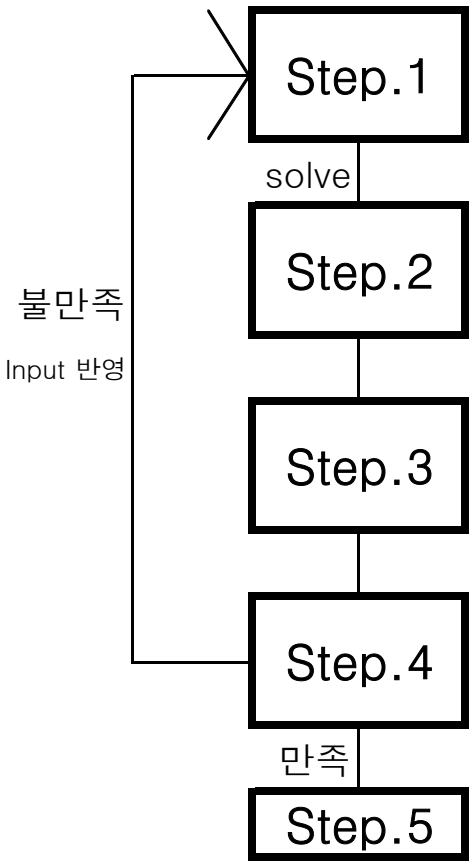
※ 반복시산법을 통한 축강성 결정 순서도



Strut 및 Tie의 축강성을 가정한다.

