

2.1 Asin Pumping Station

2.1.3 Stress Analysis of Gate

Name of Structure	Asin Gate	Category of calculation	Stress Analysis	Page	1 / 116
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Stress Analysis was done at following part of gate.

1. Gate frame
2. Pier & Footing
3. O/M Bridge (refer to the results of Baru Gate)

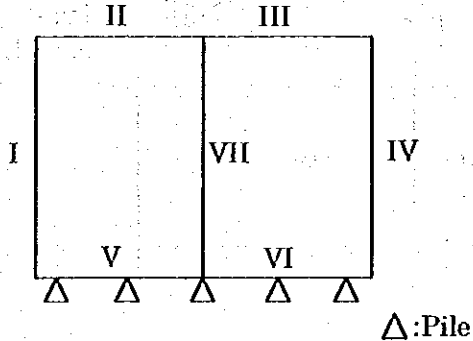
General characteristics of material are as follows:

- Young's module of reinforced concrete:
245,000 kgf/cm² = 2.45 tf/m²
- Unit weight of reinforced concrete:
2.5 t/m³
- Linear expansion coefficient:
1.0 x 10⁻⁵

1. Gate frame

Following two cases were analyzed.

Case-A (model for front view of gate)



△:Pile

Case-B (model for side view of gate)

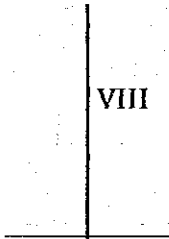


Figure-1 Analyzed Case

Case-A

1) Gate dimensions

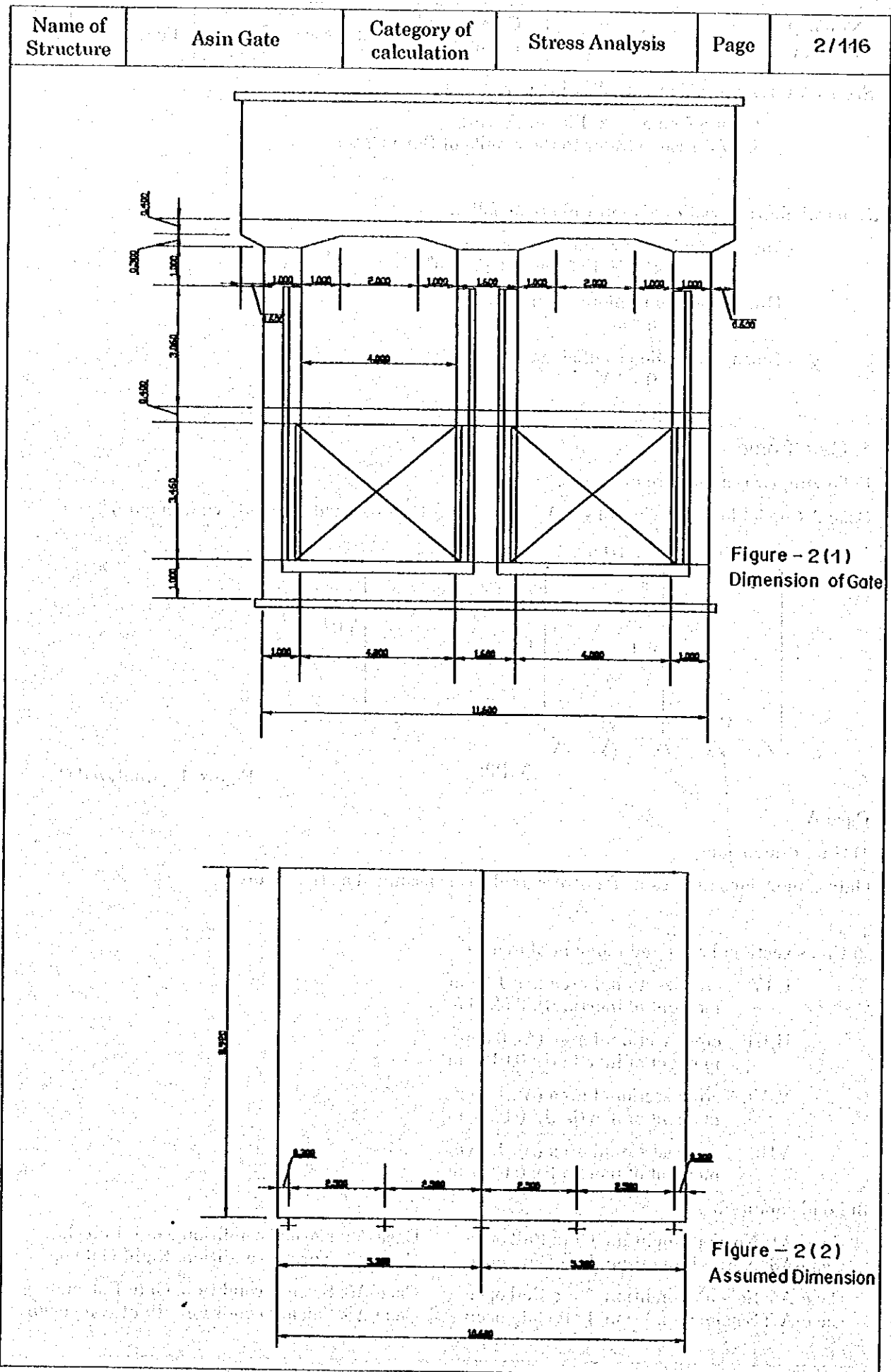
Gate dimensions and frame for stress analysis is assumed as the Figure-2.

2) Cross sectional area and moment of inertia

I, IV:	cross sectional area (A): 1.03 m ² moment of inertia (I): 0.0228 m ⁴
II,III:	cross sectional area (A): 0.8 m ² moment of inertia (I): 0.0107 m ⁴
V, VI:	cross sectional area (A): 1.4 m ² moment of inertia (I): 0.0572 m ⁴
VII:	cross sectional area (A): 1.26 m ² moment of inertia (I): 0.0417 m ⁴

3) Load condition

Case-A1: Normal condition, Gate Full open	Case-A2: Normal condition, Gate Full close
Case-A3: Normal condition, Left Gate open	Case-A4: Normal condition, Right Gate open
Case-A5: Seismic condition, Gate Full open	Case-A6: Seismic condition, Gate Full close
Case-A7: Seismic condition, Left Gate open	Case-A8: Seismic condition, Right Gate open



Name of Structure	Asin Gate	Category of calculation	Stress Analysis	Page	3/116
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Loads to be considered are as follows:

- self-weight
- gate 4.5 t/unit
- hoist 3.0 t/unit
- motor 0.5 t/unit
- control room *1
- embedded materials 3.0 t/unit
- water pressure (static and dynamic)
- sediment pressure
- earth pressure *2
- earthquake force

*1: total weight of control room: 80 t \rightarrow 80 / 10.6 = 7.5471 \rightarrow 7.5 t/m

*2: earth pressure

(normal condition)

Total earth pressure (E): V: 5.14 t H: 29.13 t
earth pressure by surcharge (S): V: 2.00 t H: 11.54 t
E: (V) 5.14 / 10 x 2 = 1.028, (H) 29.13 / 10 x 2 = 5.286 Y = 1.11
S: (V) 2.00 / 10 x 2 = 0.400, (H) 11.54 / 10 x 2 = 2.308 Y = 1.73

(earthquake condition)

Total earth pressure (E): V: 46.50 t
E: (V) 9.30 t, Y = 1.06

Load conditions are shown in Figure-3 to Figure-10.

4) Results of stress analysis

Summary of results are as follows: (details, see attached Figures-11 to 18)

	Normal			
	A1	A2	A3	A4
Bending Moment	36.319	31.151	37.079	37.128
Shear Stress	53.379	51.089	53.451	52.179
Axial Stress	94.745	90.324	92.450	92.535
Displacement	0.3469	0.3722	0.3519	0.3576
	Seismic			
	A5	A6	A7	A8
Bending Moment	59.168	52.439	53.444	59.836
Shear Stress	58.404	55.752	55.876	58.213
Axial Stress	94.687	90.266	92.516	92.573
Displacement	1.2733	1.2216	1.2613	1.2296

Case-B

1) Assumed dimensions

Model for Case-B is assumed as a beam as shown in Figure-1 with the height of 8.92 m.

Asin-Normal

Case 1 : Asin-normal-full open

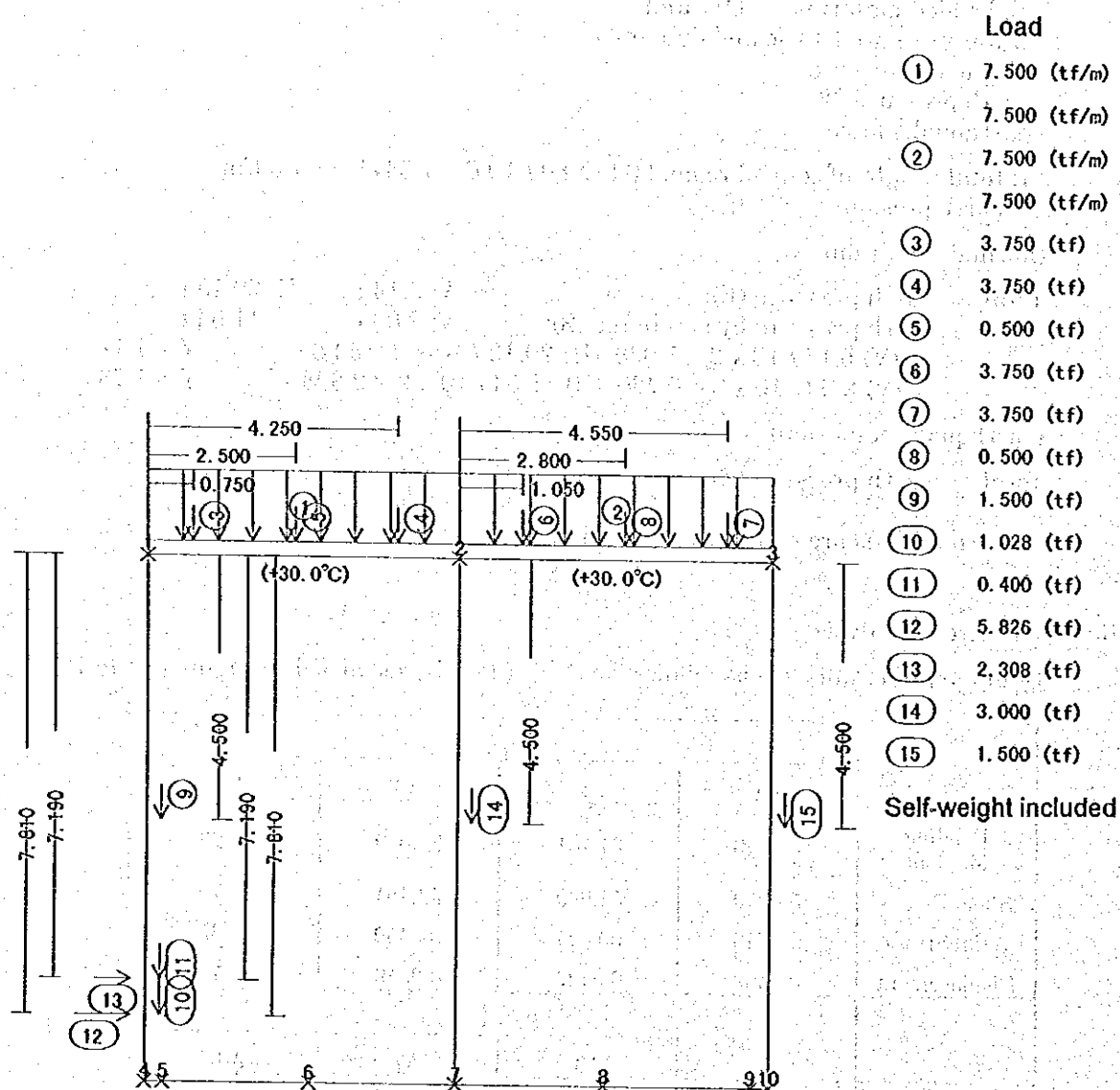


Figure - 3

Asin-Normal

Case 2 : Asin-normal-full close

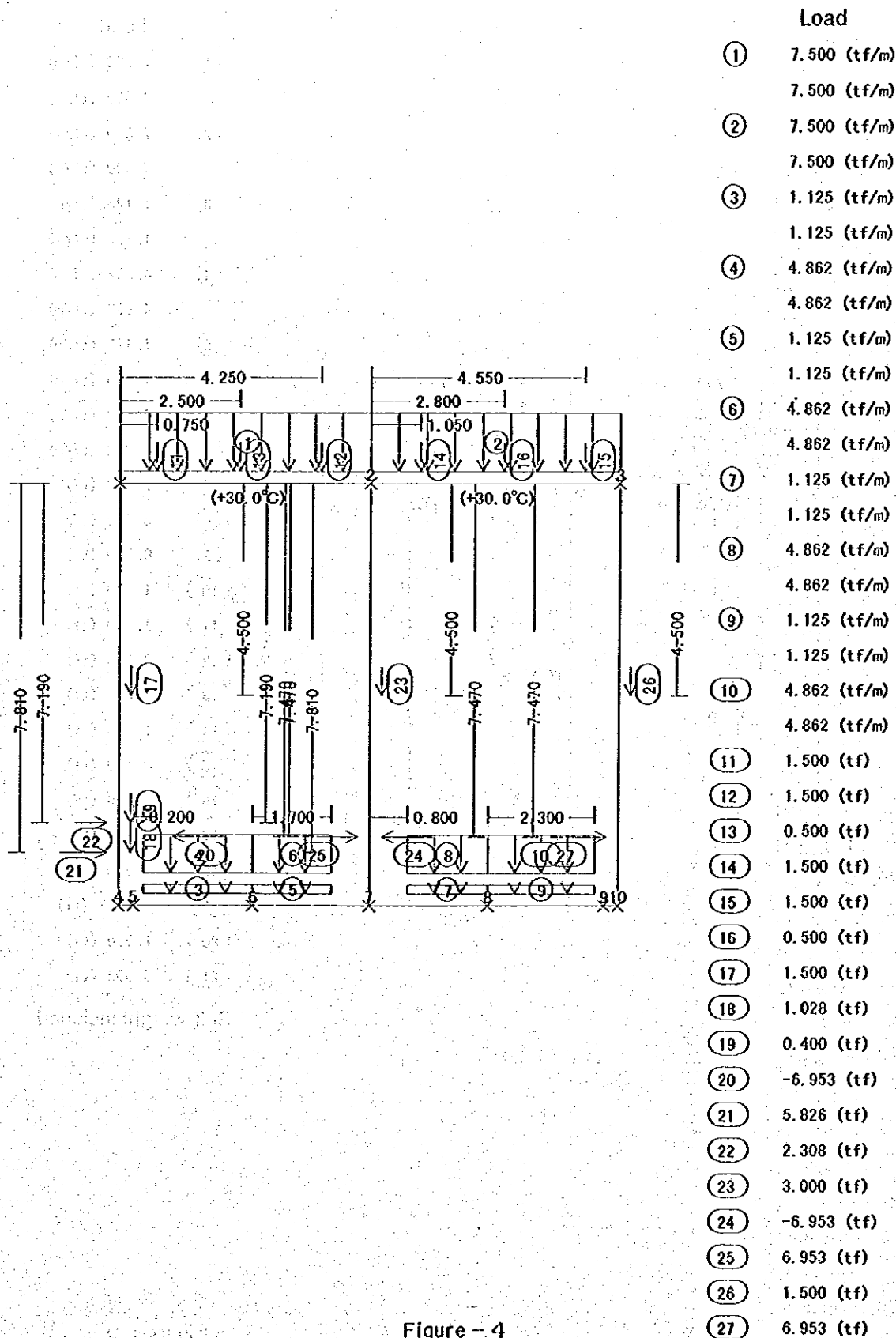
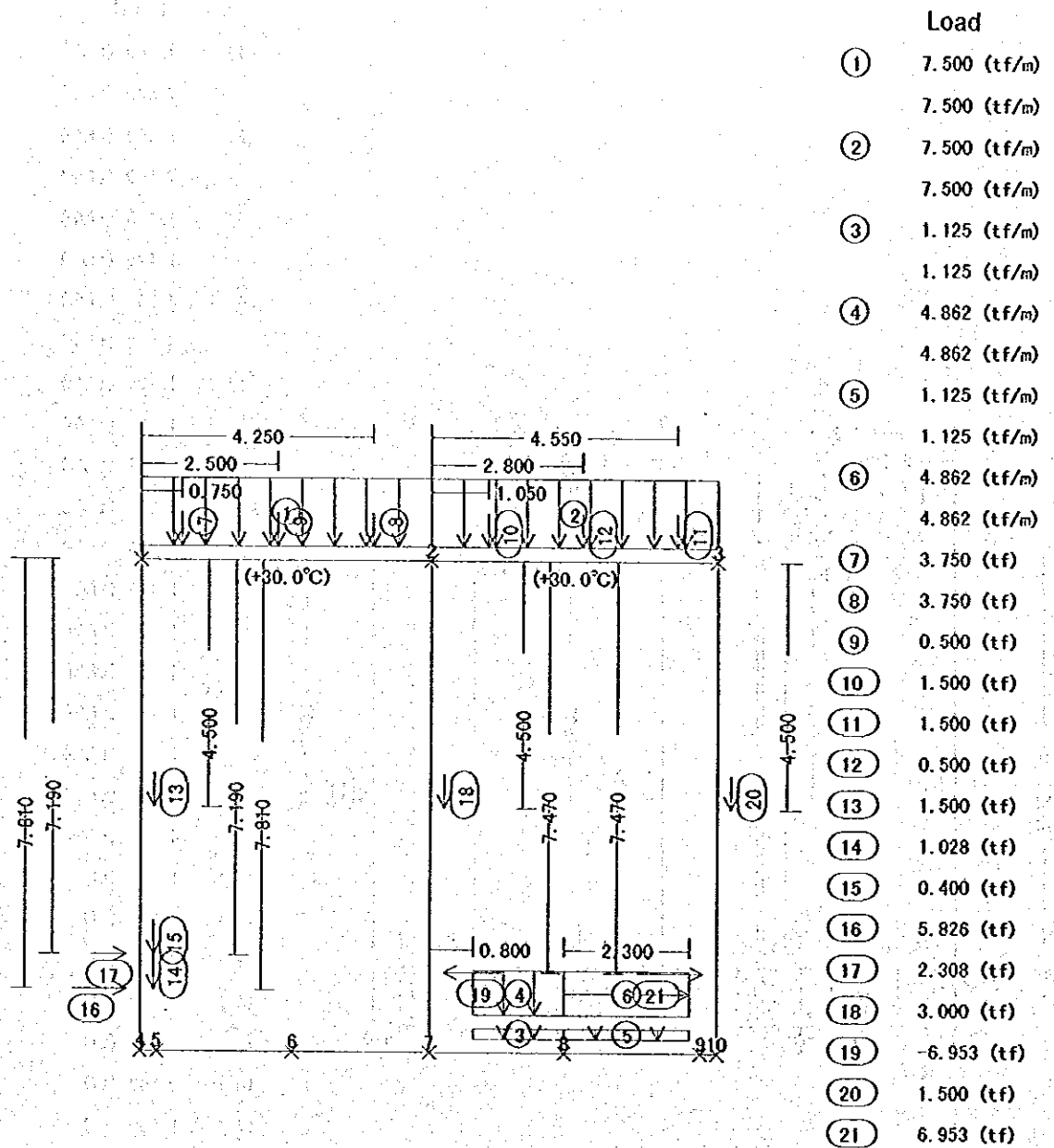


