

5-105



POZA HONDA INLET, CASE 1  
 POZA HONDA - MANCHA GRANDE TUNNEL



POZAH02  
 FRAME  
 OUTPUT P  
 LOAD 1

CASE 1

AFTER CONSTRUCTION

MIN < 1 >  
 - .10226E+03  
 AT .00  
 MAX < 3 >  
 - .4224E+02  
 AT .00

CAP90

-42.244

-97.545

-45.902

-102.585

-42.244

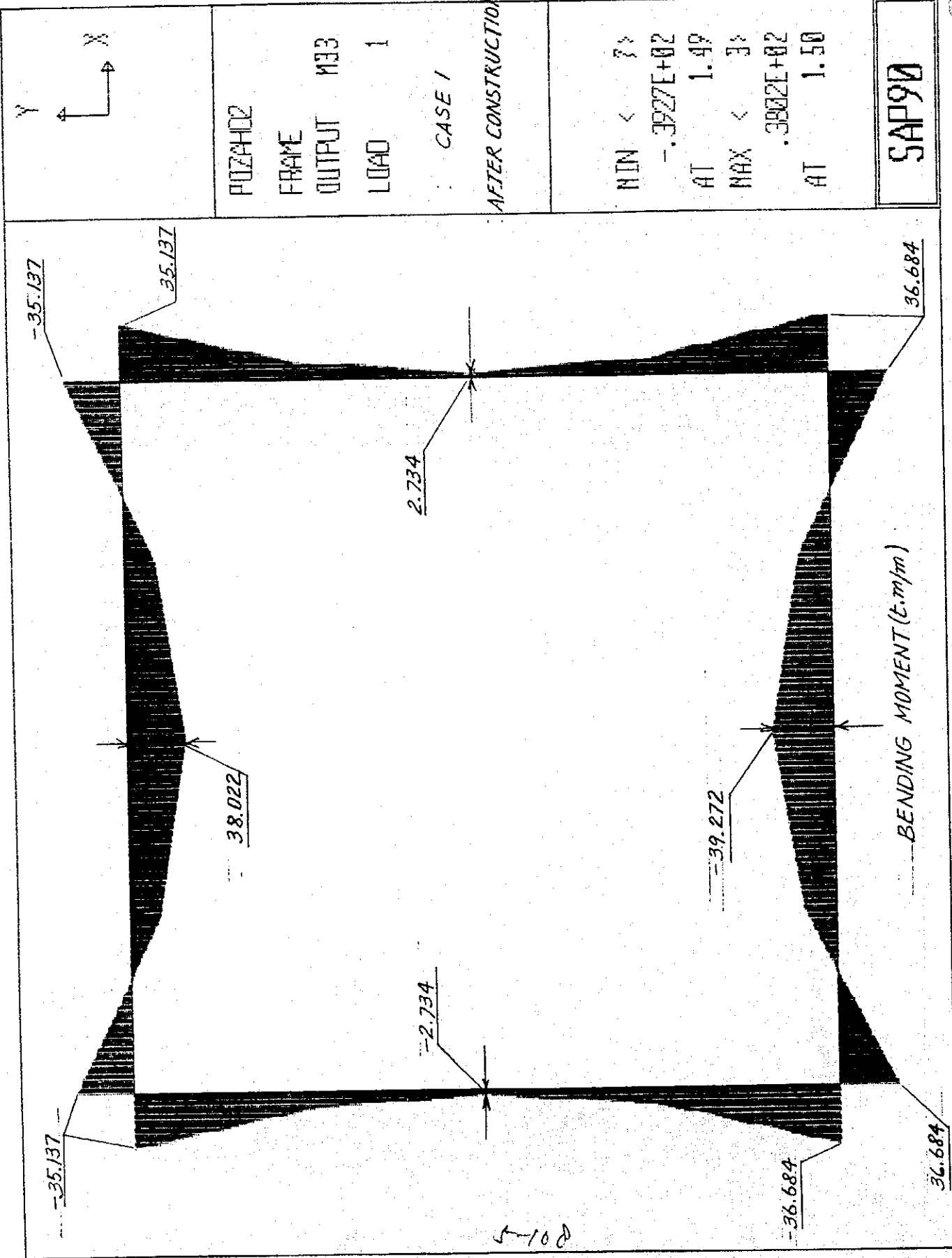
-97.545

-45.902

-102.585

AXIAL FORCE (t)

R-107





POZAH02  
 FRAME  
 OUTPUT V22  
 LOAD 1

CASE 1

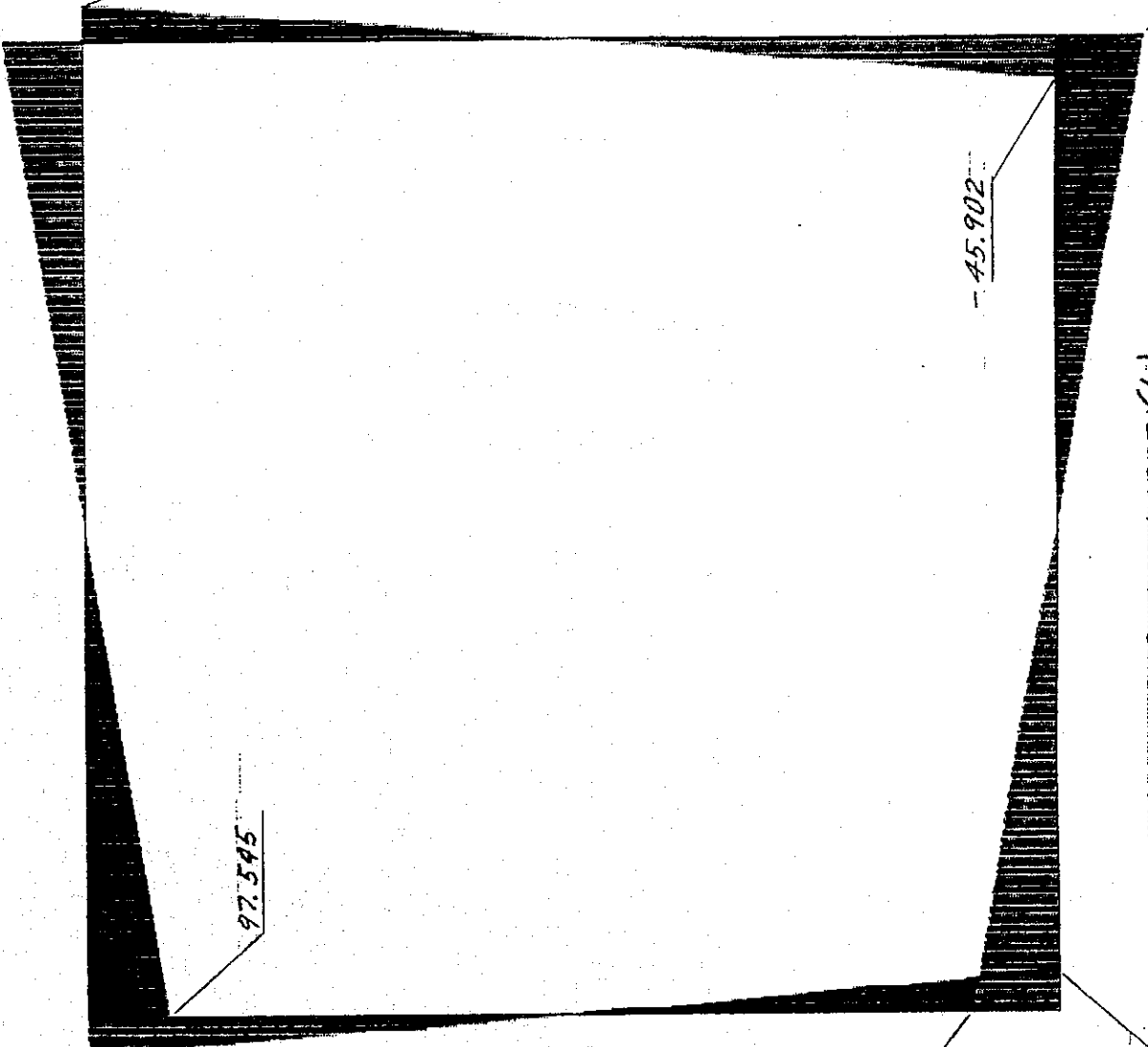
AFTER CONSTRUCTION

MIN < 7 >  
 - .1006E+03  
 AT .00  
 MAX < 6 >  
 .1006E+03  
 AT .00

SAP90

-97.545

42.244



SHEAR FORCE (k)

-42.244

97.545

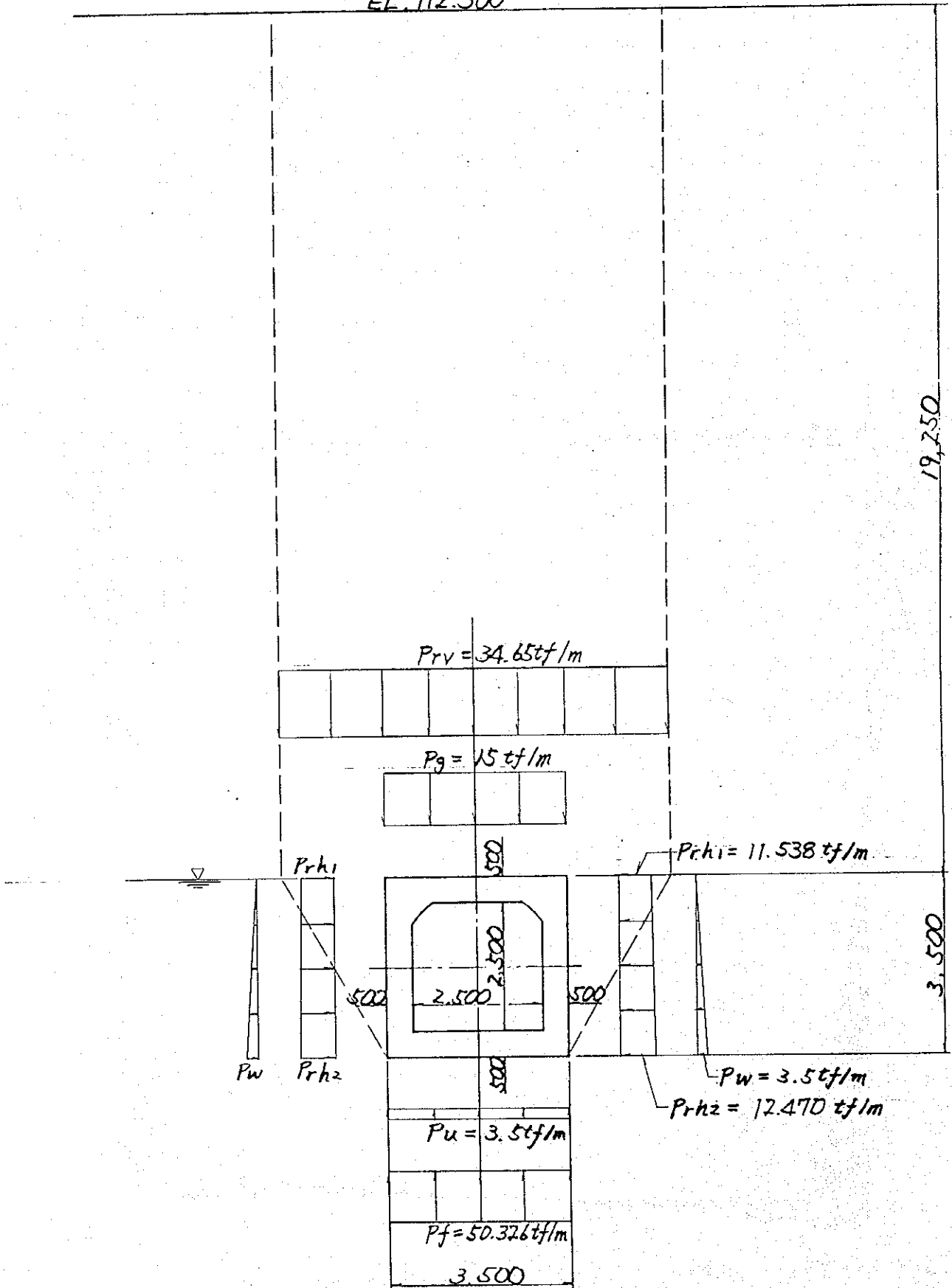
-45.902

-100.605

45.902

601-5


EL. 112.300

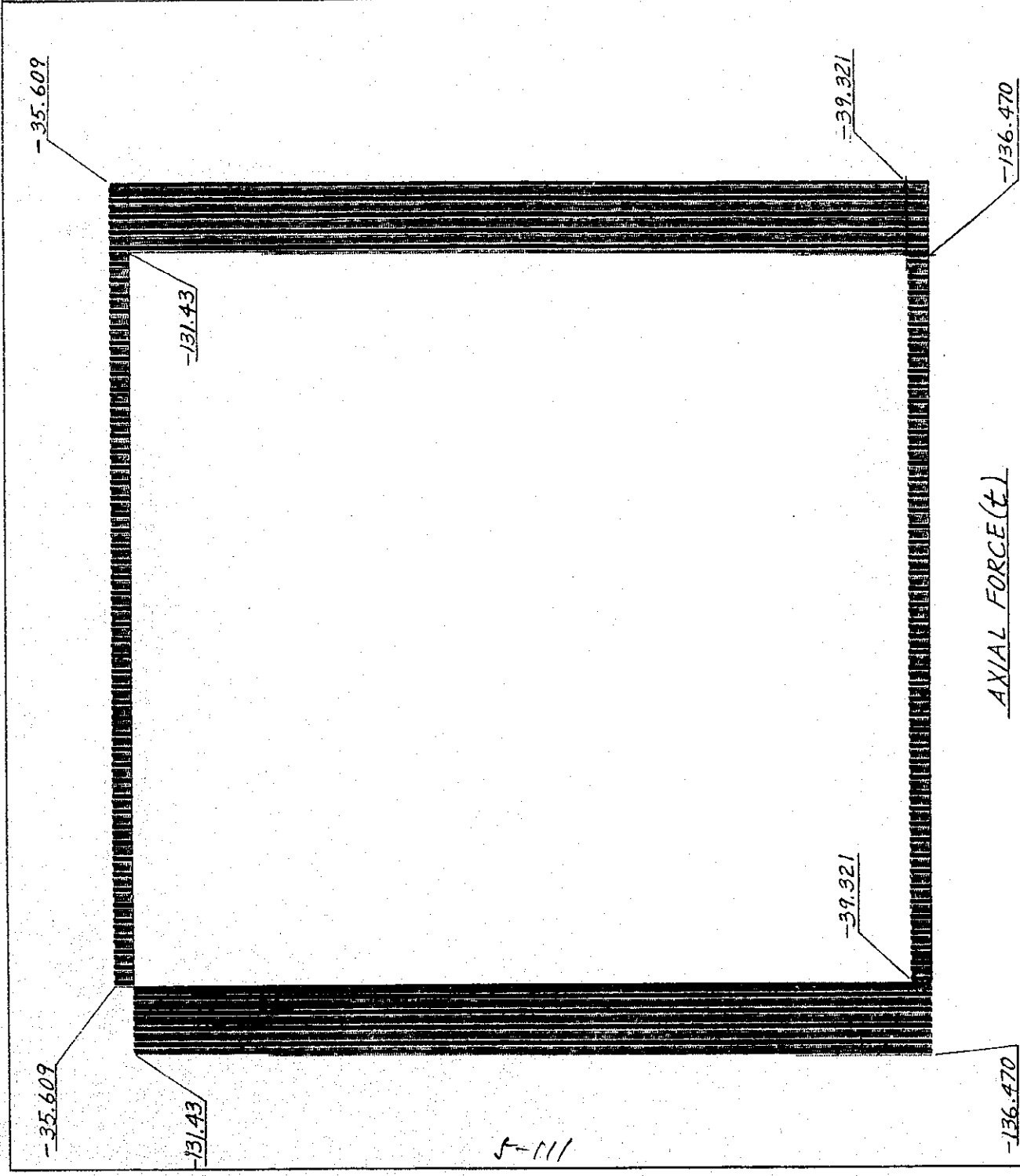


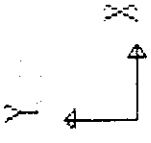
POZA HONDA INLET, CASE 2

POZA HONDA ~ MANCHA GRANDE TUNNEL



|   |   |
|---|---|
|  | POZADOM<br>FRAME<br>OUTPUT P<br>LOAD I<br><br>CASE 2<br>DURING CONSTRUCTION |
| MIN < 1><br>- .1365E+03<br>AT .00   | MAX < 3><br>- .3561E+02<br>AT .00   |
| <b>CADOM</b>  |   |