부정정 스트럿-타이 모델에 대한 구조해석

각 Strut 및 Tie의 단면력을 결정

단면력을 각 Strut 및 Tie의 유효강도로 나누어 Strut 및 Tie의 단면적 결정

Strut 및 Tie의 단면적에 탄성계수를 곱하여 Strut 및 Tie의 축강성을 결정

Step.1의 가정된 축강성과 Step.3의 축강성 차이가 허용한계를 만족

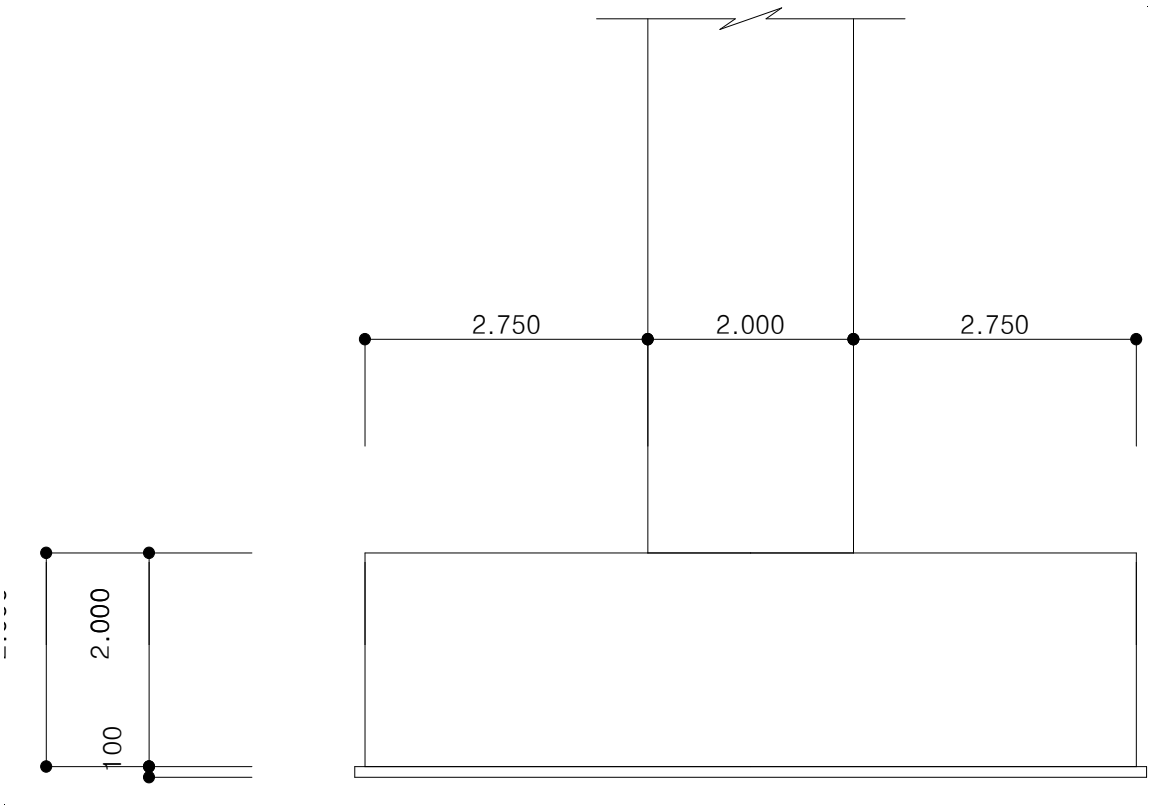
결정된 단면력과 필요 단면적으로 검토

1. STM 해석 : 기초 교축방향

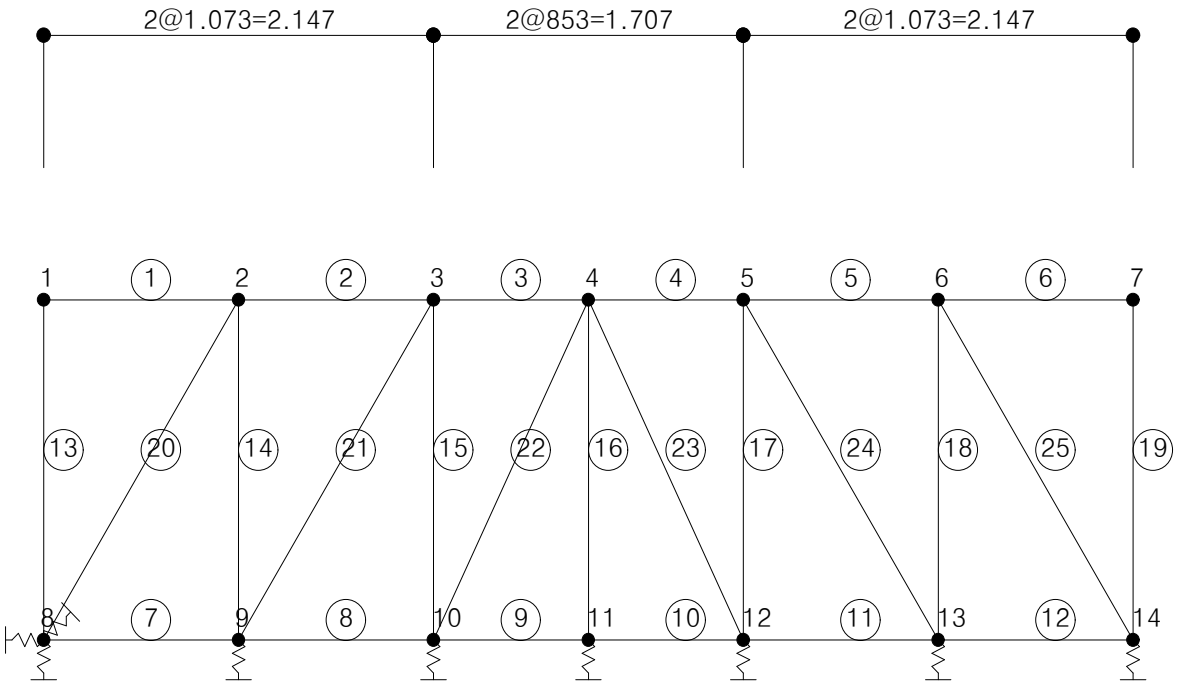
1.1 설계조건

1) 본체강도 : fck = 27 MPa
2) 철근강도 : fy = 400 MPa
3) 기초폭 : 7500 mm

1.2 단면형상



1.3 해석 모델링



1) 절점 좌표

구분	Y	Z	절점	구분	Y	Z	절점
1	0.750	1.900	1	8	0.750	0.100	8
2	1.823	1.900	2	9	1.823	0.100	9
3	2.897	1.900	3	10	2.897	0.100	10
4	3.750	1.900	4	11	3.750	0.100	11
5	4.603	1.900	5	12	4.603	0.100	12
6	5.677	1.900	6	13	5.677	0.100	13
7	6.750	1.900	7	14	6.750	0.100	14

2) 지반 Spring 산정

< 연직방향 지반반력계수 >

- 사질토층이 우세한 경우 $$K_V = K_{V0}\left(\frac{B_v}{0.3}\right)^{-1/2}$$

- 사질토와 점성토의 혼합층인 경우 $$K_V = K_{V0}\left(\frac{B_v}{0.3}\right)^{-3/4}$$

- 점성토층이 우세한 경우 $$K_V = K_{V0}\left(\frac{B_v}{0.3}\right)^{-1}$$

α = Eo 의 산정방법에 대한 보정계수

Eo = 지반의 탄성계수

$$K_V = K_{V0}\left(\frac{B_v}{0.3}\right)^{-3/4}$$

여기서, $$K_{vo} = \frac{1}{0.3} \times \alpha \times E_0$$

Eo : 지반탄성계수 (kN/m²)

① 평상시

α = 1

Eo = 2800 x N = 2800 x 40 = 112000.000 kN/m²

Bv = √(B × L) = √(7.500 × 7.500) = 7.500 m (L < B)

Kvo = 1 / 0.3 x 1.000 x 112000.000 = 373333.333 kN/m²

Kv = 373333.333 x (7.500 / 0.3) ^ (-3 / 4) = 33391.948 kN/m²

② 지진시

α = 2

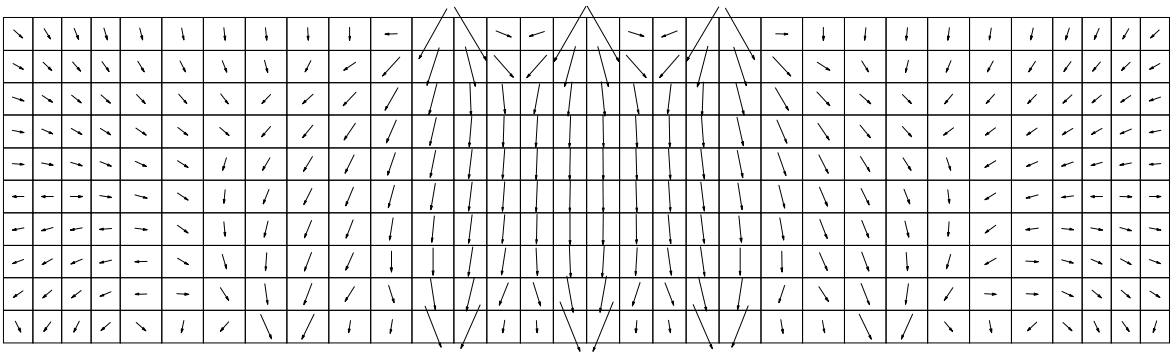
Eo = 2800 x N = 2800 x 40 = 112000.000 kN/m²

Bv = √(B × B) = √(7.500 × 7.500) = 7.500 m (L > B)

Kvo = 1 / 0.3 x 2.000 x 112000.000 = 746666.667 kN/m²

Kv = 746666.667 x (7.500 / 0.3) ^ (-3 / 4) = 66783.897 kN/m²

3) 주응력 흐름도



1.4 하중산정

1) 작용하중 집계표

구 분	P(kN)	Vx(kN)	My(kN)	∑V(kN)	Mr(kN.m)	Mo(kN.m)	비 고
ULB01	18966.985	0.000	-229.750	22341.985	84837.131	229.750	축력최대
ULB14	11828.831	1318.849	-15023.360	15063.206	57541.710	12385.662	모멘트최대
UEB14	8989.912	1318.849	-14903.360	11380.537	43731.701	12265.662	편심최대
ULB22	9463.065	874.385	8142.449	11994.315	46033.369	9891.219	지진시

2) 기초자중 (SW)

: 기초 자중은 구간별 평균두께로 산정하여 기초상단절점에 분할하여 재하한다.

절점	분담폭	평균두께	단위폭	단위중량	수직하중(kN)
3	7.500	2.000	7.500	25.000	-124.626
4	7.500	2.000	7.500	25.000	-31.998
5	7.500	2.000	7.500	25.000	-124.626

3) 축력최대 (ULB01-P)

: 기초중앙작용력을 수직력 및 수평력으로 재하된다.

절점	수직력(kN)	Mo(kN)	수직하중(kN)	수평하중(kN)
3	7447.328	134.629	-7312.699	0.000
4	7447.328	134.629	-7447.328	0.000
5	7447.328	134.629	-7581.957	0.000

4) 모멘트최대 (ULB14-M)

: 기초중앙작용력을 수직력 및 수평력으로 재하된다.

절점	수직력(kN)	Mo(kN)	수직하중(kN)	수평하중(kN)
3	5021.069	7257.754	3782.324	439.616
4	5021.069	7257.754	-5021.069	439.616
5	5021.069	7257.754	-13824.461	439.616

5) 편심최대 (UEB14-E)

: 기초중앙작용력을 수직력 및 수평력으로 재하된다.