Figure - 4

Self-weight included

Asin-Normal

Case 3 : Asin-nomal-left open



Self-weight included

Figure - 5

Asin-Normal

Case 4 : Asin-nomal-right open

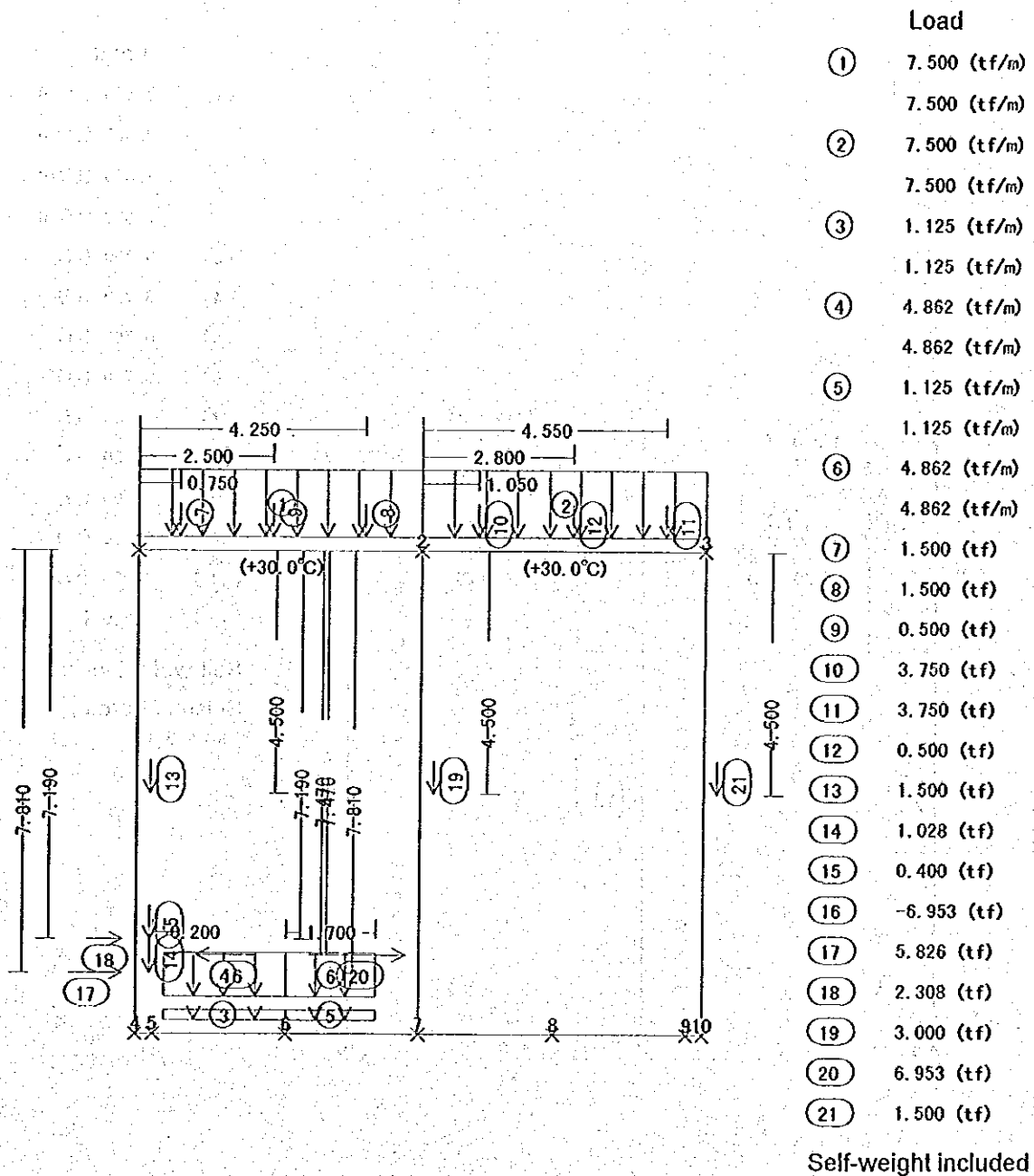


Figure - 6

Asin-Seismic

Case 1 : Asin-seismic-full open

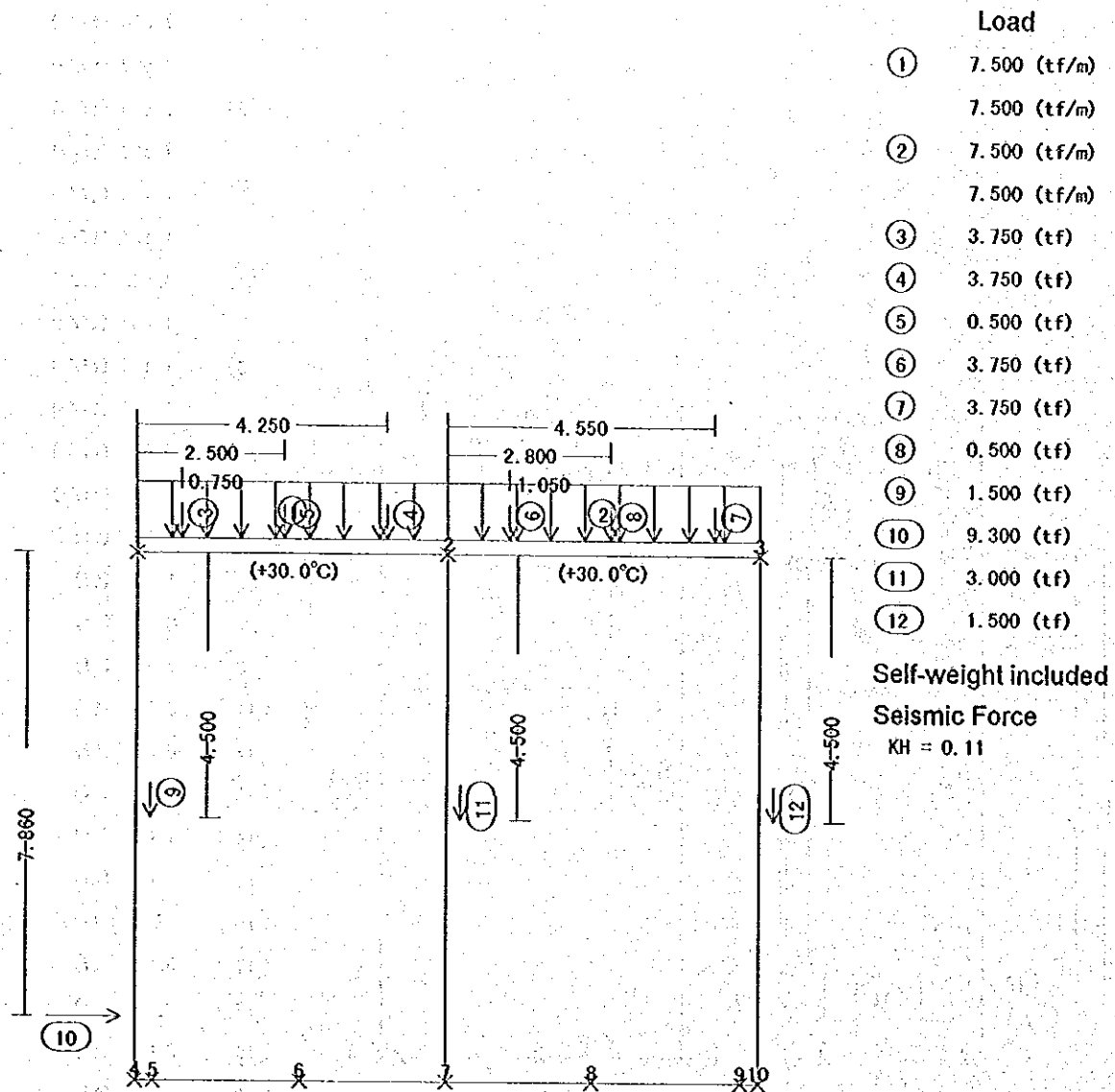


Figure - 7

Asin-Seismic

Case 3 : Asin-seismic-left open

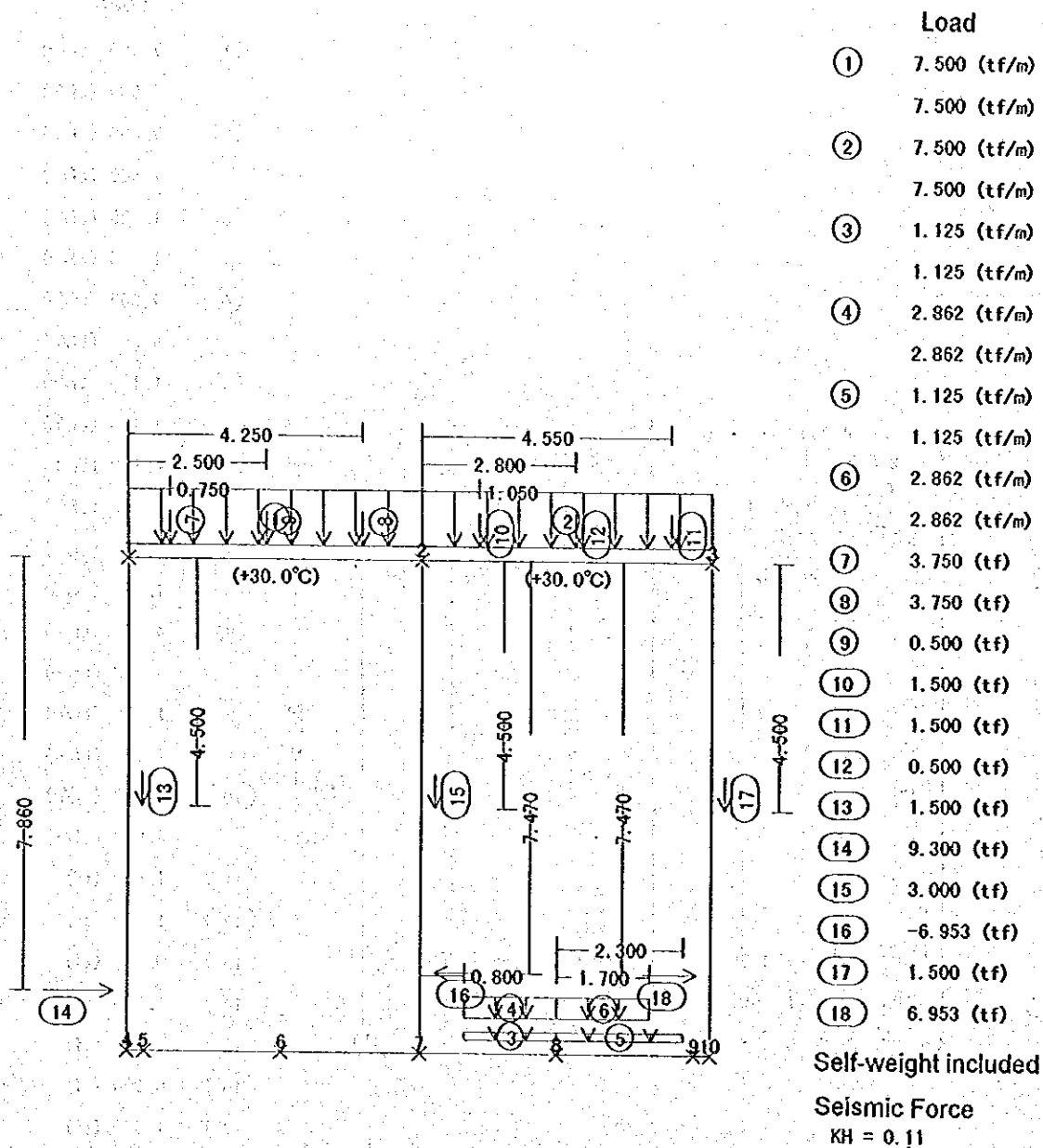
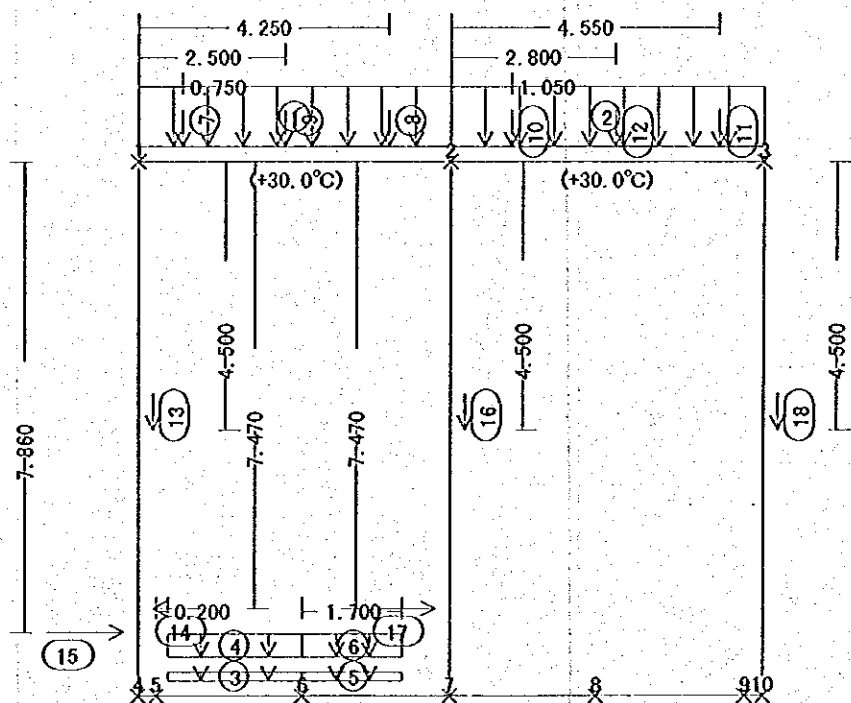


Figure-9

Asin-Seismic

Case 4 : Asin-seismic-right open



Load

- | | |
|---|--------------|
| ① | 7.500 (tf/m) |
| | 7.500 (tf/m) |
| ② | 7.500 (tf/m) |
| | 7.500 (tf/m) |
| ③ | 1.125 (tf/m) |
| | 1.125 (tf/m) |
| ④ | 2.862 (tf/m) |
| | 2.862 (tf/m) |
| ⑤ | 1.125 (tf/m) |
| | 1.125 (tf/m) |
| ⑥ | 2.862 (tf/m) |
| | 2.862 (tf/m) |
| ⑦ | 1.500 (tf) |
| ⑧ | 1.500 (tf) |
| ⑨ | 0.500 (tf) |
| ⑩ | 3.750 (tf) |
| ⑪ | 3.750 (tf) |
| ⑫ | 0.500 (tf) |
| ⑬ | 1.500 (tf) |
| ⑭ | -6.953 (tf) |
| ⑮ | 9.300 (tf) |
| ⑯ | 3.000 (tf) |
| ⑰ | 6.953 (tf) |
| ⑱ | 1.500 (tf) |

Self-weight included

Seismic Force

KH = 0.11

Figure - 10

Asin-Normal

Case 1: Asin-nomal-full open

Deformation

Scale

: 0.372cm

max. : 0.347 cm

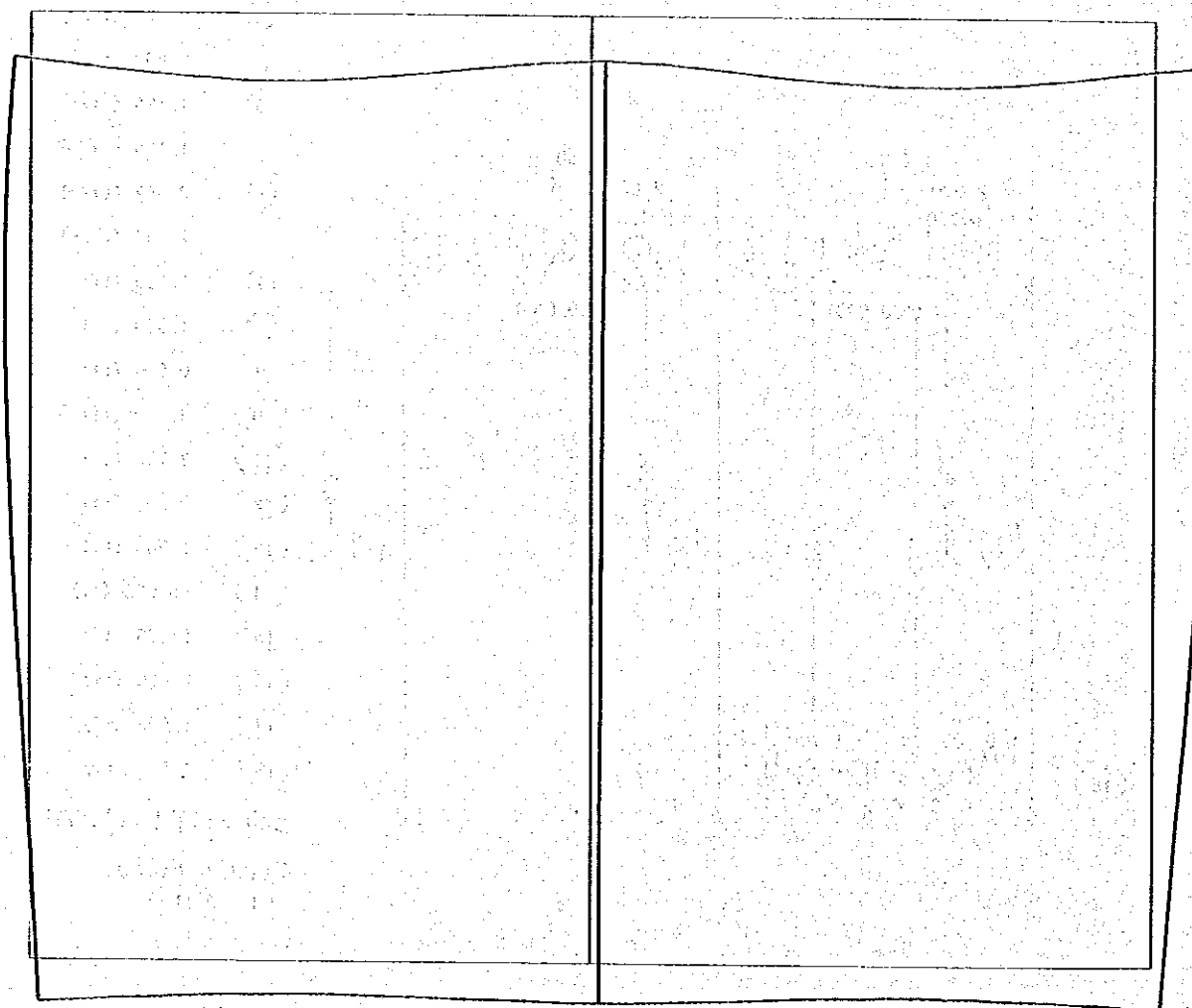


Figure - 11(1)

Asin-Normal

Case 1: Asin-normal-full open

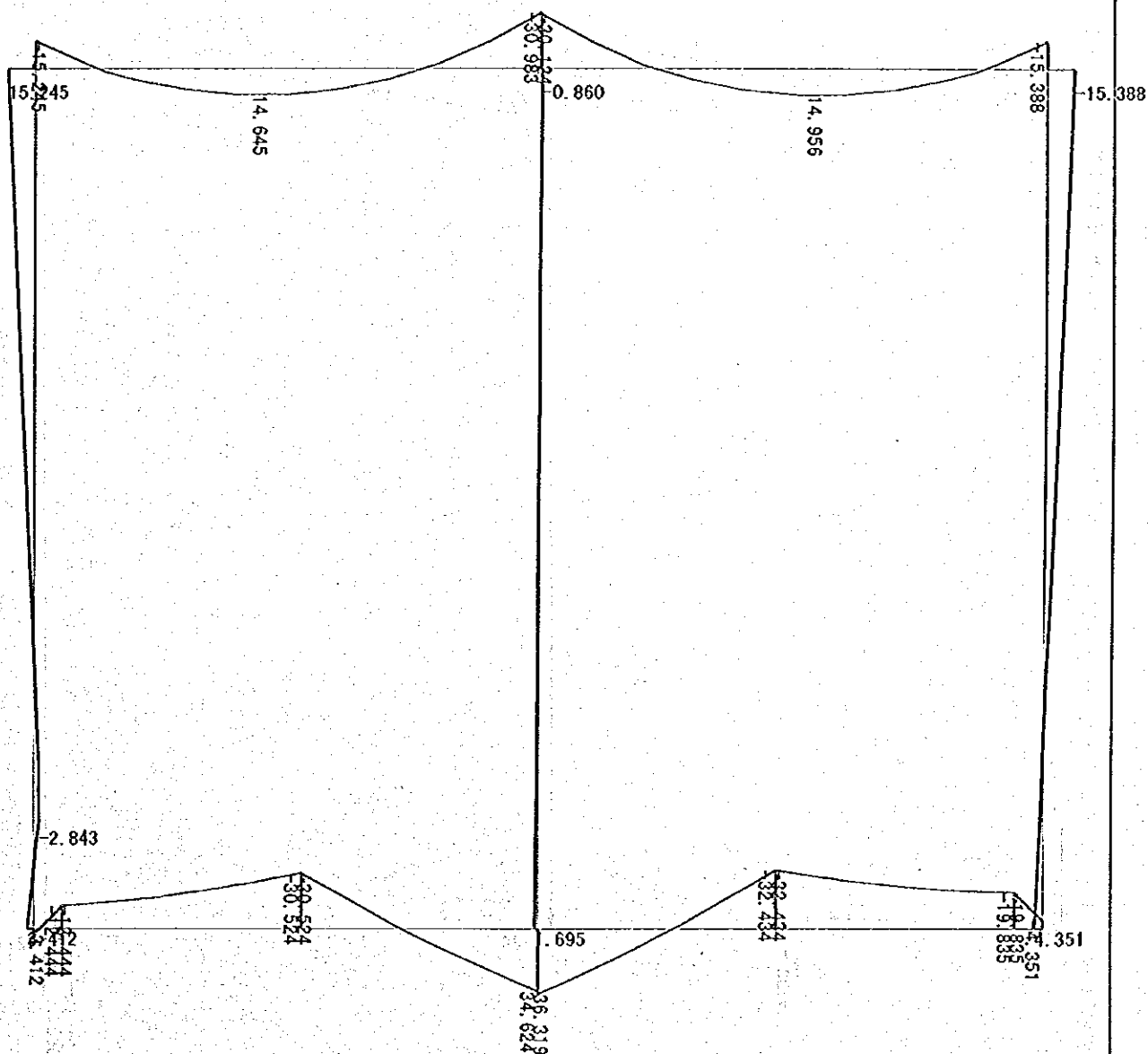
Bending Moment Scale ---|---| : 37.22 tf·m max. : 36.32 tf·m

Figure - 11 (2)

