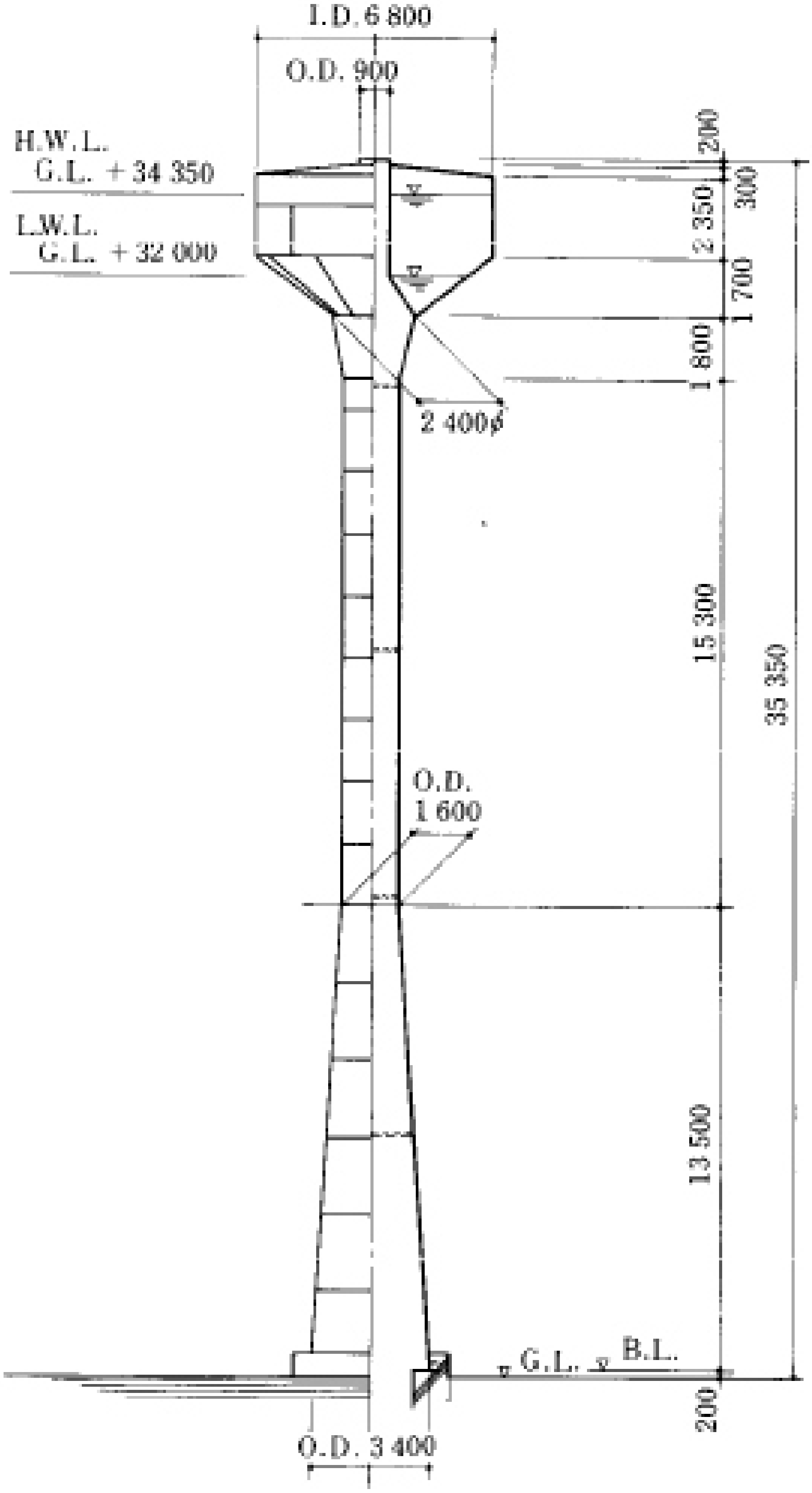


ตัวอย่าง

การออกแบบและคำนวณ

Steel Water Tower Tank

APPENDIX A

DESIGN AND CALCULATION EXAMPLES

APPENDIX A1 STEEL WATER TOWER TANKS

A1.1 Description of water tower tank

A1.1.1 Outline

The structural outline and design conditions are shown in Table A1.1.

Table A1.1 Design Conditions

Description	Usage Structural type Shape	Tower for water supply Steel plate tower Vessel – Cylindrical shell Tower – Cylindrical column
Outline of structure	Height Vessel diameter Diameter of tower	GL + 35.35m 6.8m 1.6~3.4m
Outline of vessel	H.W.L L.W.L Water capacity Total volume	GL + 34.35m GL + 32.0m 80m^3 93.4m^3
Design Conditions	Standards and codes	a. Building Standard Law b. Design Recommendation for Storage Tanks and Their Supports (AIJ) c. Design Standard for Steel Structures (AIJ) d. Standard for Structural Calculation of RC Structures (AIJ) e. Japanese Industrial Standards (JIS)
		Steel – JIS G 3136 SN400B Concrete – Fc = 21N/mm^2 Reinforced bars – SD295
	Allowable stress	Refer to b. and c.

