CHAPTER V

SEISMIC DESIGN

5.1. Earthquake Zone

According to figure 1 SNI 03-1726-2002, page 19, “Tangcity Mall” building is in the earthquake zone 3. The soil is classified as soft soil.

5.2. Importance Factor I

According to table 1 SNI 03-1726-2002 section 4.1 page 7, building for office function I = 1.

5.3. Natural Period

Natural period was taken from the period that is occurred in 1st Mode:

T_1 < ζ . n

1.7465 seconds > 0.18 x 9

1.7465 seconds > 1.62 seconds; not OK

But the story drift is okay.

5.4. Seismic Response Factor C_1

From response spectrum seismic design figure 3 in SNI 03 – 1726 -2002, for soft soil and earthquake zone 3, T_1 = 1.7465 seconds, obtained C_1 = 0.4294

5.5. Seismic Reduction Factor R

Seismic reduction factor for irregular building was taken from table 3 maximum ductility factor SNI 03-1726-2002 section 4.3 which is determined based on building structure system and subsystem. According to Table 3 SNI 03-1726-2002, "Tangcity Mall" building is Special Moment Resisting Frame, where it has R_m = 8.5

Nominal base shear force as first mode response:

$$V_1 = \frac{C_1.I}{R}Wt = \frac{0.4294x1}{8.5} \text{ x } 1403600.525 = 70911.6 \text{ KN}$$

From the output of Dynamic Analysis:

$V_{dynamic\ x\text{-}axis}$ = 26890.37 KN

$V_{dynamic\ y\text{-}axis}$ = 28836.49 KN

$V_{dynamic\ x\text{-}axis} > 0.8\ V_1$

26890.37 KN < 0.8 x 70911.6 KN

26890.37 KN < 56729.28 KN (not OK)

$V_{dynamic\ y\text{-}axis} > 0.8\ V_1$

26890.37 KN < 0.8 x 70911.6 KN

26890.37 KN < 56729.28 KN (not OK)

Since the results are not OK, so use $V_{static} = V_1$= 70911.6 KN

Table 5.1. Building Weight

Floor	Mass (KN)	W (KN)
Top Floor	1914.63	18782.53
3rd Floor	11668.74	114470.34
2nd Floor	14565.16	142884.26
1st Floor	16817.09	164975.69
UG Floor	17385.23	170549.08
G Floor	20268.17	198830.72
LG Floor	20556.76	201661.77
Basement 1	20181.99	197985.37
Basement 2	19720.77	193460.76

5.6. Distribution of F_i

Nominal Shear Force (V) should be distributed to the building's height as static equivalent forces F_i applied at floor levels. The formula for F_i is based on SNI 03-1726-2002, act 6.1.3:

$$F_i = \frac{W_i . z_i}{\sum_{i=1}^{n} W_i . z_i} . V$$

Table 5.2. Horizontal distribution of story shear

Base Shear force each floor due to first mode response T_1 = 1.7465 seconds

V_1 = 70911.6 KN

Story	Story Height (m)	Wi (KN)	Wi.hi (KN-m)	Fi x-y (KN)	Vi (KN)
Top	46.2	18782.53	867752.66	2223.08	2223.08
3rd	40.5	114470.34	4636048.94	11877.01	14100.09
2nd	35.1	142884.26	5015237.62	12848.45	26948.54
1st	30.1	164975.69	4965768.39	12721.72	39670.26
UG	24	170549.08	4093177.84	10486.24	50156.50
G	18	198830.72	3578953.00	9168.86	59325.36
LG	12	201661.77	2419941.23	6199.61	65524.96
B1	7.2	197985.37	1425494.66	3651.95	69176.91
B2	3.5	193460.76	677112.66	1734.68	70911.60
	∑ =	1403600.53	27679487.03		

5.7. T Rayleigh Analysis

Table 5.3. T Rayleigh analysis due to earthquake in X direction

Story	Story Height (m)	Wi (KN)	F (KN)	di (m)	Wi di^2 (KN-m^2)	F di (KN-m)
Top	46.2	18782.53	2223.08	0.051	48.853348	113.3771
3rd	40.5	114470.34	11877.01	0.0399	182.23793	473.8928
2nd	35.1	142884.26	12848.45	0.0342	167.12315	439.417
1st	30.1	164975.69	12721.72	0.0275	124.76287	349.8472
UG	24	170549.08	10486.24	0.0169	48.710522	177.2175
G	18	198830.72	9168.86	0.0062	7.643053	56.84692
LG	12	201661.77	6199.61	0	0	0
B1	7.2	197985.37	3651.95	0	0	0
B2	3.5	193460.76	1734.68	0	0	0
∑					579.33087	1610.599

$$T_{rayleigh} = 6.3\sqrt{\frac{\sum_{i=1}^{n} Wi.di^2}{g\sum_{i=1}^{n} Fi.di}} \qquad = 1.206357 \text{ seconds}$$