Asin-Normal

Case 1: Asin-nomal-full open

Axial Stress

Scale |——| : 94.75tf max. : 94.75 tf

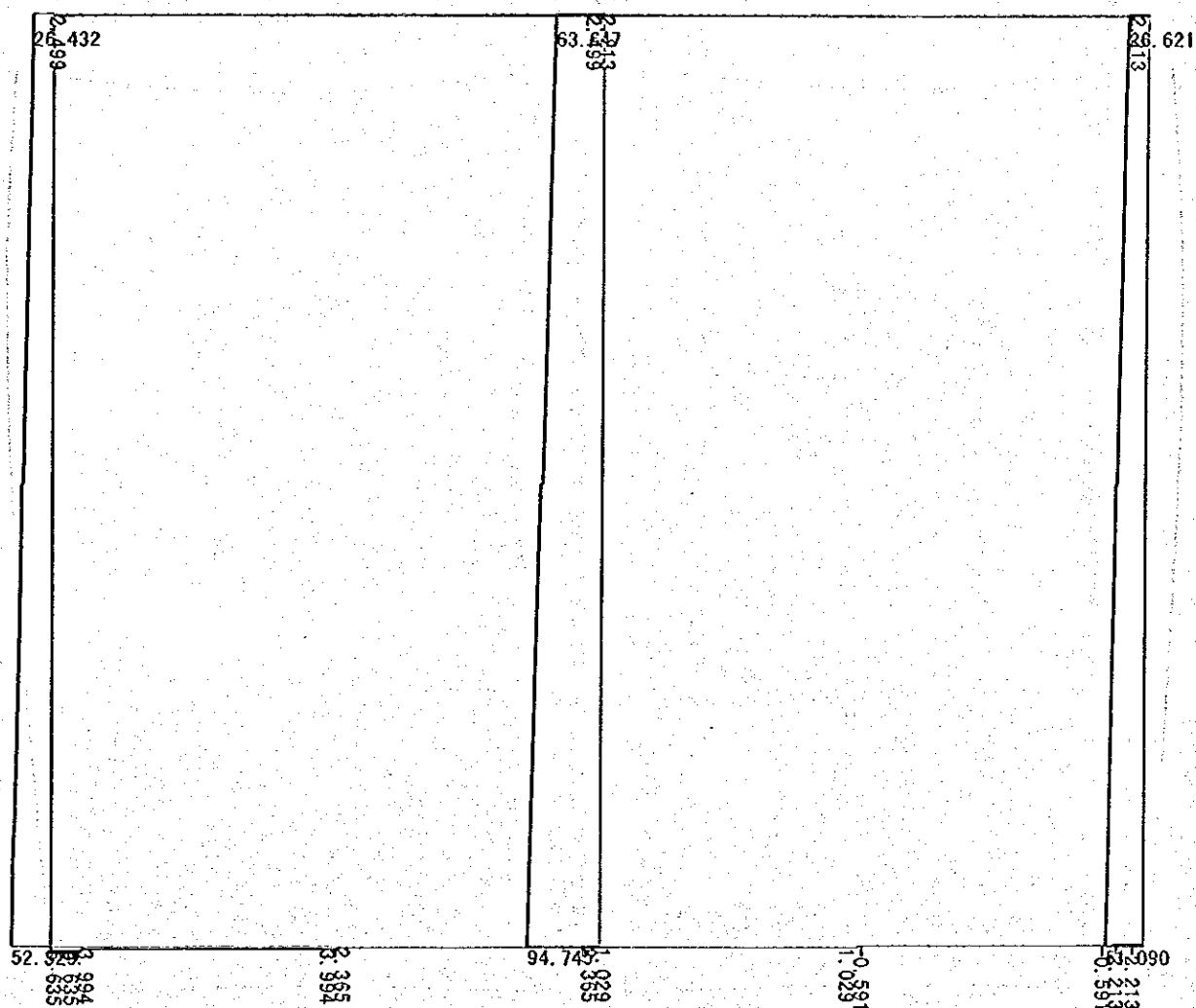


Figure-11 (4)

Asin-Normal

Case 2: Asin-normal-full close

Deformation


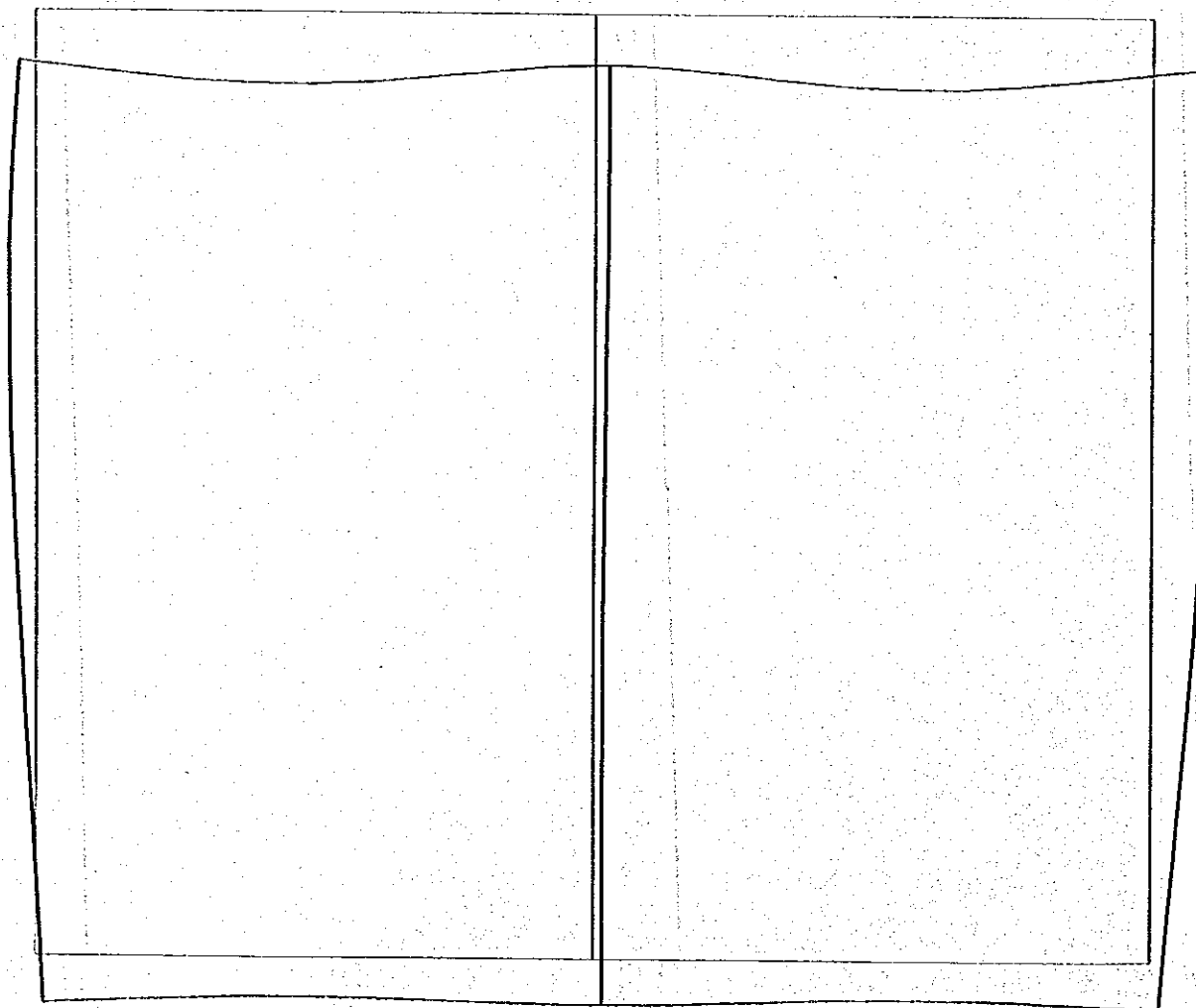
Scale  : 0.372cm max. : 0.372 cm

Figure-12 (1)

Asin-Normal

Case 2: Asin-normal-full close

Bending Moment : Scale | : 37.22tf·m max. : -31.15 tf·m

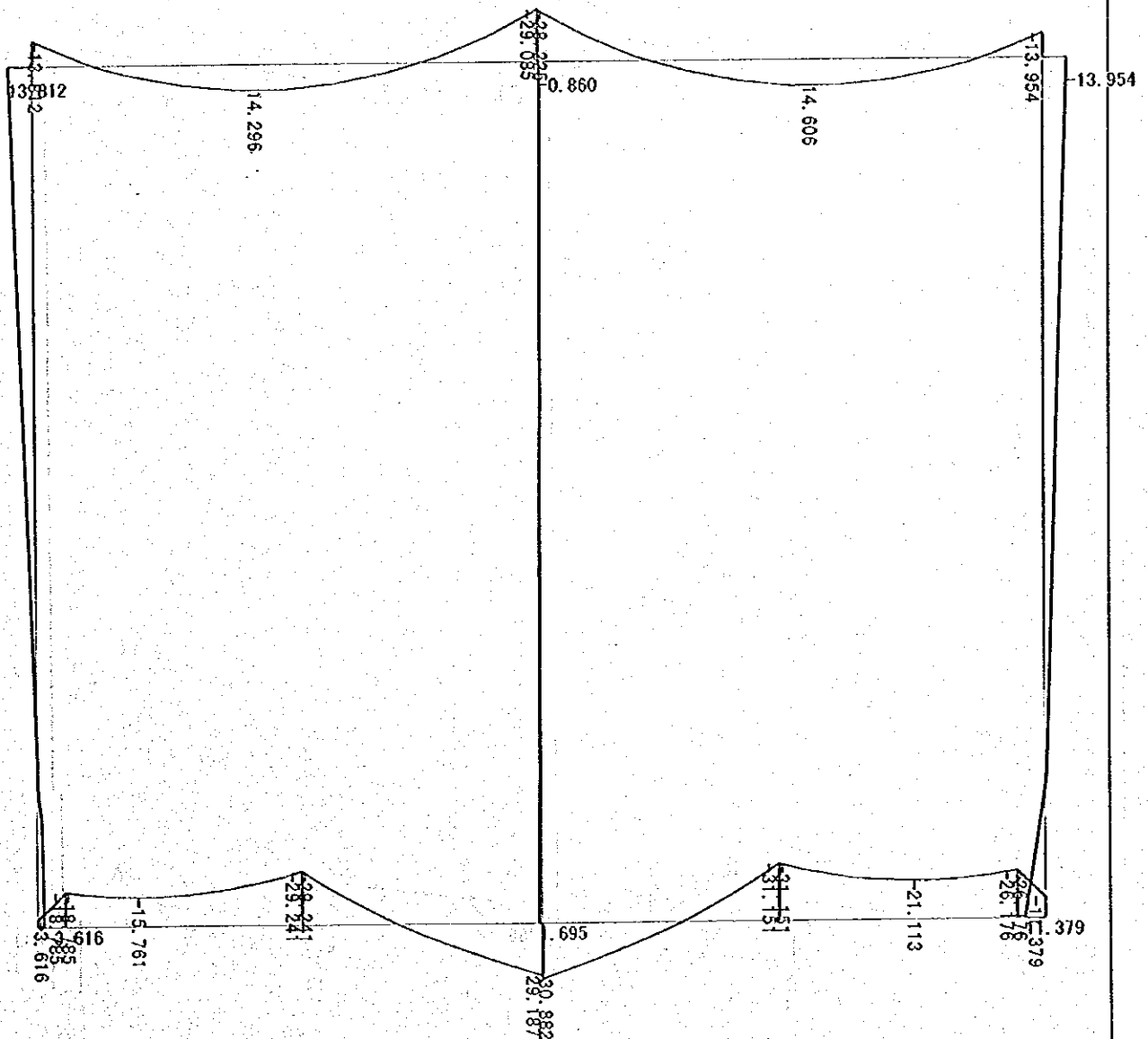


Figure - 12(2)

Asin-Normal

Case 2: Asin-normal-full close

Shear Stress

Scale | : 53.45tf max. : -51.09 tf

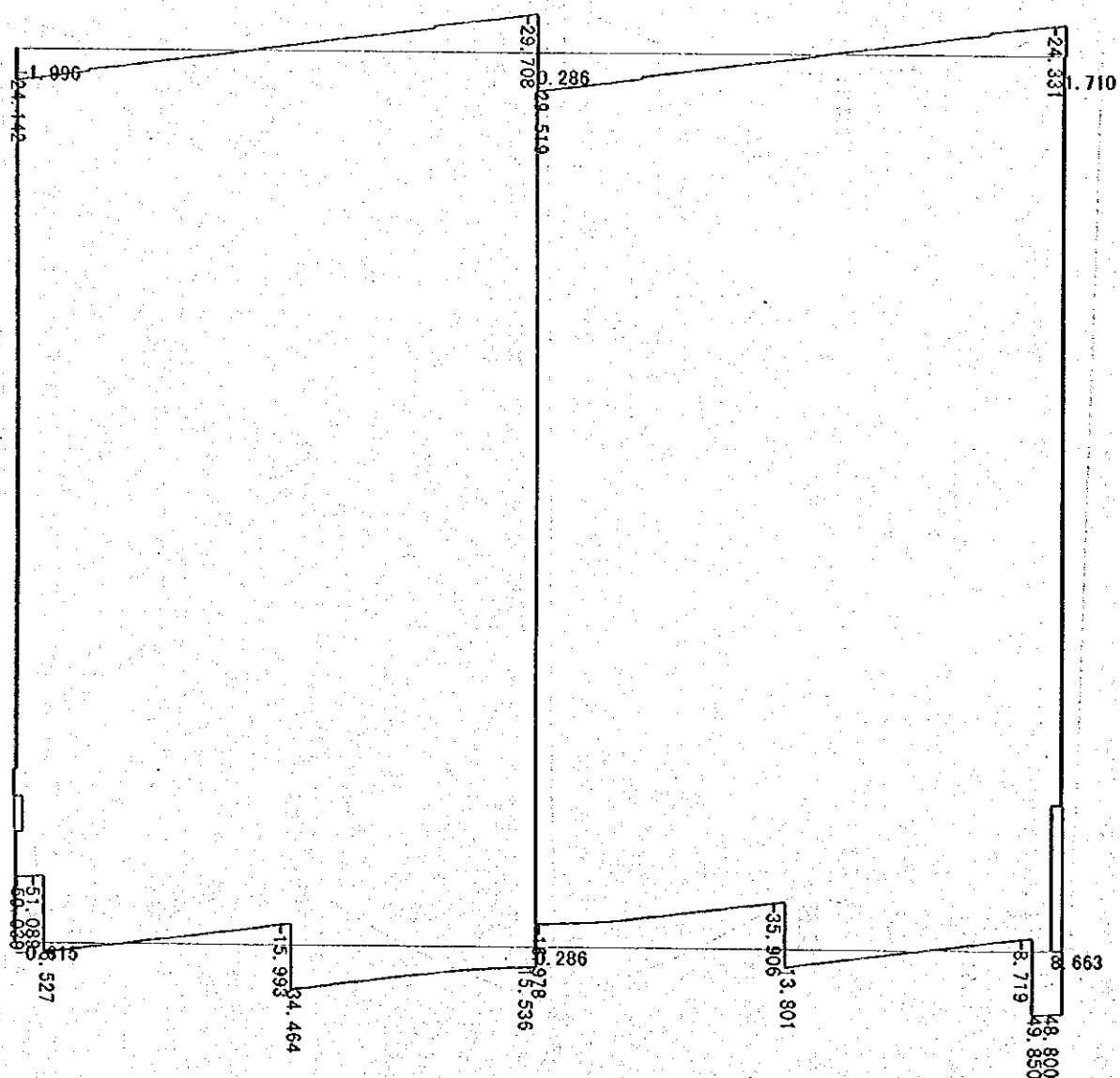


Figure - 12 (3)

Asin-Normal

Case 2: Asin-normal-full close

Axial Stress

Scale |——| : 94.75tf max. : 90.32 tf

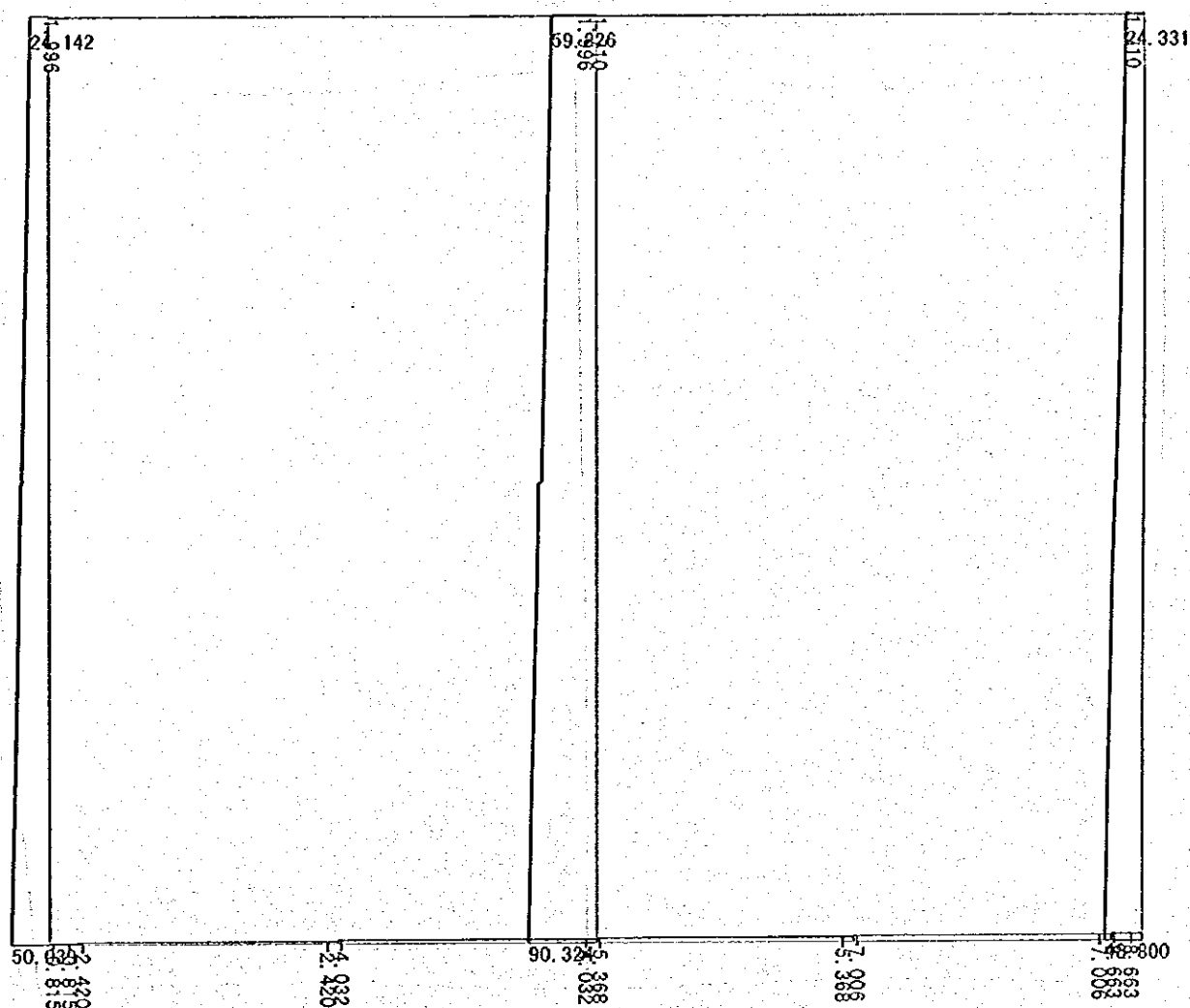


Figure - 12 (4)

Asin-Normal

Case 3: Asin-nomal-left open

Deformation

Scale |—| : 0.372cm max. : 0.352 cm

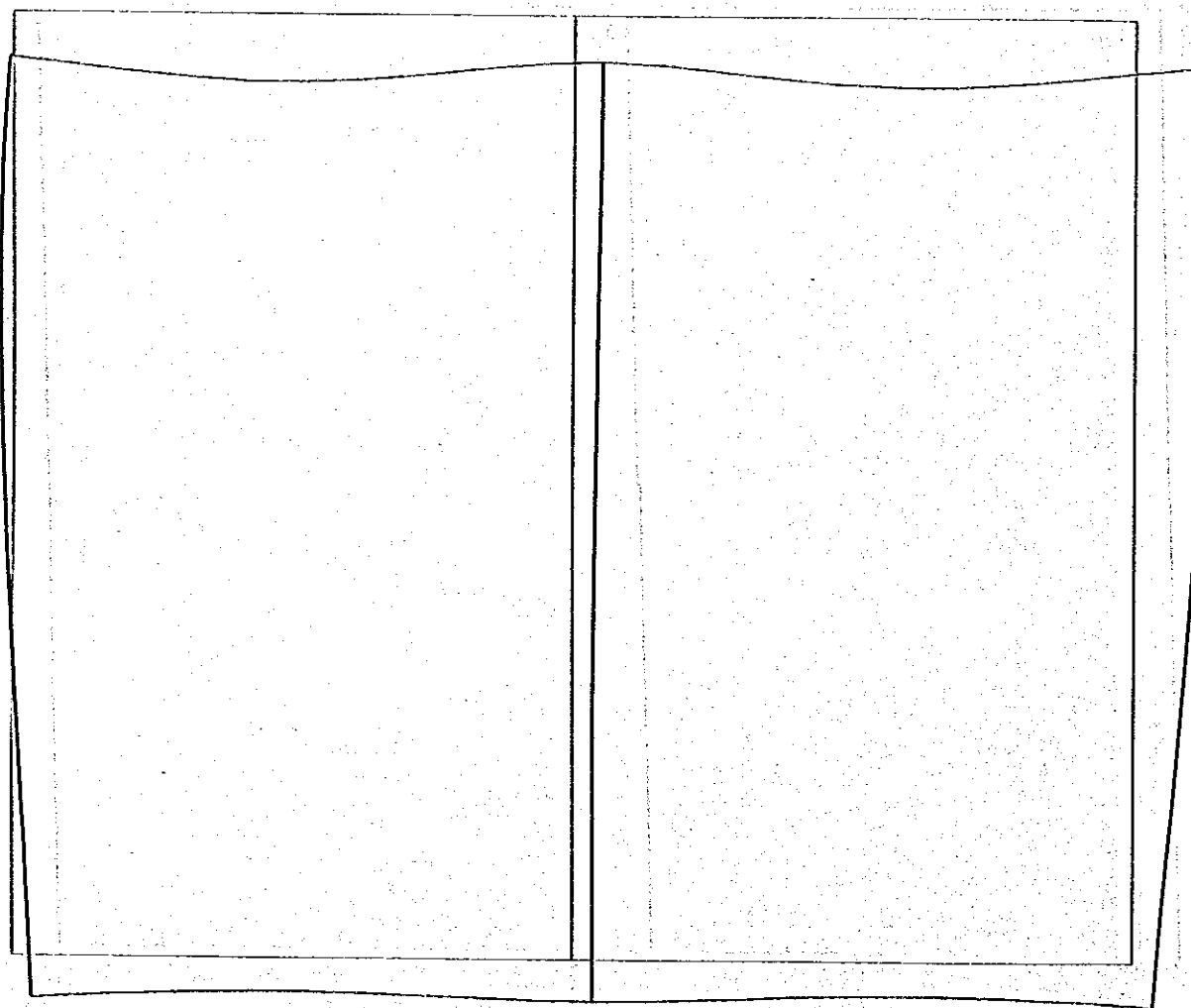


Figure-13(1)