절점	수직력(kN)	Mo(kN)	수직하중(kN)	수평하중(kN)
3	3793.512	7187.436	4939.563	439.616
4	3793.512	7187.436	-3793.512	439.616
5	3793.512	7187.436	-12526.587	439.616

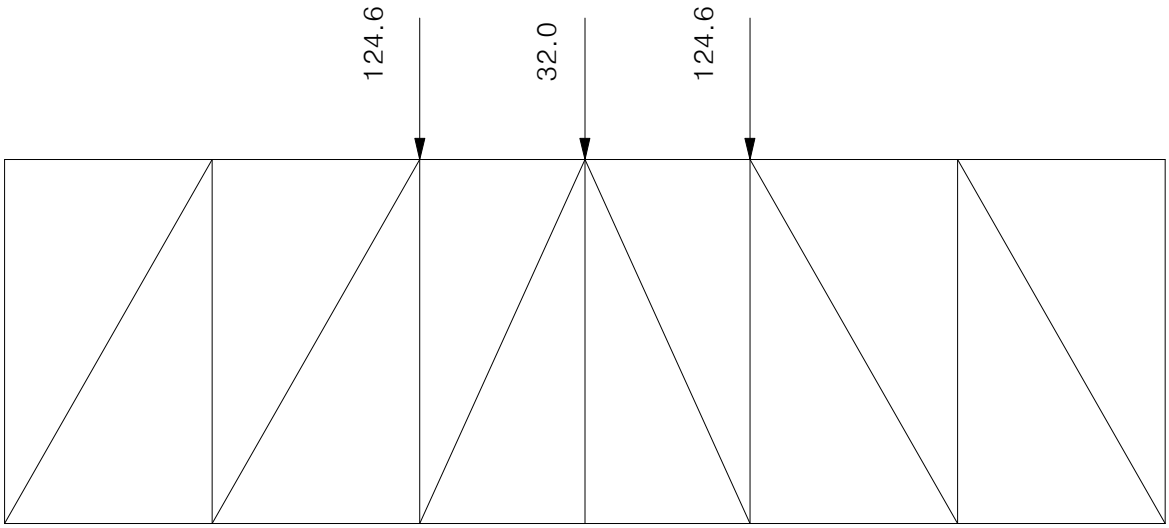
6) 지진시 (ULB22-Q)

: 기초중앙작용력을 수직력 및 수평력으로 재하된다.

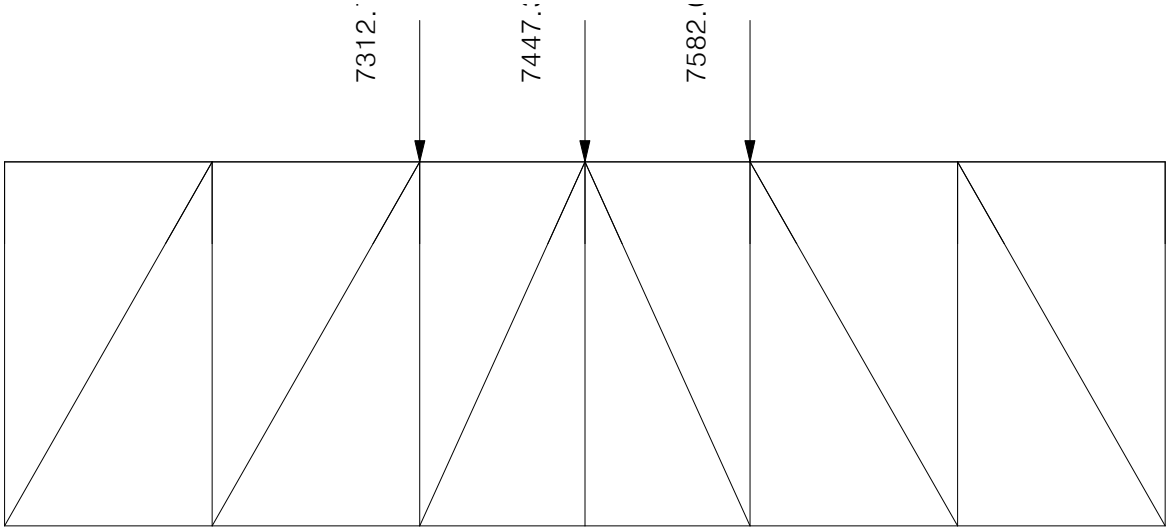
절점	수직력(kN)	Mo(kN)	수직하중(kN)	수평하중(kN)
3	3998.105	5796.059	-8769.420	291.462
4	3998.105	5796.059	-3998.105	291.462
5	3998.105	5796.059	773.210	291.462

1.5 하중 재하도

1) 기초자중 (SW)



2) 축력최대 (ULB01-P)



1.6 하중조합

구분	D	L1	L2	L3	W	WL	E
LC01	1.30	2.15					
LC02	1.30		2.15				
LC03	1.30				1.30		
LC04	1.30			1.30	0.65	1.30	
LC05	1.00						1.00