POZAH04

FRAME

OUTPUT M33

LOAD 1

CASE 2

DURING CONSTRUCTION

MIN < 3 >

-5787E+02

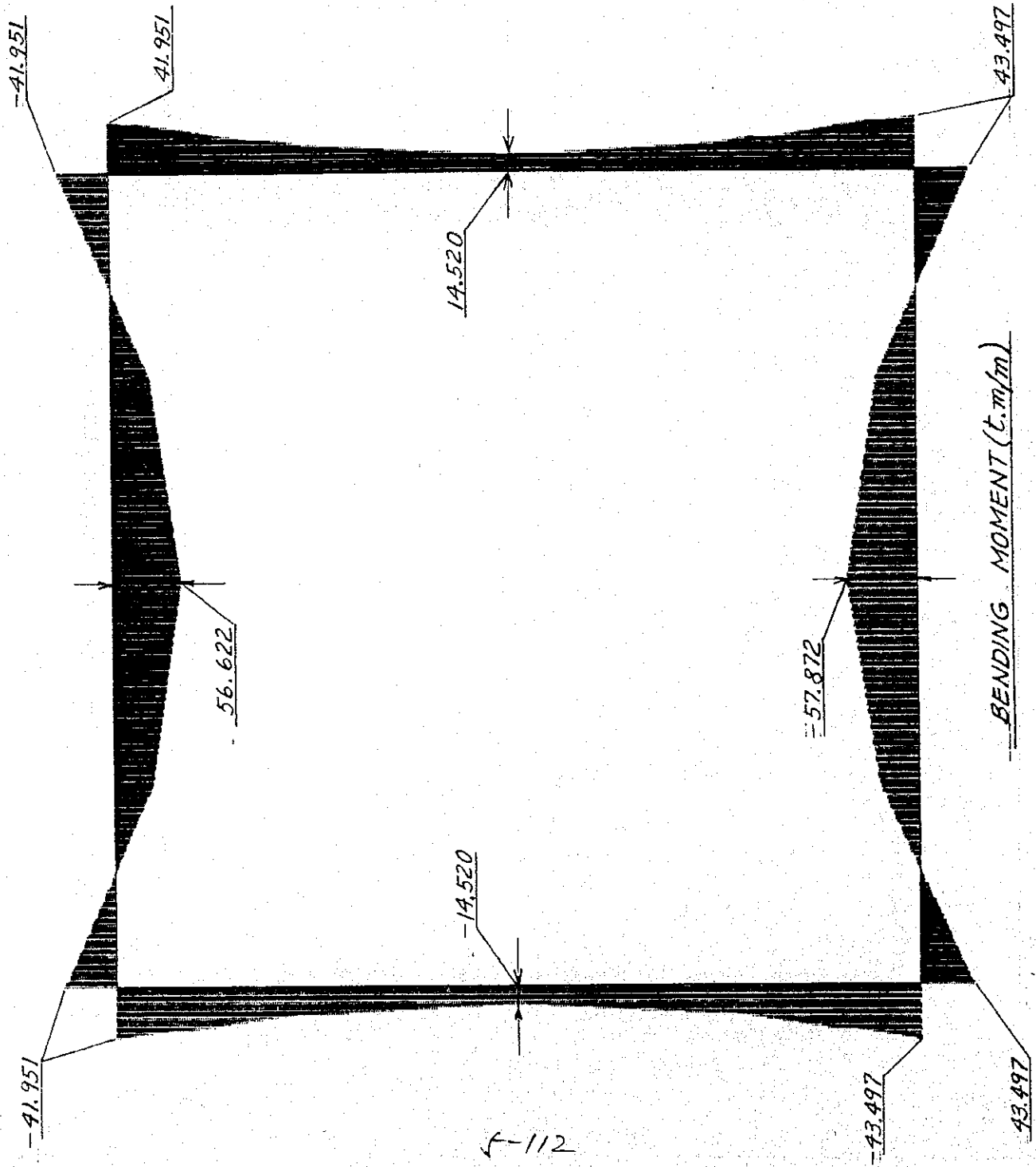
AT 1.49

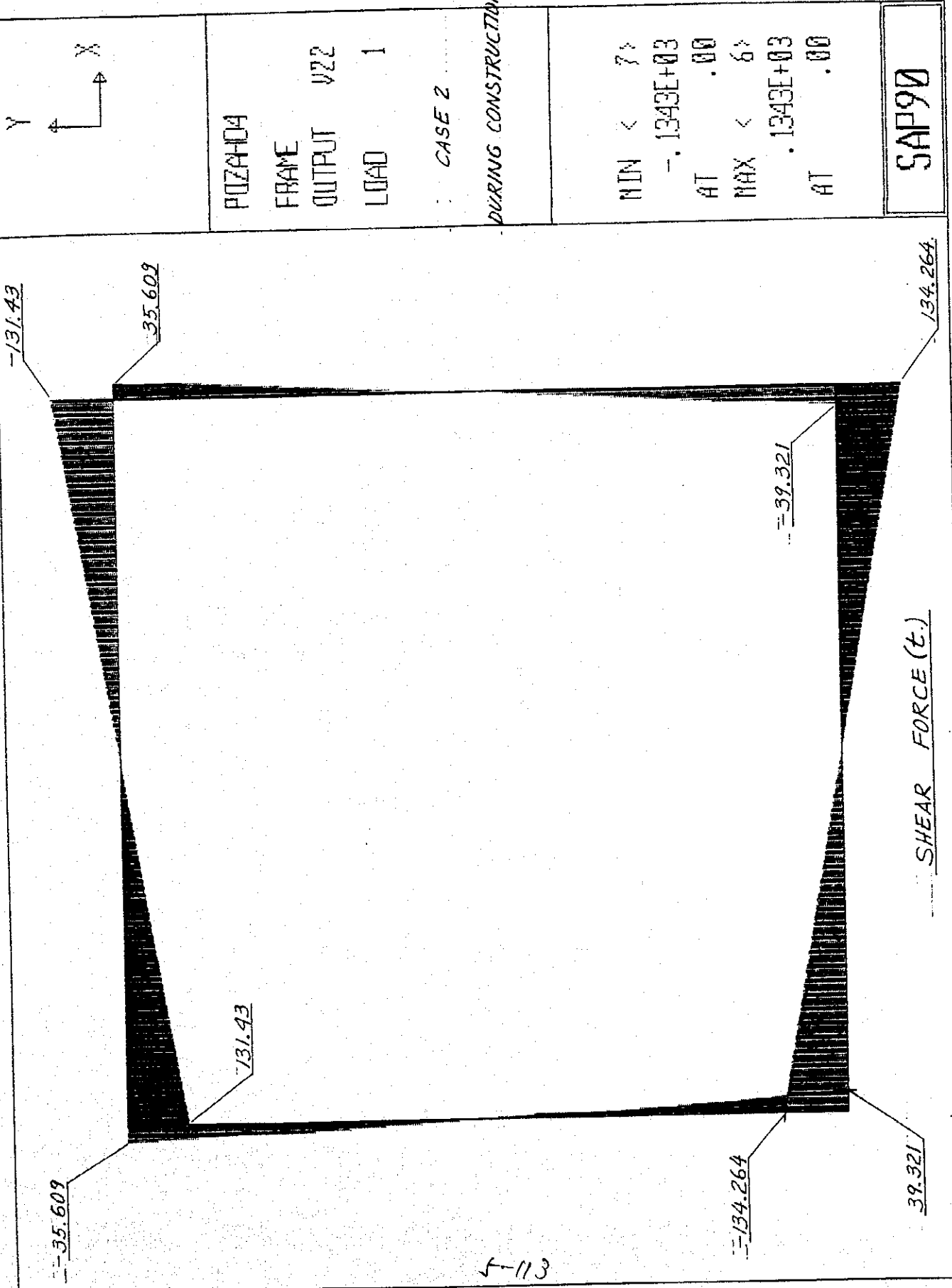
MAX < 3 >

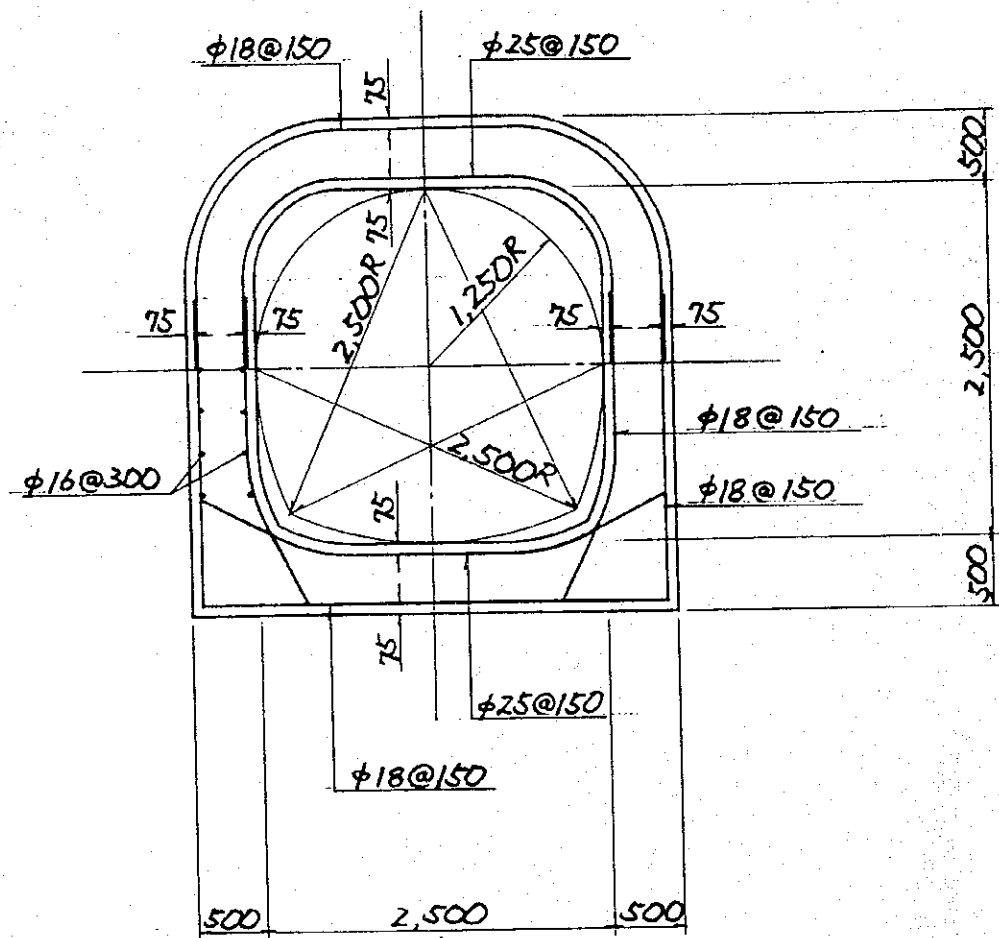
.5662E+02

AT 1.50

SAP90







POZA HONDA INLET (TRANSITION)

POZA HONDA - MANCHA GRANDE TUNNEL

J-114

(C) Pozo de Entrada

**Pozo de Entrada, Sección A - A**

Caso 1: Después de la construcción

- 1) Presión lateral del agua

$$P_w = 1,0 \times (\text{El. } 102,0 - \text{El. } 83,45) = 18,55 \text{ tf/m}$$

- 2) Presión lateral de la roca

$$K_a = \tan^2(45 - 30/2) = 0,333$$

$$P_r = 0,333 \times (1,8 - 1,0) \times 5,35 = 1,43 \text{ tf/m}$$

**Pozo de Entrada, Sección B - B**

Caso 1: Después de la construcción

- 1) Presión lateral del agua

$$P_w = 1,0 \times (\text{El. } 102,0 - \text{El. } 94,00) = 8,0 \text{ tf/m}$$

- 2) Presión lateral de la roca

$$K_a = \tan^2(45 - 30/2) = 0,333$$

$$P_r = 0,333 \times 1,8 \times 10,3 + 0,333 \times (1,8 - 1,0) \times 8,0 = 8,305 \text{ tf/m}$$

**Pozo de Entrada, Sección C - C**

Caso 1: Después de la construcción

- 1) Presión lateral del agua

$$P_w = 1,0 \times (\text{El. } 102,0 - \text{El. } 96,5) = 5,5 \text{ tf/m}$$

- 2) Presión lateral de la roca

$$K_a = \tan^2(45 - 30/2) = 0,333$$

$$P_r = 0,333 \times 1,8 \times 10,3 + 0,333 \times (1,8 - 1,0) \times 5,5 = 7,639 \text{ tf/m}$$