A1.2 Calculation of Tube Tower

A1.2.1 Assumed section of tube tower

The natural period of the tower is calculated with the thickness without reducing the 1 mm of corrosion allowance. The outline of the water tower tanks is shown in Figure A1.1.

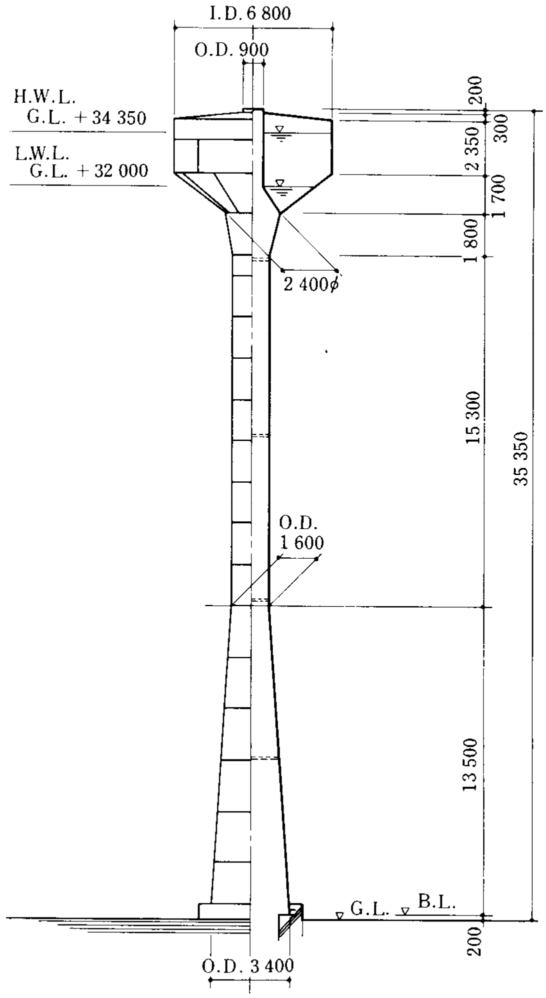


Fig. A1.1 Outline of Water Tower Tank

A1.2.2 Assumed loads

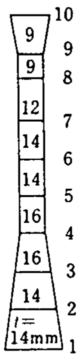
(1) Vertical Load

The total vertical load upon its base plate: mass

Water	915.32k N	(93,400 kg)
Vessel	107.80 kN	(11,000 kg)
Pipe (1.47kN/m)	47.04 kN	(4,800 kg)
Deck (26.46kN for each)	105.84 kN	(10,800 kg)
Tube weight	107.80 kN	(11,000 kg)
	1,283.80 kN	(131,000 kg)

The sectional dimensions and modeling of the tower are shown in Table A1.2 and Figrure A1.2, respectively.

Table A1.2 Sections of Tower



Level B. L+ (m)	h_n (cm)	OD (cm)	t (cm)
30.6		240	
	180		0.9
28.8		160	
	90		0.9
27.9		160	
	360		1.2
24.3		160	
	360		1.4
20.7		160	
	360		1.4
17.1		160	
	360		1.6
13.5		160	
	450		1.6
9.0		220	
	450		1.4
4.5		280	
	450		1.4
0		340	

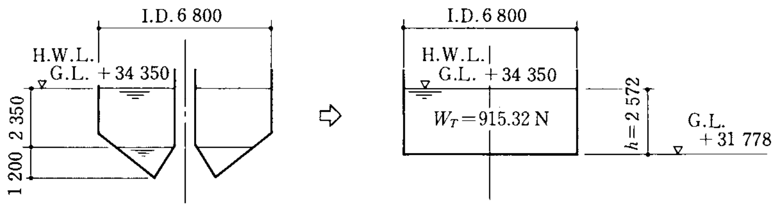


Fig.A1.2 Modeling of Tower

A1.2.3 Stress Calculation

(1) Modified Seismic Coefficient Method

The flexibility matrix and the mass matrix are obtained from the following equation:

Flexibility matrix,

$$[F]=\begin{bmatrix}0.0343 & 0.1228\\0.1228 & 1.0903\end{bmatrix}$$

Mass matrix,

$$[M]=\begin{bmatrix}m_1 & 0\\0 & m_2\end{bmatrix}$$

$\therefore T_1 = 1.572\,\text{s}$

$T_2 = 0.106\,\text{s}$

$B = 1.0, Z_s = 1.0, I = 1.0, D_s = 0.5, T_g = 0.96,$

$T_1 > T_g$

From (3.2)

$$\therefore C = Z_s \cdot I \cdot D_s \cdot \frac{T_g}{T_1} = 0.305 > 0.3 Z_s I$$