D = 고정하중 또는 이에 따른 단면력

L = 활하중 또는 이에 따른 단면력

W = 풍하중 또는 이에 따른 단면력

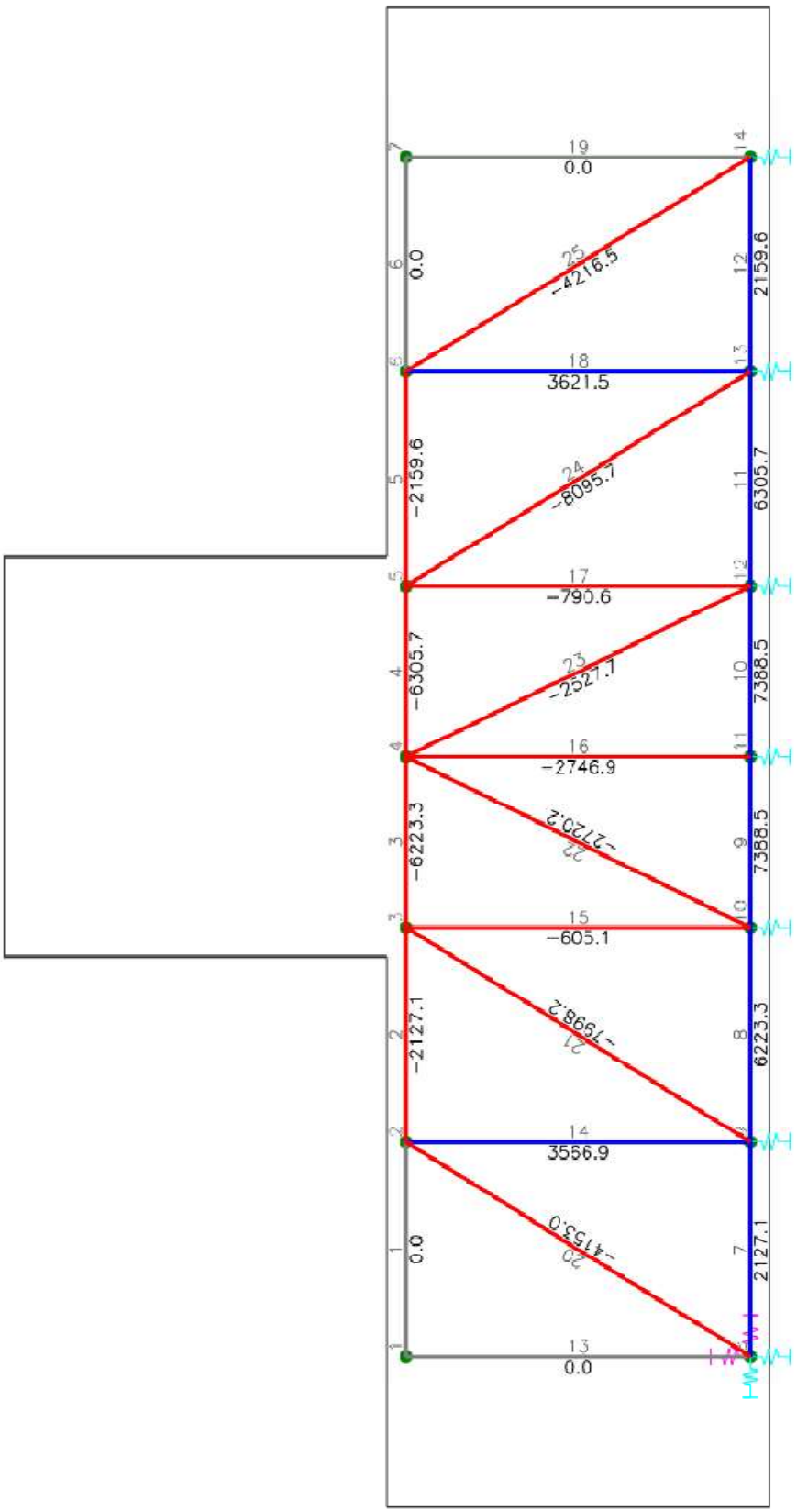
WL = 차량활하중에 작용하는 풍하중 또는 이에 따른 단면력

E = 지진하중 또는 이에 따른 단면력

CF = 원심하중 또는 이에 따른 단면력

ASTM

하중조합 UL01 : 1.3 SW + 1.0 ULB01-P

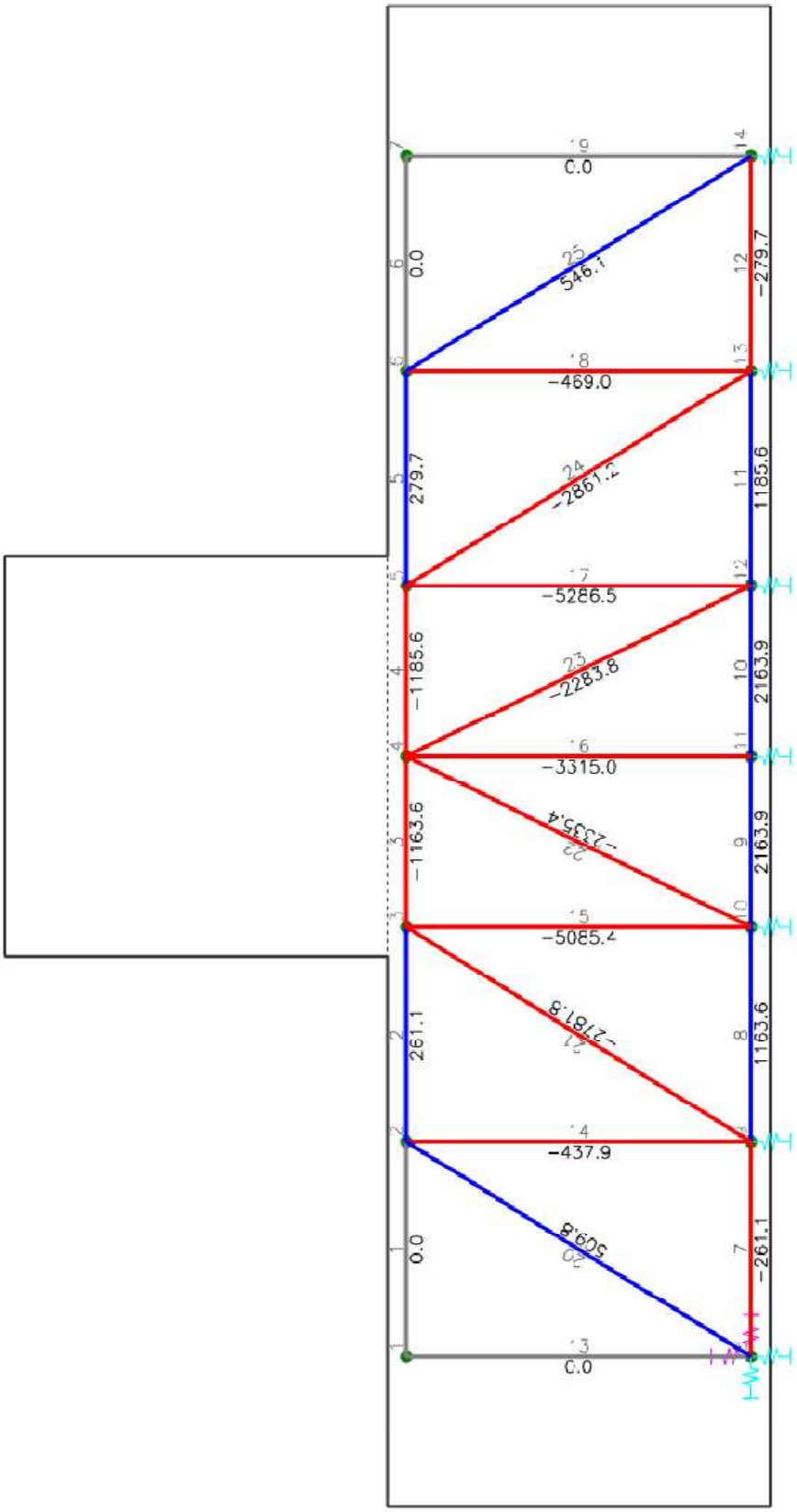


ASTM

Element	ASTM			SAP2000		SAP대비 Force
	Force	Material	Area	Force	Area	
01	0	STEEL1	0	0	0	0.0%
02	2127.1	CONC1	0.1545	2150.5	0.156	-1.1%
03	6223.3	CONC1	0.45225	6292.1	0.45675	-1.1%
04	6305.7	CONC1	0.45825	6375.4	0.46275	-1.1%
05	2159.6	CONC1	0.15675	2183.4	0.15825	-1.1%
06	0	STEEL1	0	0	0	0.0%
07	2127.08	STEEL1	0.005318	2150.56	0.005376	-1.1%
08	6223.32	STEEL1	0.015558	6292.08	0.01573	-1.1%
09	7388.52	STEEL1	0.018471	7470.16	0.018675	-1.1%
10	7388.52	STEEL1	0.018471	7470.12	0.018675	-1.1%
11	6305.76	STEEL1	0.015764	6375.44	0.015939	-1.1%
12	2159.6	STEEL1	0.005399	2183.44	0.005459	-1.1%
13	0	STEEL1	0	0	0	0.0%
14	3566.9	STEEL1	0.008917	3566.2	0.008916	0.0%
15	605.1	CONC1	0.04425	606.3	0.04425	-0.2%
16	2746.9	CONC1	0.1995	2747.8	0.1995	0.0%
17	790.6	CONC1	0.05775	791.8	0.05775	-0.2%
18	3621.5	STEEL1	0.009054	3620.7	0.009052	0.0%
19	0	STEEL1	0	0	0	0.0%
20	4153	CONC1	0.3015	4164.5	0.30225	-0.3%
21	7998.2	CONC1	0.5805	8020.5	0.58275	-0.3%
22	2720.2	CONC1	0.19725	2725.3	0.198	-0.2%
23	2527.7	CONC1	0.18375	2532.4	0.18375	-0.2%
24	8095.7	CONC1	0.588	8118.2	0.5895	-0.3%
25	4216.5	CONC1	0.306	4228.1	0.30675	-0.3%