**Pozo de Entrada, Sección D - D**

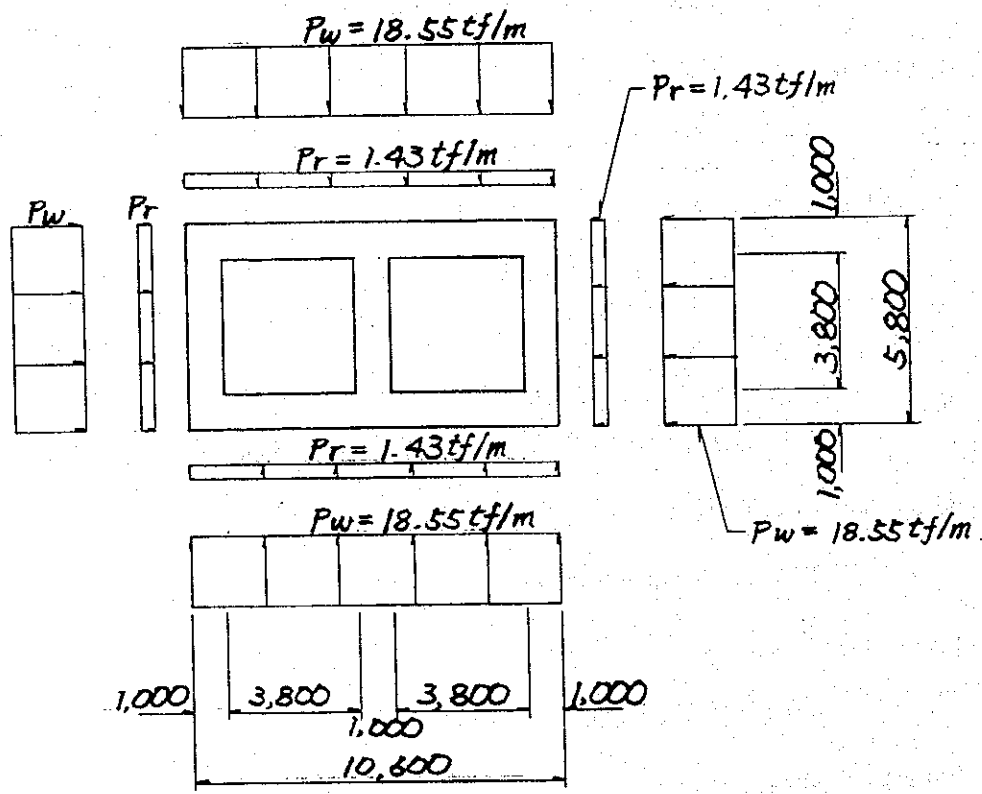
Caso 1: Después de la construcción

- 1) Presión lateral de la roca

$$K_a = \tan^2(45 - 30/2) = 0,333$$

$$P_r = 0,333 \times 1,8 \times 8,0 = 4,975 \text{ tf/m}$$

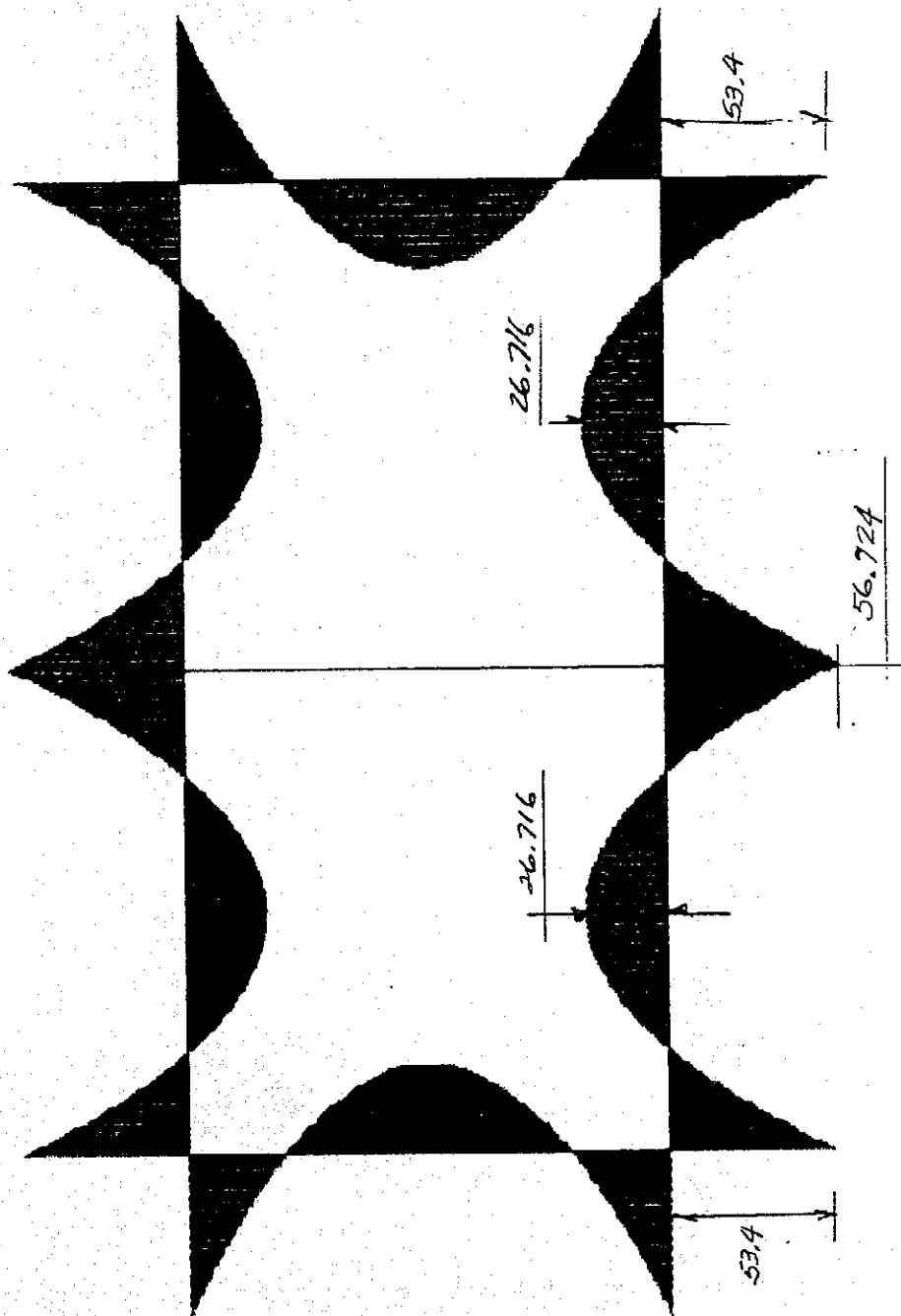
5-115



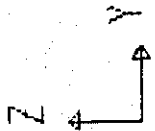
INLET SHAFT, SECTION A - A  
 POZA HONDA INLET STRUCTURE

5-116

POZA HOKIDA SHIFT



MOMENT DIAGRAM



POZHS250

FRAME

OUTPUT

M33

LOAD

1

MIN < 363

- .5672E+02

AT .80

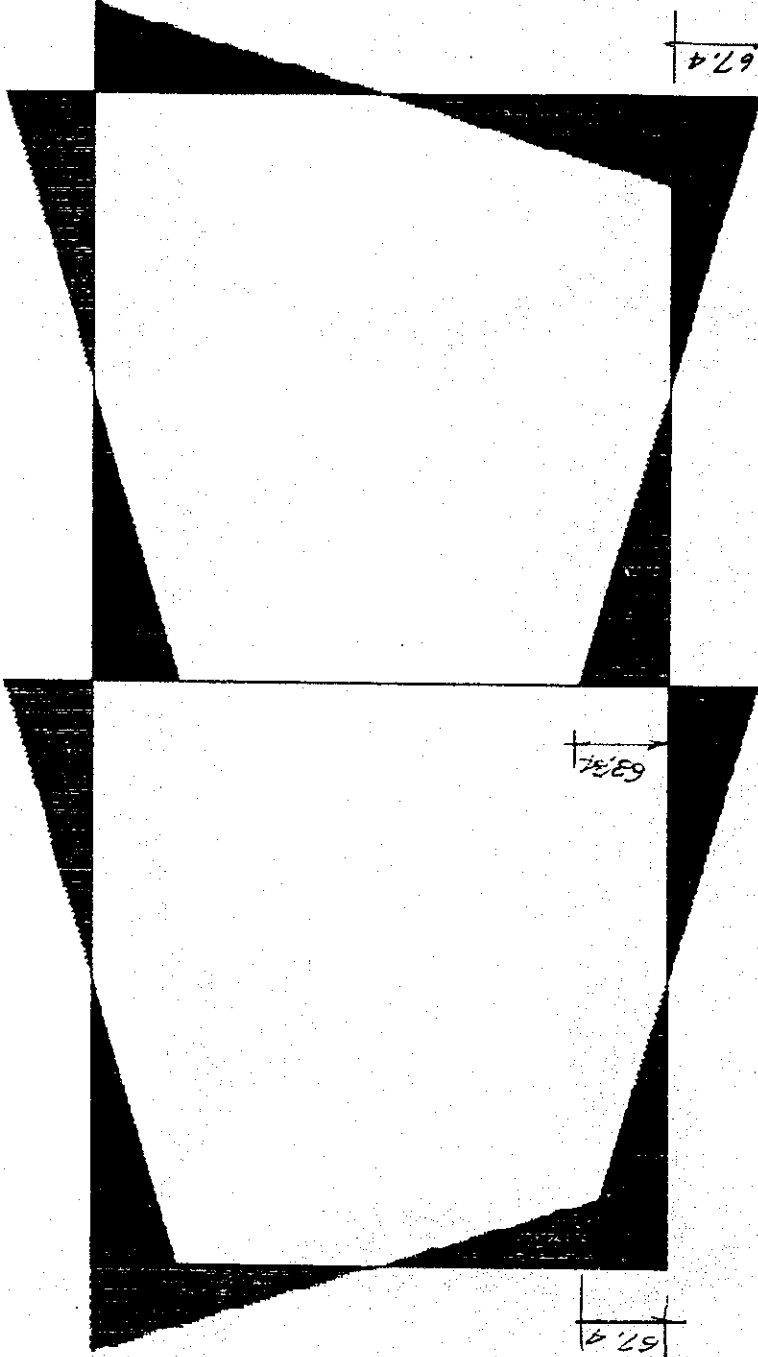
MAX < 63

.5672E+02

AT .80

SAP90

POZA HONDA SHIFT



SHEAR DIAGRAM



pozhs25o

FRAME  
OUTPUT V22  
LOAD 1

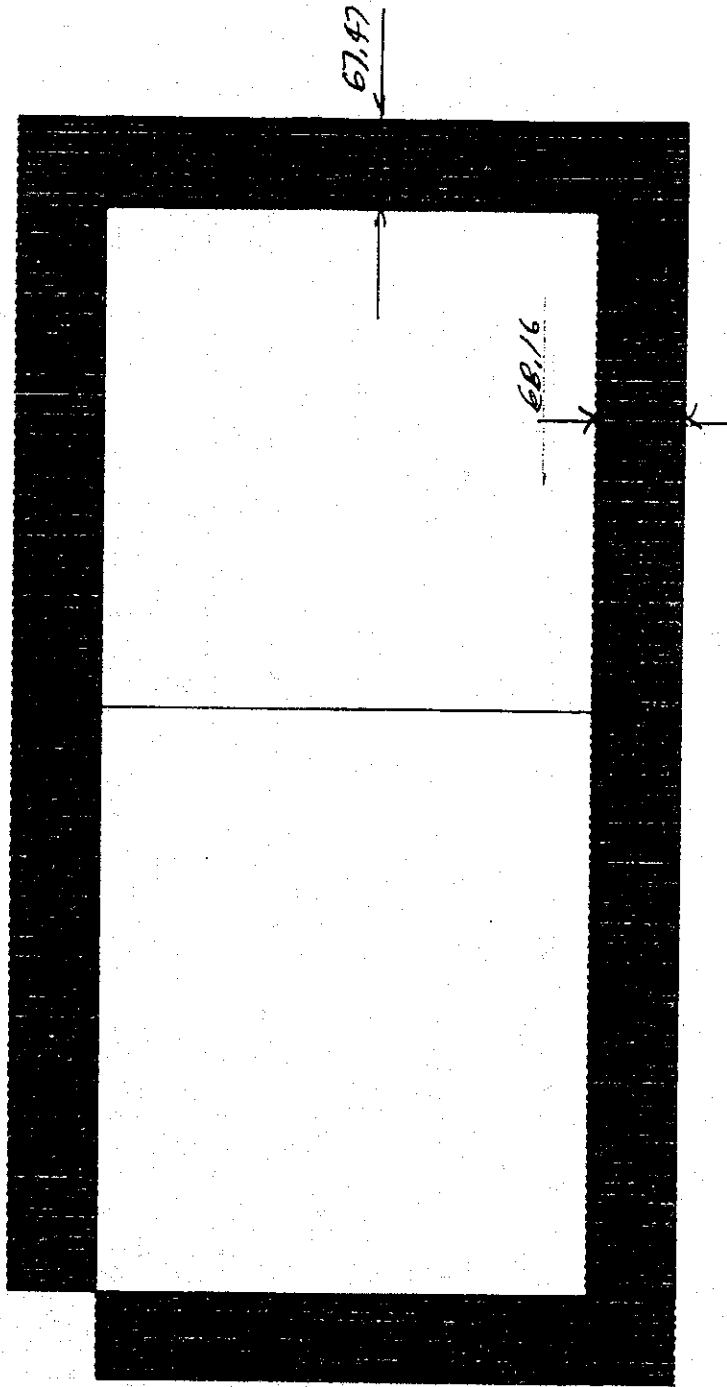
MIN < 7>  
- .6885E+02  
AT .00  
MAX < 6>  
.6885E+02  
AT .80

SAP90

5-118

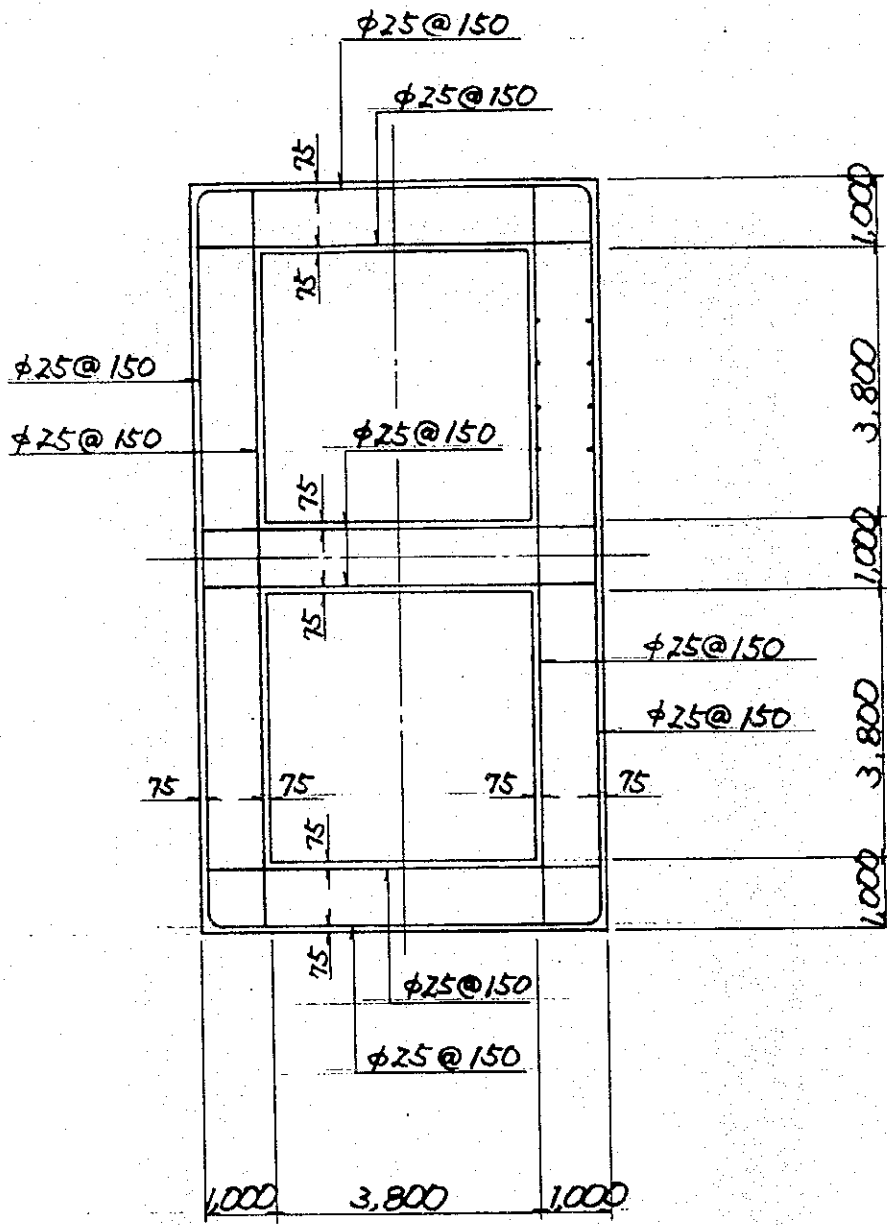


PODA HONDA SHIFT



AXIAL FORCE

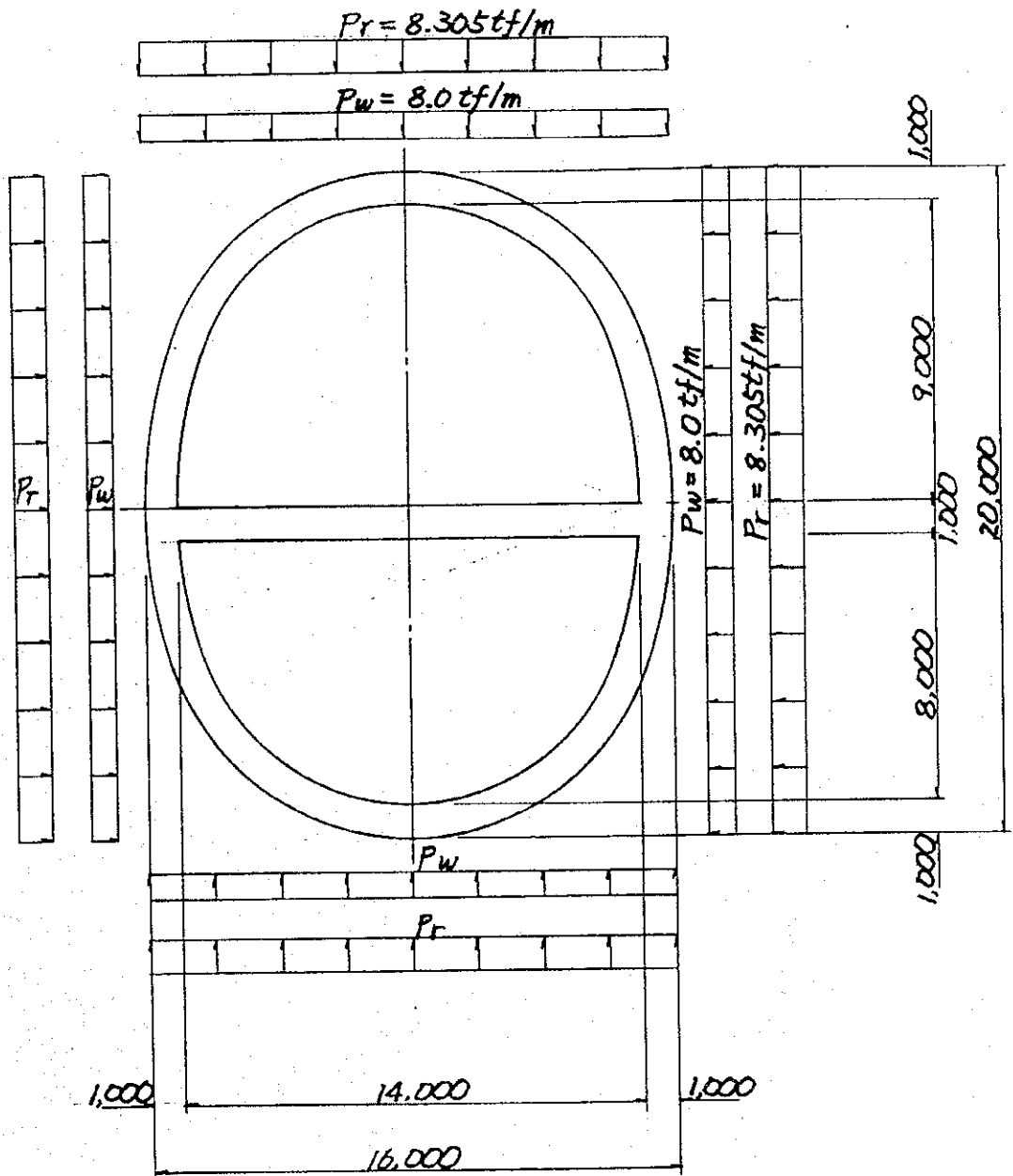
|              |   |   |
|--------------|---|---|
|              | pazhs25o<br>FRAME<br>OUTPUT P<br>LOAD 1 | MIN < 1><br>- .6816E+02<br>AT .00<br>MAX < 14><br>- .1392E-27<br>AT .00 |
| <b>SAP90</b> |   |   |