0.8 x $T_{rayleigh}$ < $T_{empiric}$ < 1.2 x $T_{rayleigh}$

0.8 x 1.206357 s < 1.7465 s < 1.2 x 1.206357 s

0.965085 s < 1.7465 s < 1.447628 s, since it is not okay, the structure needs to be stiffen. But after further analysis,since the drift is OK so it is safe to use the structure.

Table 5.4. T Rayleigh analysis due to earthquake in Y direction

Story	Story Height (m)	Wi (KN)	F (KN)	di (m)	Wi di^2 (KN-m^2)	F di (KN-m)
Top	46.2	18782.53	2223.08	0.0454	38.71379	100.9279
3rd	40.5	114470.34	11877.01	0.0425	206.76206	504.7731
2nd	35.1	142884.26	12848.45	0.0376	202.00406	483.1017
1st	30.1	164975.69	12721.72	0.03	148.47812	381.6515
UG	24	170549.08	10486.24	0.0186	59.003159	195.0441
G	18	198830.72	9168.86	0.0069	9.4663307	63.26512
LG	12	201661.77	6199.61	0	0	0
B1	7.2	197985.37	3651.95	0	0	0
B2	3.5	193460.76	1734.68	0	0	0
∑					664.42752	1728.763

$$T_{rayleigh} = 6.3\sqrt{\frac{\sum_{i=1}^{n} Wi.di^2}{g\sum_{i=1}^{n} Fi.di}} \qquad = 1.246987 \text{ seconds}$$

0.8 x $T_{rayleigh}$ < $T_{empiric}$ < 1.2 x $T_{rayleigh}$

0.8 x 1.246987 s < 1.7465 s < 1.2 x 1.246987 s

0.99759 s < 1.7465 s < 1.496385 s, since it is not okay, the structure needs to be stiffen. But after further analysis,since the drift is OK so it is safe to use the structure.

5.8. Service Story Drift

Based on SNI 03-1726-2002 act 8.1(2), the requirement of Service Story Drift cannot be more than 0.03/R times the specific floor height or 30 mm, and choose the smallest one from both.

Table 5.5. Service Story Drift X-axis

Story	hi (m)	U_x (mm)	Drift (Δs) Each story (mm)	(0.03 . h_1) / R (mm)	Note
Top	5.7	51	11.1	20.117647	Ok!
3rd	5.4	39.9	5.7	19.058824	Ok!
2nd	5	34.2	6.7	17.647059	Ok!
1st	6.1	27.5	10.6	21.529412	Ok!
UG	6	16.9	10.7	21.176471	Ok!
G	6	6.2	6.2	21.176471	Ok!
LG	4.8	0	0	16.941176	Ok!
B1	3.7	0	0	13.058824	Ok!
B2	3.5	0	0	12.352941	Ok!