$W = W_1 + W_2 = 683.52\,\text{kN}$

$Q_d = C \cdot W = 208.47\,\text{kN}$

$Q_{ei} = Q_{di} / B$

From (3.4)

$$f_{di} = Q_d \frac{\sum_{m=i}^{n} W_m \cdot h_m}{\sum_{m=1}^{n} W_m \cdot h_m}$$

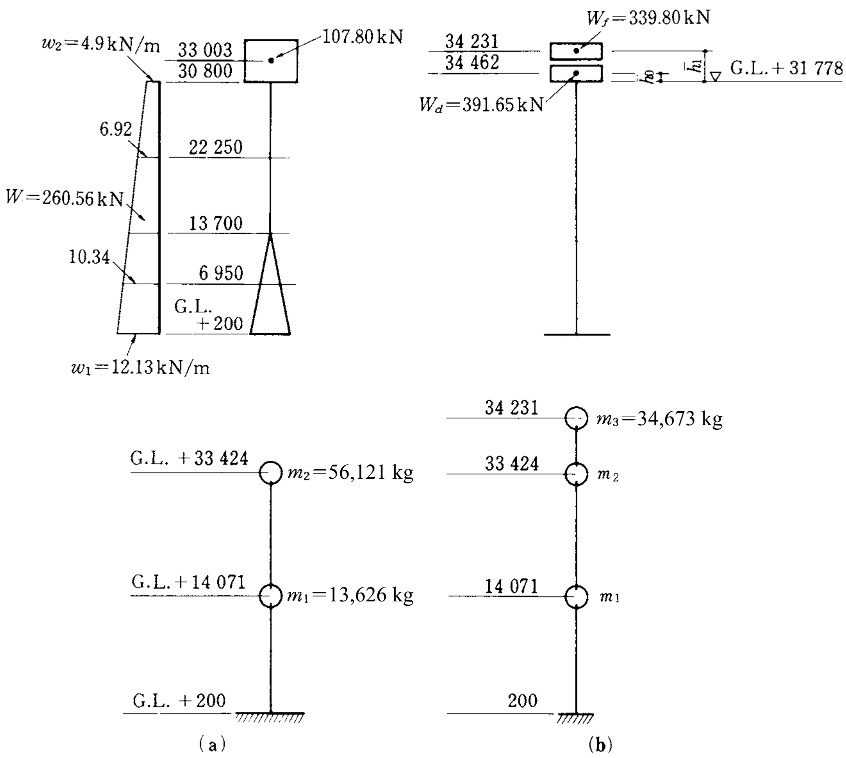


Fig.A1.3 Lumped Mass Model

Table.A1.3 Q_{ei} Obtained by Calculations

i	W_i (kN)	ΣW_i (kN)	h_i B. L.+ (m)	$\sum_{m=i}^{n} W_m \cdot h_m$	$\frac{\sum_{m=i}^{n} W_m \cdot h_m}{\sum_{m=1}^{n} W_m \cdot h_m}$	$\frac{Q_d}{B}$	Q_{ei} (kN)	M_{ei} (kN·m)
2	549.99	549.99	33.224	18 272.9	0.908	208.47	189.14	3 650.5
1	133.53	683.52	13.871	20 125.1	1.0		208.47	6 552.3

(2) Modal Analysis

The flexibility matrix and the mass matrix are obtained from the model shown in Fig. A1.3(b) as follows:

$$[F]=\begin{bmatrix} 0.0343 & 0.1228 & 0.1265 \\ 0.1228 & 1.0903 & 1.1415 \\ 0.1265 & 1.1415 & 7.2404 \end{bmatrix}$$

$\delta'_{33}=1/K_2$ is added to δ_{33} from stiffness coefficient, where K_2 is the spring constant for the convective mass.

$$[M]=\begin{bmatrix} m_1 & 0 & 0 \\ 0 & m_2 & 0 \\ 0 & 0 & m_3 \end{bmatrix}$$

Q_{d1}=157.09 kN < $0.3Z_sIW$=205.02 kN

Stresses in modal analysis are obtained by multiplying with $\frac{0.3Z_sIW}{Q_{d1}}$ as follows:

$$Q_{ei}=\frac{Q_{di}}{B}\cdot\frac{0.3Z_sIW}{Q_{d1}}$$

Table.A1.4 Natural Periods, u, β and C

j (th)	i	T_j (s)	u_{ij}	β_j	S_{aj}	C_j
1	3 2 1	3.259	1.0 0.196 0.0218	1.248	288.7	0.147
2	3 2 1	1.402	1.0 −3.147 −0.358	−0.248	671.0	0.342
3	3 2 1	0.106	1.0 −162.54 5 895.3	0.00015	980	0.500