Asin-Normal

Case 3: Asin-nomal-left open

Shear Stress

Scale



: 53.45tf

max. : -53.45 tf

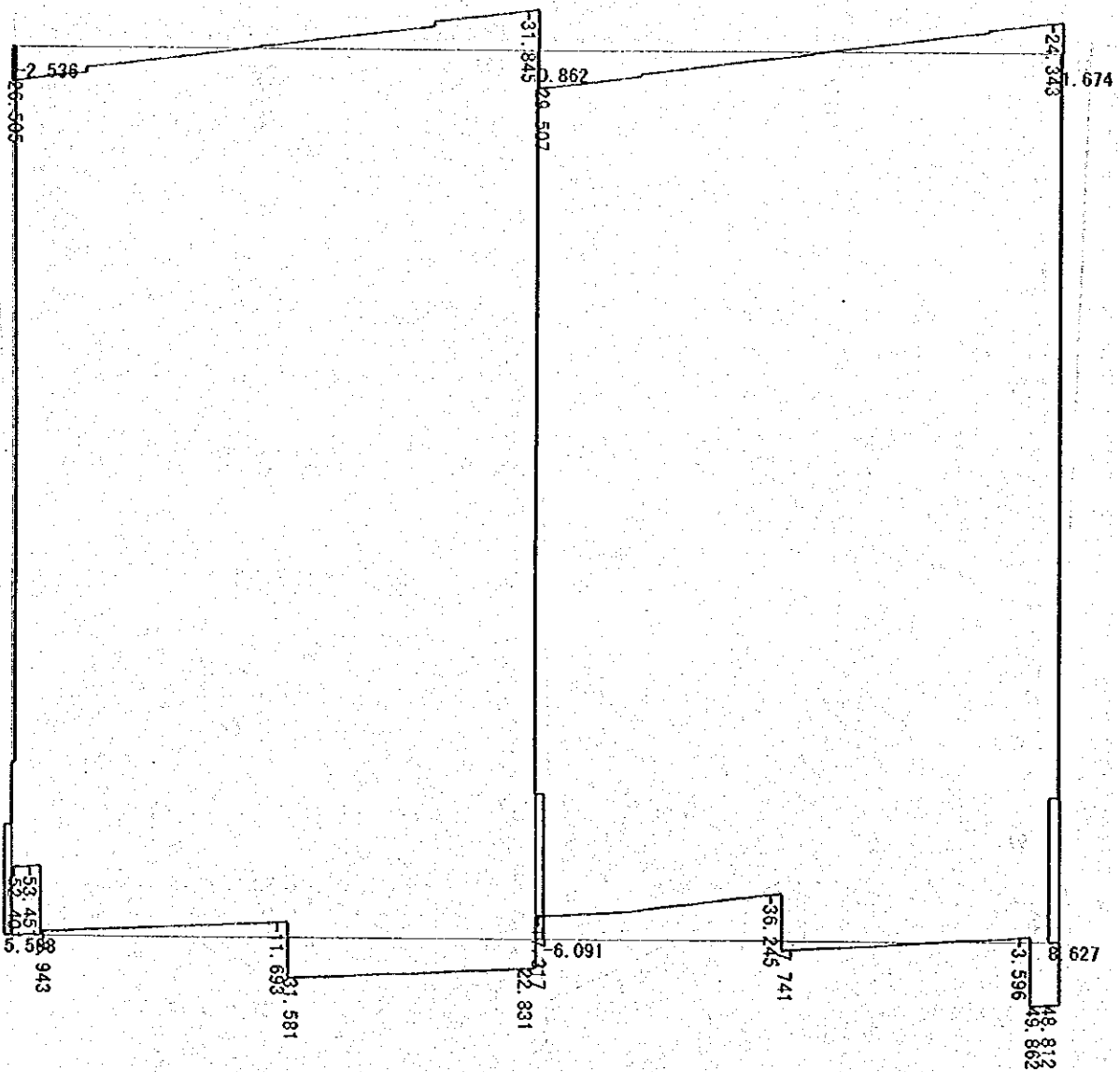


Figure-13(3)

Asin-Normal

Case 3: Asin-nomal-left open

Axial Stress

Scale | : 94.75tf max. : 92.45 tf

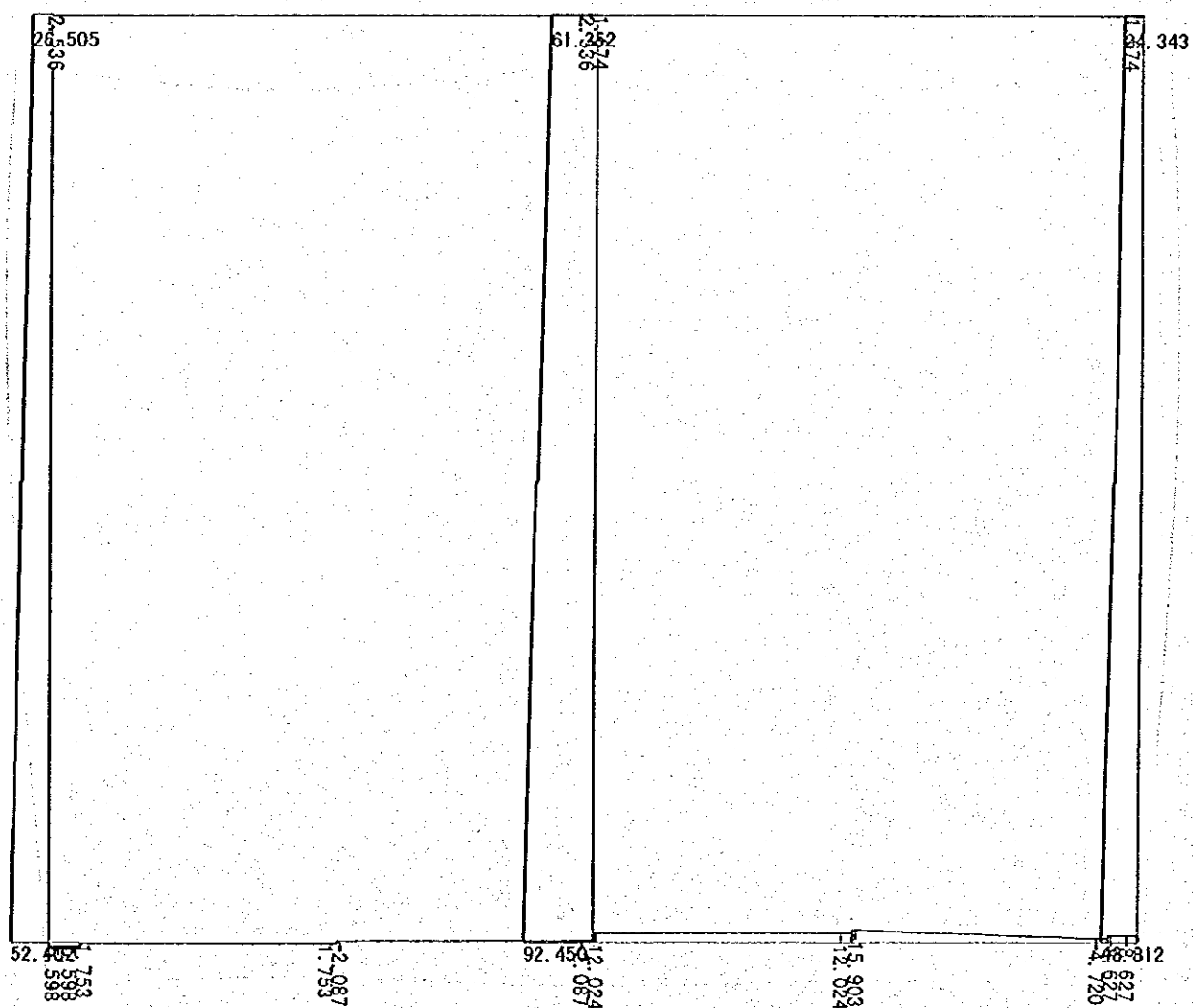


Figure - 13(4)

Asin-Normal

Case 4: Asin-normal-right open

Deformation

Scale |——| : 0.372cm max. : 0.358 cm

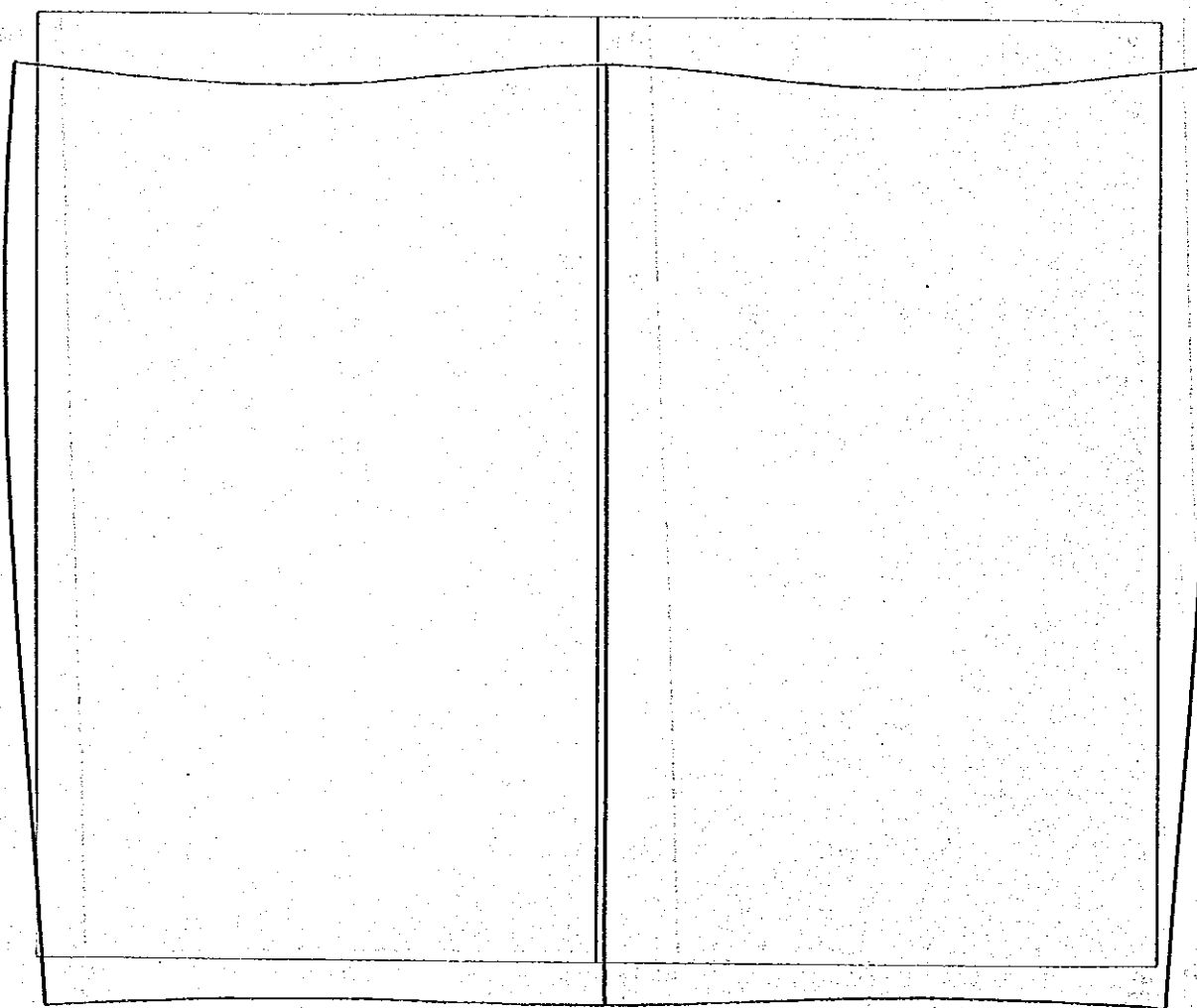


Figure -14(1)

Asin-Normal

Case 4: Asin-normal-right open

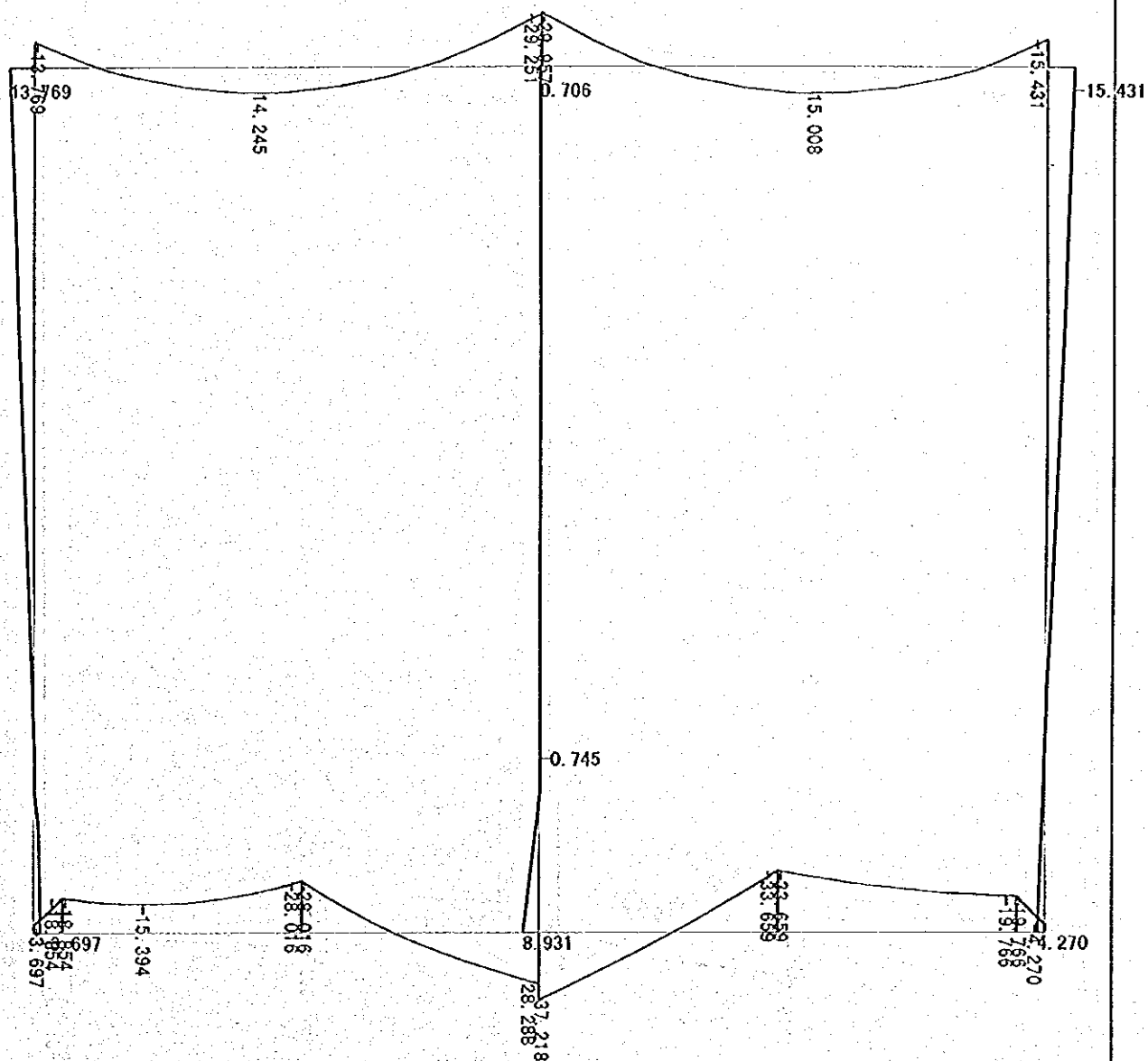
Bending Moment Scale $\text{---} : 37.22 \text{ tf}\cdot\text{m}$ max. : $37.22 \text{ tf}\cdot\text{m}$ 

Figure - 14(2)

Asin-Normal

Case 4: Asin-normal-right open

Shear Stress

Scale | : 53.45tf max. : 52.18 tf

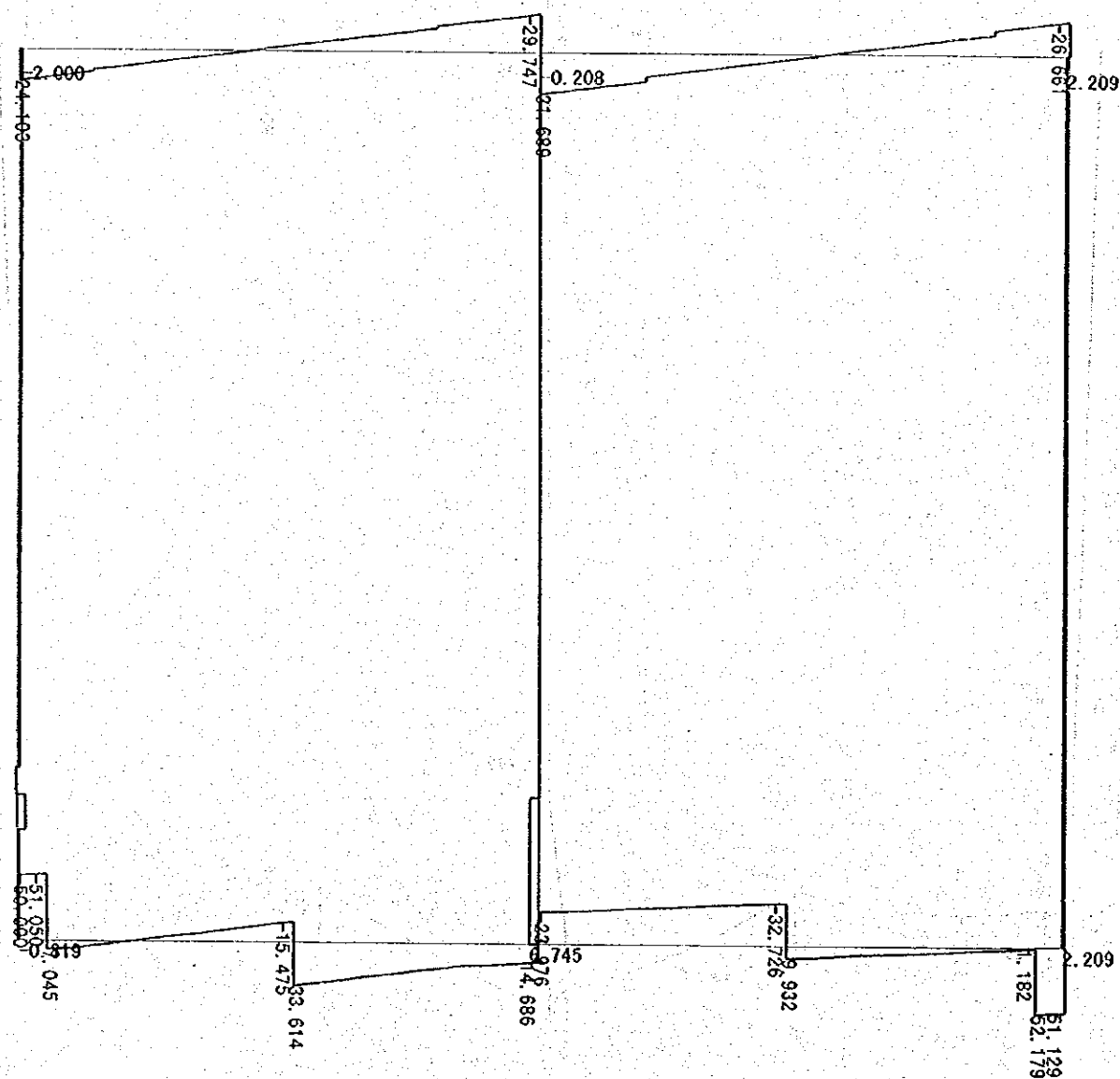


Figure - 14(3)

