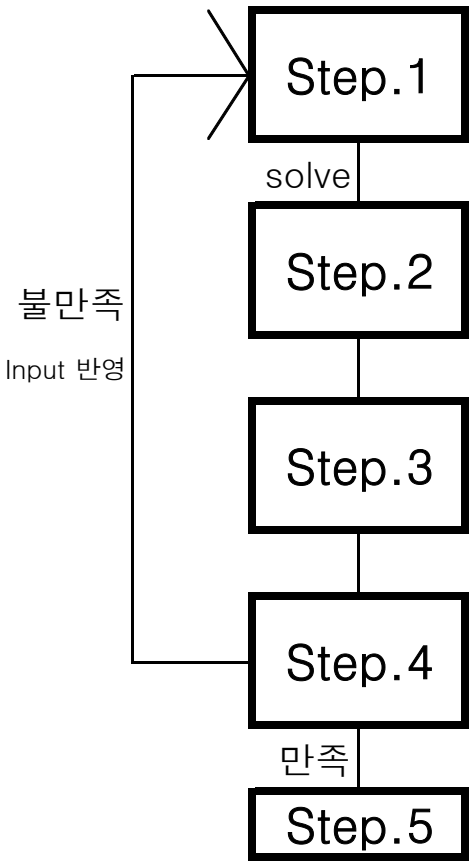
## ※ 반복시산법을 통한 축강성 결정 순서도




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

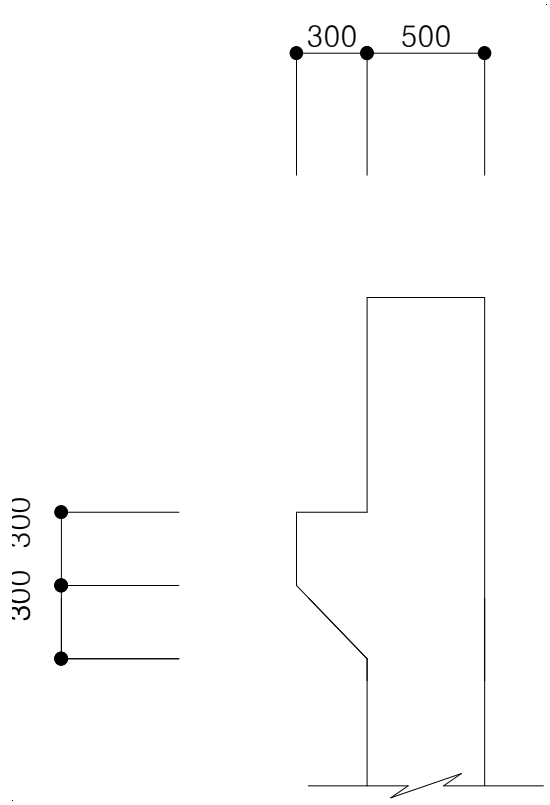
결정된 단면력과 필요 단면적으로 검토

# 2. STM 해석 : 브래킷

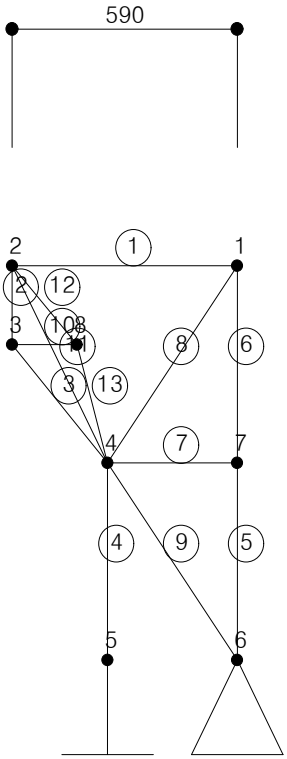
## 2.1 설계조건

1) 본체강도 : fck = 24 MPa
2) 철근강도 : fy = 300 MPa

## 2.2 단면형상



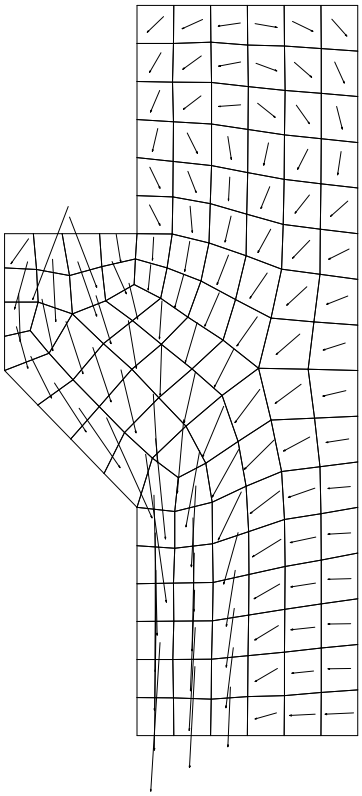
## 2.3 해석 모델링




1) 절점 좌표

| 구분 | X | Z | 절점 | 구분 | X | Z | 절점 |
|---|---|---|---|---|---|---|---|
| 1 | -0.080 | 1.000 | 1 | 5 | -0.420 | 0.000 | 5 |
| 2 | -0.670 | 1.000 | 2 | 6 | -0.080 | 0.000 | 6 |
| 3 | -0.670 | 0.800 | 3 | 7 | -0.080 | 0.500 | 7 |
| 4 | -0.420 | 0.500 | 4 | 8 | -0.500 | 0.800 | 8 |