Z_s=1.0, I=1.0, D_s=0.5, T_o=0.96 s

Table.A1.5 Q_{ei} Obtained by calculation

mass	W_i (kN)	$\beta_1 \cdot u_{i1}$	$C_1 \sum_{m=i}^{3} W_m \cdot \beta_1 \cdot u_{i1}$	$\beta_2 \cdot u_{i2}$	$C_2 \sum_{m=i}^{3} W_m \cdot \beta_2 \cdot u_{i2}$	$\beta_3 \cdot u_{i3}$	$C_3 \sum_{m=i}^{3} W_m \cdot \beta_3 \cdot u_{i3}$	Q_{di} (kN)
3	339.80	1.249	62.39	−0.249	−28.93	0.00015	0.03	68.80
2	549.99	0.246	82.27	0.778	117.40	−0.0246	−6.73	143.57
1	133.53	0.130	84.83	0.0894	121.48	0.884	52.28	157.09

Table.A1.6 Calculation of Q_{ei} and M_{ei}

i	h_i B. L. + (m)	Q_{ei} (kN)	M_{ei} (kN·m)
3	34.031	89.77	72.423
2	33.224	187.38	3 698.52
1	13.871	205.02	6 542.48

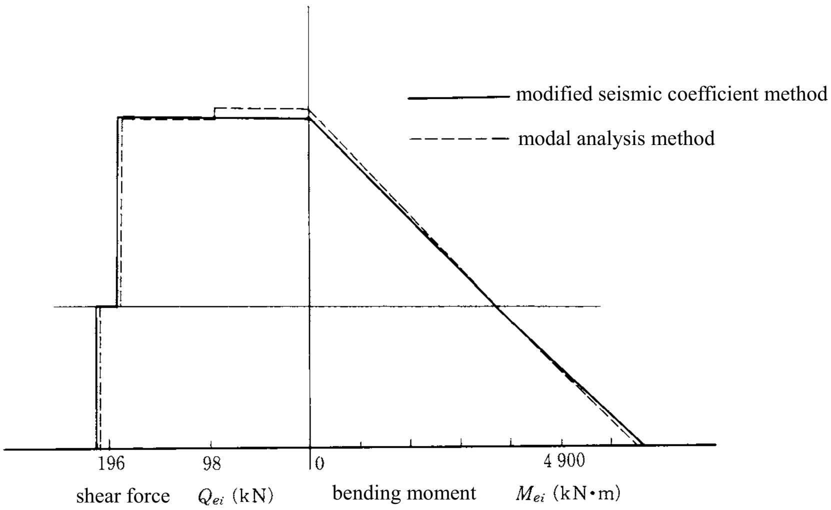


Fig.A1.4 Comparision of Stresses obtained using the Modified Seismic Coefficient Method and the Modal Analysis

A1.3 Water Pressure Imposed on the Tank

Impulsive mass (water),

$$Q = (Q_{e2} - Q_{e1})\frac{W_d}{56.21} = 69.39 \text{ kN} = \iint \overline{P} \cdot Rd\varphi \cdot dy$$

Convective mass (water),

$$Q' = 89.77\ \text{kN} = \iint \overline{P} R d\varphi \cdot dy$$

Height of wave due to sloshing; from (7.9),

$$\eta_s = \frac{0.802 \cdot Z_s \cdot I \cdot S_{v1}}{B} \sqrt{\frac{D}{g} \tanh\left(\frac{3.682h}{D}\right)} = 1.104\ \text{m}$$

$$S_{v1} = 2.11 \times \frac{1}{1.2} = 1.758\ \text{m/s}$$

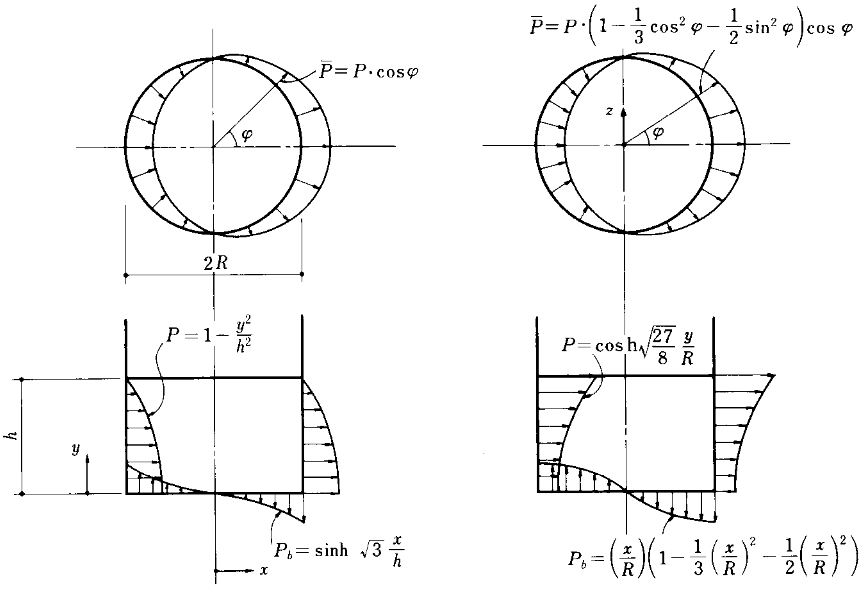


Fig.A1.5 Water Pressure due to Sloshing

A1.4 Wind Loads

(1) Wind loads

Wind loads are obtained from chapter 6 “Wind Loads” of Recommendations for Loads on Buildings (2004), AIJ.