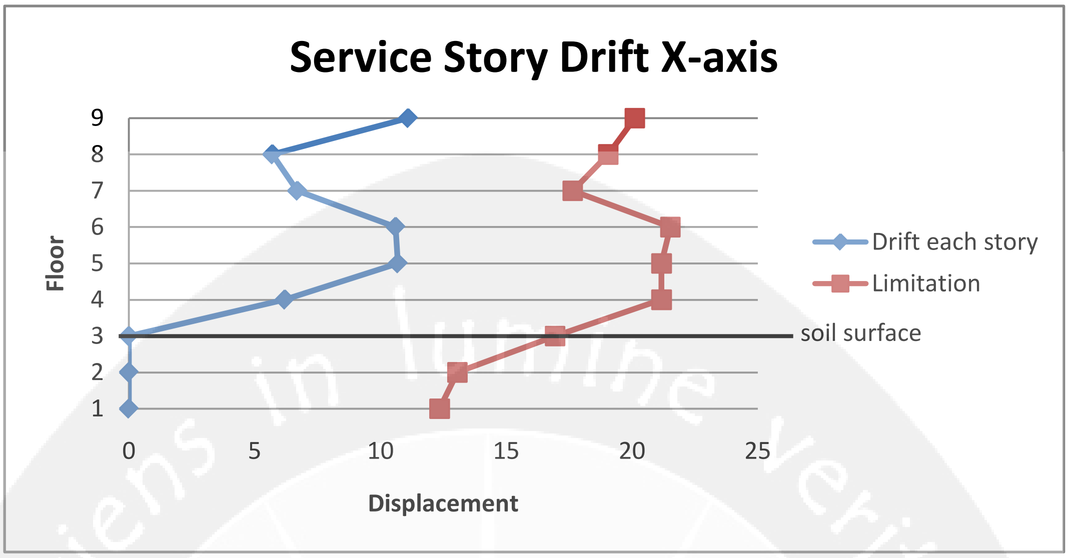

Figure 5.1. Service Story Drift X-axis

Table 5.6. Service Story Drift Y-axis

Story	hi (m)	U_y (mm)	Drift (Δs) Each story (mm)	$(0.03 . h_1) / R$ (mm)	Note
Top	5.7	45.4	2.9	20.117647	Ok!
3rd	5.4	42.5	4.9	19.058824	Ok!
2nd	5	37.6	7.6	17.647059	Ok!
1st	6.1	30	11.4	21.529412	Ok!
UG	6	18.6	11.7	21.176471	Ok!
G	6	6.9	6.9	21.176471	Ok!
LG	4.8	0	0	16.941176	Ok!
B1	3.7	0	0	13.058824	Ok!
B2	3.5	0	0	12.352941	Ok!

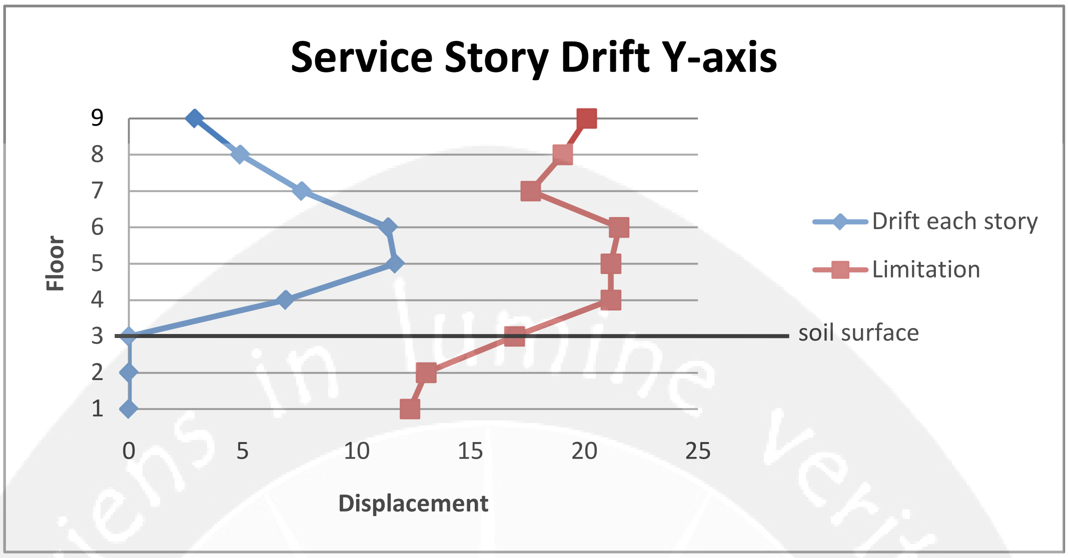

Figure 5.2. Service Story Drift Y-axis

5.9. Ultimate Story Drift

Based on SNI 03-1726-2002 act 8.2(1), the value of ultimate story drift (Δm) is taken from $\xi \,.\, \Delta s$, in which for irregural building structure;

$$\xi = \frac{0.7.R}{ScaleFactor}$$

Based on SNI 03-1726-2002 act 8.2(2), the requirement of Ultimate Story Drift cannot be more than 0.02 times the specific floor height.

Table 5.7. Ultimate Story Drift X-axis

Story	hi (m)	Drift (Δs) Each story (mm)	ξ . Δs (mm)	0.02. h_1 (mm)	Note
Top	5.7	11.1	31.31	114	Ok!
3rd	5.4	5.7	16.08	108	Ok!
2nd	5	6.7	18.90	100	Ok!
1st	6.1	10.6	29.90	122	Ok!
UG	6	10.7	30.18	120	Ok!
G	6	6.2	17.49	120	Ok!
LG	4.8	0	0.00	96	Ok!
B1	3.7	0	0.00	74	Ok!
B2	3.5	0	0.00	70	Ok!