INLET SHAFT, SECTION A - A

POZA HONDA INLET STRUCTURE

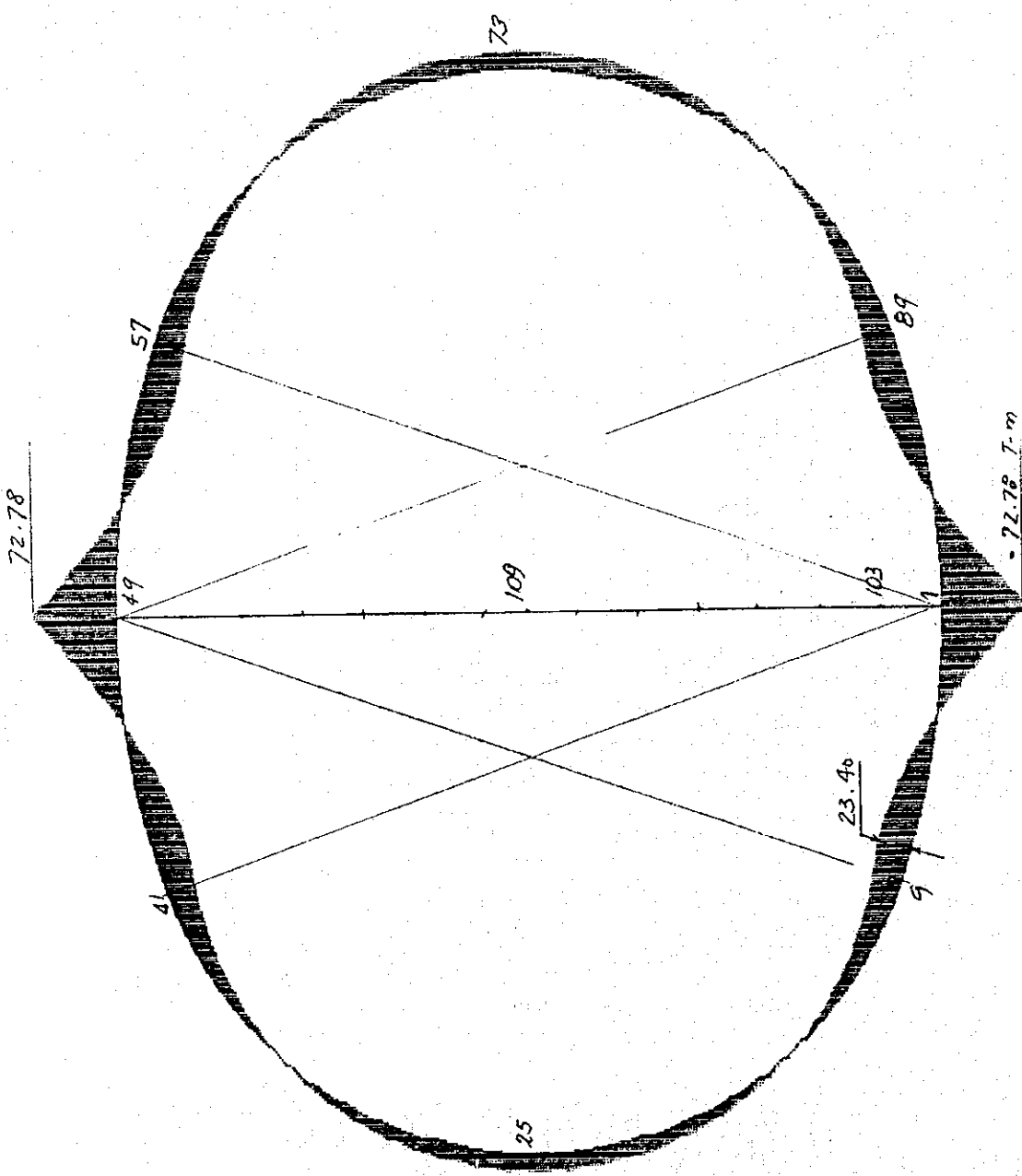
5-120



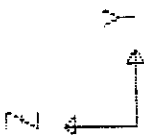
INLET SHAFT, SECTION B - B  
 POZA HONDA INLET STRUCTURE

5-121

POZA HONDA SHAFT SEC. B-B



MOMENT DIAGRAM



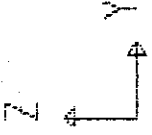
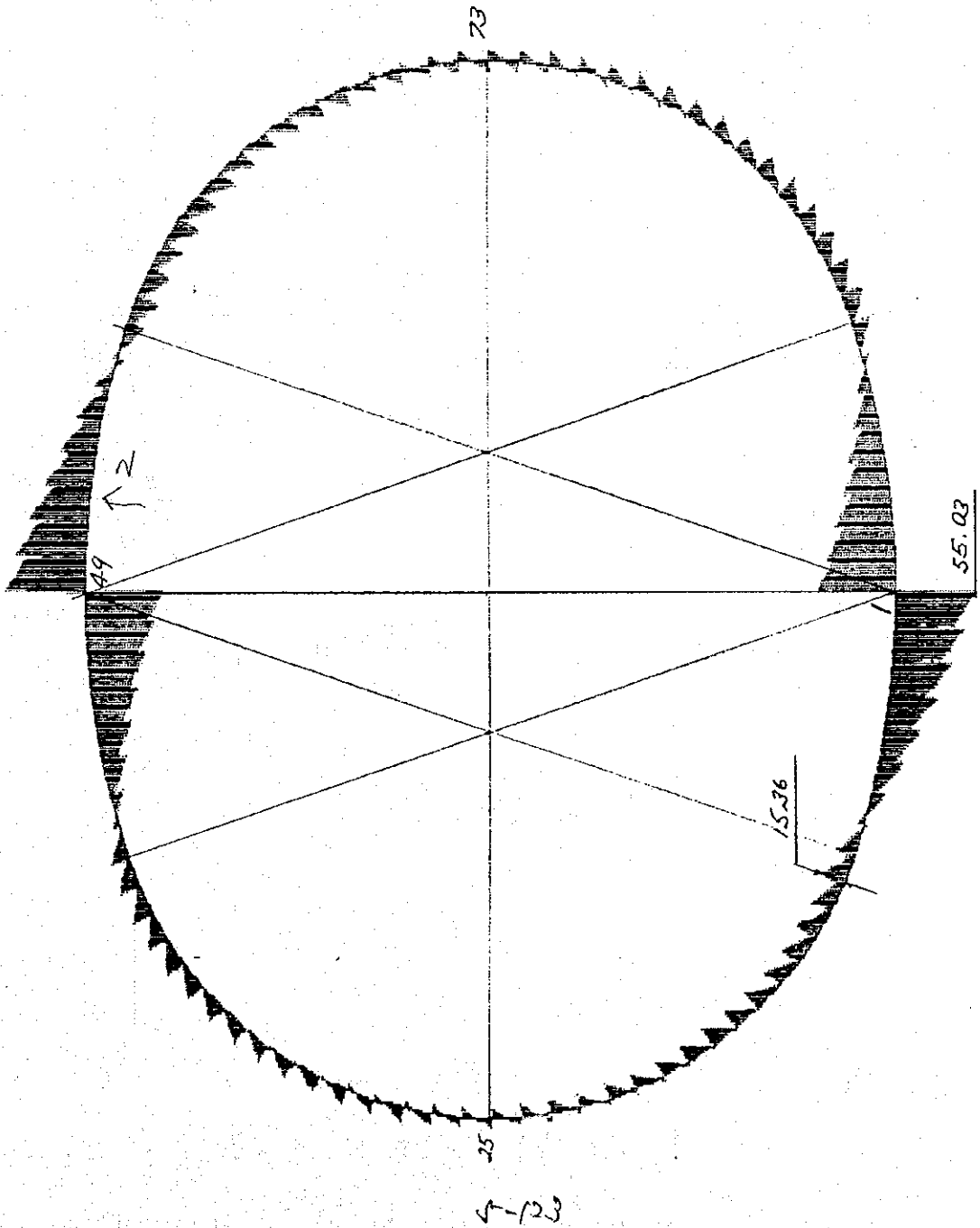
POHDSHA  
 FRAME M33  
 OUTPUT M33  
 LOAD 1

MIN < 96>  
 -.7280E+02  
 AT .58  
 MAX < 90>  
 .2977E+02  
 AT .14

SAP90

5/22

POZA HONDA SHAFT SEC. B-B

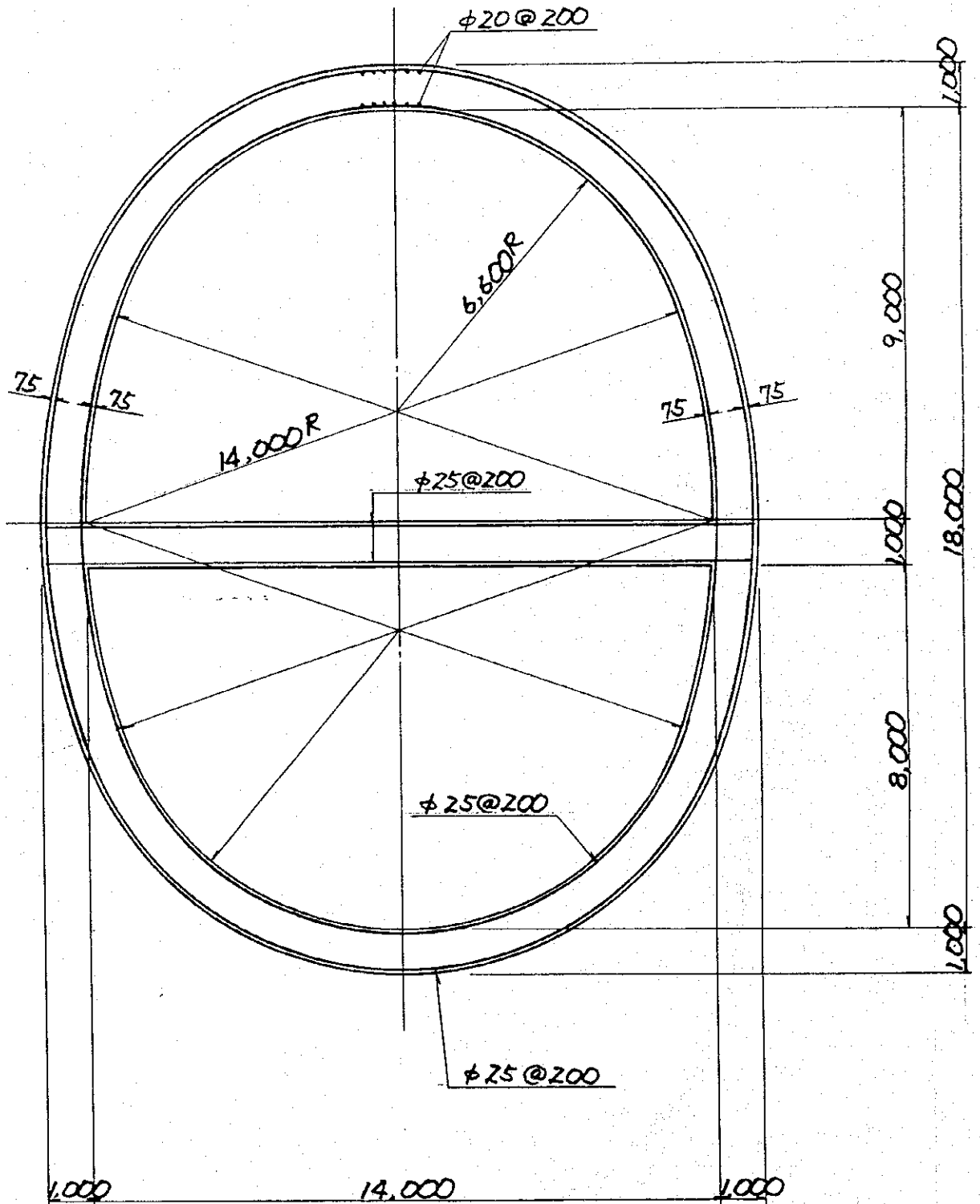


POHOSHA  
 FRAME W22  
 OUTPUT I  
 LOAD I

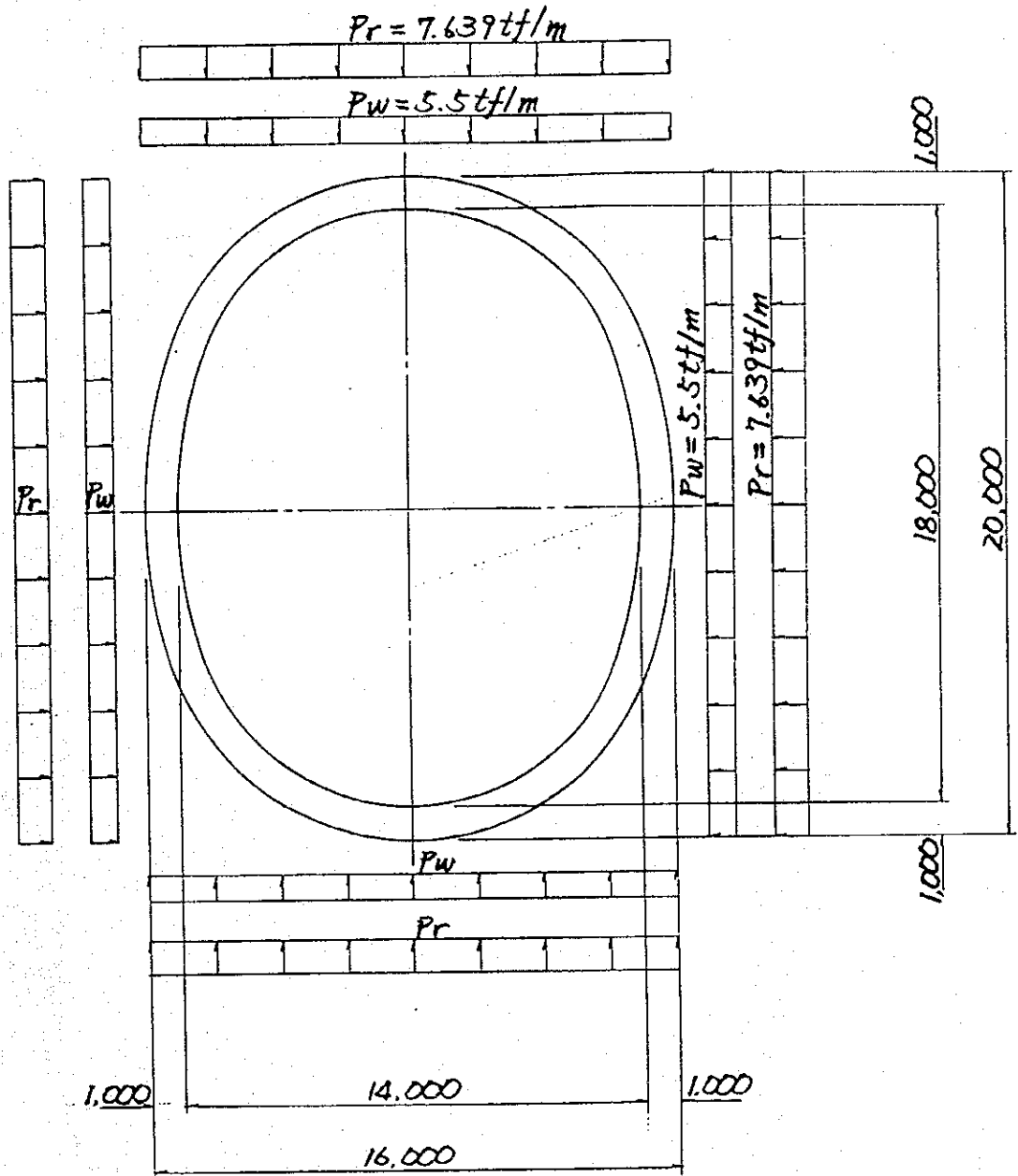
MIN < 96>  
 -.5513E+02  
 AT .58  
 MAX < 49>  
 .5504E+02  
 AT .00