Asin-Normal

Case 4: Asin-nomal-right open

Axial Stress

Scale | : 94.75tf max. : 92.53 tf

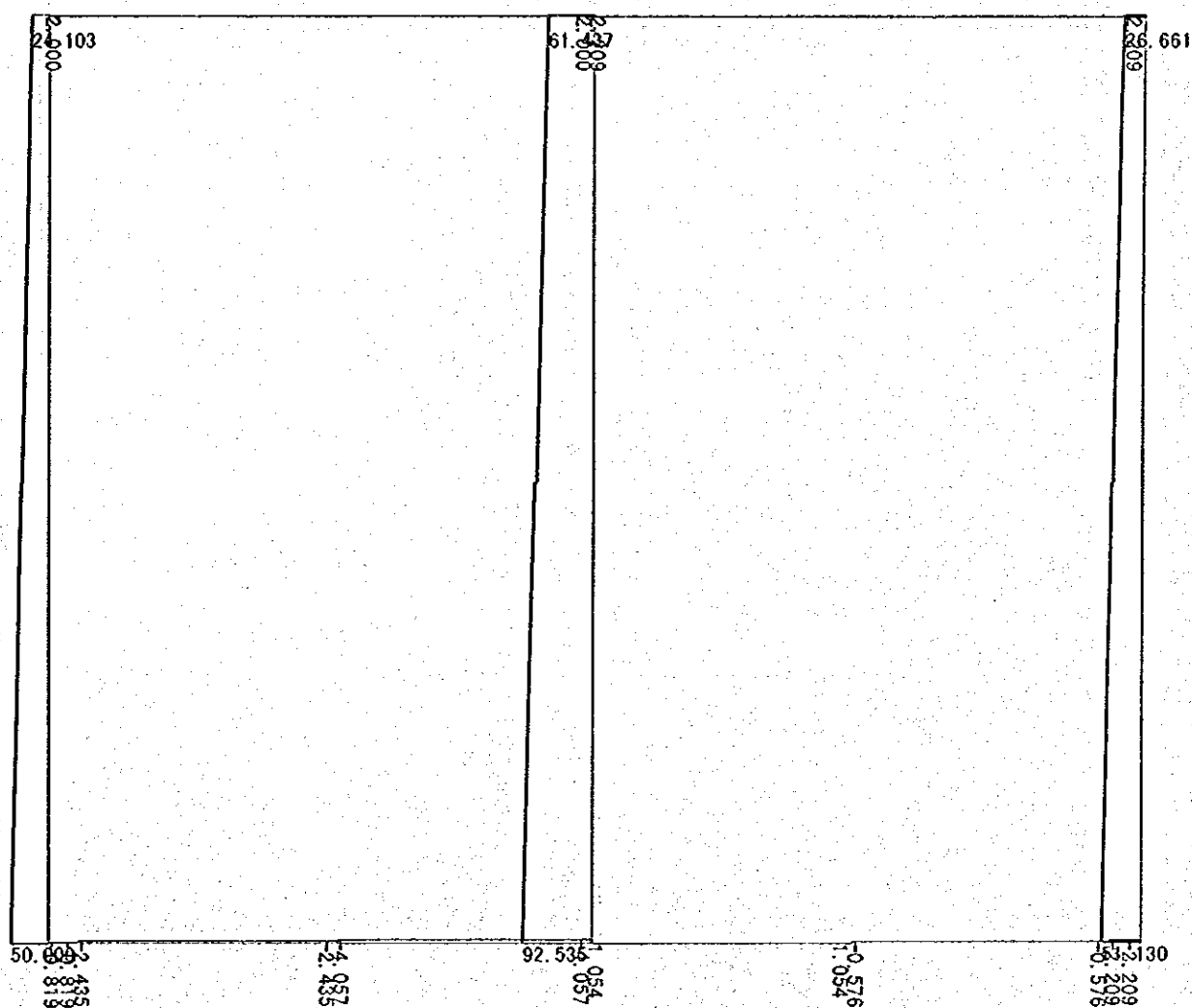


Figure -14(4)

Asin-Seismic

Case 9: Asin-seismic-full open + seismic force-full open

Deformation


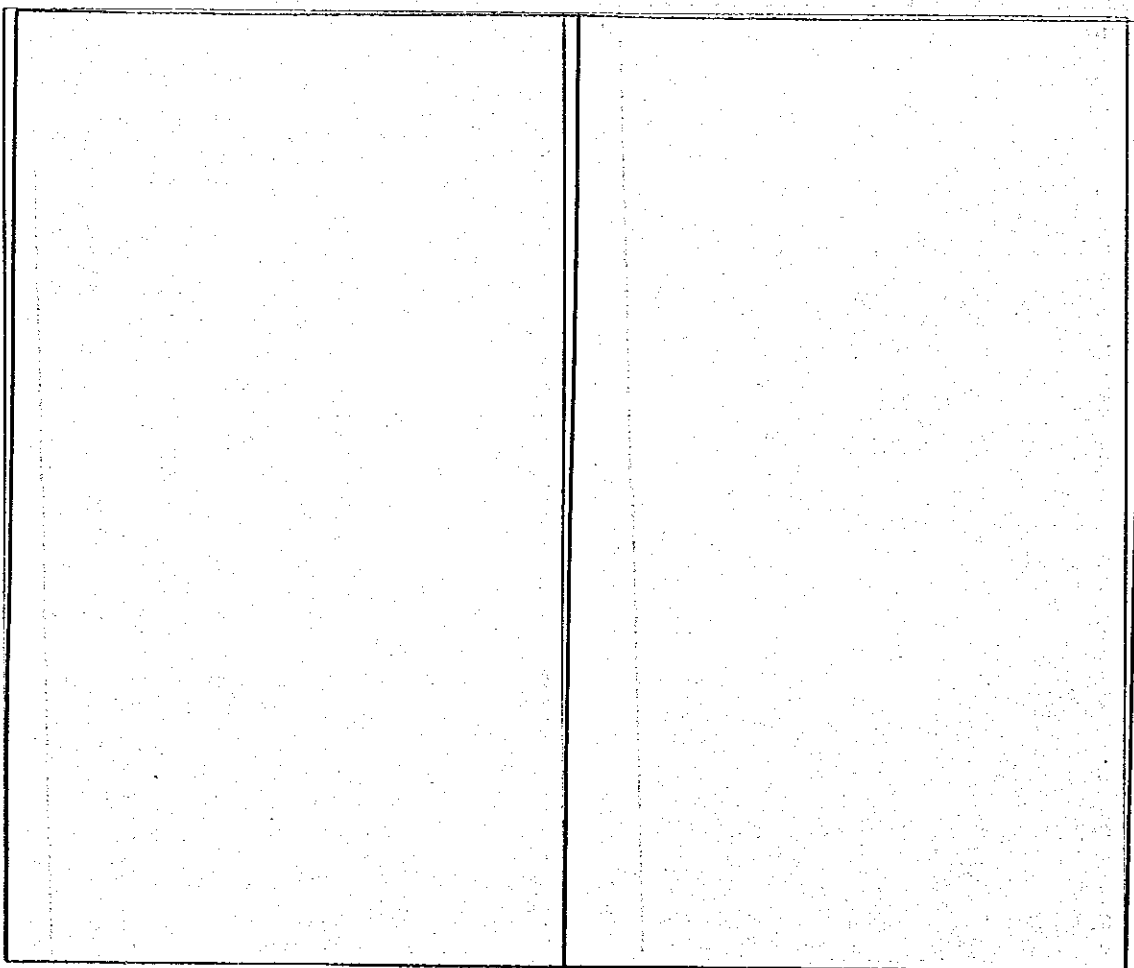
Scale  : 5.673cm max. : 1.273 cm

Figure -15 (1)

Asin-Seismic

Case 9: Asin-seismic-full open + seismic force-full open

Bending Moment Scale |——| : 259.91 tf·m max. : 59.17 tf·m

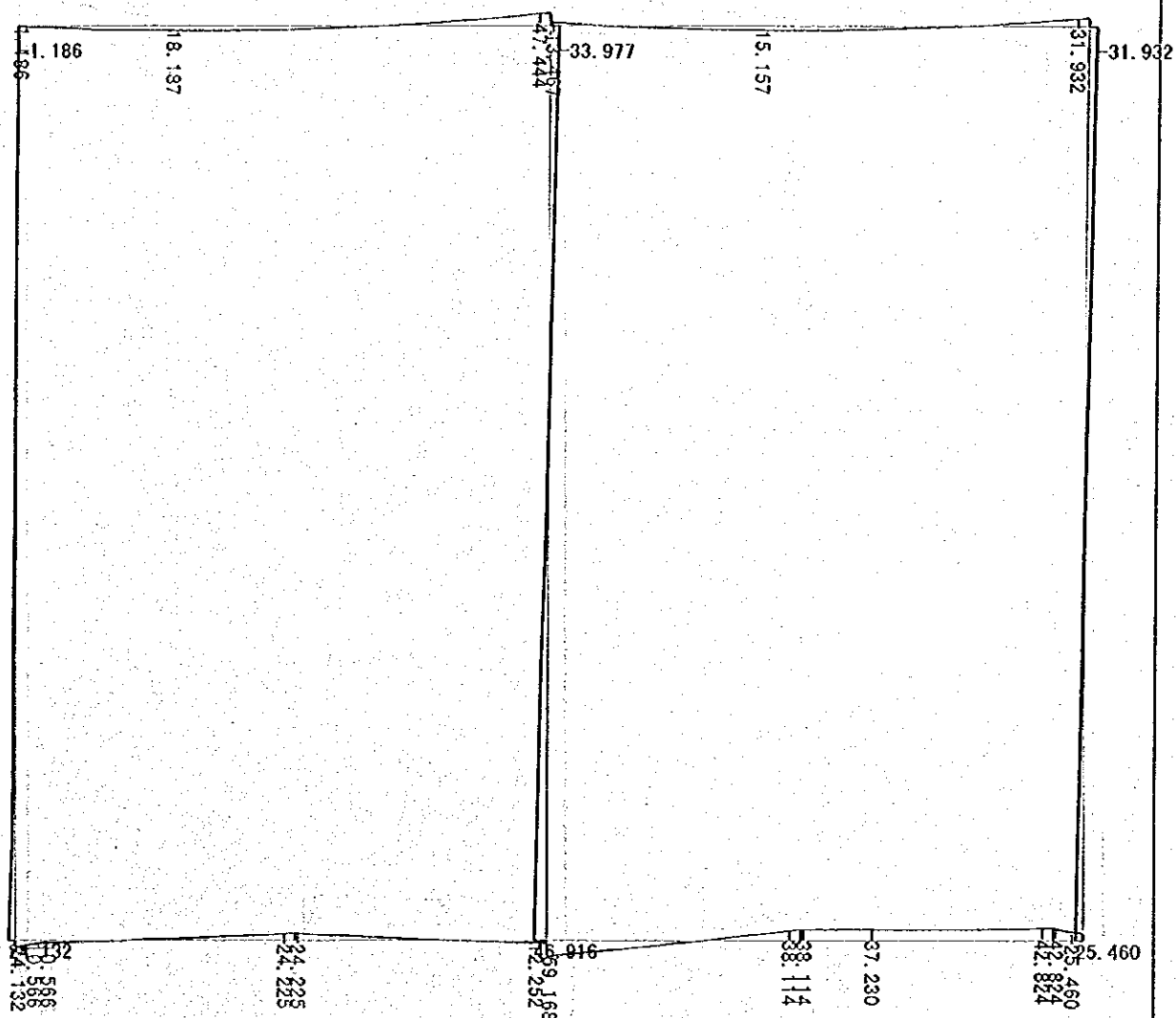


Figure-15 (2)

Asin-Seismic

Case 9: Asin-seismic-full open + seismic force-full open

Shear Stress

Scale | : 65.02tf max. : 58.40 tf

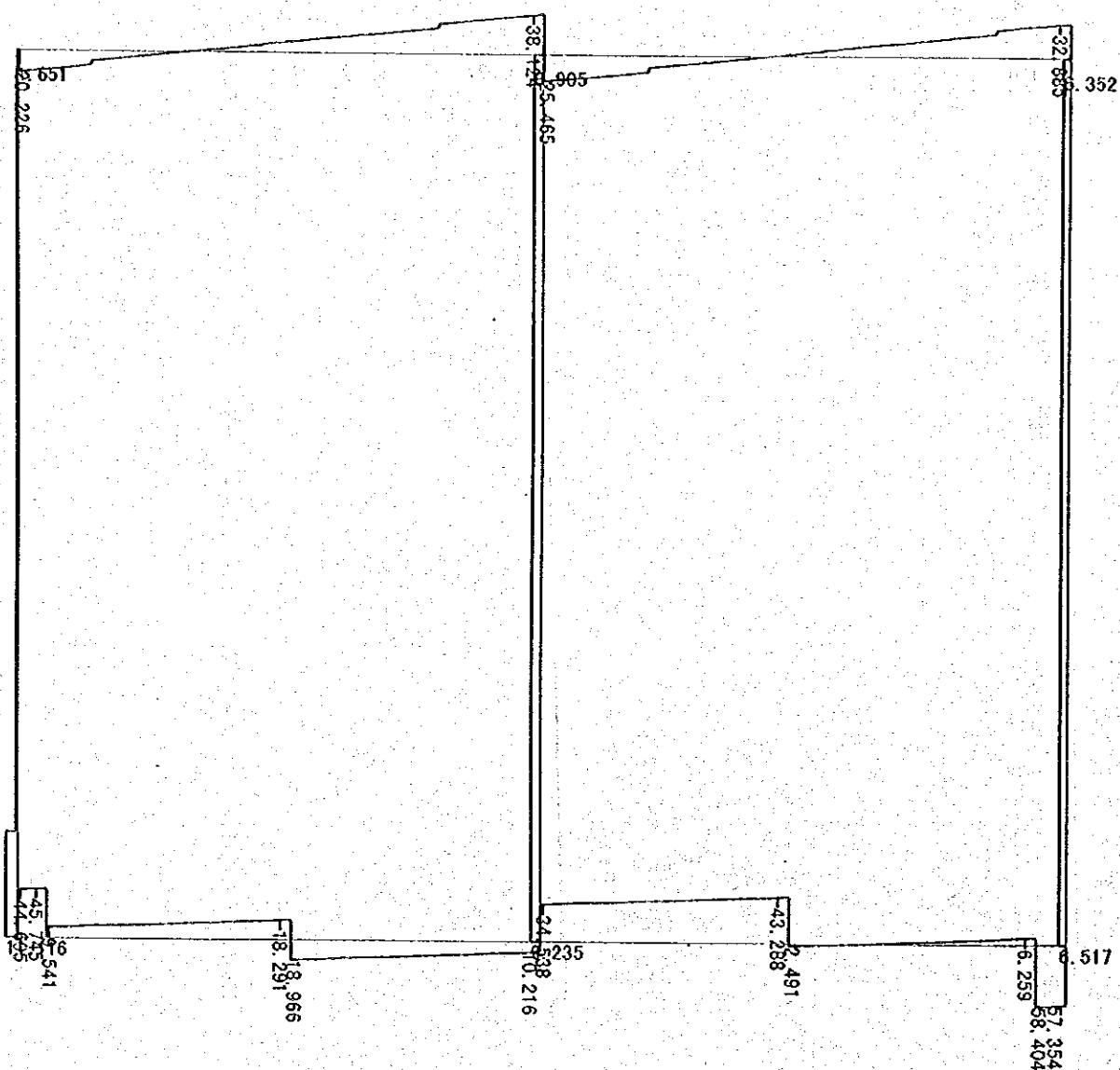


Figure- 15 (3)

Asin-Seismic

Case 9: Asin-seismic-full open + seismic force-full open

Axial Stress

Scale | : 94.69tf max. : 94.69 tf

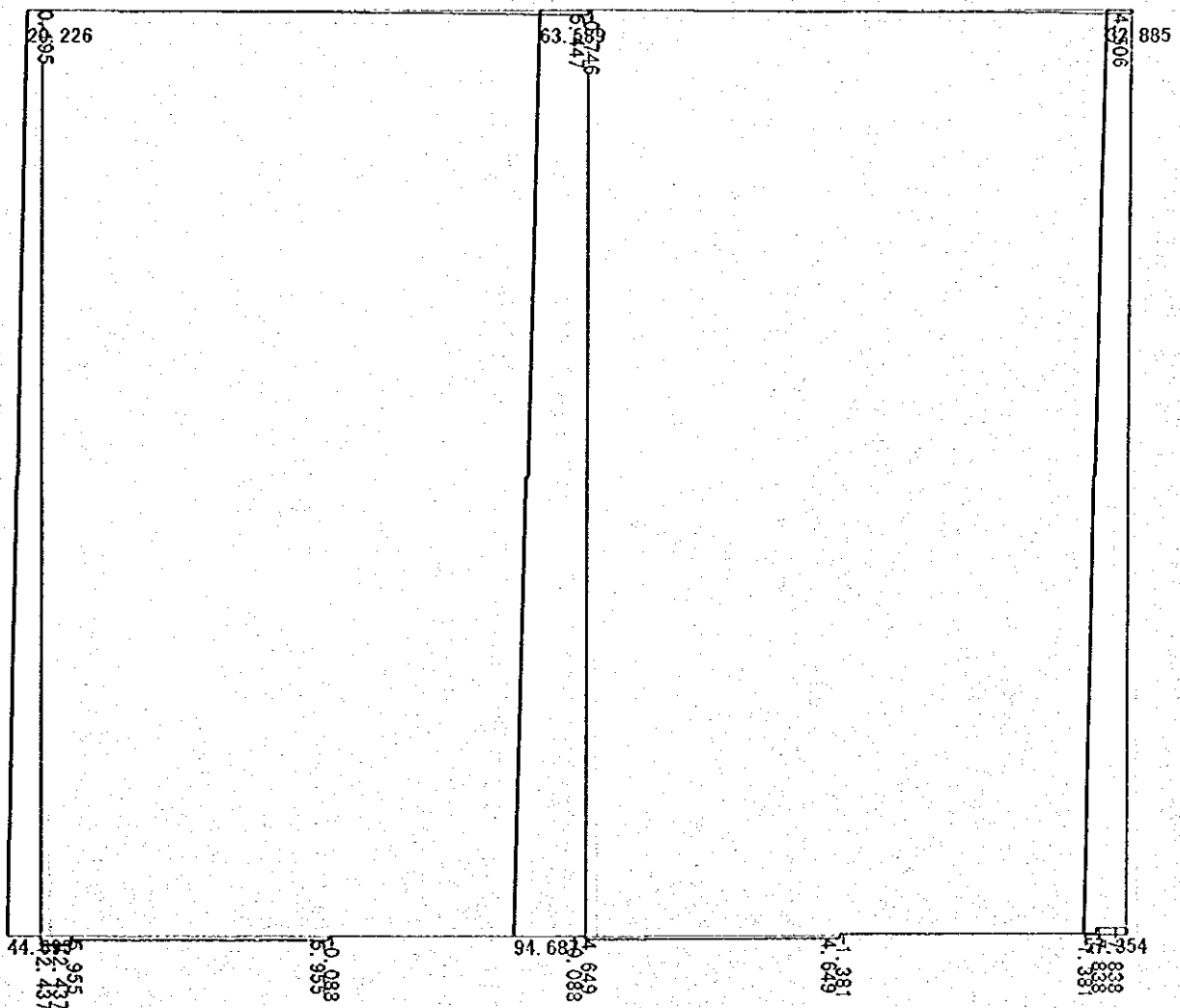


Figure - 15(4)

Asin-Seismic

Case 10: Asin-seismic-full close + seismic force-full close

Deformation

Scale |-----| : 5.673cm max. : 1.222 cm

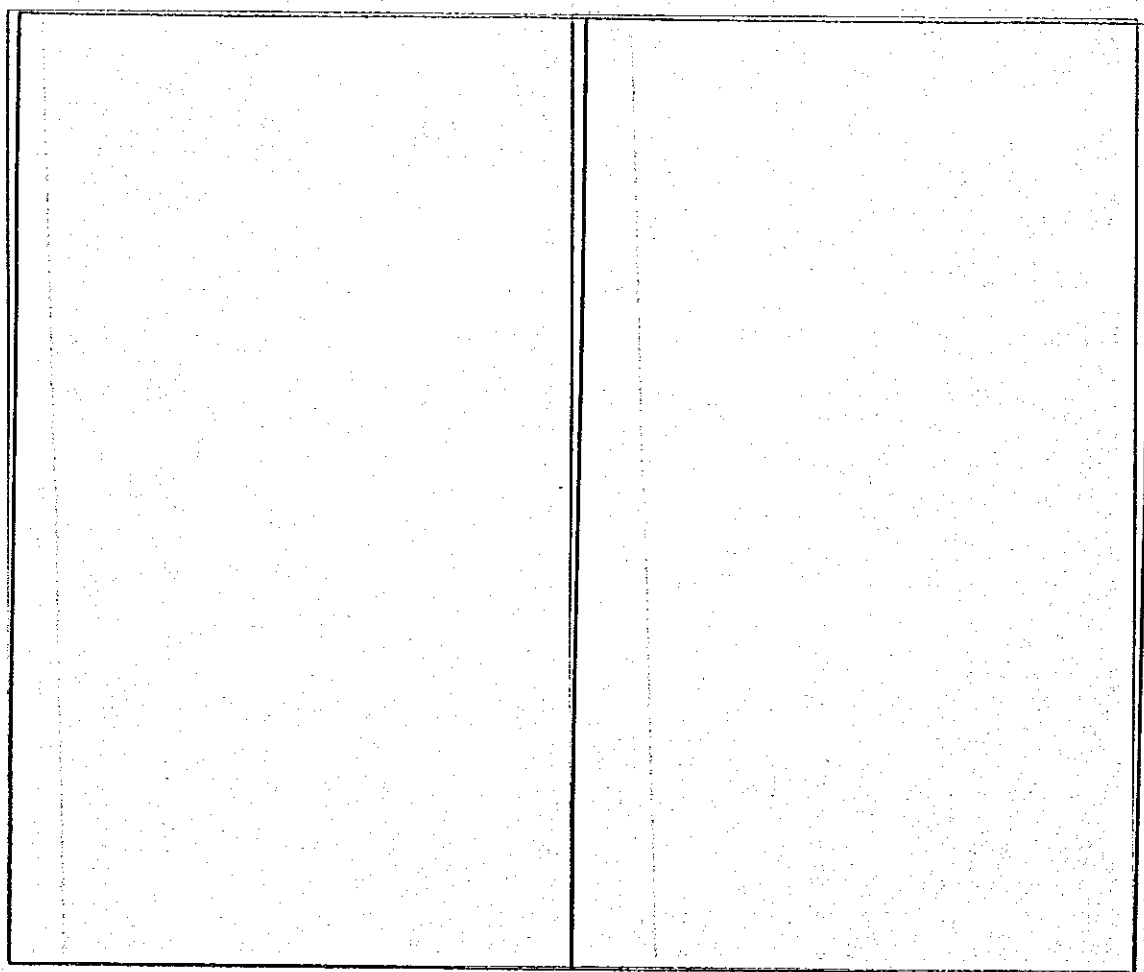


Figure - 16(1)