2) 주응력 흐름도



## 2.4 하중산정

1) 브래킷자중 (SW)

: 자중은 구간별 평균두께로 산정하여 상단절점에 분할하여 재하, 수평력은 자중의 20%로 산정한다.

| 절점 | 분담폭 | 평균두께 | 단위폭 | 단위중량 | 수직하중(kN) | 수평하중(kN) |
|---|---|---|---|---|---|---|
| 2 | 0.300 | 0.000 | 0.300 | 25.000 | -3.375 | -0.675 |

2) 고정하중 (D)

: 고정하중은 접속슬래브 설계-받침부 설계참조, 수평력은 고정하중의 20%로 산정한다.

| 절점 | 수직하중(kN) | 수평하중(kN) |
|---|---|---|
| 2 | -58.729 | -11.746 |

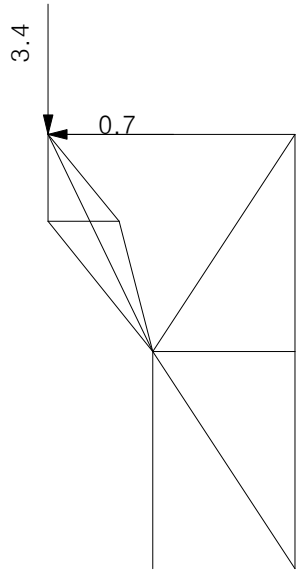
3) 활하중 (L)

: 활하중은 접속슬래브 설계-받침부 설계참조, 수평력은 고정하중의 20%로 산정한다.

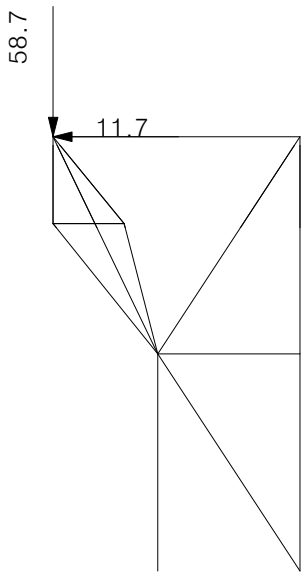
| 절점 | 수직하중(kN) | 수평하중(kN) |
|---|---|---|
| 2 | -96.000 | -19.200 |

## 2.5 하중재하도

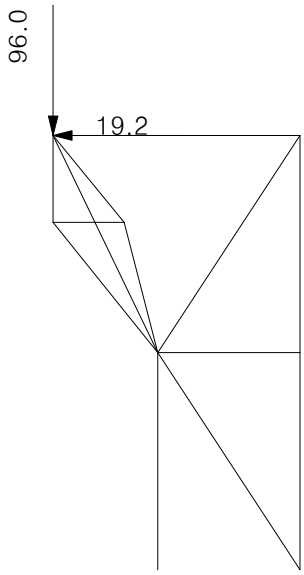
1) 브래킷자중 (SW)




2) 고정하중 (D)