a) Design wind speed

Basic wind speed $U_0 = 36$ (m/s)

Height Coefficient

$E_H = E_r \cdot E_g = 1.205 \times 1.0 = 1.205$

From exposure II,

$Z_b = 5\ \text{m}, \quad Z_G = 350\ \text{m}, \quad \alpha = 0.15$

$$E_r = 1.7 \times \left(\frac{35.35}{350} \right)^{0.15} = 1.205$$

Return period conversion coefficient

$k_{rw} = 0.63(\lambda_u - 1)I_{nr} - 2.9\lambda_u + 3.9 = 0.952$

Return period $r = 50$ years, $\lambda_u = U_{500} / U_0 = 1.111$

Design wind speed at standard height

$U_H = U_0 \cdot k_D \cdot E_H \cdot k_{rw} = 36 \times 1.00 \times 1.205 \times 0.952 = 41.29$ (m/s)

b) Design velocity pressure

$$q_H = \frac{1}{2} \times \rho \times U_H^2 = \frac{1}{2} \times 1.22 \times 41.29^2 = 1{,}040 \text{ (N/m}^2\text{)}$$

Air Density $\rho = 1.22$ (kg/m^3)

c) Pressure coefficient

From $H / D = 35.35 / 4.6 = 7.68$

$Z \leqq 5$m,

$$C_D = 1.2 \times k_1 \cdot k_2 \cdot k_Z = 1.2 \times 0.6 \times \left(\frac{H}{D} \right)^{0.14} \times 0.75 \times \left(\frac{Z_b}{H} \right)^{2\alpha}$$

$$= 1.2 \times 0.6 \times 7.7^{0.14} \times 0.75 \left(\frac{5.0}{35.35} \right)^{2 \times 0.15} = 0.400$$

$28.28\text{m} > Z > 5\text{m}$,

$$C_D = 1.2 \times k_1 \cdot k_2 \cdot k_Z = 1.2 \times 0.6 \times 7.7^{0.14} \times 0.75 \times \left(\frac{Z}{35.35} \right)^{0.3} = 0.247 \times Z^{0.3}$$

$Z \geqq 28.28$m,

$$C_D = 1.2 \times k_1 \cdot k_2 \cdot k_Z = 1.2 \times 0.6 \times 7.7^{0.14} \times 0.75 \times 0.8^{0.3} = 0.672$$

d) Gust effect factor

exponent for mode shape β	2.500
total building mass M	104420kg
generalized building mass M_D	84644kg
λ	0.633
mode correction factor ϕ_D	0.174
turbulence scale at reference height L_H	108.6m
turbulence intensity at reference height Ir_H	0.158

topography factor for the standard deviation	
of fluctuating wind speed E_I	1.000
topography factor for turbulence intensity E_{gI}	1.000
$I_H = Ir_H \cdot E_{gI}$	0.158

gust effect factor

natural frequency for the first mode in	
along-wind direction f_D	0.713Hz
damping ratio for the first mode in	
along-wind direction ζ_D	0.010
C_g	0.457
k	0.070
C'_g	0.127
R	0.386
F	0.075
S_D	0.404
F_D	0.033
R_D	2.593
v_D	0.606
g_D	3.604
gust effect factor G_D	2.044

e) Wind load

$$W_D = q_H \cdot C_D \cdot G_D \cdot A$$

$Z \leqq 5$m

$$W_D = 1{,}040 \times 0.400 \times 2.044 \times A = 850 \times A$$

28.28m $> Z >$ 5m

$$W_D = 1{,}040 \times 0.247 \times Z^{0.3} \times 2.044 \times A = 0.525 \times Z^{0.3} \times A$$

Z$\geqq$28.28m

$$W_D = 1{,}040 \times 0.672 \times 2.044 \times A = 1{,}429 \times A$$

(2) Wind load for vortex oscillation

a) Calculation model

In this example, the calculation model is assumed to have the shape shown in Fig. A1.6, and the water content is assumed to be empty.