Asin-Seismic

Case 10: Asin-seismic-full close + seismic force-full close

Bending Moment Scale |----| : 259.91 tf·m max. : 52.44 tf·m

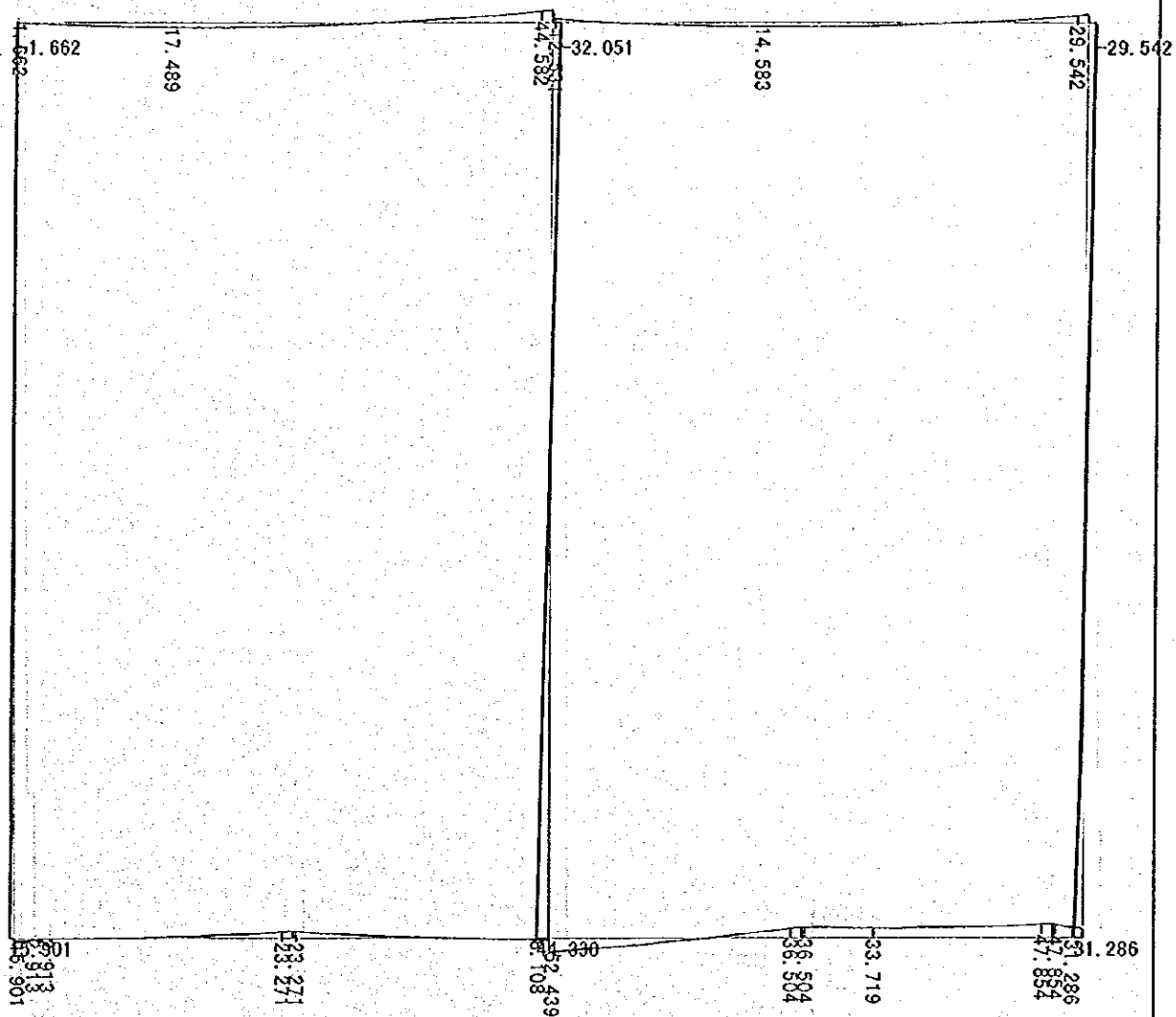


Figure - 16 (2)

Asin-Seismic

Case 10: Asin-seismic-full close + seismic force-full close

Shear Stress

Scale |---| : 65.02tf

max. : 55.75 tf

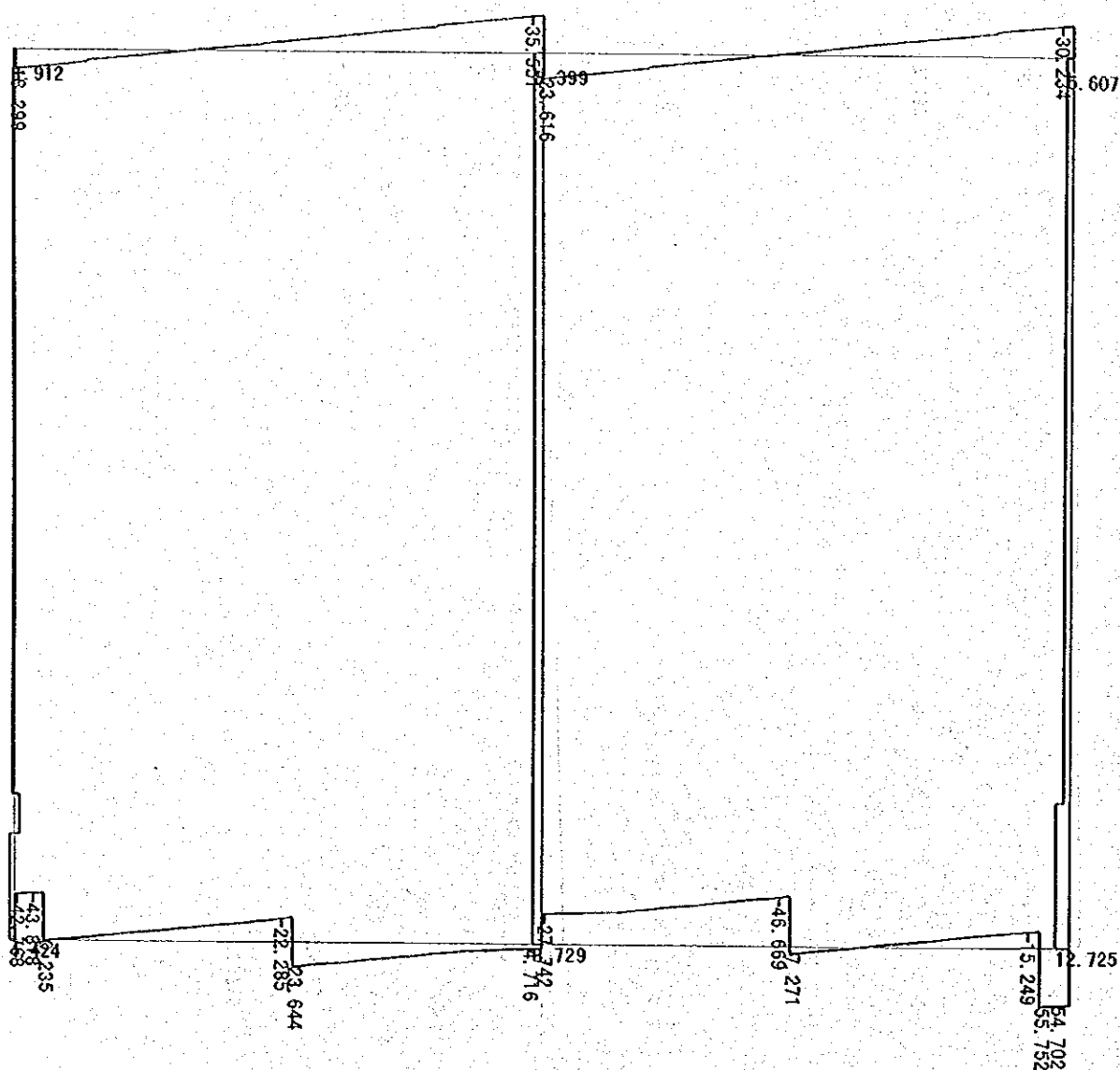


Figure - 16 (3)

Asin-Seismic

Case 10: Asin-seismic-full close + seismic force-full close

Axial Stress

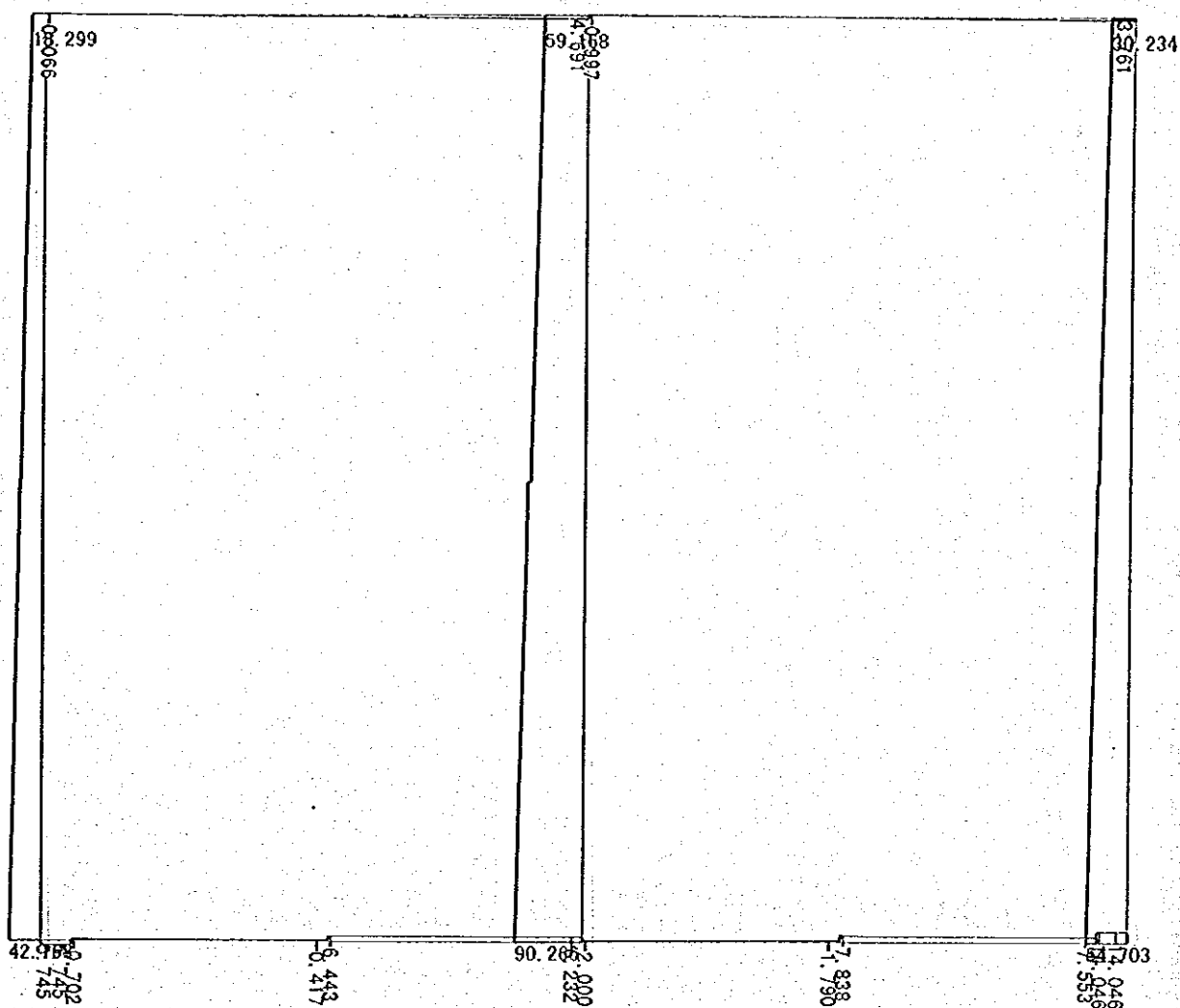
Scale ---|---| : 94.69tf max. : 90.27 tf

Figure - 16 (4)

Asin-Seismic

Case 11: Asin-seismic-left open + seismic force-left open

Deformation Scale |-----| : 5.673cm max. : 1.261 cm

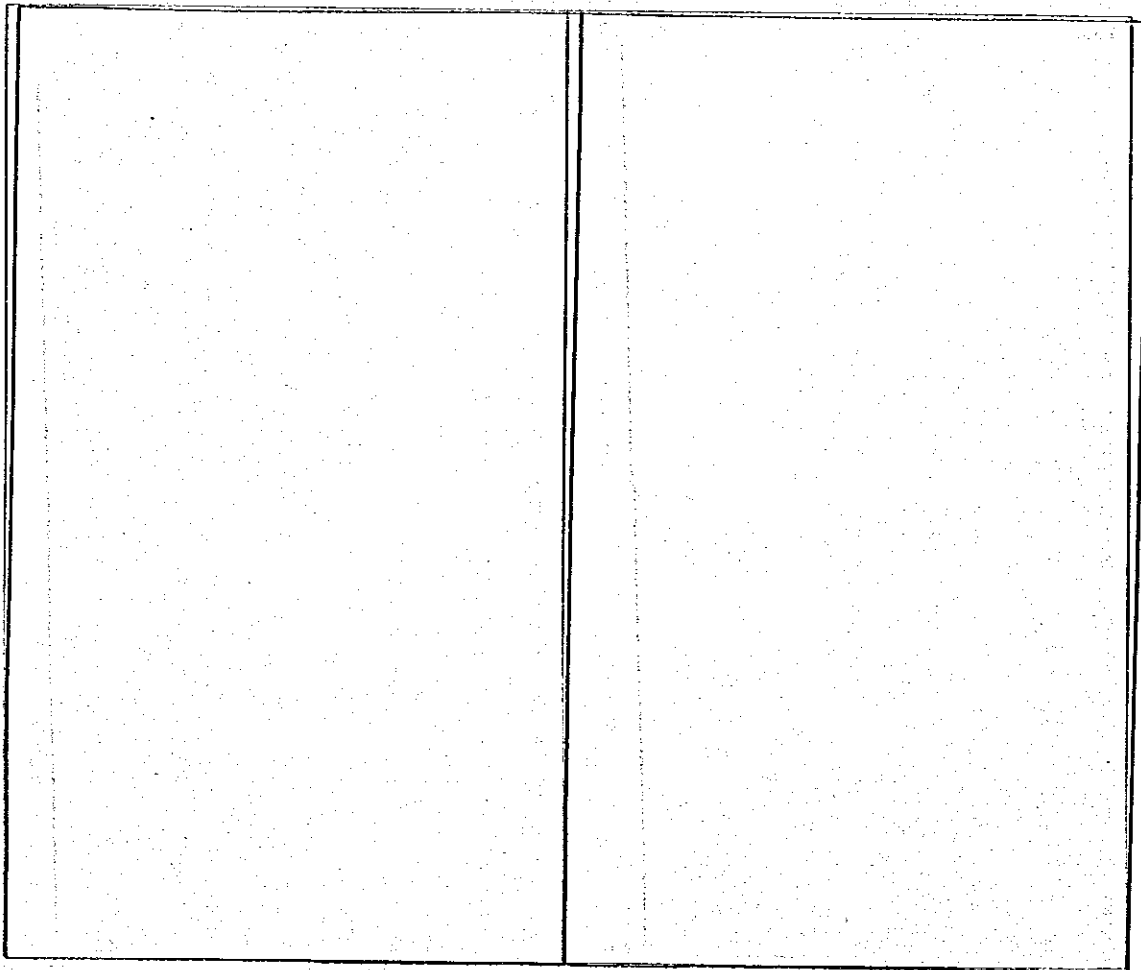


Figure-17 (1)

Asin-Seismic

Case 11: Asin-seismic-left open + seismic force-left open

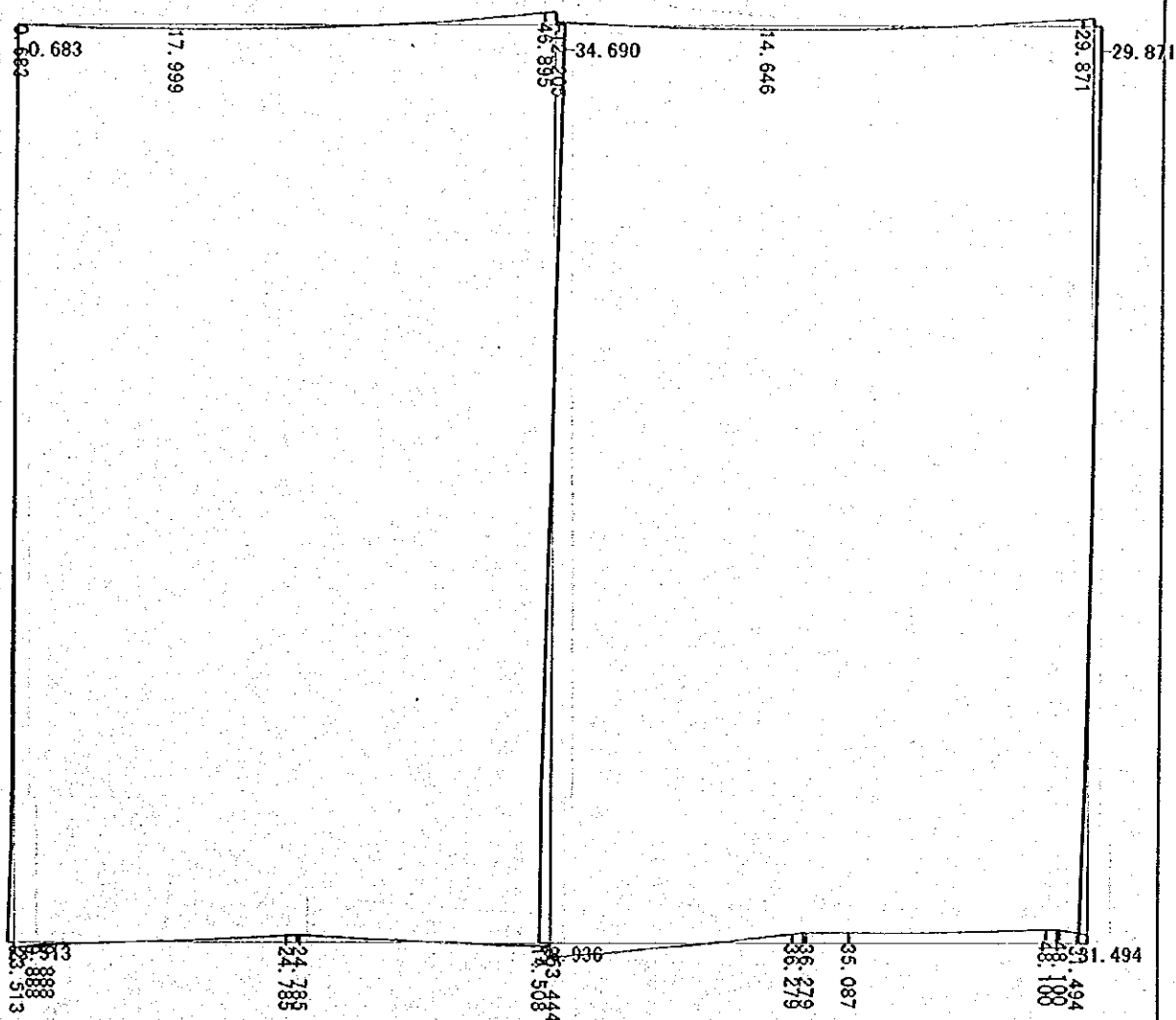
Bending Moment Scale ---|---| :259.91tf·m max. : 53.44 tf·m

Figure -17(2)