SAP2000-STAGE01

하중조합 UL01 : 1.3 SW + 1.0 ULB01-P

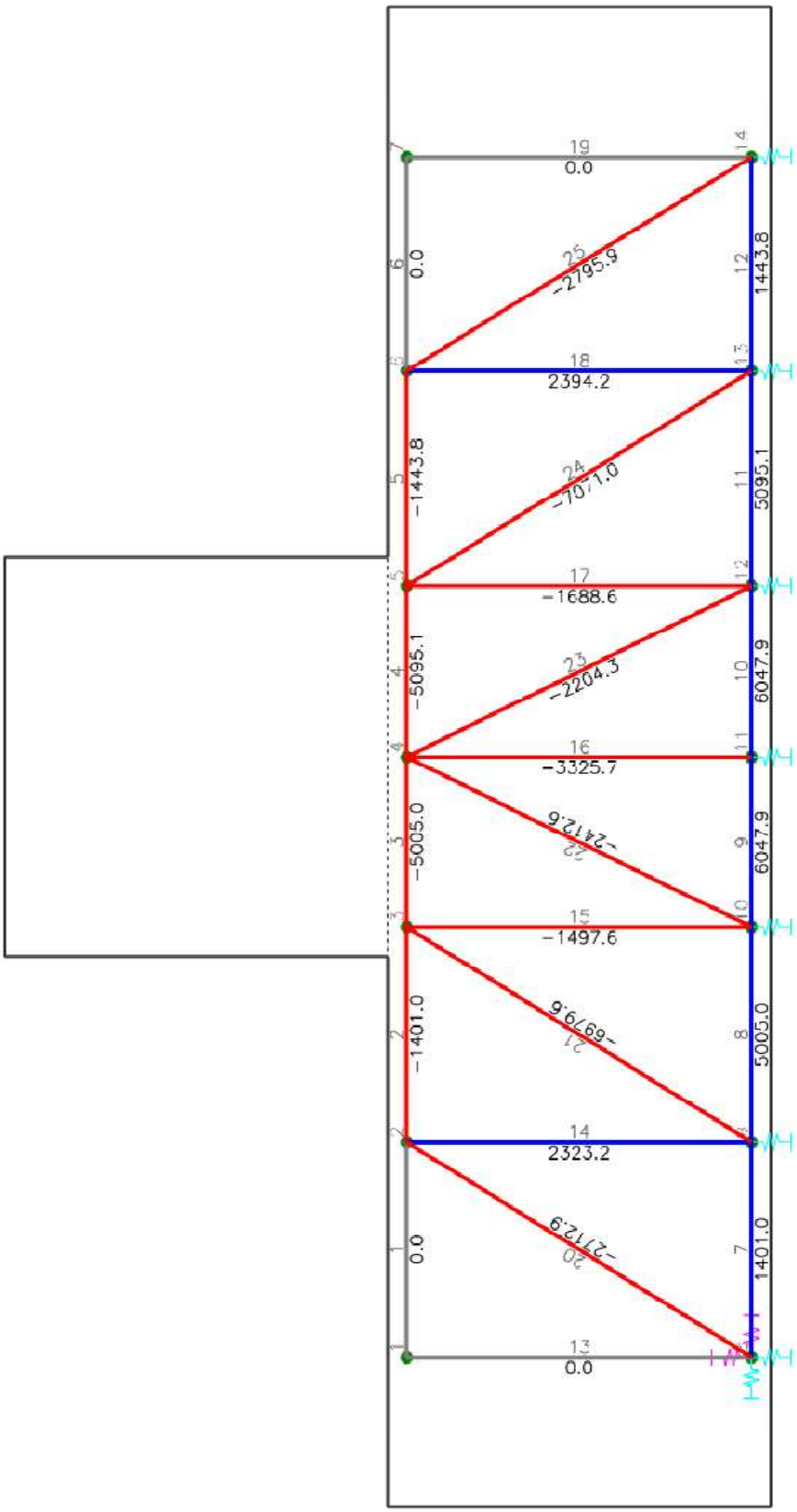


STAGE01

Element	Force	Material	Area
01	0	STEEL1	0
02	267.24	STEEL1	0.000668
03	1159	CONC1	0.084
04	1181.2	CONC1	0.0855
05	285.88	STEEL1	0.000715
06	0	STEEL1	0
07	267.2	CONC1	0.0195
08	1159.04	STEEL1	0.002898
09	2166.44	STEEL1	0.005416
10	2163.92	STEEL1	0.00541
11	1181.2	STEEL1	0.002953
12	285.9	CONC1	0.021
13	0	STEEL1	0
14	443.1	CONC1	0.03225
15	5109.3	CONC1	0.37125
16	3332.3	CONC1	0.24225
17	5310.9	CONC1	0.3855
18	474.1	CONC1	0.0345
19	0	STEEL1	0
20	517.52	STEEL1	0.001294
21	2762.1	CONC1	0.20025
22	2330.4	CONC1	0.1695
23	2279.1	CONC1	0.16575
24	2841.2	CONC1	0.20625
25	553.6	STEEL1	0.001384