Natural period T_1,

From $[F]=\begin{bmatrix}0.0343 & 0.1111\\ 0.1111 & 0.7952\end{bmatrix}$

$T_1 = 0.726$ s

$$[M]=\begin{bmatrix}m_1 & 0\\ 0 & m'_2\end{bmatrix}$$

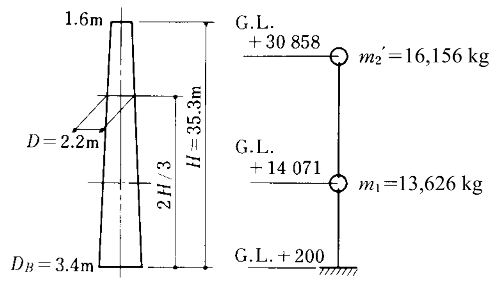
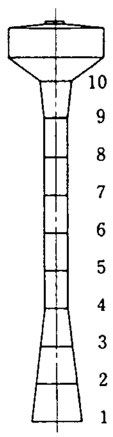


Fig.A1.6 Calculation Model

Table.A1.7 Sectional Forces by Wind Load in the Along Direction



Level GL+ (m)	$q_H \cdot C_D \cdot G_D$ (kN/m²)	A_w (m²)	Q_n (kN)	h_n (m)	M (kN·m)
33.003	1.429	23.12	33.04	2.203	0
30.8	1.429	1.98	35.87	1.8	72.79
29.0	1.429	2.34	39.21	0.9	137.35
28.1	1.428	3.6	44.35	3.6	172.64
24.5	1.371	5.76	52.25	3.6	332.30
20.9	1.307	5.76	59.78	3.6	520.40
17.3	1.235	5.76	66.89	3.6	735.61
13.7	1.151	6.82	74.74	4.5	976.41
9.2	1.022	9.9	84.86	4.5	1312.74
4.7	0.850	12.6	95.57	4.5	1694.61
0.2	0.850	7.31	101.78		2124.68

b) Calculation of wind load for vortex oscillation

The possibility of vortex oscillation is checked according to Chapter 6 "Wind Load" of the "Recommendations for Loads on Buildings (2004)", AIJ as follows.

$$W_r = 0.8 \cdot \rho U_r^2 C_r \frac{Z}{H} A$$

in which,

$U_r = 5 \cdot f_L \cdot D_m = 5 \times 1.38 \times 2.2 = 15.18$ (m/s) : resonance wind speed

where,

$f_L = 1.38$: natural frequency of water tower tank (Hz)

$\rho = 1.22$ (kg/m^3) : air density

$H = 35.3$ (m) : tower height

$D_m = 2.20$ (m) : diameter at the level 2/3 H

$C_r = 4.03$: pressure coefficient in resonance

$$\left.\begin{array}{l} U_r \cdot D_m = 15.18 \times 2.2 = 33.4 > 6.0 \\ \rho_s \sqrt{\zeta_L} = 142 \times \sqrt{0.02} = 20.1 > 5.0 \end{array}\right\} \text{ then, } C_r = \frac{0.57}{\sqrt{\zeta_L}} = 4.03$$

$\zeta_L = 0.02$: damping ratio of water tower tank

$$\rho_s = \frac{M}{H \cdot D_m \cdot D_B} = \frac{37{,}600}{35.3 \times 2.2 \times 3.4} = 142 \text{ (kg/m}^3\text{)}$$

$M = 37{,}600$ (kg)

Then,

$$W_r = 0.8 \rho U_r^2 C_r \frac{Z}{H} A = 0.8 \times 1.22 \times 15.18^2 \times 4.03 \times \frac{Z}{35.3} \times A = 25.7 \times Z \times A \text{ (N)}$$

The cross section of the tower should be designed with the composite force of obtained from the wind load itself and the wind load for vortex oscillation

Table.A1.8　Forces Caused by Wind Load Vortex Oscillation

Level GL+ (m)	$0.8\rho U_r^2 \frac{C_r}{H}$ (kN/m²)	A_w (m²)	W_r (kN)	Q_h (kN)	h_h (m)	M (kN·m)	Section forces in wind along direction		Composite forces	
							Q'_n (kN)	M'_n (kN·m)	Q (kN)	M (kN·m)
33.003	0.0257	23.12	19.61	19.61	2.203	0	33.04	0	39.41	0
30.8	0.0257	1.98	1.57	21.18	1.80	43.20	35.87	72.79	41.66	84.64
29.0	0.0257	2.34	1.74	22.92	0.90	81.32	39.21	137.35	45.42	159.62
28.1	0.0257	2.60	1.88	24.80	3.60	101.95	44.35	172.64	50.81	200.50
24.5	0.0257	5.76	3.63	28.43	3.60	191.23	52.25	332.30	59.48	383.40
20.9	0.0257	5.76	3.09	31.52	3.60	293.58	59.78	520.40	67.58	597.50
17.3	0.0257	5.76	2.56	34.08	3.60	407.05	66.89	735.61	75.07	840.72
13.7	0.0257	6.82	2.40	36.48	4.50	529.74	74.74	976.41	83.17	1110.86
9.2	0.0257	9.90	2.34	38.82	4.50	693.90	84.86	1312.74	93.32	1484.85
4.7	0.0257	12.60	1.52	40.34	4.50	868.59	95.57	1694.61	103.73	1904.25
0.2	0.0257	7.31	0.04	40.38		1050.12	101.78	2124.68	109.50	2370.02