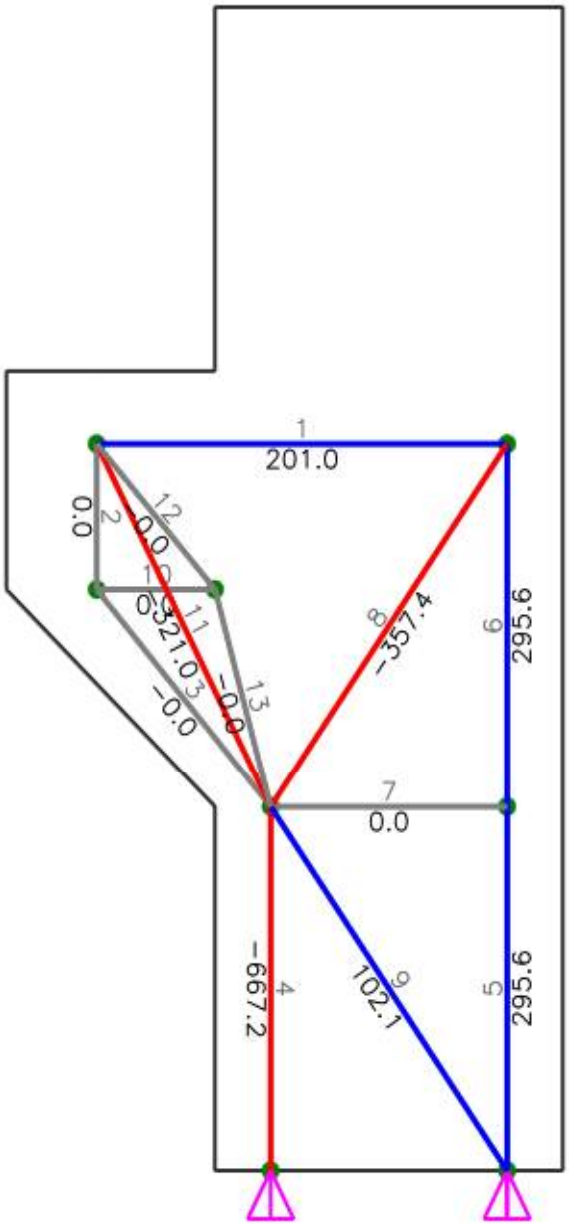


3) 활하중 (L)