SAP2000-STAGE02

하중조합 UL01 : 1.3 SW + 1.0 ULB01-P

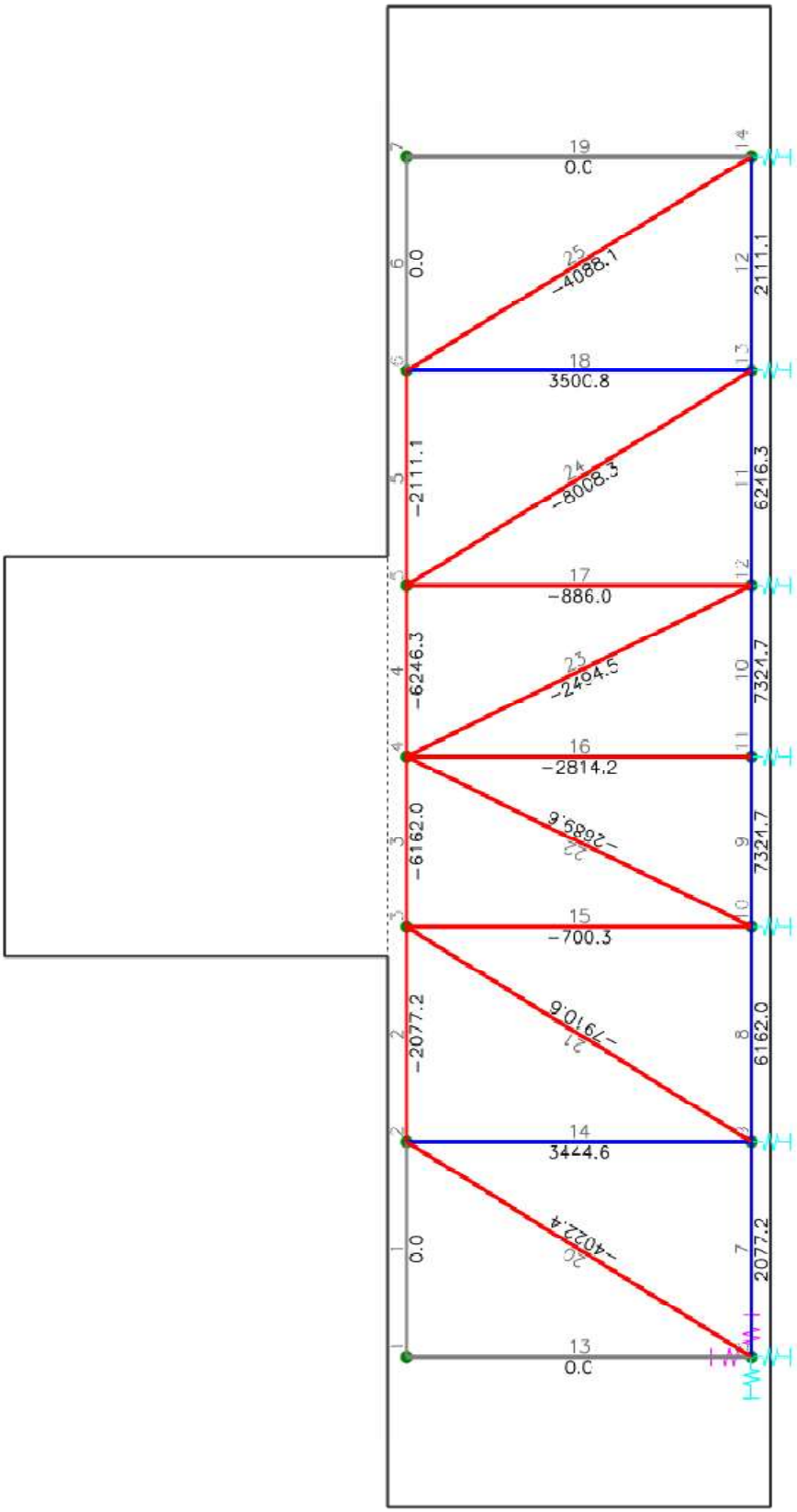


STAGE02

Element	Force	Material	Area	증감율
01	0	STEEL1	0	0.0%
02	1401	CONC1	0.102	99.3%
03	5005	CONC1	0.36375	76.9%
04	5095.1	CONC1	0.36975	76.9%
05	1443.8	CONC1	0.105	99.3%
06	0	STEEL1	0	0.0%
07	1400.96	STEEL1	0.003502	-456.8%
08	5005	STEEL1	0.012513	76.8%
09	6047.92	STEEL1	0.01512	64.2%
10	6047.92	STEEL1	0.01512	64.2%
11	5095.08	STEEL1	0.012738	76.8%
12	1443.8	STEEL1	0.00361	-481.8%
13	0	STEEL1	0	0.0%
14	2323.2	STEEL1	0.005808	-455.3%
15	1497.6	CONC1	0.10875	-241.4%
16	3325.7	CONC1	0.2415	-0.3%
17	1688.6	CONC1	0.123	-213.4%
18	2394.2	STEEL1	0.005986	-476.4%
19	0	STEEL1	0	0.0%
20	2712.9	CONC1	0.19725	99.3%
21	6979.6	CONC1	0.507	60.5%
22	2412.6	CONC1	0.1755	3.4%
23	2204.3	CONC1	0.15975	-3.8%
24	7071	CONC1	0.51375	59.9%
25	2795.9	CONC1	0.20325	99.3%