CAPOD

SHEAR DIAGRAM



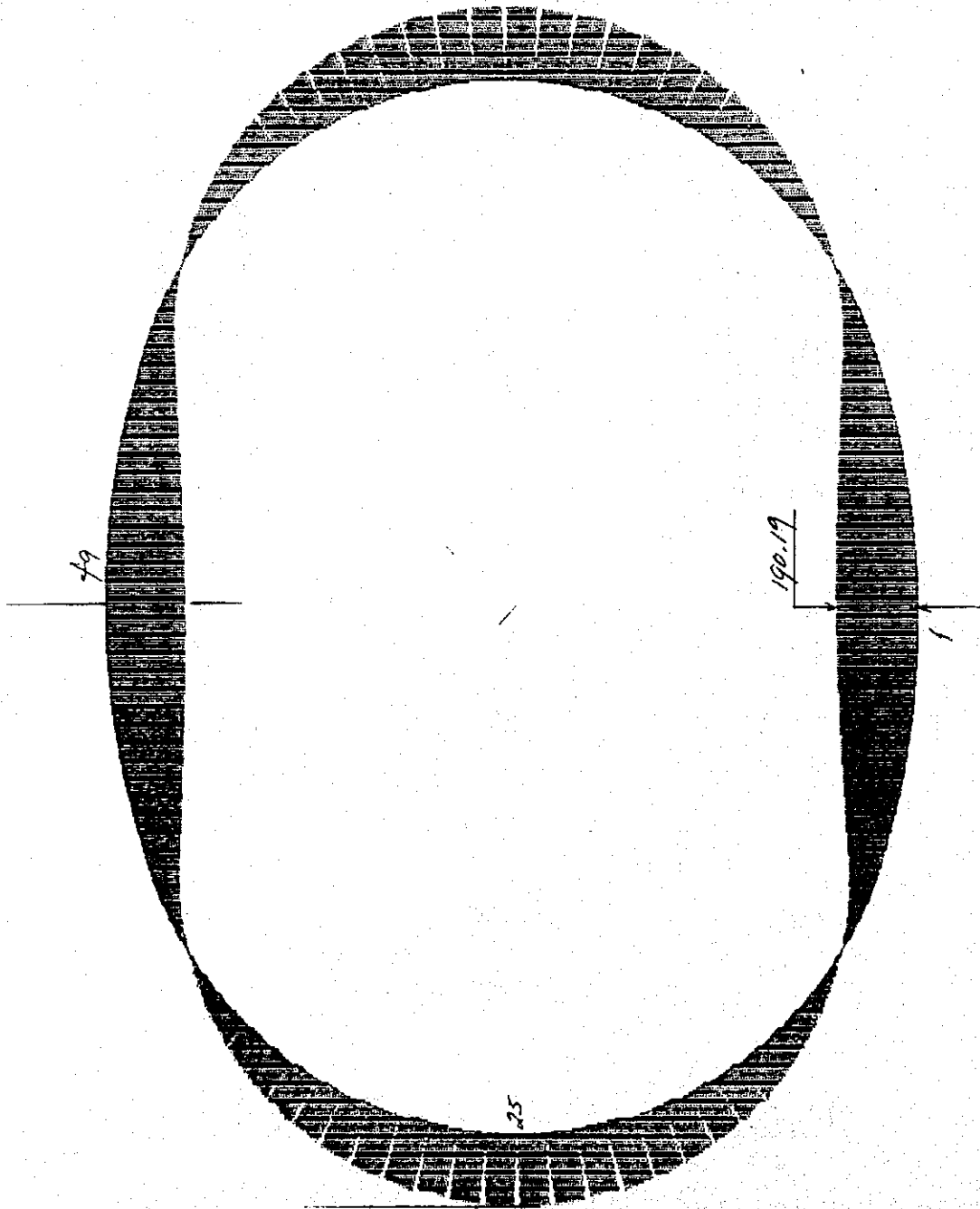
INLET SHAFT, SECTION B - B  
 POZA HONDA INLET STRUCTURE



INLET SHAFT, SECTION C - C

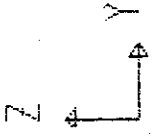
POZA HONDA INLET STRUCTURE

PO2A HOODA SHAFT SEC. C-C



92-5 170.46

SHAFT DIAGRAM



POHOSH

FRAME

OUTPUT

LOAD

M33

1

MIN < 72>

- .1705E+03

AT .51

MAX < 48>

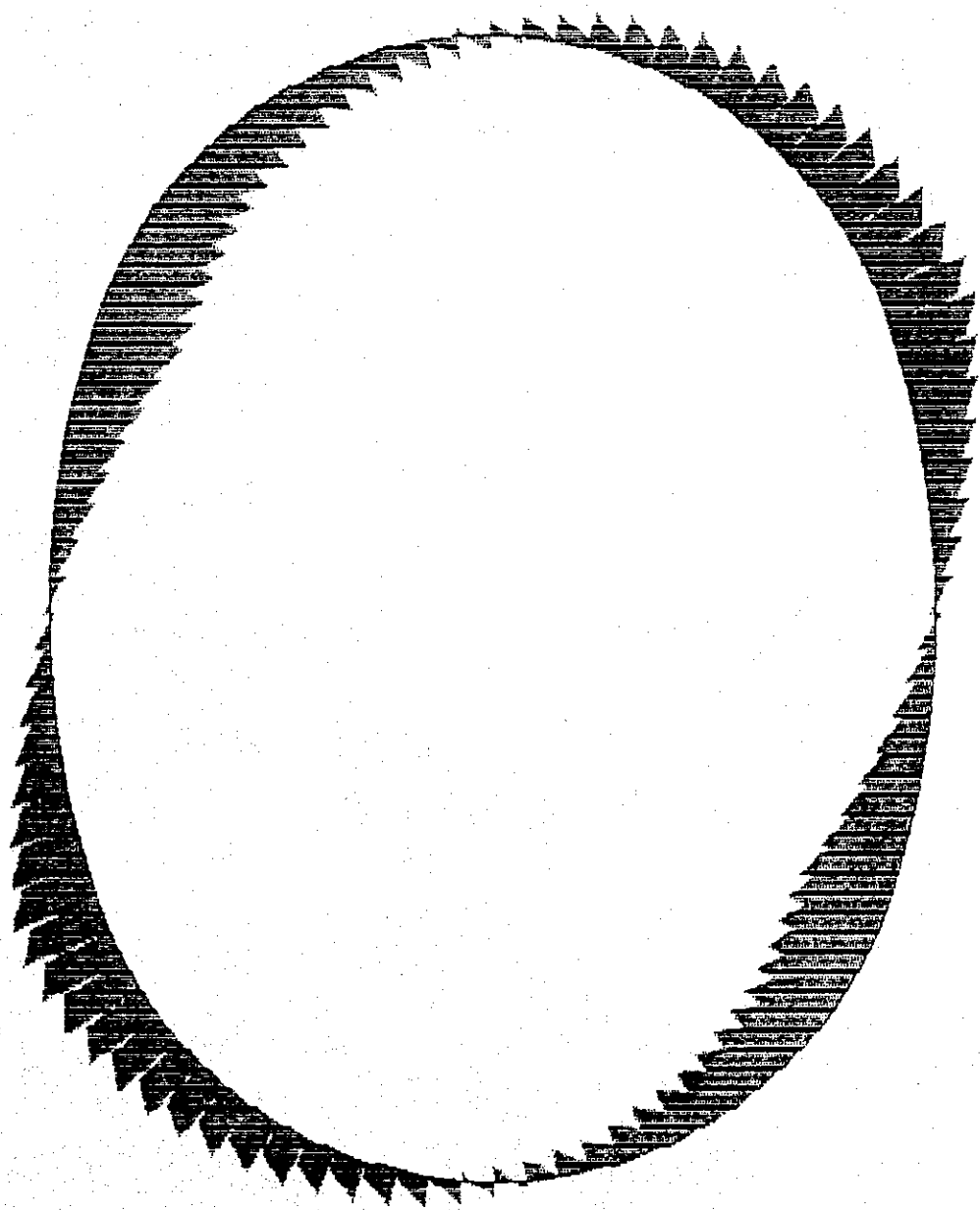
.1904E+03

AT .43

SAP90

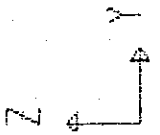


== PO24 HUBBARD SHAFT SEC. C-C



5-127

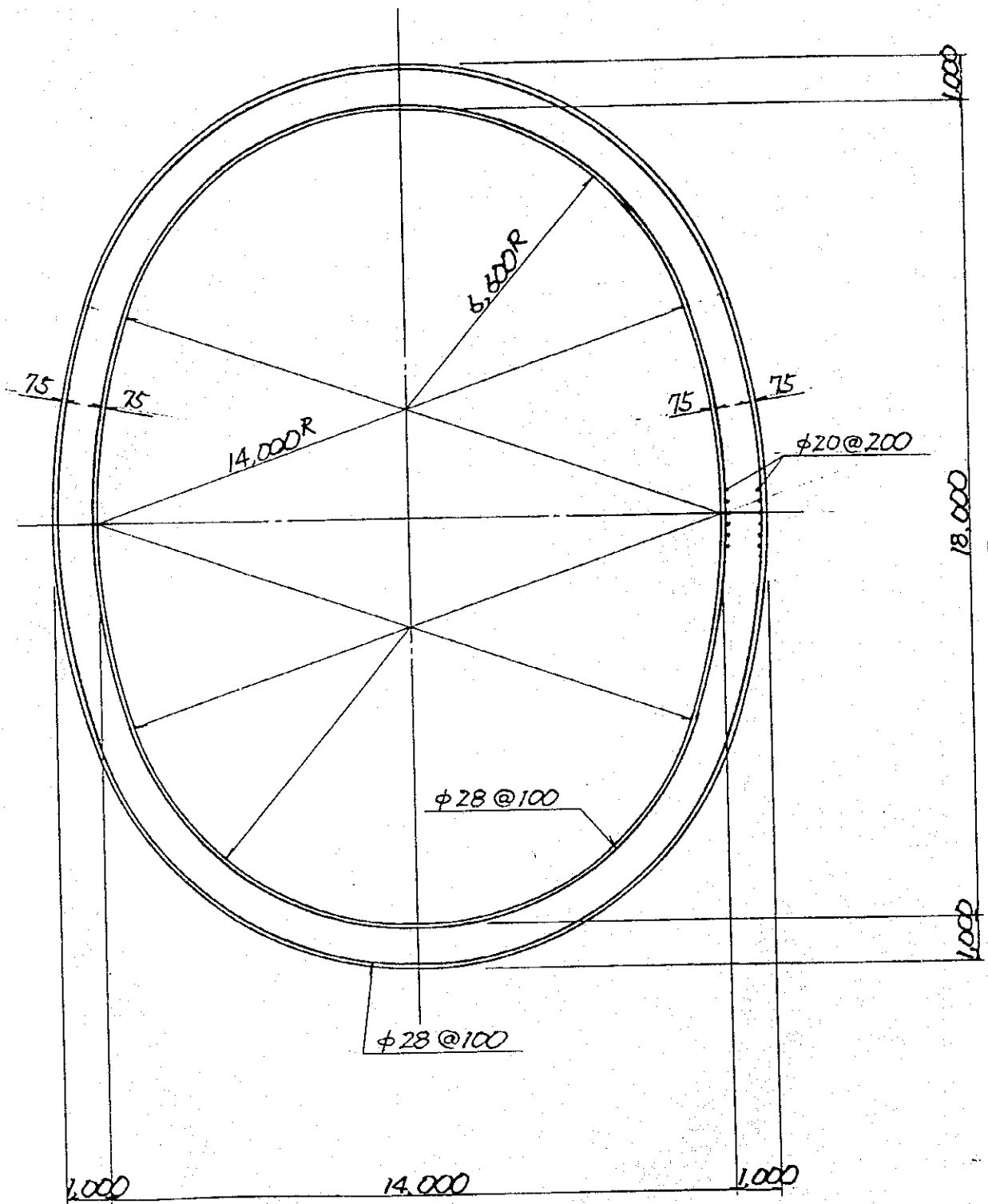
SHEAR DIAGRAM



POHOSH  
FRAME  
OUTPUT V22  
LOAD 1

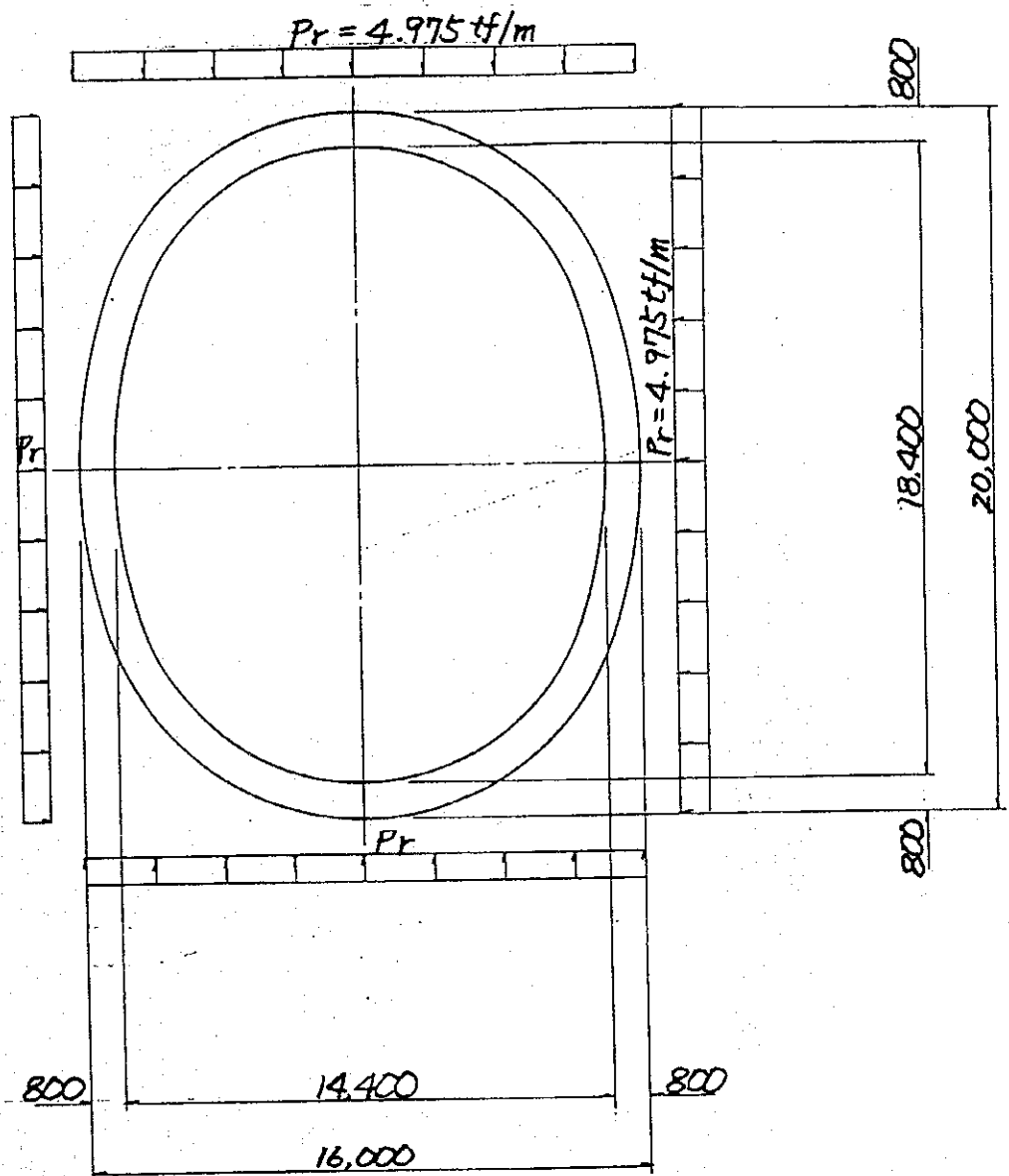
MIN < 9  
-5635E+02  
AT .51  
MAX < 88  
.5622E+02  
AT .00

SAP90



INLET SHAFT, SECTION C - C

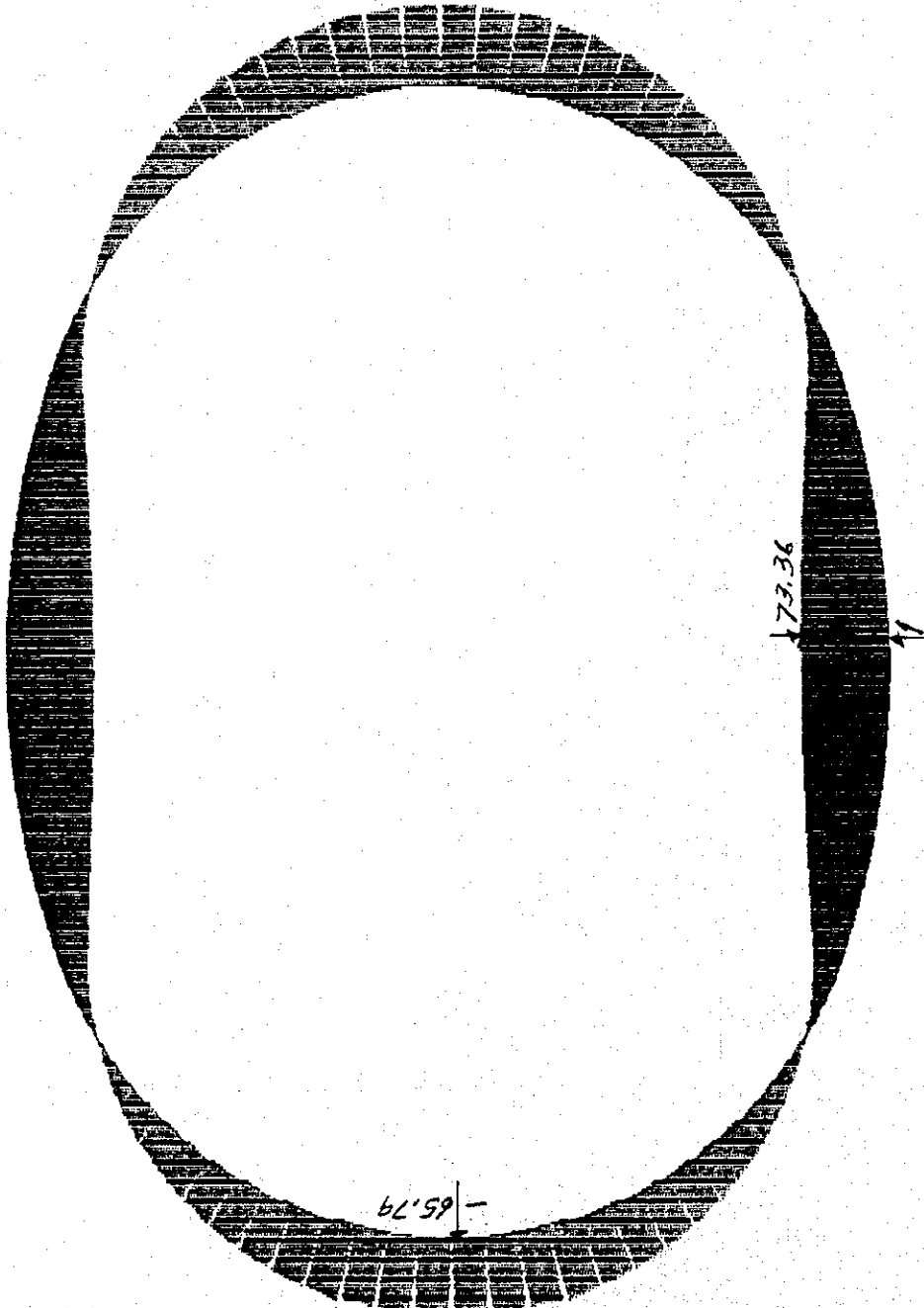
POZA HONDA INLET STRUCTURE



INLET SHAFT, SECTION D - D

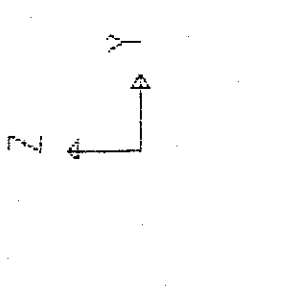
POZA HONDA INLET STRUCTURE

POZA HODDA SHAFT SEC. D-D



6-130

MOMENT DIAGRAM

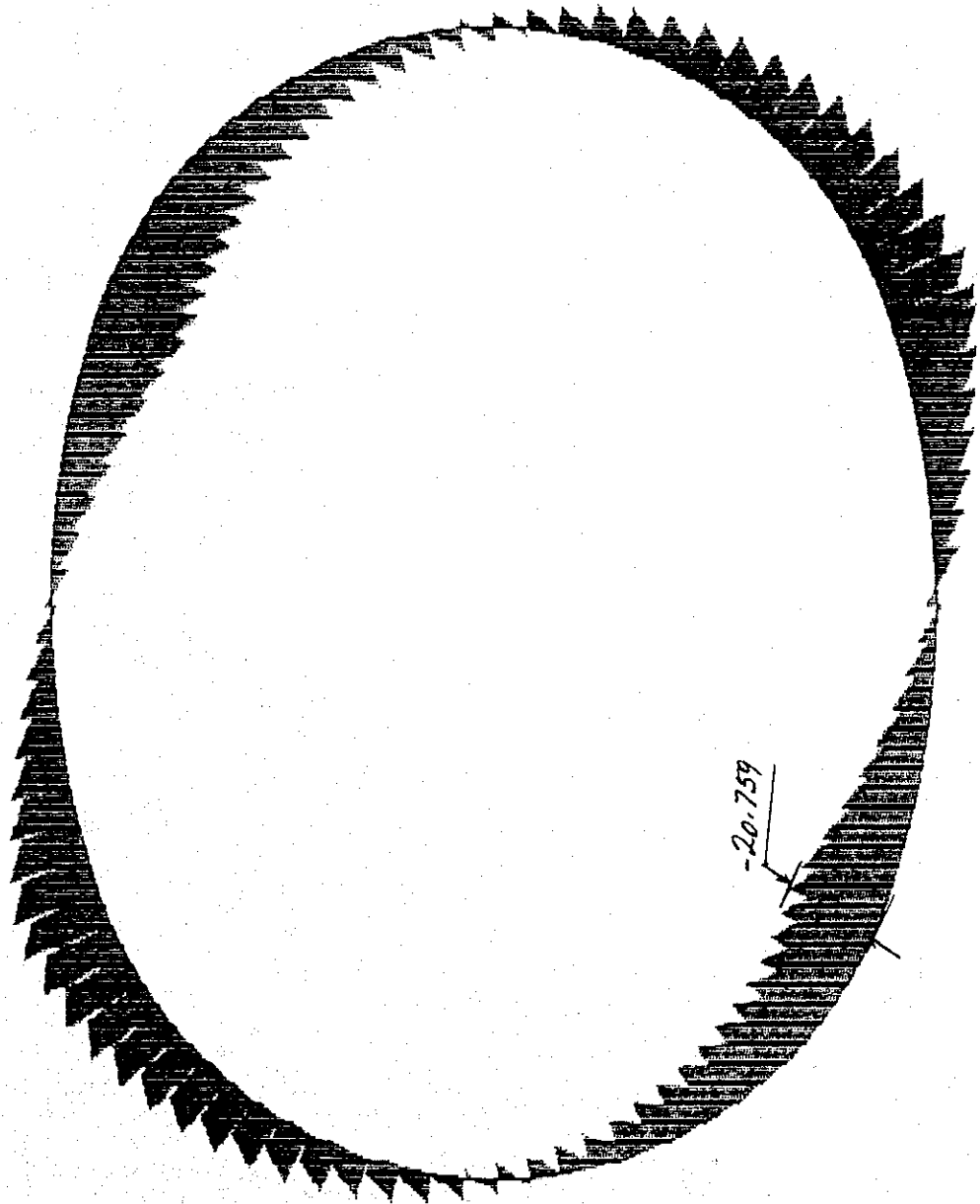


PUNCH  
FRAME M83  
OUTPUT M83  
LOAD 1

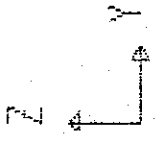
MIN < 72  
-6581E+02  
AT .52  
MAX < 96  
.7362E+02  
AT .67