Asin-Seismic

Case 11: Asin-seismic-left open + seismic force-left open

Shear Stress

Scale : 65.02tf max. : 55.88 tf

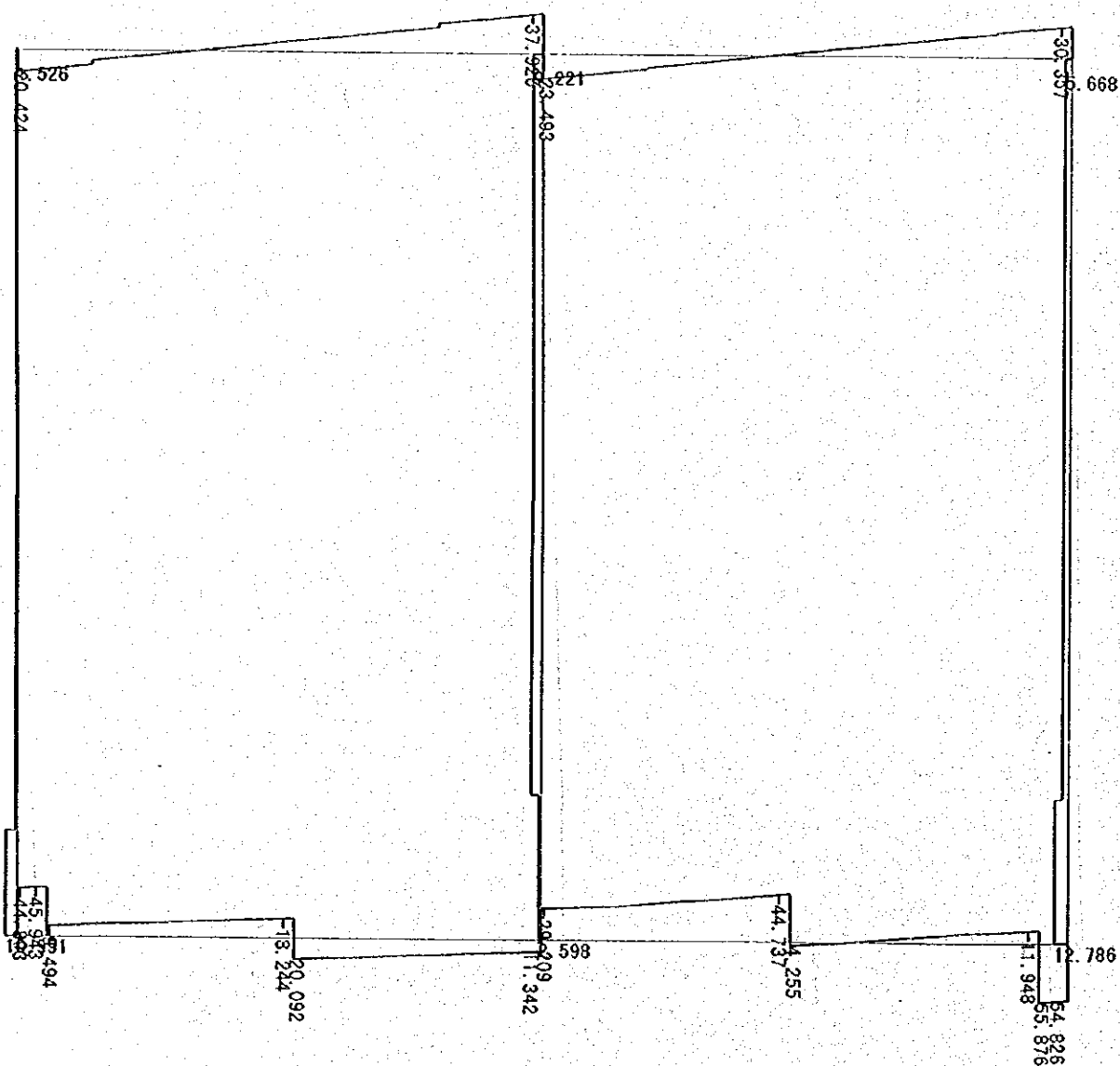


Figure - 17 (3)

Asin-Seismic

Case 11: Asin-seismic-left open + seismic force-left open

Axial Stress

Scale | : 94.69tf max. : 92.52 tf

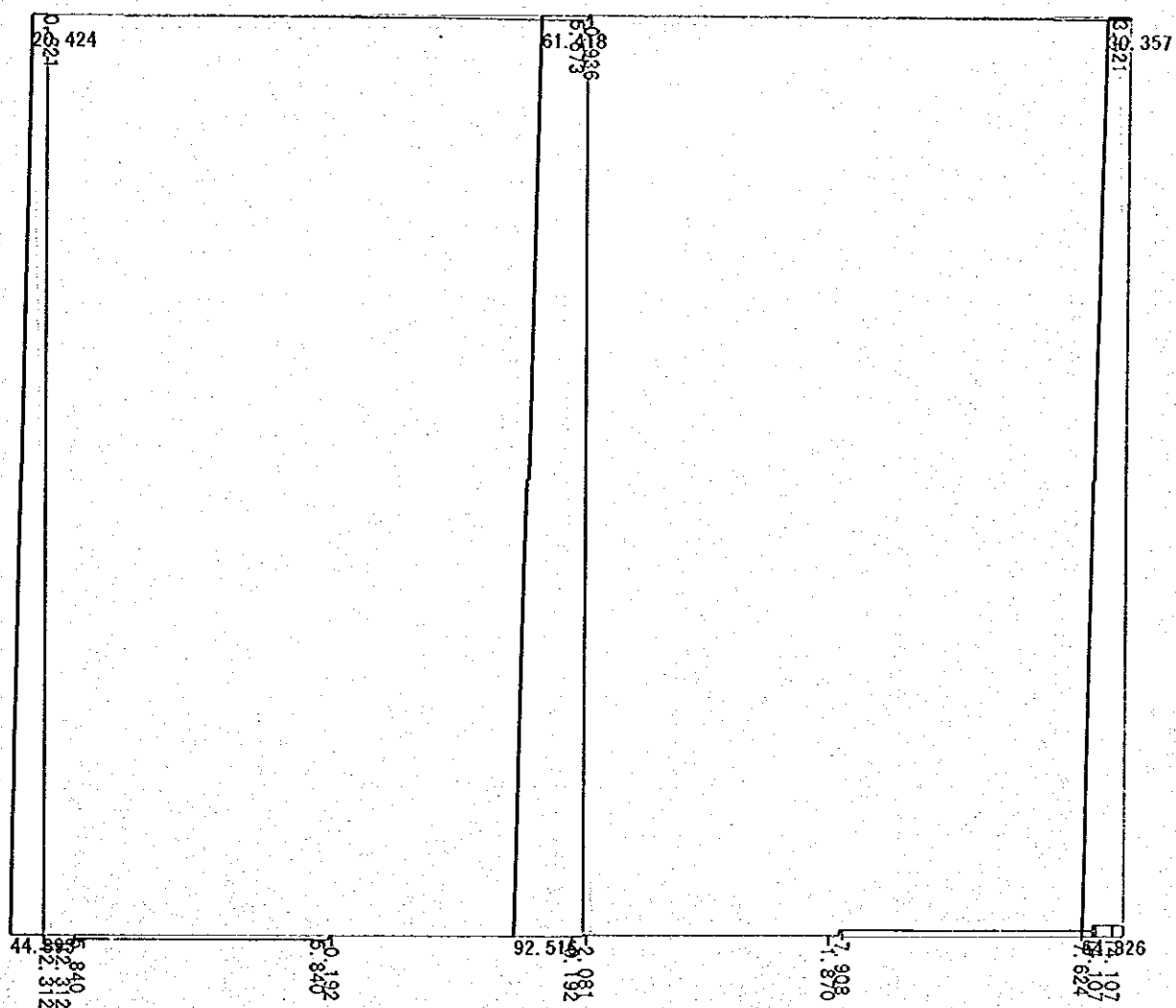


Figure - 17.(4)

Asin-Seismic

Case 12: Asin-seismic-right open + seismic force-right open


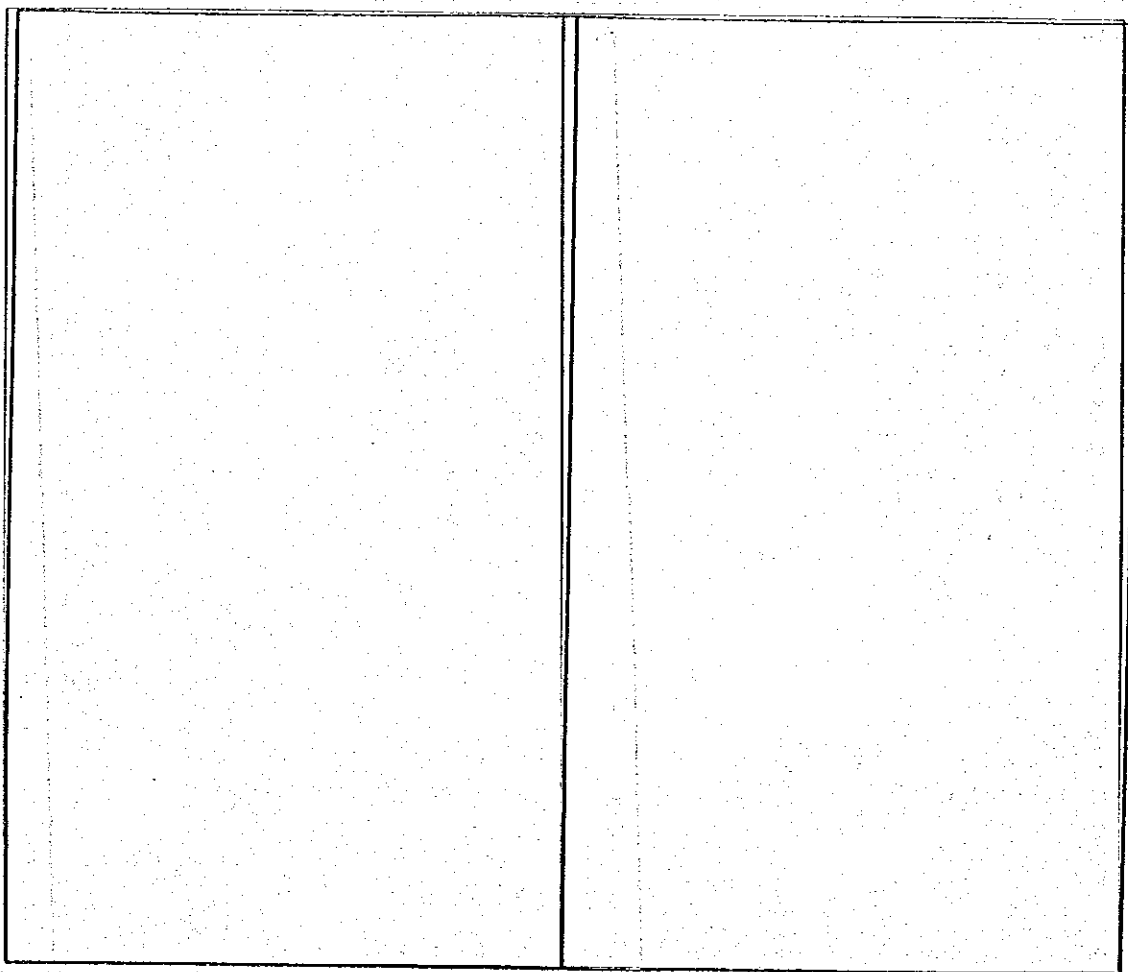
Deformation Scale  : 5.673cm max. : 1.230 cm

Figure -18 (1)

Asin-Seismic

Case 12: Asin-seismic-right open + seismic force-right open

Bending Moment Scale |——| :259.91tf·m max. : 59.84 tf·m

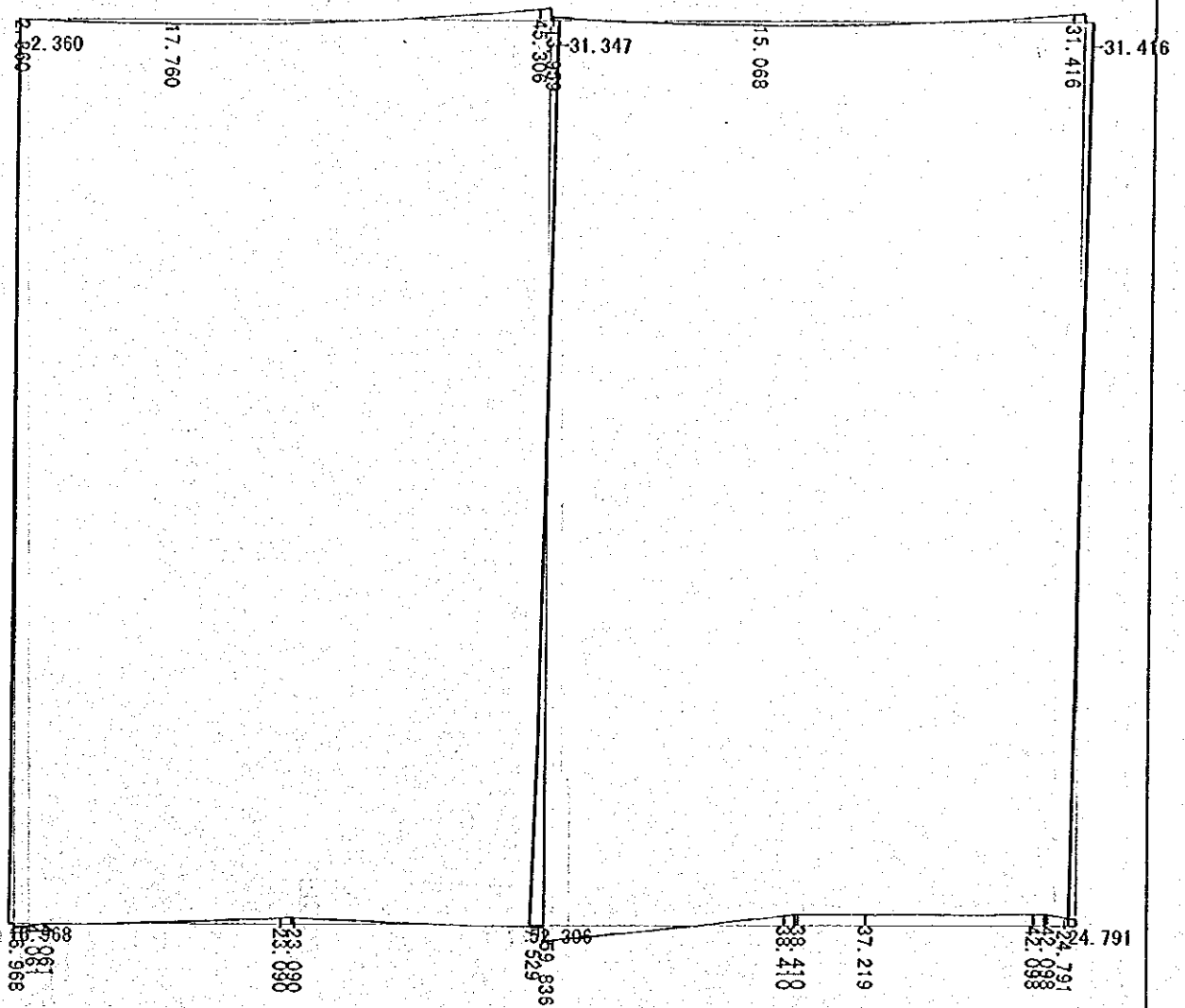


Figure - 18(2)

Asin-Seismic

Case 12: Asin-seismic-right open + seismic force-right open

Shear Stress Scale |——| : 65.02tf max. : 58.21 tf

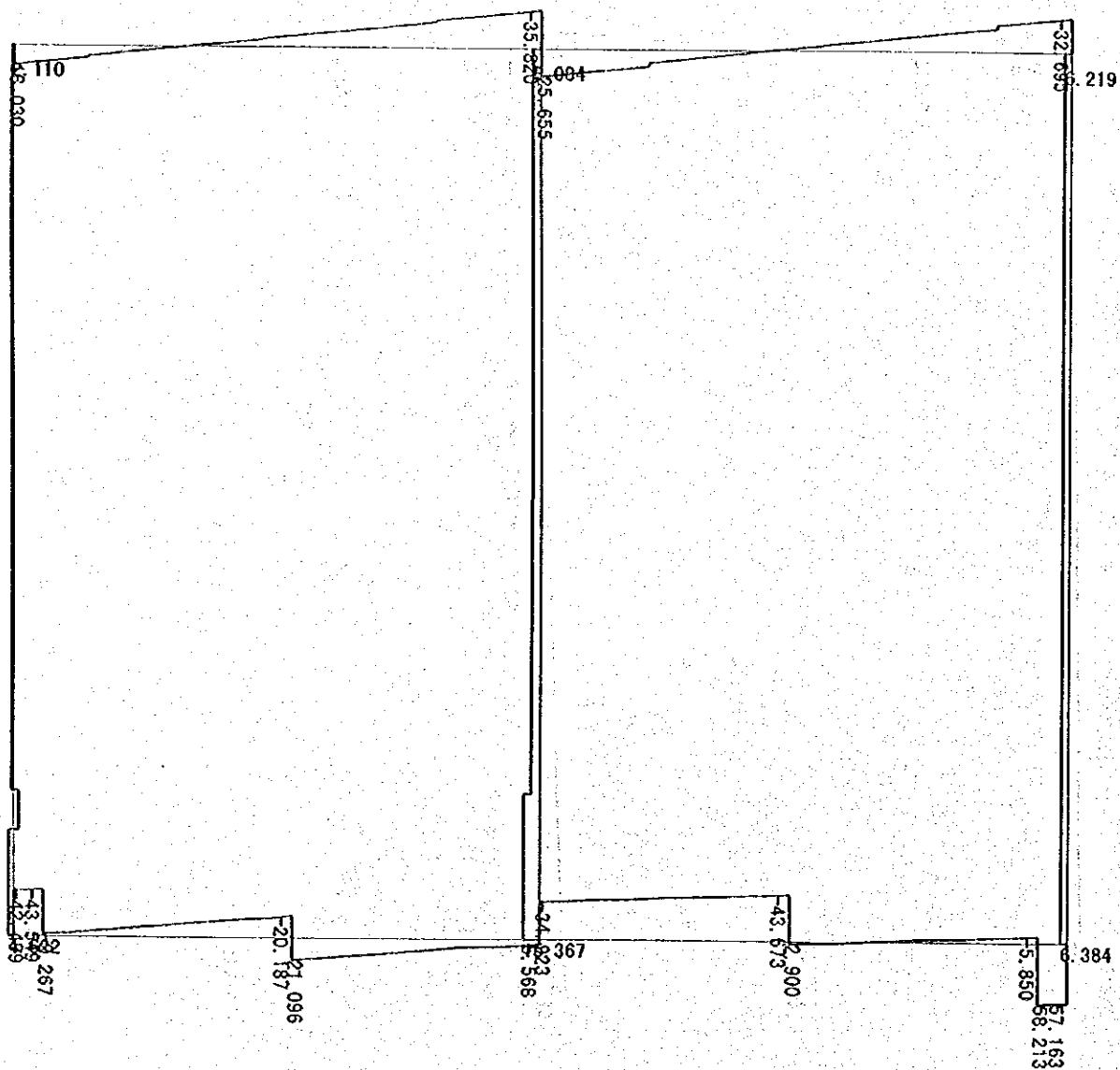


Figure-18(3)

Asin-Seismic

Case 12: Asin-seismic-right open + seismic force-right open

Axial Stress Scale |——| : 94.69tf max. : 92.57 tf

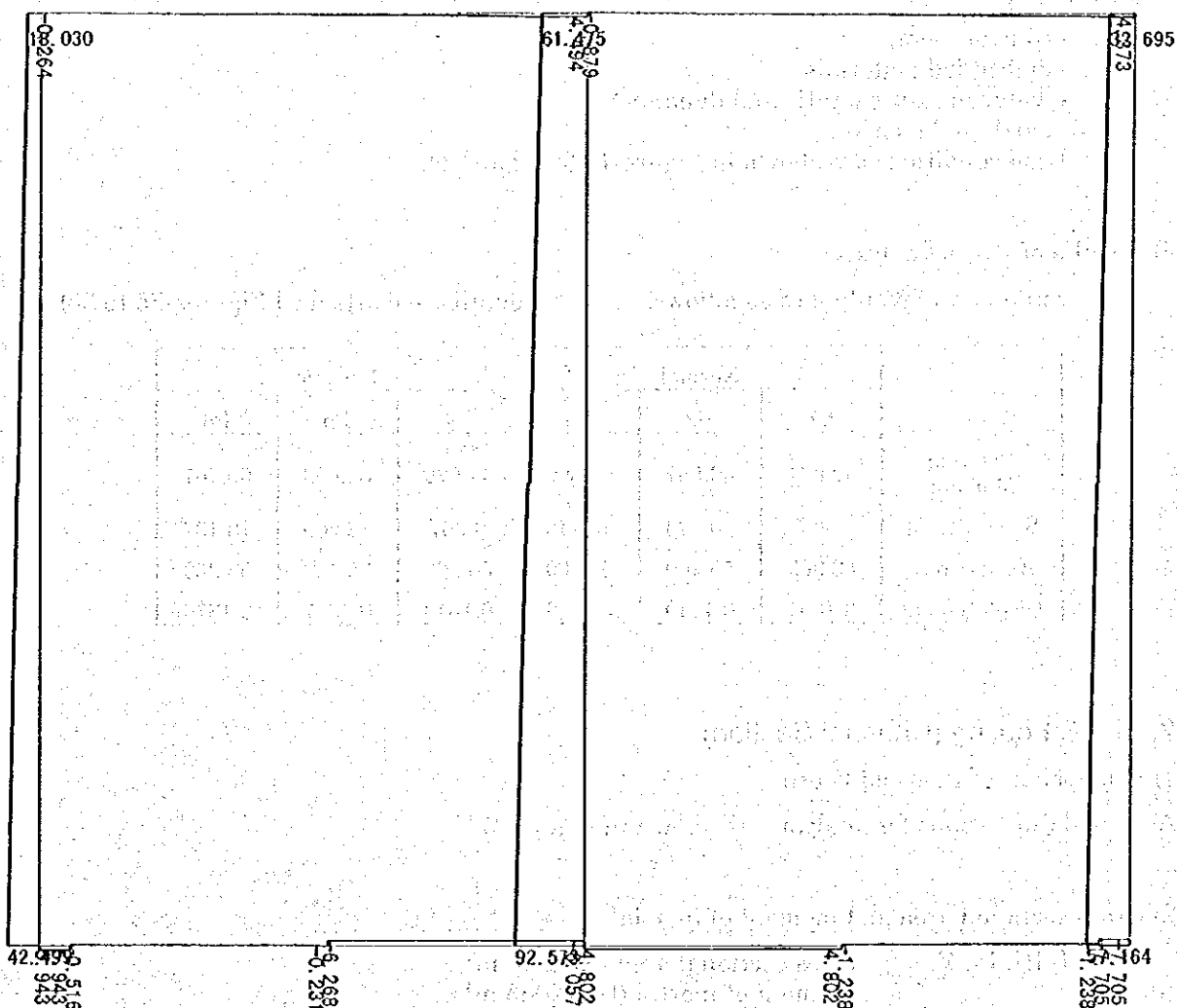


Figure-18 (4)

Name of Structure	Asin Gate	Category of calculation	Stress Analysis	Page	44 / 116
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2) Cross sectional area and moment of inertia

VIII cross sectional area (A): 1.03 m²
moment of inertia (I): 0.3433 m⁴

3) Load condition

Case-B1: Normal condition, Gate open

Case-B3: Normal condition, Gate close

Case-B5: Seismic condition, One Gate open

Case-B2: Normal condition, One Gate Open

Case-B4: Seismic condition, Gate Open

Case-B6: Seismic condition, Gate close

Loads to be considered are as follows:

- self-weight
- gate
- hoist
- motor
- control room
- embedded materials
- water pressure (static and dynamic)
- earthquake force

Load conditions are shown in Figure-19 to Figure-24.