SAP2000-STAGE03

하중조합 UL01 : 1.3 SW + 1.0 ULB01-P

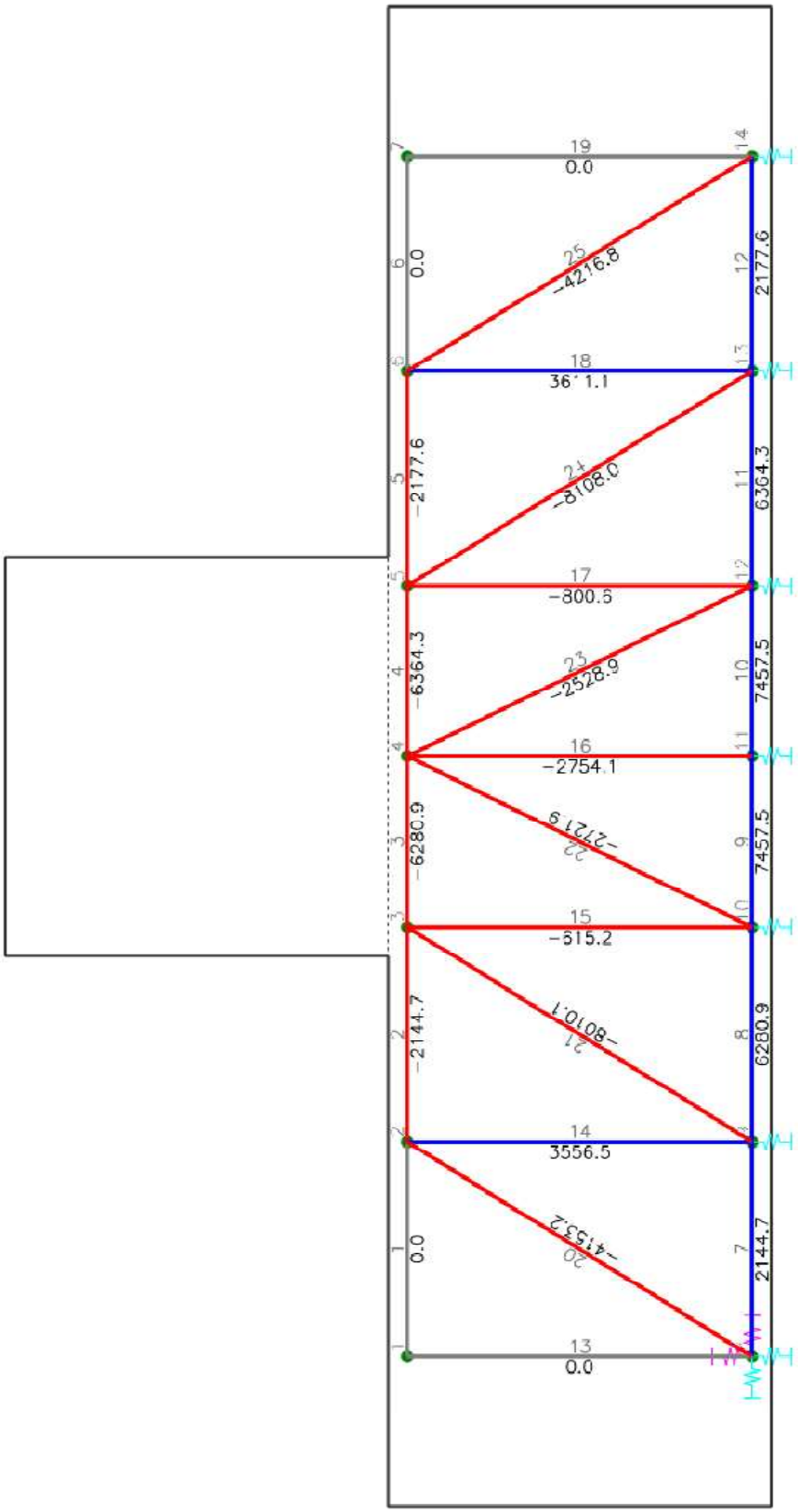


STAGE03

Element	Force	Material	Area	증감율
01	0	STEEL1	0	0.0%
02	2077.2	CONC1	0.15075	32.3%
03	6162	CONC1	0.44775	18.8%
04	6246.3	CONC1	0.45375	18.5%
05	2111.1	CONC1	0.153	31.4%
06	0	STEEL1	0	0.0%
07	2077.2	STEEL1	0.005193	32.6%
08	6162	STEEL1	0.015405	18.8%
09	7324.68	STEEL1	0.018312	17.4%
10	7324.72	STEEL1	0.018312	17.4%
11	6246.36	STEEL1	0.015616	18.4%
12	2111.12	STEEL1	0.005278	31.6%
13	0	STEEL1	0	0.0%
14	3444.6	STEEL1	0.008612	32.6%
15	700.3	CONC1	0.051	-113.2%
16	2814.2	CONC1	0.204	-18.4%
17	886	CONC1	0.0645	-90.7%
18	3500.8	STEEL1	0.008752	31.6%
19	0	STEEL1	0	0.0%
20	4022.4	CONC1	0.29175	32.4%
21	7910.6	CONC1	0.5745	11.7%
22	2689.6	CONC1	0.195	10.0%
23	2494.5	CONC1	0.1815	12.0%
24	8008.3	CONC1	0.58125	11.6%
25	4088.1	CONC1	0.297	31.6%

SAP2000-STAGE04

하중조합 UL01 : 1.3 SW + 1.0 ULB01-P

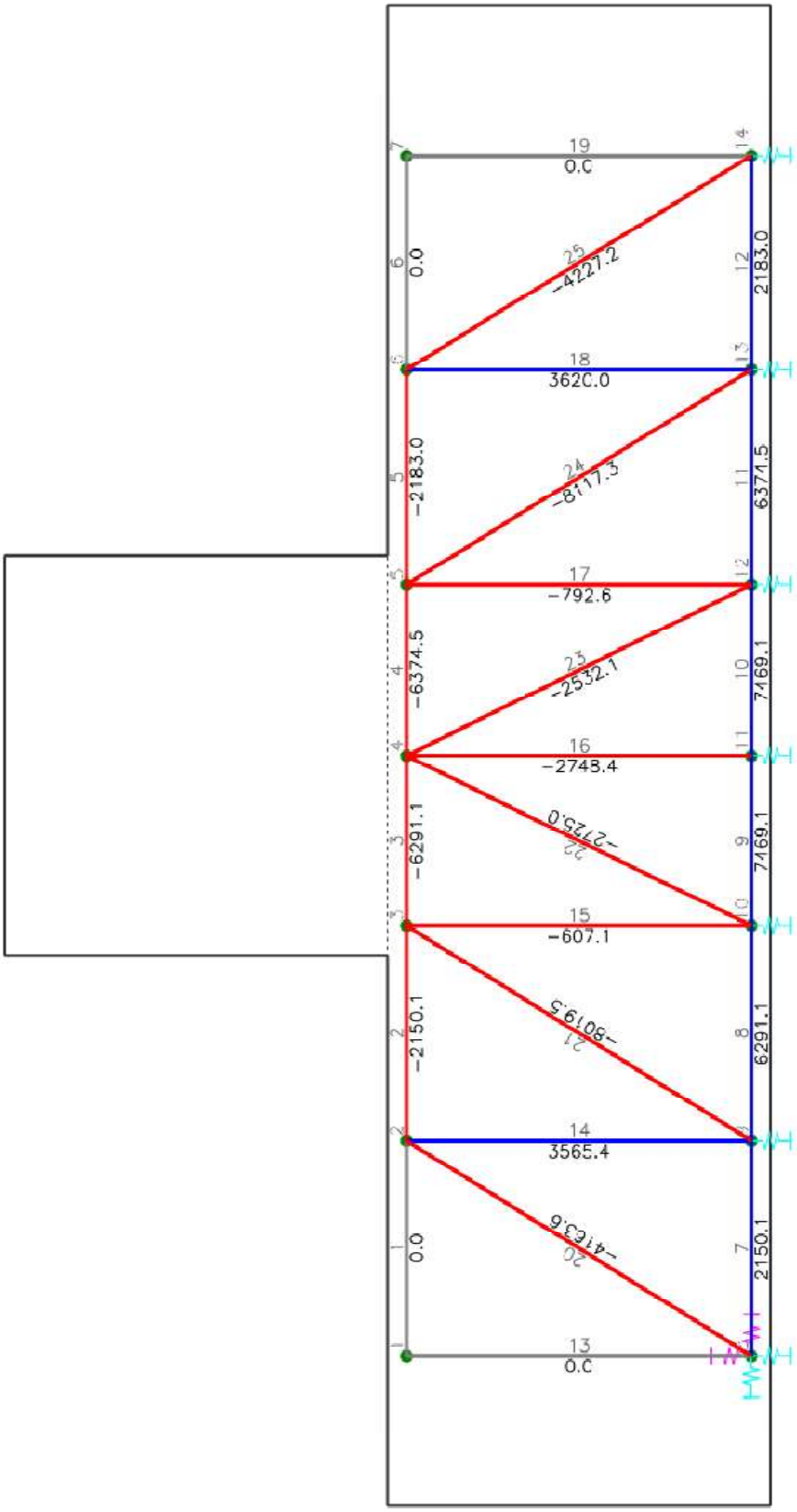


STAGE04

Element	Force	Material	Area	증감율
01	0	STEEL1	0	0.0%
02	2144.7	CONC1	0.156	3.4%
03	6280.9	CONC1	0.456	1.8%
04	6364.3	CONC1	0.462	1.8%
05	2177.6	CONC1	0.15825	3.3%
06	0	STEEL1	0	0.0%
07	2144.72	STEEL1	0.005362	3.1%
08	6280.84	STEEL1	0.015702	1.9%
09	7457.48	STEEL1	0.018644	1.8%
10	7457.52	STEEL1	0.018644	1.8%
11	6364.28	STEEL1	0.015911	1.9%
12	2177.6	STEEL1	0.005444	3.1%
13	0	STEEL1	0	0.0%
14	3556.5	STEEL1	0.008891	3.1%
15	615.2	CONC1	0.045	-13.3%
16	2754.1	CONC1	0.20025	-1.9%
17	800.6	CONC1	0.0585	-10.3%
18	3611.1	STEEL1	0.009028	3.1%
19	0	STEEL1	0	0.0%
20	4153.2	CONC1	0.3015	3.2%
21	8010.1	CONC1	0.582	1.3%
22	2721.9	CONC1	0.198	1.5%
23	2528.9	CONC1	0.18375	1.2%
24	8108	CONC1	0.58875	1.3%
25	4216.8	CONC1	0.306	2.9%