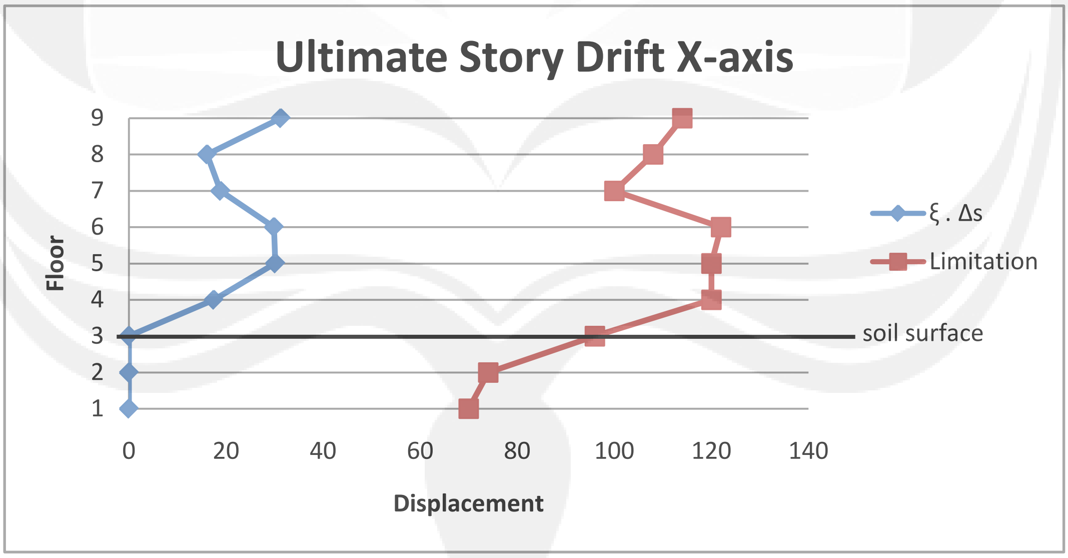

Figure 5.3. Ultimate Story Drift X-axis

Table 5.8. Ultimate Story Drift Y-axis

Story	hi (m)	Drift (Δs) Each story (mm)	ξ . Δs (mm)	0.02. h_1 (mm)	Note
Top	5.7	2.9	8.77	114	Ok!
3^{rd}	5.4	4.9	14.82	108	Ok!
2^{nd}	5	7.6	22.99	100	Ok!
1^{st}	6.1	11.4	34.48	122	Ok!
UG	6	11.7	35.39	120	Ok!
G	6	6.9	20.87	120	Ok!
LG	4.8	0	0.00	96	Ok!
B1	3.7	0	0.00	74	Ok!
B2	3.5	0	0.00	70	Ok!

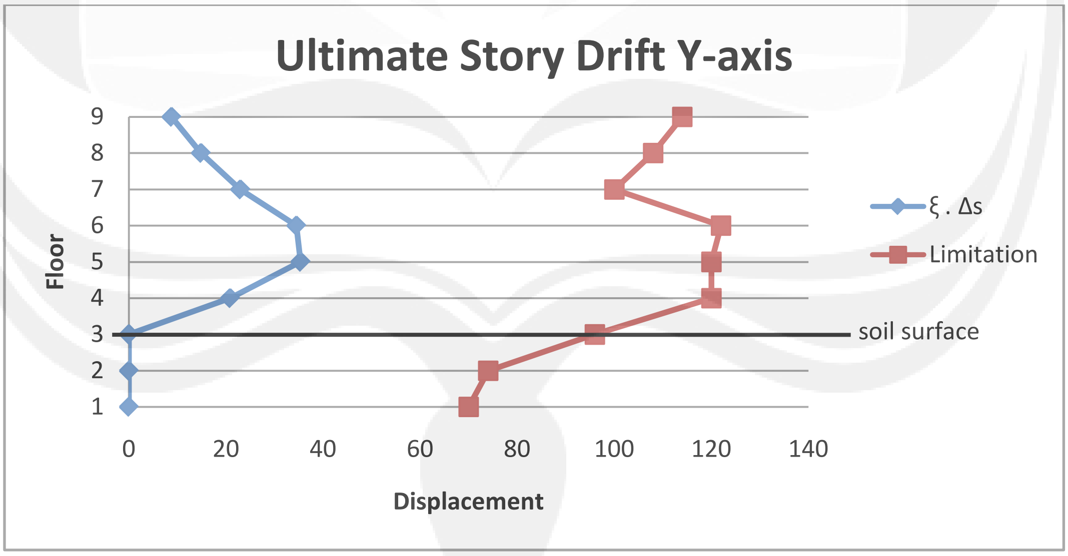

Figure 5.4. Ultimate Story Drift Y-axis