4) Results of stress analysis

Summary of results are as follows:

(details, see attached Figures-25 to 30)

	Normal			Seismic		
	B1	B2	B3	B4	B5	B6
Bending Moment	42.861	46.582	50.306	44.629	52.699	60.767
Shear Stress	4.805	10.273	15.742	6.267	12.200	18.132
Axial Stress	56.969	55.469	53.969	56.969	55.469	53.969
Displacement	0.1351	0.1249	0.1146	0.1318	0.1347	0.1376

2. Pier & Footing (Channel Section)

1) Dimensions of Pier and Footing.

Assumed dimensions for analysis are shown in Figure-31.

2) Cross sectional area and moment of inertia

I, III, IV, V: cross sectional area (A): 2.50 m²
moment of inertia (I): 0.2083 m⁴

II: cross sectional area (A): 4.00 m²
moment of inertia (I): 0.8533 m⁴

3) Load condition

Case-1: Normal condition, No water

Case-3: Normal condition, Water at right

Case-2: Normal condition, Water at left

Case-4: Normal condition, Water at both

Asin Gete

Case 1 : Asin-normal-open

Load

- ① 4.805 (tf)
- ② 34.000 (tf)

Self-weight included

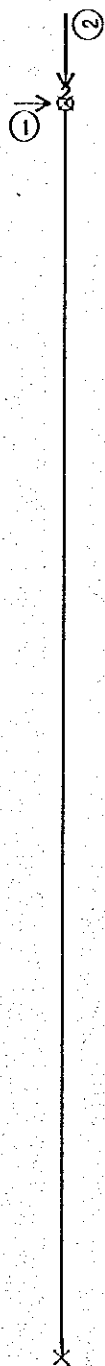
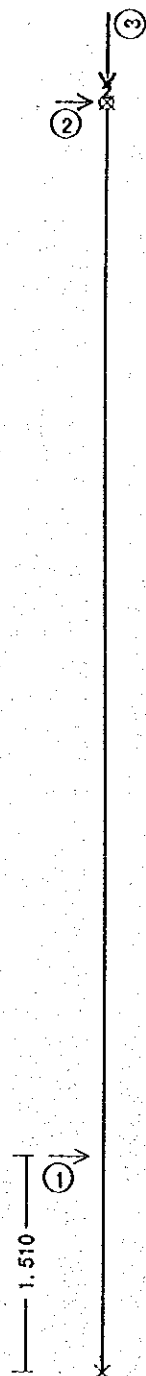


Figure - 19

Asin Gete

Case 2 : Asin-nomal-half



Load	
①	6.080 (tf)
②	4.193 (tf)
③	32.500 (tf)
Self-weight included	

Figure - 20

Asin Gate

Case 3 : Asin-normal-close

Load

- ① 12.161 (tf)
- ② 3.581 (tf)
- ③ 31.000 (tf)

Self-weight included

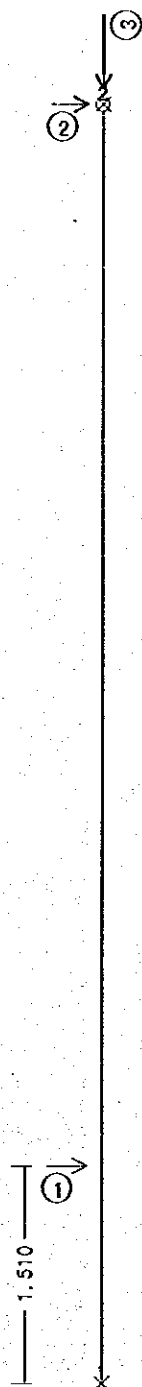
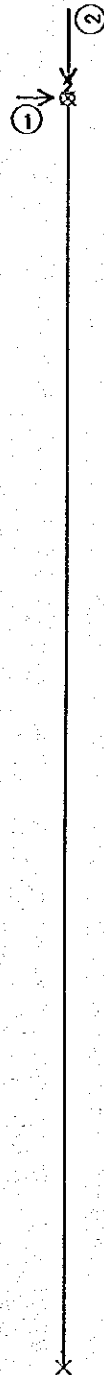


Figure - 21

Asin Gete

Case 4 : Asin-seismic-open



Load

- ① 3.740 (tf)
- ② 34.000 (tf)

Self-weight included

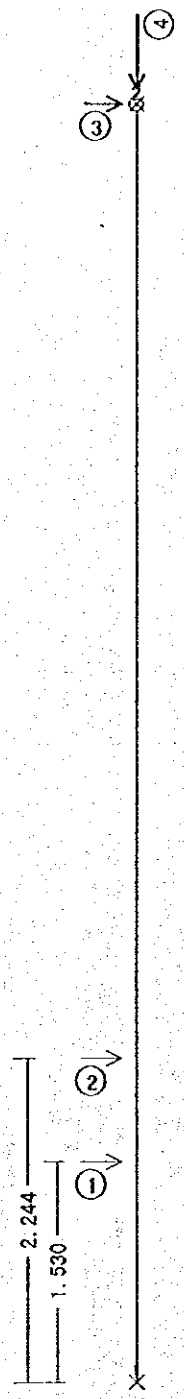
Seismic Force

 $KH = 0.11$

Figure - 22

Asin Gete

Case 5 : Asin-seismic-half



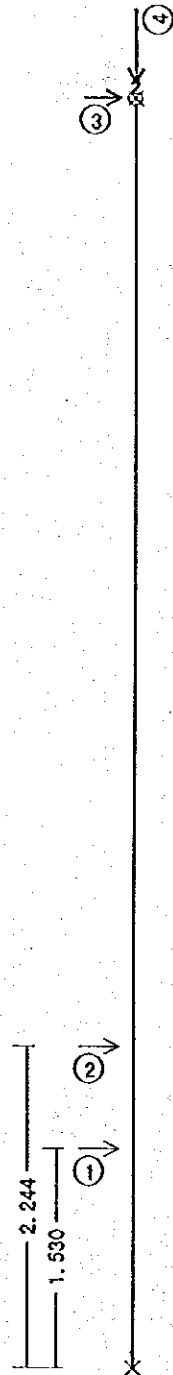
Load	
①	5.802 (tf)
②	0.296 (tf)
③	3.575 (tf)
④	32.500 (tf)

Self-weight included
Seismic Force
KH = 0.11

Figure-23

Asin Gete

Case 6 : Asin-seismic-close



Load	
①	11.603 (tf)
②	0.592 (tf)
③	3.410 (tf)
④	31.000 (tf)

Self-weight included

Seismic Force

 $KH = 0.11$

Figure-24

Asin Gete

Case 1: Asin-nomal-open

Deformation

Scale  : 0.138cm max. : 0.135 cm

Figure -25 (1)

Asin Gete

Case 1: Asin-nomal-open

Bending Moment Scale |——| : 60.77tf·m max. : -42.86 tf·m

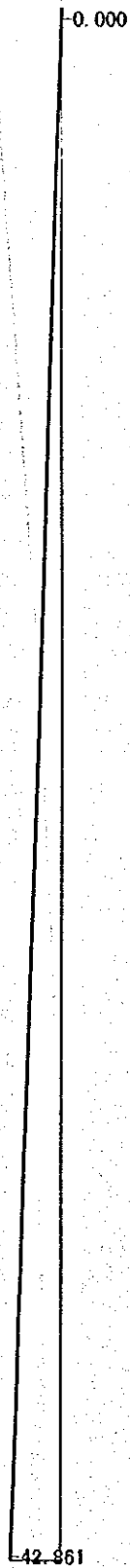


Figure-25(2)

Asin Gete

Case 1: Asin-nomal-open

Shear Stress

Scale |——| : 18.13tf

max. : 4.80 tf

4.805

4.805

Figure-25(3)

Asin Gate

Case 1: Asin-normal-open

Axial Stress

Scale |——| : 56.97tf max. : 56.97 tf

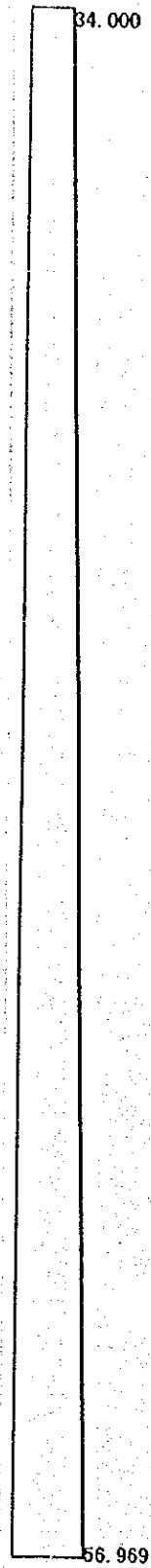


Figure --25 (4)

Asin Gete

Case 2: Asin-nomal-half

Deformation

Scale |——| : 0.138cm max. : 0.125 cm



Figure - 26 (1)

Asin Gete

Case 2: Asin-normal-half

Bending Moment Scale | : 60.77 tf·m max. : -46.58 tf·m

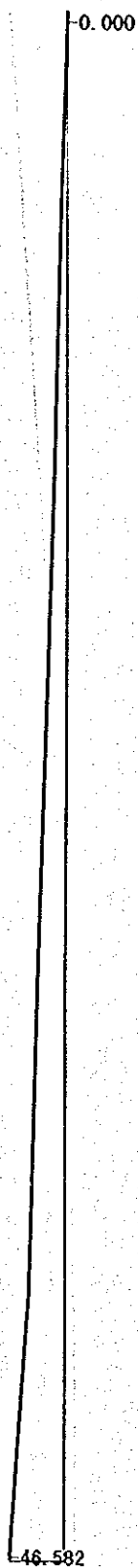


Figure - 26 (2)

Asin Gete

Case 2: Asin-nomal-half

Shear Stress

Scale |——| : 18.13tf

max. : 10.27 tf

4.193

10.273

Figure - 26 (3)

Asin Gete

Case 2: Asin-normal-half

Axial Stress

Scale |——| : 56.97tf max. : 55.47 tf

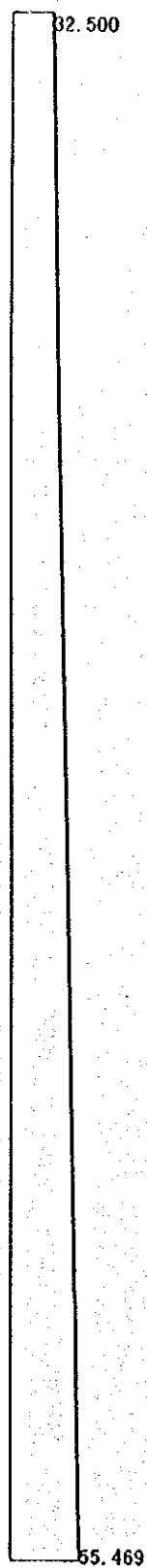


Figure - 26 (4)

Asin Gete

Case 3: Asin-normal-close

Deformation

Scale |——| : 0.138cm max. : 0.115 cm



(1) Asin-normal-close

Figure - 27 (1)

Asin Geto

Case 3: Asin-normal-close

Bending Moment Scale |——| : 60.77tf·m max. : -50.31 tf·m

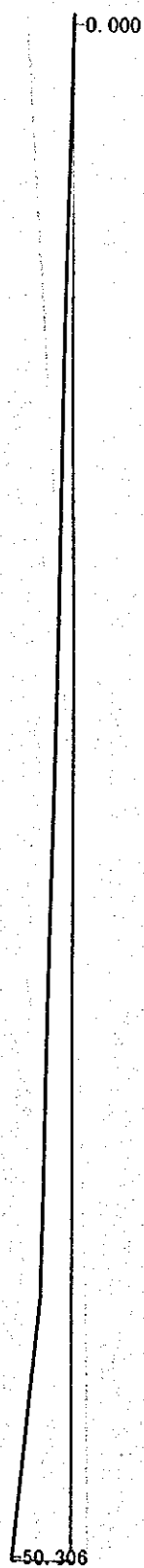


Figure - 27 (2)

Asin Gete

Case 3: Asin-normal-close

Shear Stress

Scale |——| : 18.13tf

max. : 15.74 tf

3.581

15.742

Figure - 27 (3)

Asin Gete

Case 3: Asin-normal-close

Axial Stress



Scale  : 56.97tf max. : 53.97 tf

Figure - 27 (4)

Asin Gete

Case 4: Asin-seismic-open

Deformation

Scale  : 0.138cm

max. : 0.132 cm



Figure - 28 (1)

Asin Gete

Case 4: Asin-seismic-open

Bending Moment Scale |——| : 60.77tf·m max. : -44.63 tf·m

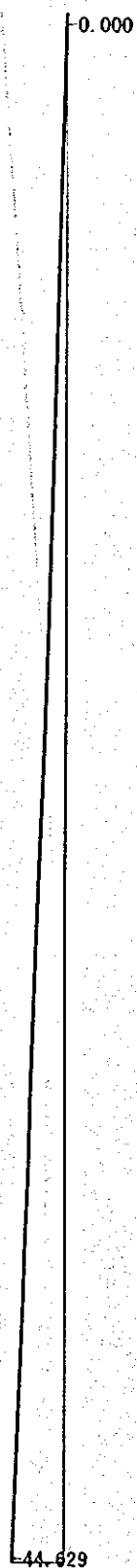


Figure - 28(2)

Asin Gete

Case 4: Asin-seismic-open

Shear Stress

Scale |——| : 18.13tf

max. : 6.27 tf

3.740

6.267

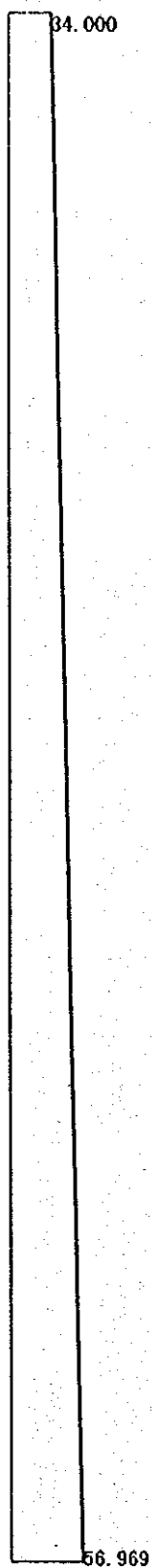
Figure - 28(3)

Asin Goto

Case 4: Asin-seismic-open

Axial Stress

Scale |——| : 56.97tf max. : 56.97 tf




(SIN - 10000)

Figure - 28(4)

Asin Geto

Case 5: Asin-seismic-half

Deformation

Scale  : 0.138 cm

max. : 0.135 cm

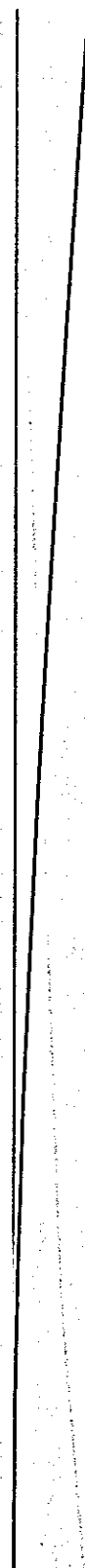


Figure — 29(1)

Asin Gete

Case 5: Asin-seismic-half

Bending Moment

Scale |——| : 60.77tf·m max. : -52.70 tf·m

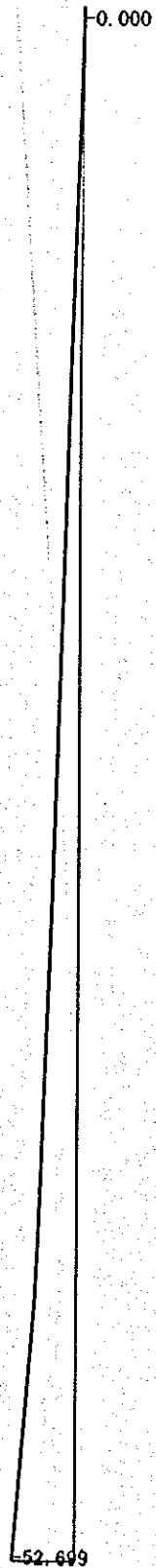


Figure — 29(2)

Asin Gete

Case 5: Asin-seismic-half

Shear Stress

Scale | — | : 18.13tf max. : 12.20 tf

8.575

12.200

Figure - 29(3)

Asin Gete

Case 5: Asin-seismic-half

Axial Stress

Scale |——| : 56.97tf max. : 55.47 tf

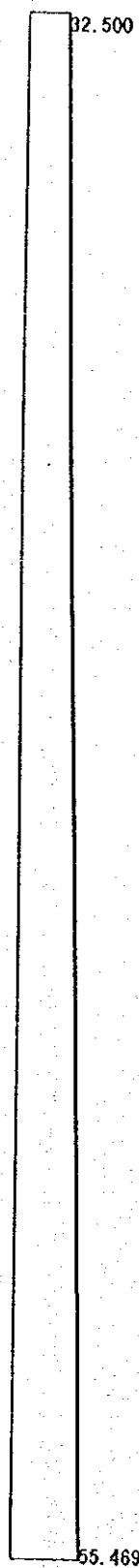


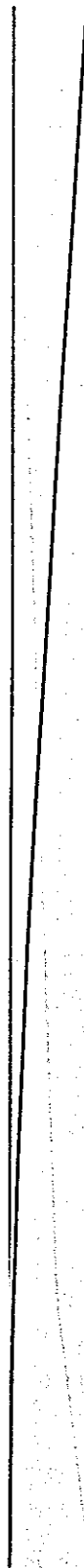
Figure - 29 (4)

Asin Geto

Case 6: Asin-seismic-close

Deformation

Scale |——| : 0.138cm max. : 0.138 cm



(S) 0.138 cm

Figure -- 30 (1)

Asin Gete

Case 6: Asin-seismic-close


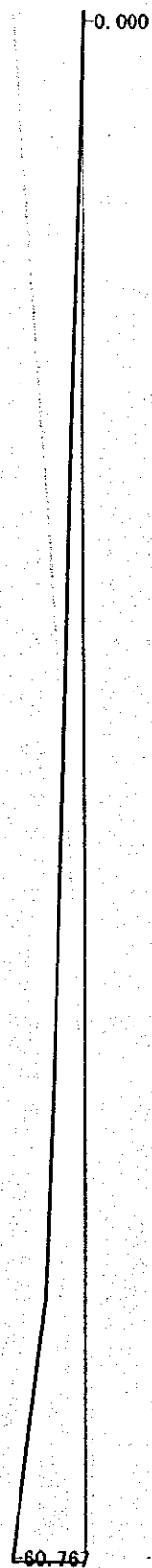
Bending Moment Scale  : 60.77 tf·m max. : -60.77 tf·m

Figure - 30 (2)

Asin Gete

Case 6: Asin-seismic-close

Shear Stress

Scale | — | : 18.13tf

max. : 18.13 tf

3.410

18.132

Figure — 30(3)

Asin Gate

Case 6: Asin-seismic-close

Axial Stress

Scale |——| : 56.97tf max. : 53.97 tf

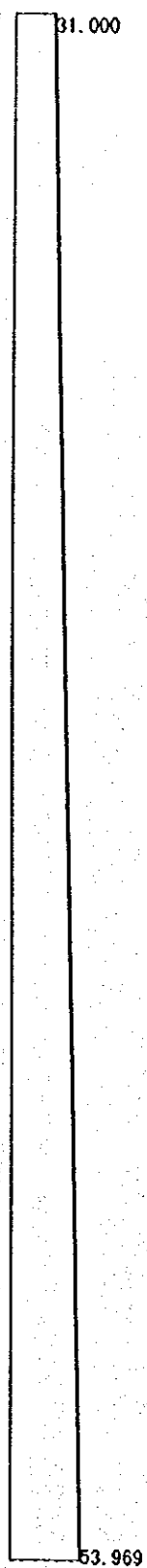


Figure - 30 (4)