SAP90

POZA HONDA SHAFT SEC. D-D



✓-131



POHOSHIC

FRAME

OUTPUT

LOAD

V22

1

MIN < .9 >

-.2138E+02

AT .52

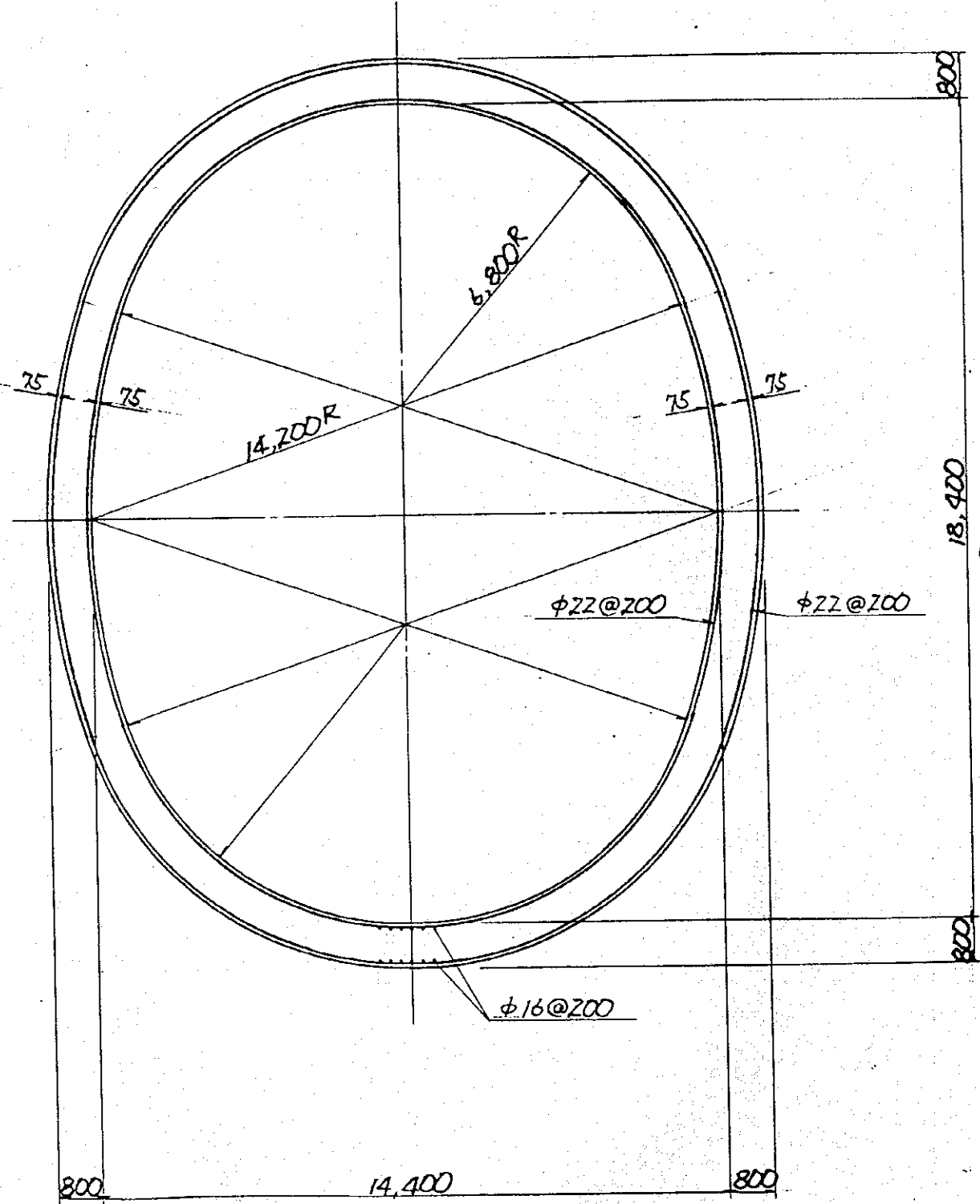
MAX < 40 >

.2139E+02

AT .00

CAEJOB

SHEAR DIAGRAM



INLET SHAFT, SECTION D - D

POZA HONDA INLET STRUCTURE

(D) Inlet Tunnel

Case 1 : After Construction

- 1) Dead weight of lining concrete

$$W_c = 0.50 \times 2.4 = 1.20 \text{ tf/m}$$

- 2) Vertical bedrock pressure

$$P_r = 2.0 \times 18.3 + (2.0 - 1.0) \times 1.2 = 37.8 \text{ tf/m}$$

- 3) Lateral bedrock pressure

$$K_a = \tan^2(45 - 30/2) = 0.333$$

$$P_{rh1} = 0.333 \times 2.0 \times 18.3 + 0.333 \times (2.0 - 1.0) \times 1.2 = 12.587 \text{ tf/m tf/m}$$

$$P_{rh2} = 0.333 \times 2.0 \times 18.3 + 0.333 \times (2.0 - 1.0) \times 4.7 = 13.753 \text{ tf/m}$$

Case 2 : During Construction

- 1) Dead weight of lining concrete

$$W_c = 0.50 \times 2.4 = 1.20 \text{ tf/m}$$

- 2) Vertical bedrock pressure and backfill grout pressure

$$P_r = 2.0 \times 19.5 = 39.0 \text{ tf/m}$$

$$P_g = 15.0 \text{ tf/m}$$

- 3) Lateral bedrock pressure water pressure

$$K_a = \tan^2(45 - 30/2) = 0.333$$

$$P_{rh1} = 0.333 \times 2.0 \times 19.5 = 12.987 \text{ tf/m tf/m}$$

$$P_{rh2} = 0.333 \times 2.0 \times 19.5 + 0.333 \times (2.0 - 1.0) \times 3.5 = 14.153 \text{ tf/m}$$

$$P_w = 1.0 \times 3.5 = 3.5 \text{ tf/m}$$

- 4) Uplift pressure

$$P_u = 1.0 \times 3.5 = 3.5 \text{ tf/m}$$

5-123

EL. 112.3

Unit weight of bedrock  
 $\gamma = 1.8 \text{ tf/m}^3$   
 $\phi = 30^\circ$

19.500

$P_{rv} = 37.8 \text{ tf/m}$

M.W.L. 94.000

$P_{rh1}$

$P_{rh1} = 12.587 \text{ tf/m}$

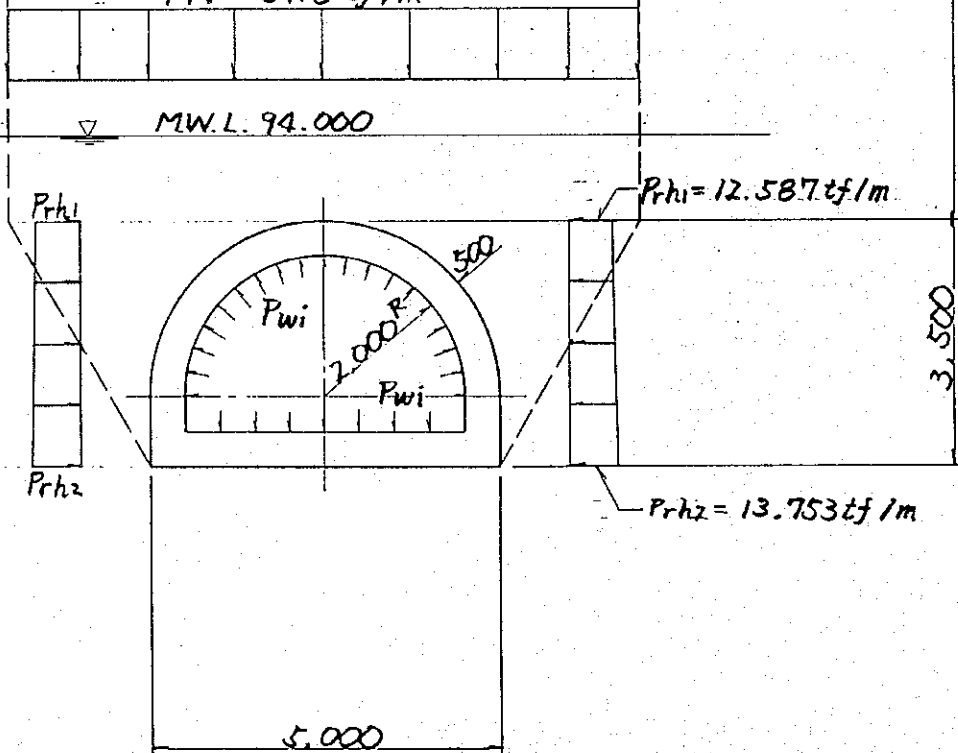
$P_{rh2}$

$P_{rh2} = 13.753 \text{ tf/m}$

3.500

5.000

INLET TUNNEL, CASE 1  
POZA HONDA INET STRUCTURE





EL. 112.3

Unit weight of bedrock  
 $\gamma = 1.8 \text{ tf/m}^3$   
 $\phi = 30^\circ$

19.500

$P_{rv} = 38.2 \text{ tf/m}$

$P_g = 15 \text{ tf/m}$

$P_{rh1}$

$P_{rh1} = 12.721 \text{ tf/m}$

$P_w$

$P_{rh2}$

$P_u = 3.5 \text{ tf/m}$

$P_w = 3.5 \text{ tf/m}$

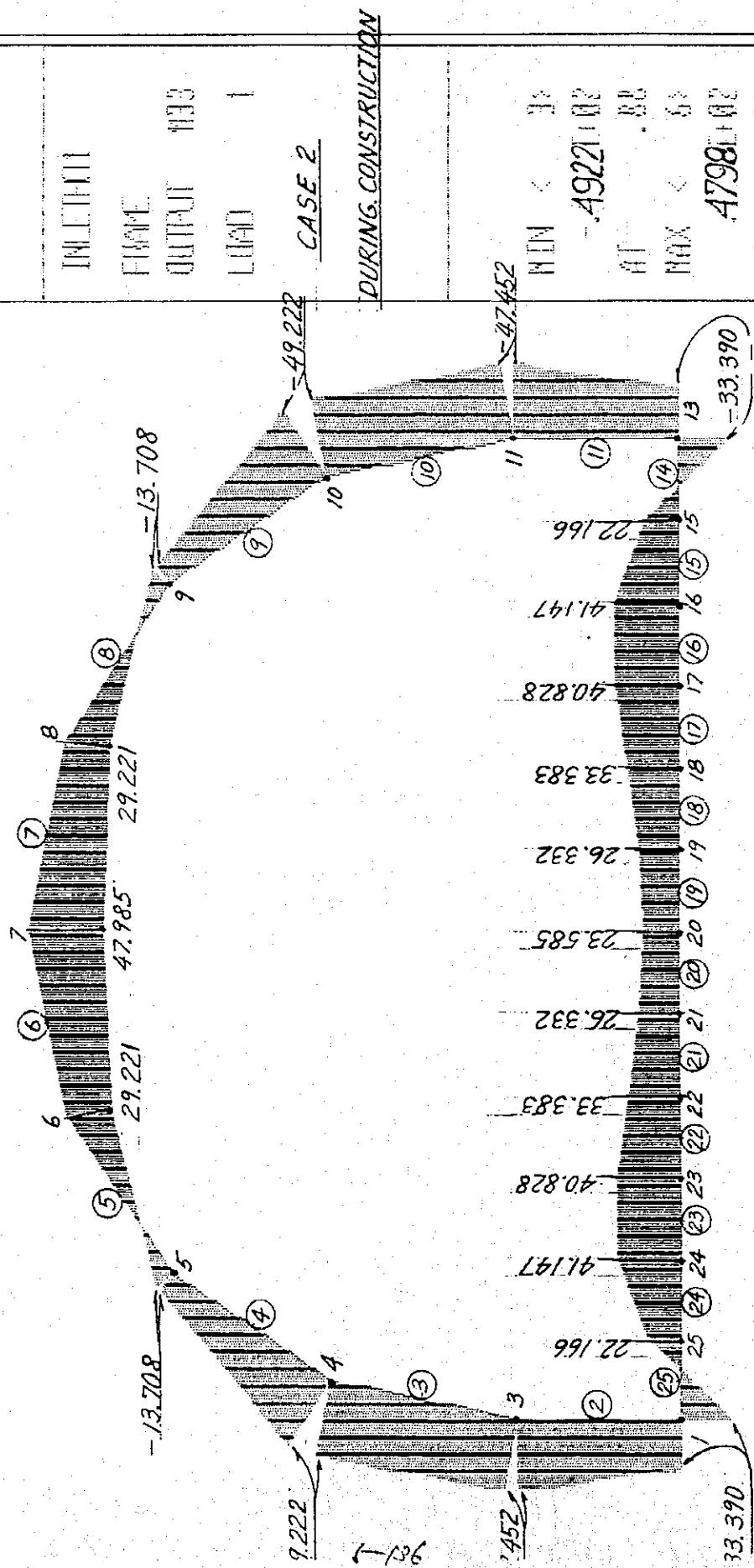
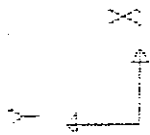
$P_{rh2} = 13.886 \text{ tf/m}$

5.000

3.500

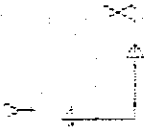
INLET TUNNEL, CASE 2

POZA HONDA INLET STRICTIIDE



BENDING MOMENT (t.m/m)

54190



INLET/PI

FRAME

OUTPUT VZ2

LOAD 1

CASE 2

DURING CONSTRUCTION

MIN < 263

AT 14951.03

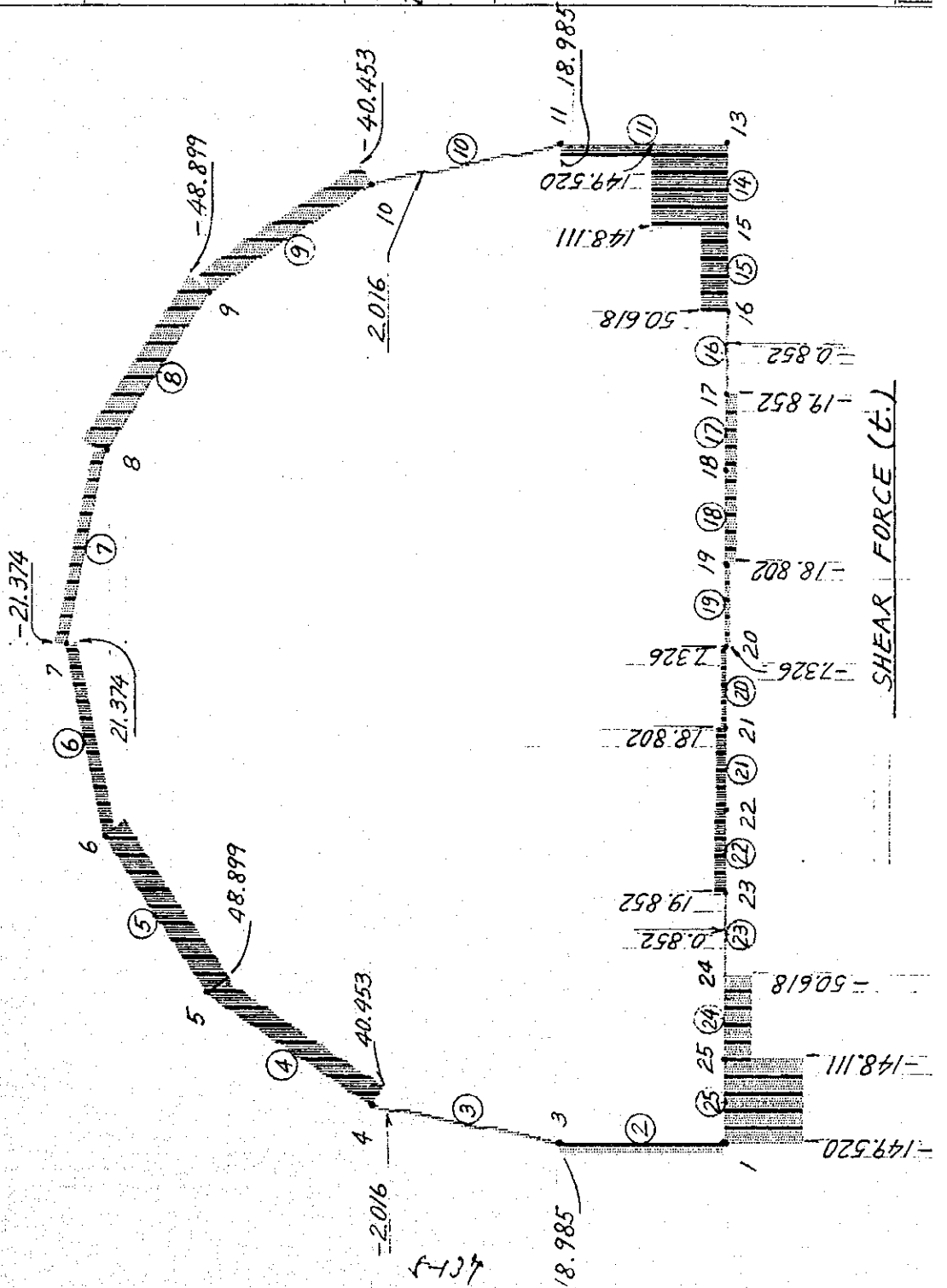
MAX < 133

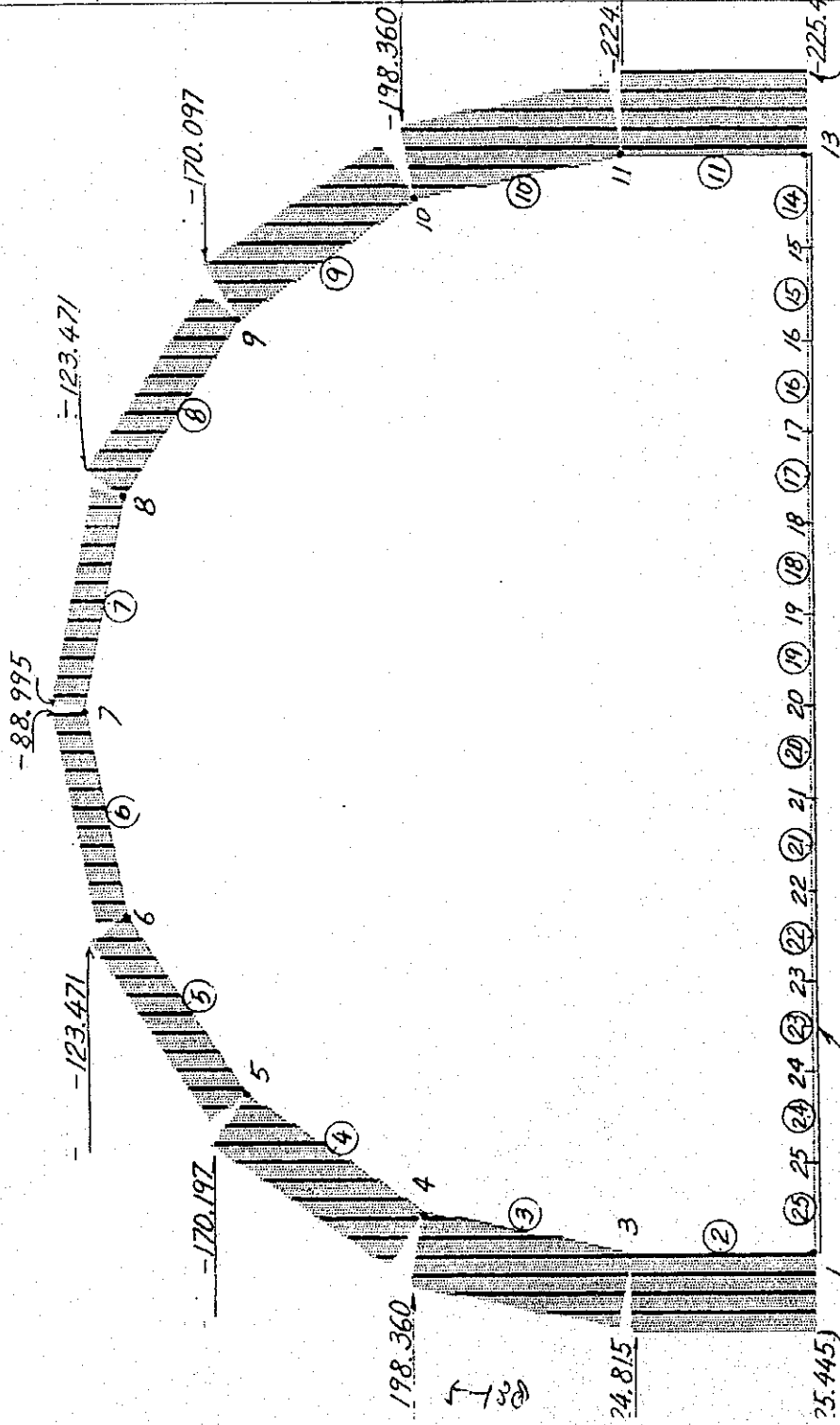
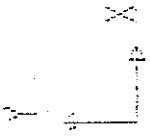
AT 14951.03