# ASTM

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

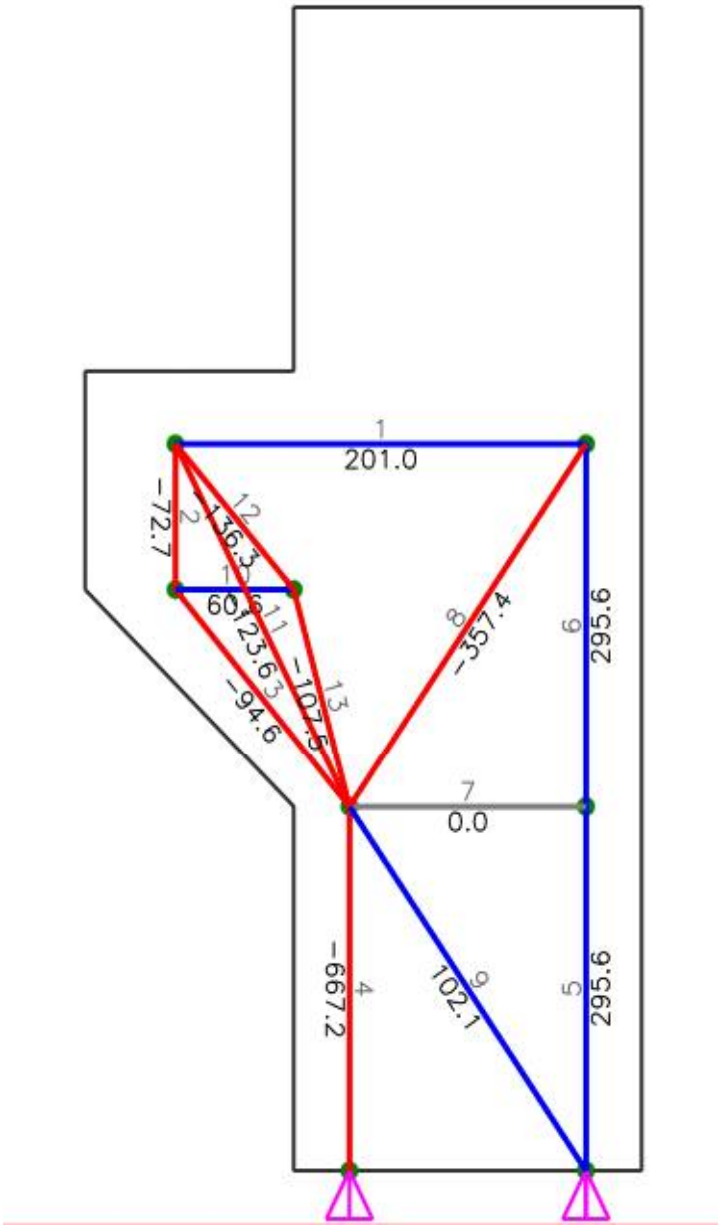


# ASTM

| Element | ASTM | | | SAP2000 | | SAP대비 Force |
|---|---|---|---|---|---|---|
| | Force | Material | Area | Force | Area | |
| 01 | 201 | STEEL1 | 0.00067 | 201 | 0.00067 | 0.0% |
| 02 | 0 | STEEL1 | 0 | 0 | 0 | 0.0% |
| 03 | 0 | STEEL1 | 0 | 0 | 0 | 0.0% |
| 04 | 667.2 | CONC1 | 0.0545 | 667.2 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 295.6 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 295.6 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 357.4 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 102.1 | 0.00034 | 0.0% |
| 10 | 0 | STEEL1 | 0 | 0 | 0 | 0.0% |
| 11 | 321 | CONC1 | 0.0262 | 321 | 0.0262 | 0.0% |
| 12 | 0 | STEEL1 | 0 | 0 | 0 | 0.0% |
| 13 | 0 | STEEL1 | 0 | 0 | 0 | 0.0% |