SAP2000-STAGE05

하중조합 UL01 : 1.3 SW + 1.0 ULB01-P

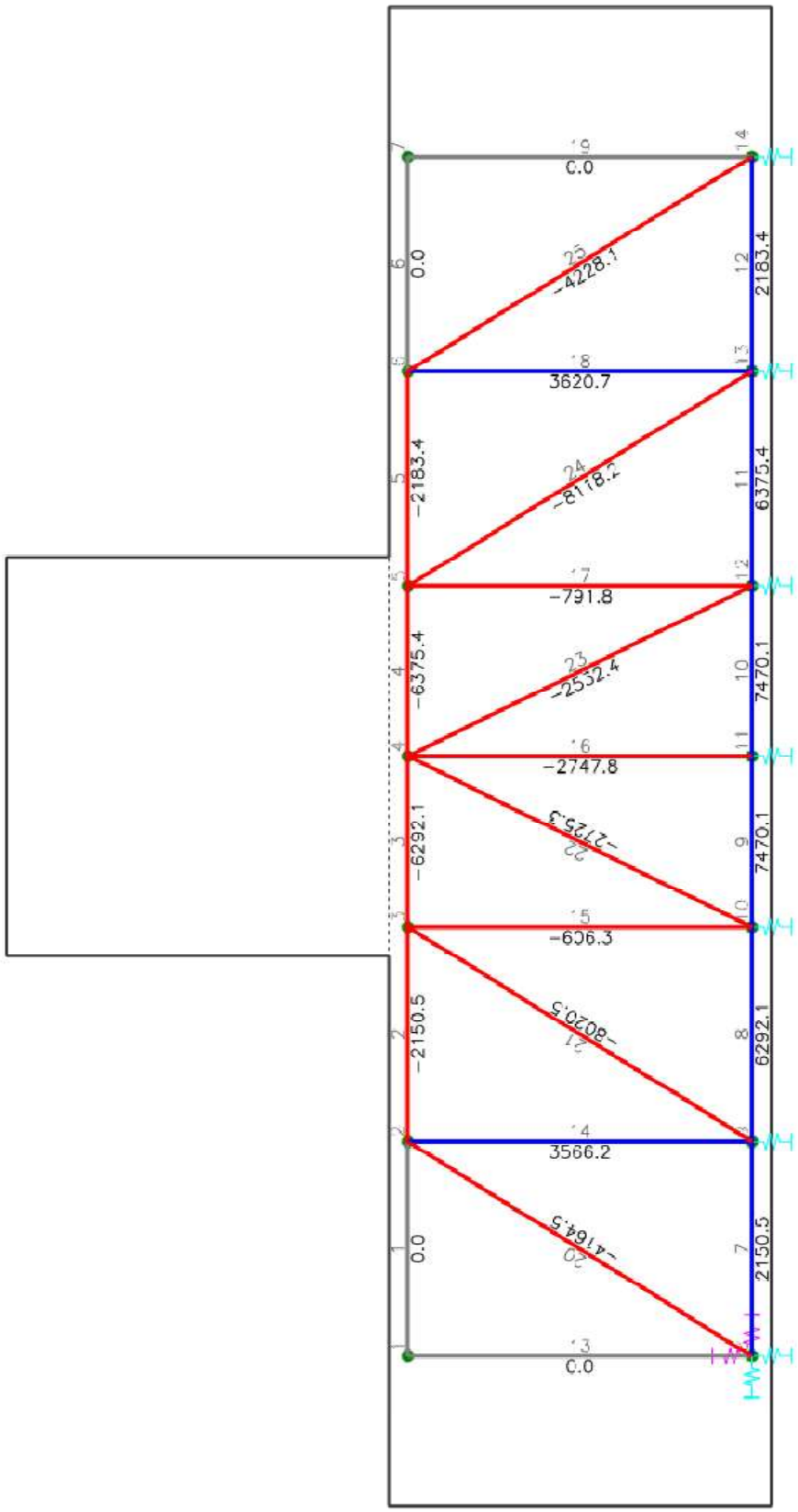


STAGE05

Element	Force	Material	Area	증감율
01	0	STEEL1	0	0.0%
02	2150.1	CONC1	0.156	0.0%
03	6291.1	CONC1	0.45675	0.2%
04	6374.5	CONC1	0.46275	0.2%
05	2183	CONC1	0.15825	0.0%
06	0	STEEL1	0	0.0%
07	2150.08	STEEL1	0.005375	0.2%
08	6291.12	STEEL1	0.015728	0.2%
09	7469.08	STEEL1	0.018673	0.2%
10	7469.12	STEEL1	0.018673	0.2%
11	6374.48	STEEL1	0.015936	0.2%
12	2182.96	STEEL1	0.005457	0.2%
13	0	STEEL1	0	0.0%
14	3565.4	STEEL1	0.008914	0.2%
15	607.1	CONC1	0.04425	-1.7%
16	2748.4	CONC1	0.1995	-0.4%
17	792.6	CONC1	0.05775	-1.3%
18	3620	STEEL1	0.00905	0.2%
19	0	STEEL1	0	0.0%
20	4163.6	CONC1	0.30225	0.2%
21	8019.5	CONC1	0.58275	0.1%
22	2725	CONC1	0.198	0.0%
23	2532.1	CONC1	0.18375	0.0%
24	8117.3	CONC1	0.5895	0.1%
25	4227.2	CONC1	0.30675	0.2%

SAP2000-STAGE06

하중조합 UL01 : 1.3 SW + 1.0 ULB01-P



STAGE06

Element	Force	Material	Area	증감율
01	0	STEEL1	0	0.0%
02	2150.5	CONC1	0.156	0.0%
03	6292.1	CONC1	0.45675	0.2%
04	6375.4	CONC1	0.46275	0.2%
05	2183.4	CONC1	0.15825	0.0%
06	0	STEEL1	0	0.0%
07	2150.56	STEEL1	0.005376	0.3%
08	6292.08	STEEL1	0.01573	0.2%
09	7470.16	STEEL1	0.018675	0.2%
10	7470.12	STEEL1	0.018675	0.2%
11	6375.44	STEEL1	0.015939	0.2%
12	2183.44	STEEL1	0.005459	0.3%
13	0	STEEL1	0	0.0%
14	3566.2	STEEL1	0.008916	0.3%
15	606.3	CONC1	0.04425	-1.7%
16	2747.8	CONC1	0.1995	-0.4%
17	791.8	CONC1	0.05775	-1.3%
18	3620.7	STEEL1	0.009052	0.3%
19	0	STEEL1	0	0.0%
20	4164.5	CONC1	0.30225	0.2%
21	8020.5	CONC1	0.58275	0.1%
22	2725.3	CONC1	0.198	0.0%
23	2532.4	CONC1	0.18375	0.0%
24	8118.2	CONC1	0.5895	0.1%
25	4228.1	CONC1	0.30675	0.2%