MIN < 263

AT 14951.03

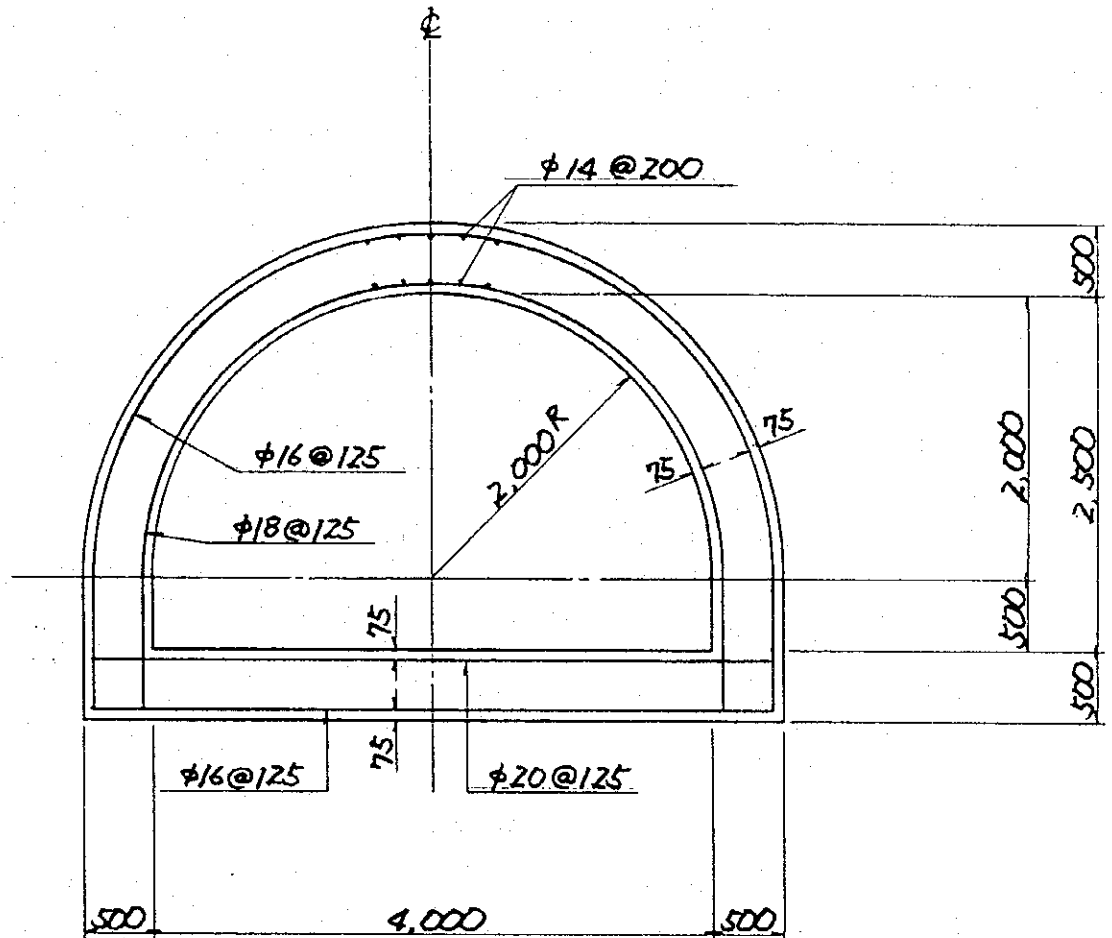
CATION





AXIAL FORCE (t)

SAP90



INLET TUNNEL

POZA HONDA INLET STRUCTURE

## (6) Mancha Grande Outlet

Case 1 : After construction

1) Dead weight of lining concrete

$$W_c = 0.5 \times 2.4 = 1.2 \text{ tf/m}$$

2) Vertical bedrock pressure

$$P_r = 2.0 \times 12.0 = 24.0 \text{ tf/m}$$

3) Lateral bedrock pressure and water pressure

$$K_a = \tan^2(45 - 30/2) = 0.333$$

$$P_{rh1} = 0.333 \times 2.0 \times 12.0 = 7.992 \text{ tf/m}$$

$$P_{rh2} = 0.333 \times 2.0 \times 12.0 + 0.333 \times (2.0 - 1.8) \times 3.5 = 9.158 \text{ tf/m}$$

$$P_w = 1.0 \times 3.266 = 3.266 \text{ tf/m}$$

4) Uplift pressure and foundation reaction

$$P_u = 1.0 \times 3.266 = 3.266 \text{ tf/m}$$

$$P_f = (24.0 \times 3.5 + 13.805)/3.5 - 3.266 = 24.678 \text{ tf/m}$$

Case 2 : During construction

1) Dead weight of lining concrete

$$W_c = 0.5 \times 2.4 = 1.2 \text{ tf/m}$$

2) Vertical bedrock pressure and backfill grout pressure

$$P_r = 2.0 \times 12.0 = 24.0 \text{ tf/m}$$

$$P_g = 15.0 \text{ tf/m}$$

3) Lateral bedrock pressure

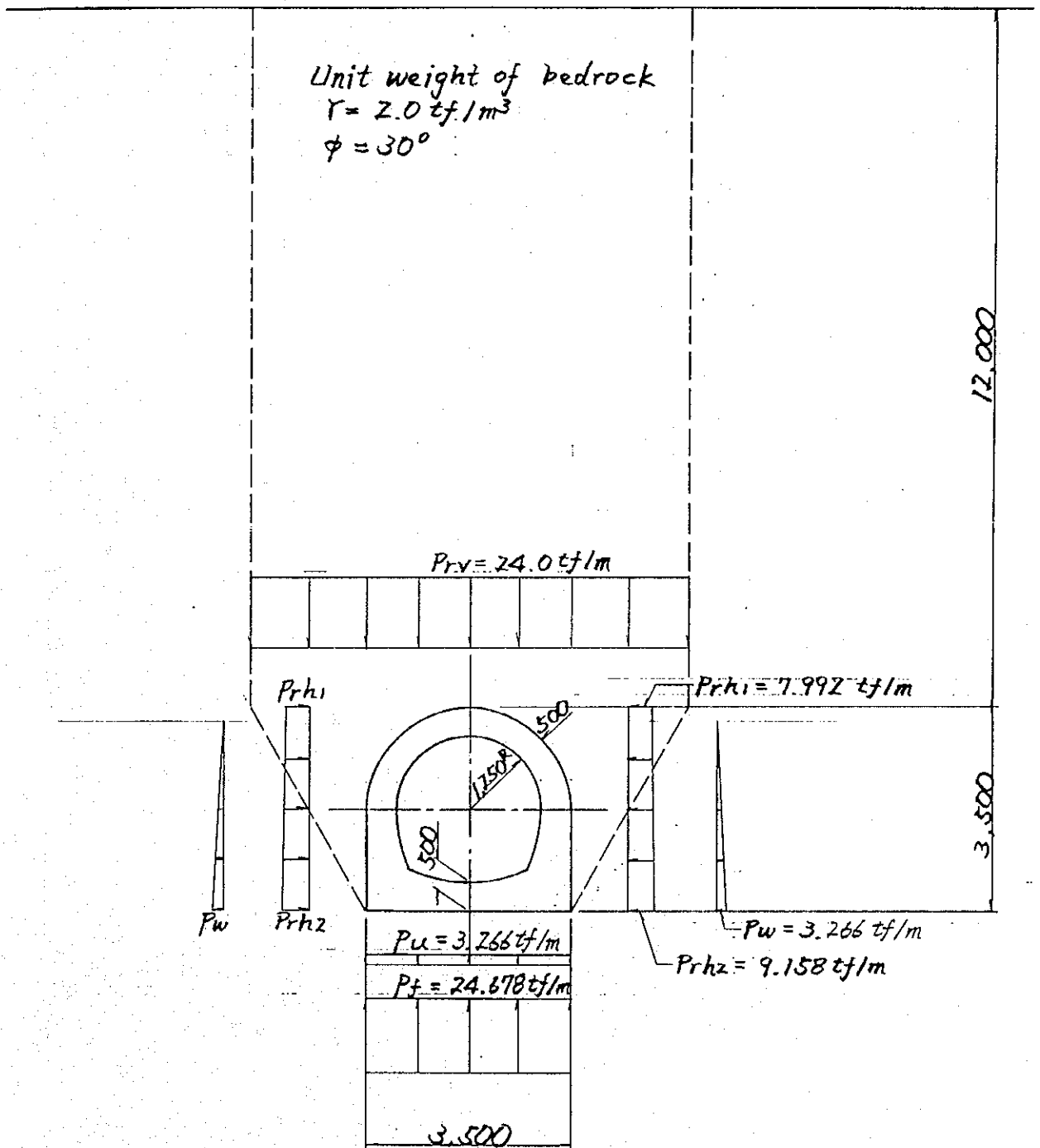
$$K_a = \tan^2(45 - 30/2) = 0.333$$

$$P_{rh1} = 0.333 \times 2.0 \times 12.0 = 7.992 \text{ tf/m}$$

$$P_{rh2} = 0.333 \times 2.0 \times 15.5 = 10.323 \text{ tf/m}$$

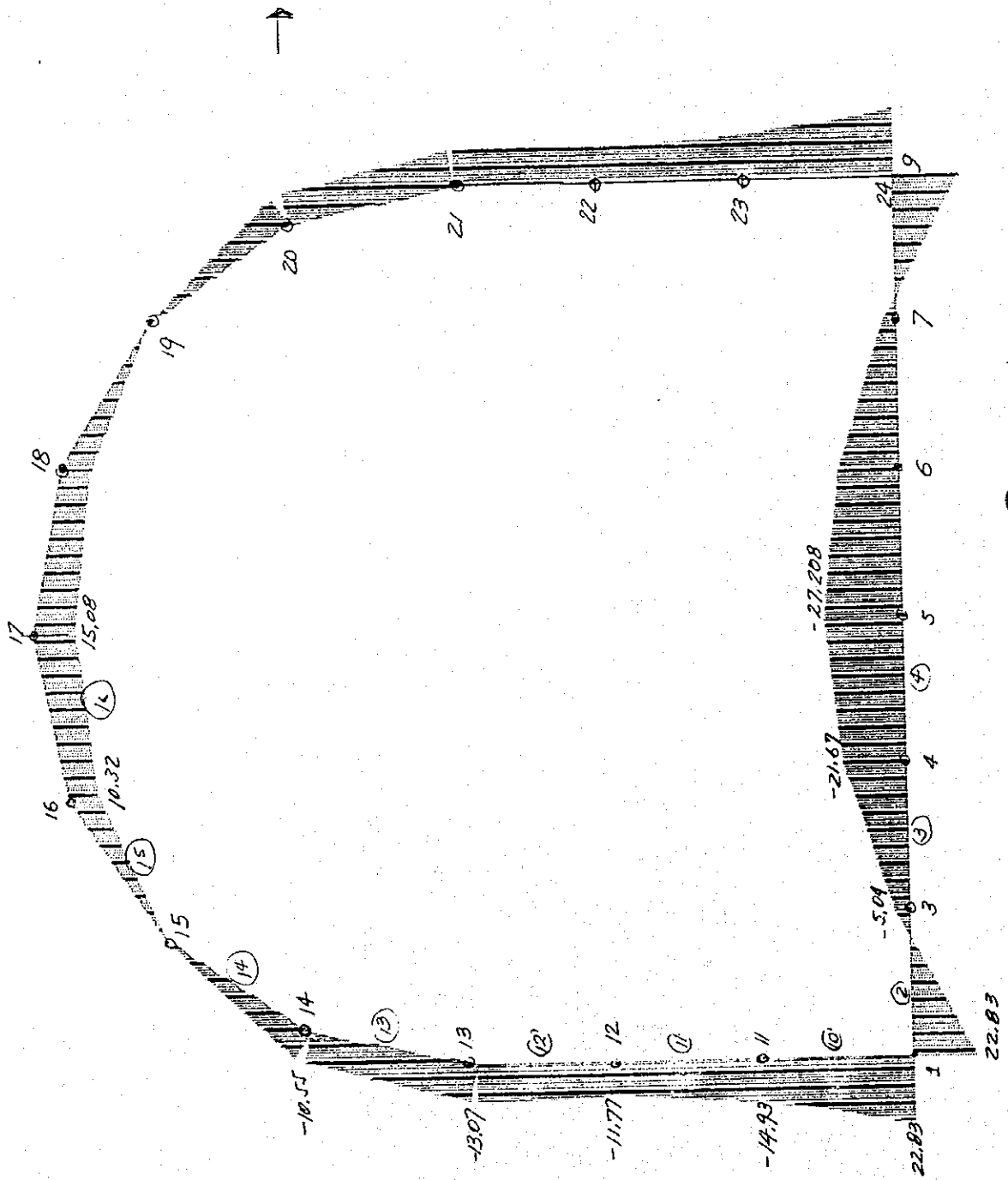
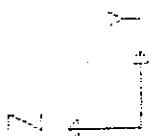
4) Foundation reaction

$$P_f = (24.0 \times 3.5 + 15.0 \times 3.5 + 13.805)/3.5 = 42.944 \text{ tf/m}$$



MANCHA GRANDE OUTLET, CASE 1  
 POZA HONDA ~ MANCHA GRANDE TUNNEL

MANCHA GRANDE OULET CAS. 1  
(MOMENT DIAGRAM)