Table.A1.9　Forces List

Joint No.	Axial force N(kN)		Seismic (modified seismic coefficient)		Seismic (modal analysis)		Wind in along dir.		Wind for vortex oscillation	
	Full	Empty	Q (kN)	M (kN·m)	Q (kN)	M (kN·m)	Q (kN)	M (kN·m)	Q (kN)	M (kN·m)
10	1 023.12	107.80	189.14	491.96	187.38	558.60	35.87	72.79	21.18	43.20
9	1 031.94	116.62	189.14	832.02	187.38	896.70	39.21	137.35	22.92	81.32
8	1 036.84	121.52	189.14	1 002.54	187.38	1 065.26	44.35	172.64	24.80	101.95
7	1 058.40	143.08	189.14	1 683.64	187.38	1 739.50	52.25	332.30	28.43	191.23
6	1 082.90	167.58	189.14	2 364.74	187.38	2 413.74	59.78	520.40	31.52	293.58
5	1 110.34	195.02	189.14	3 044.86	187.38	3 088.96	66.89	735.61	34.08	407.05
4	1 141.70	226.38	208.74	3 731.84	205.02	3 768.10	74.74	976.41	36.48	529.74
3	1 183.84	268.52	208.74	4 671.66	205.02	4 691.26	84.86	1312.74	38.82	693.90
2	1 231.86	316.54	208.74	5 610.50	205.02	5 613.44	95.57	1694.61	40.34	868.59
1	1 283.80	368.48	208.74	6 552.28	205.02	6 542.48	101.78	2124.68	40.38	1050.12

Table.A1.10 Section Properties and Allowable Stresses

Joint No.	OD (cm)	t (cm)	A (cm²)	Z (cm²)	Long term $_c\bar{f}_{cr}$ (kN/cm²)	Long term $_b\bar{f}_{cr}$ (kN/cm²)	Long term $_s\bar{f}_{cr}$ (kN/cm²)	Seismic $_c\bar{f}_{cr}$ (kN/cm²)	Seismic $_b\bar{f}_{cr}$ (kN/cm²)	Seismic $_s\bar{f}_{cr}$ (kN/cm²)
10	239.8	0.8	600.7	35 771	12.417	13.201	3.205	20.247	21.041	7.703
9	159.8	0.8	399.6	15 805	14.053	14.504	5.449	21.883	22.344	9.967
8	159.8	0.8	399.6	15 805	14.053	14.504	5.449	21.883	22.344	9.967
7	159.8	1.1	548.4	21 610	14.955	15.210	6.733	22.785	23.050	11.201
6	159.8	1.3	647.3	25 443	14.955	15.504	7.183	23.138	23.344	11.701
5	159.8	1.3	647.3	25 443	14.955	15.504	7.183	23.138	23.344	11.701
4	159.8	1.5	746.0	29 247	15.582	15.680	7.556	23.412	23.520	12.064
3	219.8	1.3	892.4	48 459	14.563	14.906	6.145	22.383	22.746	10.652
2	279.8	1.3	1 137.4	78 826	13.798	14.298	5.106	21.629	22.138	9.614
1	339.8	1.3	1 382.5	116 545	13.044	13.720	4.057	20.874	21.540	8.565

Table.A1.11 Design of Section

(1) Full water tank (modified seismic coefficient method)

Joint No.	N (kN)	M (kN·m)	Q (kN)	σ_t	$\frac{\sigma_c}{_c\bar{f}_{cr}}$ ①	σ_b	$\frac{\sigma_2}{_b\bar{f}_{cr}}$ ②	①+②	τ	$\frac{\tau_s}{_c\bar{f}_{cr}}$
10	1 023.12	491.96	189.14	1.705	0.084	1.372	0.065	0.149	0.627	0.082
9	1 031.94	832.02	189.14	2.587	0.118	5.263	0.236	0.354	0.951	0.095
8	1 036.84	1 002.54	189.14	2.597	0.119	6.341	0.284	0.402	0.951	0.095
7	1 058.40	1 683.64	189.14	1.931	0.085	7.791	0.338	0.423	0.686	0.062
6	1 082.90	2 364.74	189.14	1.676	0.072	9.290	0.398	0.470	0.588	0.050
5	1 110.34	3 044.86	189.14	1.715	0.074	11.966	0.513	0.587	0.588	0.050
4	1 141.70	3 731.84	208.74	1.529	0.065	12.760	0.543	0.608	0.559	0.046
3	1 183.84	4 671.66	208.74	1.323	0.059	9.643	0.424	0.483	0.470	0.044
2	1 231.86	5 610.50	208.74	1.088	0.050	7.115	0.322	0.372	0.363	0.038
1	1 283.80	6 552.28	208.74	0.931	0.044	5.625	0.261	0.305	0.304	0.035