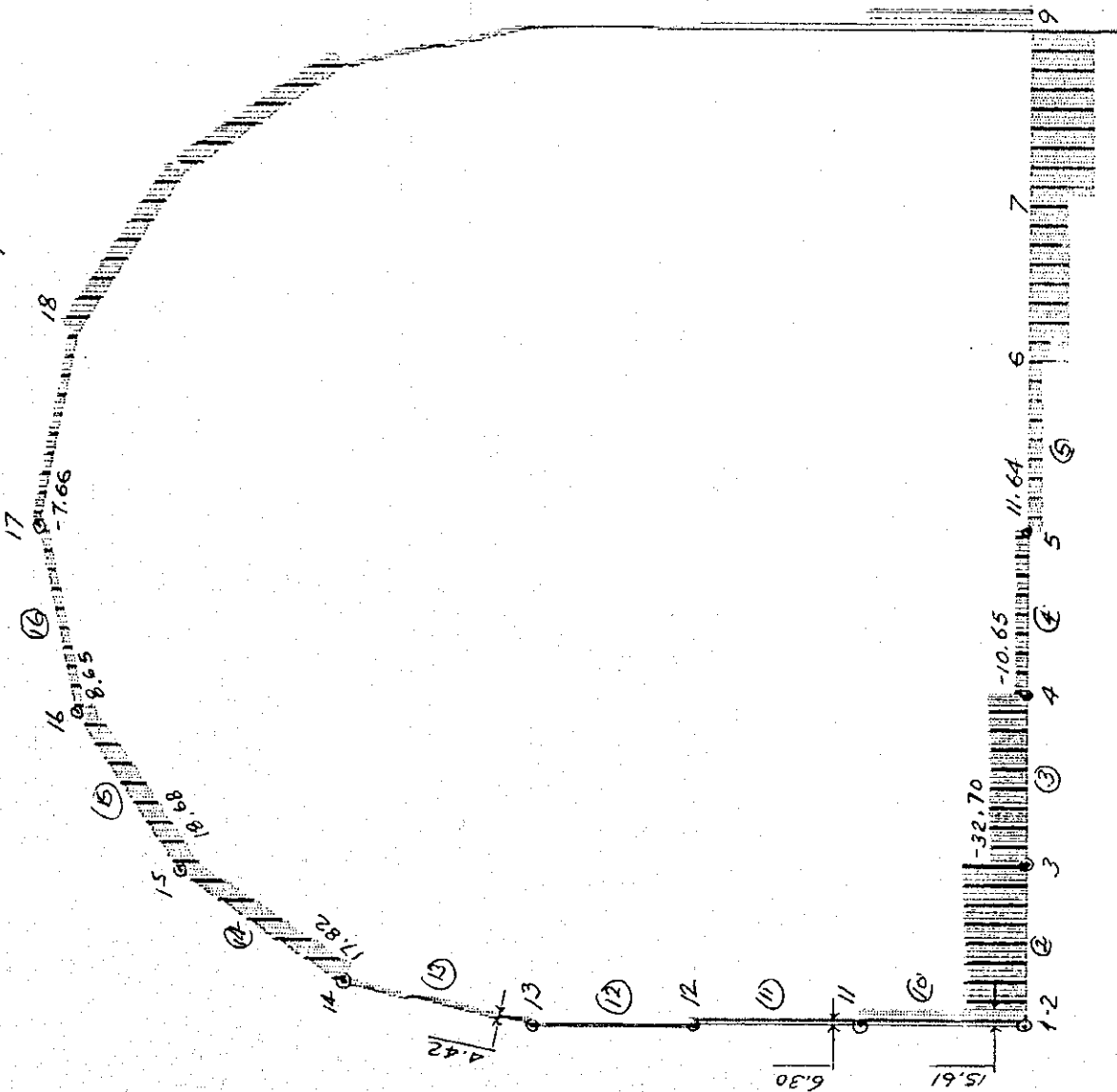
MANCHA  
FRAME  
OUTPUT 1133  
LOAD 1

MIN < 0  
- .23451-02  
AT .01  
MAX < 4  
.27211-02  
AT .50

SAP80



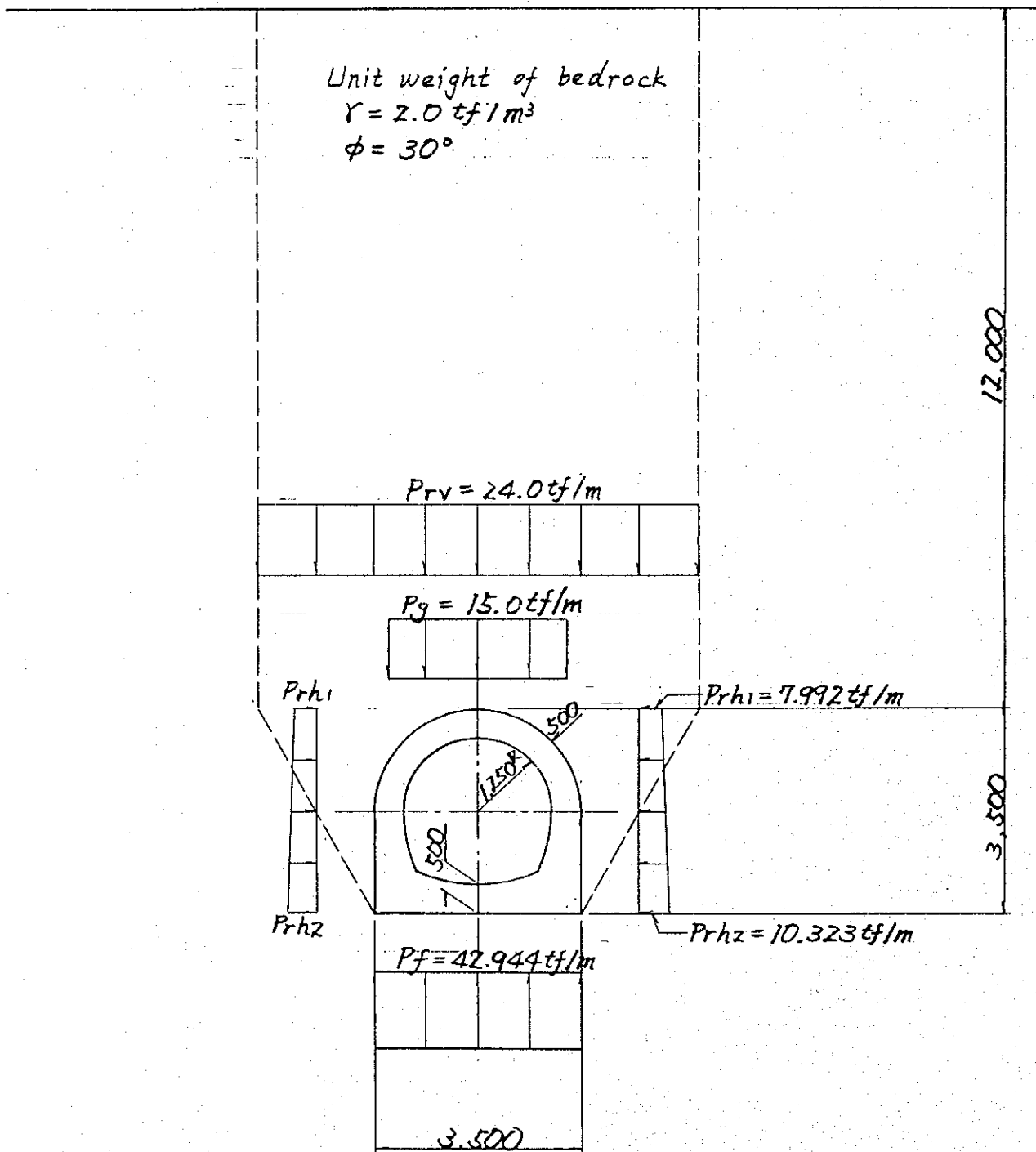
MANCHA GRANDE OUTLET CAS. 1  
 ( SHEAR DIAGRAM )



MANCHA GRANDE  
 CAS. 1  
 SHEAR DIAGRAM

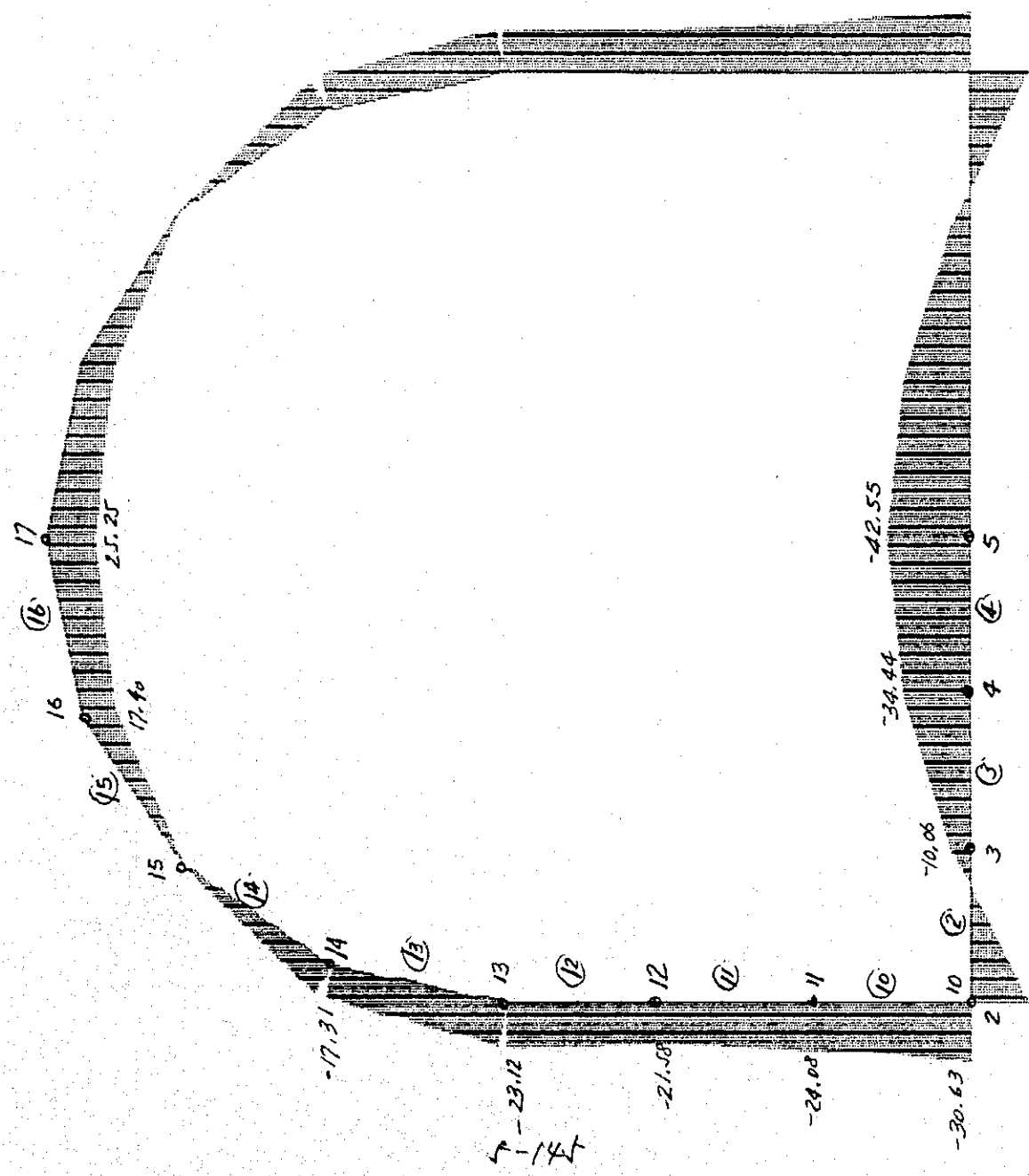
MIN : 32.70  
 MAX : 11.64  
 AT : 10  
 BAR : 1  
 AT : 10

06/19/90



MANCHA GRANDE OUTLET, CASE 2  
 POZA HONDA ~ MANCHA GRANDE TUNNEL

MANCHA GRANDE OUTLET  
CASE 2



MOMENT DIAGRAM



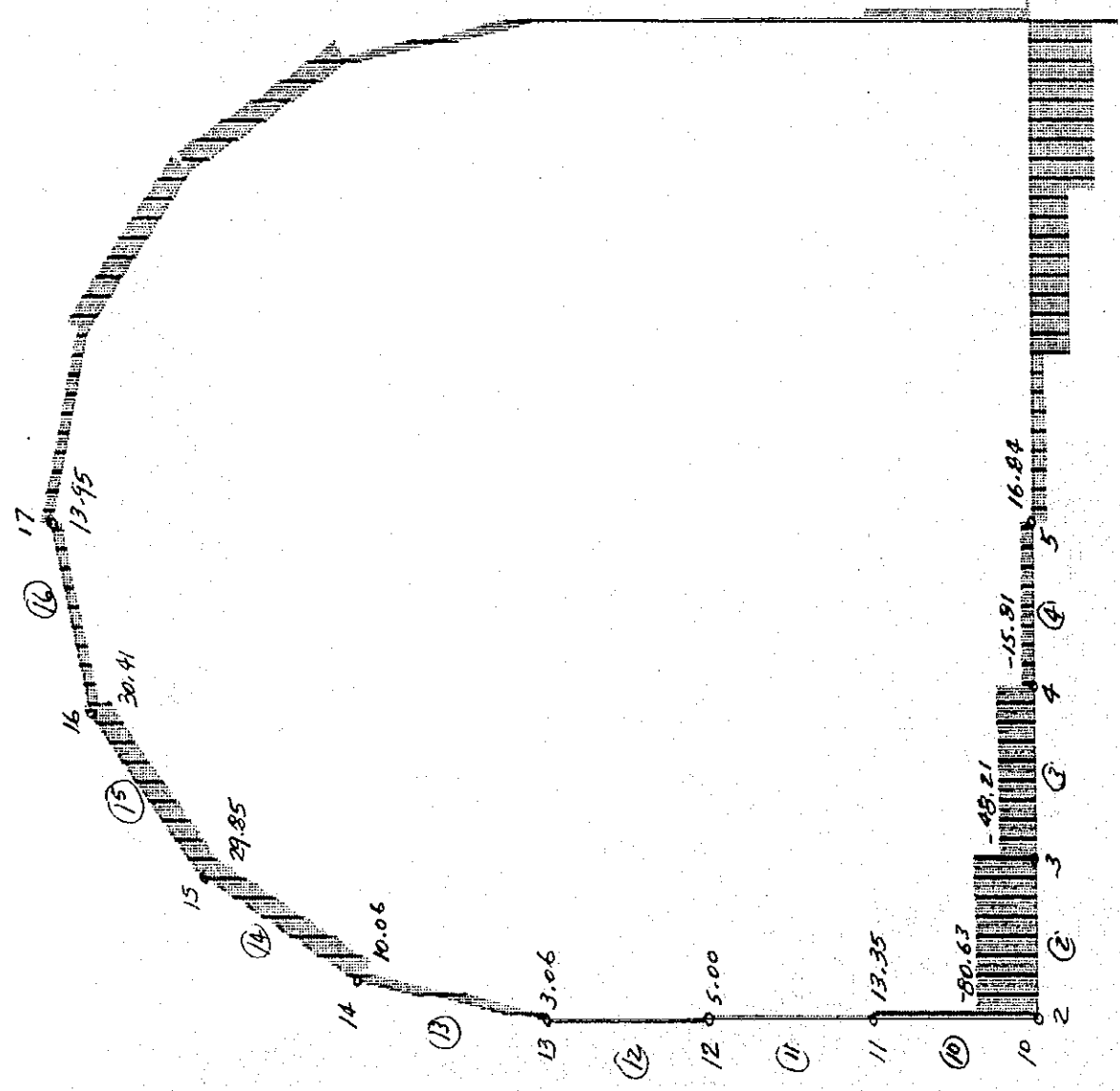
MANCHA02  
FRAME  
OUTPUT 183  
LOAD 1

MIN < 43  
-42561+02  
AT .50  
MAX < 83  
.3114E+02  
AT .01

SAP90

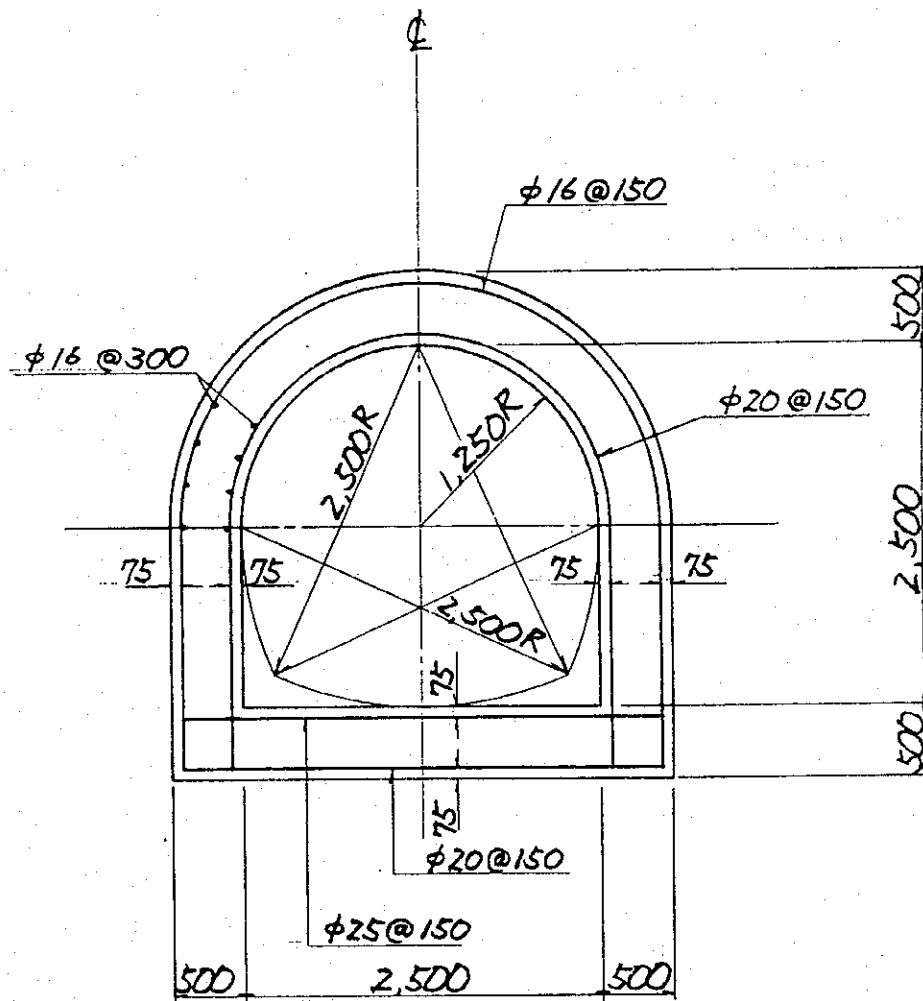
MANCHA GRANDE QUICCI  
CASE 2

|  |     |
|--|-----|
|  |     |
| MANCHA2  |     |
| FRAME  | V22 |
| OUTPUT   |     |
| LOAD   | 1   |
| MIN < .01<br>AT .1141E+03<br>MAX < .01<br>AT .1143E+03<br>AT .00 |     |
| SAP90  |     |



SHEAR DIAGRAM

5-146



MANCHA GRANDE OUTLET (TRANSITION)  
 POZA HONDA ~ MANCHA GRANDE TUNNEL

(B) Pozo de Entrada

**Pozo de Entrada, Sección A - A**

Caso 1: Después de la construcción

- 1) Presión lateral del agua

$$P_w = 1,0 \times (\text{El. } 80,0 - \text{El. } 56,63) = 23,37 \text{ tf/m}$$

- 2) Presión lateral de la roca

$$K_a = \tan^2(45 - 40/2) = 0,217$$

$$P_r = 0,217 \times (1,8 - 1,0) \times 8,3 = 1,44 \text{ tf/m}$$

**Pozo de Entrada, Sección B - B**

Caso 1: Después de la construcción

- 1) Presión lateral del agua

$$P_w = 1,0 \times (\text{El. } 80,0 - \text{El. } 71,00) = 9,0 \text{ tf/m}$$

- 2) Presión lateral de la roca

$$K_a = \tan^2(45 - 40/2) = 0,217$$

$$P_r = 0,217 \times 1,8 \times 10,00 + 0,217 \times (1,8 - 1,0) \times 9,0 = 5,468 \text{ tf/m}$$

**Pozo de Entrada, Sección C - C**

Caso 1: Después de la construcción

- 1) Presión lateral del agua

$$P_w = 1,0 \times (\text{El. } 80,0 - \text{El. } 74,0) = 6,0 \text{ tf/m}$$

- 2) Presión lateral de la roca

$$K_a = \tan^2(45 - 40/2) = 0,217$$

$$P_r = 0,217 \times 1,8 \times 10,0 + 0,217 \times (1,8 - 1,0) \times 6,0 = 4,948 \text{ tf/m}$$

**Pozo de Entrada, Sección D - D**

Caso 1: Después de la construcción

- 1) Presión lateral de la roca

$$K_a = \tan^2(45 - 40/2) = 0,217$$

$$P_r = 0,217 \times 1,8 \times 8,0 = 3,125 \text{ tf/m}$$