(2) Full water tank (modal analysis)

Joint No.	N (kN)	M (kN·m)	Q (kN)	σ_c	$\frac{\sigma_c}{_c\bar{f}_{cr}}$ ①	σ_b	$\frac{\sigma_b}{_b\bar{f}_{cr}}$ ②	①+②	τ	$\frac{\tau_s}{_c\bar{f}_{cr}}$
10	1 023.12	558.60	187.38	1.705	0.084	1.558	0.074	0.158	0.627	0.080
9	1 031.94	896.70	187.38	2.587	0.118	5.674	0.254	0.372	0.941	0.094
8	1 036.84	1 065.26	187.38	2.597	0.119	6.742	0.302	0.420	0.941	0.094
7	1 058.40	1 739.50	187.38	1.931	0.085	8.046	0.349	0.434	0.686	0.062
6	1 082.90	2 413.74	187.38	1.676	0.072	9.486	0.406	0.479	0.588	0.050
5	1 110.34	3 088.96	187.38	1.715	0.074	12.142	0.520	0.594	0.588	0.050
4	1 141.70	3 768.10	205.02	1.529	0.065	12.887	0.548	0.613	0.549	0.046
3	1 183.84	4 691.26	205.02	1.323	0.059	9.682	0.426	0.485	0.451	0.044
2	1 231.86	5 613.44	205.02	1.088	0.050	7.125	0.322	0.372	0.382	0.036
1	1 283.80	6 542.48	205.02	0.931	0.045	5.615	0.261	0.305	0.294	0.034

(3) Wind with full water tank (in along direction)

Joint No.	N (kN)	M (kN·m)	Q (kN)	σ_c	$\frac{\sigma_c}{1.5_c\bar{f}_{cr}}$ ①	σ_b	$\frac{\sigma_b}{1.5_b\bar{f}_{cr}}$ ②	①+②	τ	$\frac{\tau}{1.5_s\bar{f}_{cr}}$
10	1 023.12	72.79	35.87	1.705	0.092	0.203	0.010	0.102	0.119	0.025
9	1 031.94	137.35	39.21	2.587	0.123	0.869	0.040	0.163	0.196	0.024
8	1 036.84	172.64	44.35	2.597	0.123	1.092	0.050	0.173	0.222	0.027
7	1 058.40	332.30	52.25	1.931	0.086	1.538	0.067	0.153	0.191	0.019
6	1 082.90	520.40	59.78	1.676	0.073	2.045	0.088	0.161	0.185	0.017
5	1 110.34	735.61	66.89	1.715	0.075	2.891	0.124	0.199	0.207	0.019
4	1 141.70	976.41	74.74	1.529	0.065	3.338	0.142	0.207	0.200	0.018
3	1 183.84	1312.74	84.86	1.323	0.061	2.709	0.121	0.182	0.190	0.021
2	1 231.86	1694.61	95.57	1.088	0.053	2.150	0.100	0.153	0.168	0.022
1	1 283.80	2124.68	101.78	0.931	0.048	1.823	0.089	0.137	0.147	0.024

(4) Wind with empty water tank (for vortex osc.)

Joint No.	N (kN)	M (kN·m)	Q (kN)	σ_c	$\frac{\sigma_c}{1.5_c\bar{f}_{cr}}$ ①	σ_b	$\frac{\sigma_b}{1.5_b\bar{f}_{cr}}$ ②	1.5 (①+②)	τ	$\frac{\tau}{1.5_s\bar{f}_{cr}}$ ③	1.5③
10	107.80	84.64	41.66	0.176	0.009	0.237	0.012	0.032	0.139	0.029	0.043
9	116.62	159.62	45.42	0.294	0.014	1.010	0.046	0.090	0.227	0.028	0.042
8	121.52	200.50	50.81	0.304	0.014	1.269	0.058	0.108	0.254	0.031	0.047
7	143.08	383.40	59.48	0.265	0.012	1.774	0.078	0.135	0.217	0.021	0.032
6	167.58	597.50	67.58	0.255	0.011	2.348	0.101	0.168	0.209	0.019	0.029
5	195.02	840.72	75.07	0.304	0.013	3.304	0.142	0.233	0.232	0.022	0.032
4	226.38	1110.86	83.17	0.304	0.013	3.798	0.161	0.261	0.223	0.020	0.030
3	268.52	1484.85	93.32	0.304	0.014	3.064	0.137	0.227	0.209	0.023	0.034
2	316.54	1904.25	103.73	0.274	0.013	2.416	0.113	0.189	0.182	0.024	0.036
1	368.48	2370.02	109.50	0.265	0.014	2.034	0.099	0.170	0.158	0.026	0.039

1.5(①+②) <1.0 OK

1.5③ <1.0 OK