# SAP2000-STAGE01

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

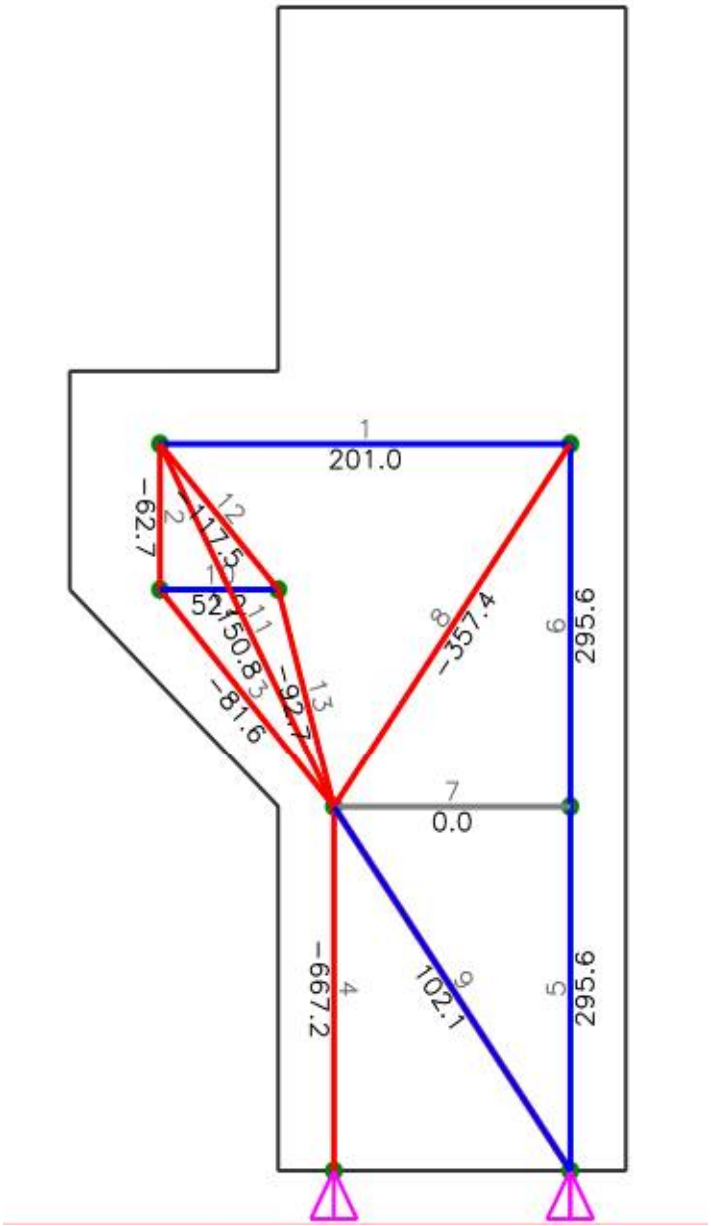


# STAGE01

| Element | Force | Material | Area |
|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 |
| 02 | 72.7 | CONC1 | 0.0059 |
| 03 | 94.6 | CONC1 | 0.0077 |
| 04 | 667.2 | CONC1 | 0.0545 |
| 05 | 295.6 | STEEL1 | 0.000985 |
| 06 | 295.6 | STEEL1 | 0.000985 |
| 07 | 0 | STEEL1 | 0 |
| 08 | 357.4 | CONC1 | 0.0292 |
| 09 | 102.1 | STEEL1 | 0.00034 |
| 10 | 60.6 | STEEL1 | 0.000202 |
| 11 | 123.6 | CONC1 | 0.0101 |
| 12 | 136.3 | CONC1 | 0.0111 |
| 13 | 107.5 | CONC1 | 0.0088 |

# SAP2000-STAGE02

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

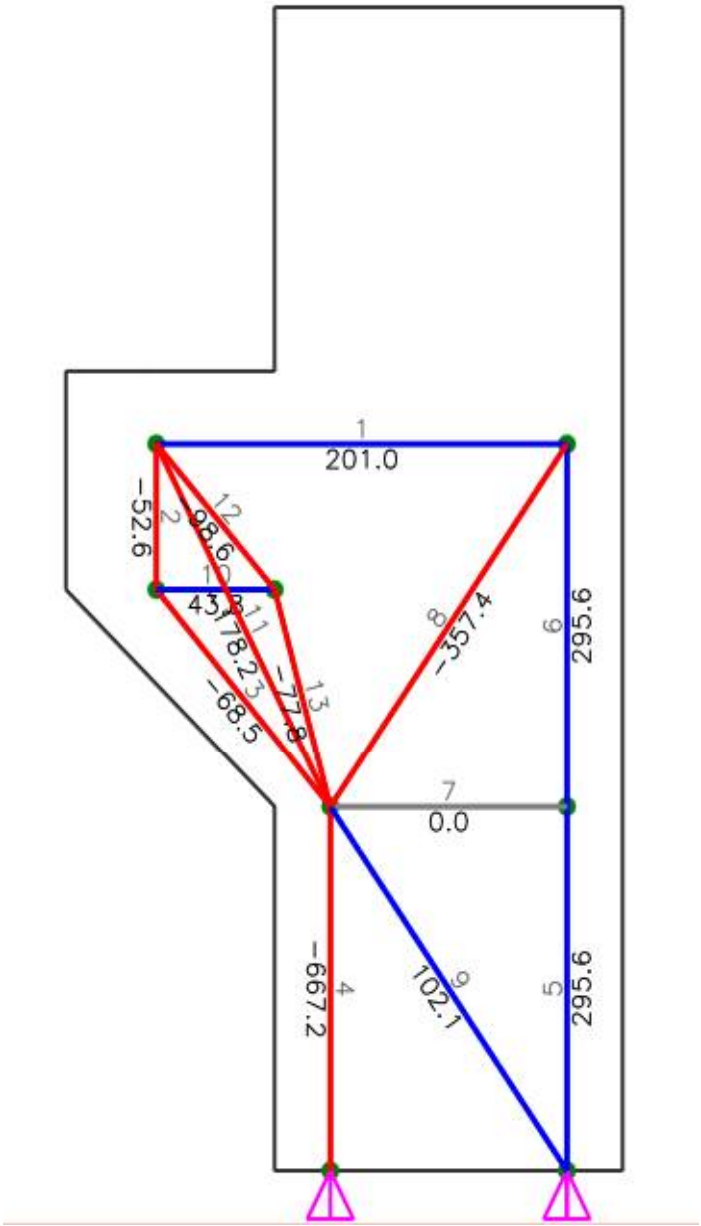


# STAGE02

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 62.7 | CONC1 | 0.0051 | -15.7% |
| 03 | 81.6 | CONC1 | 0.0067 | -14.9% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 52.2 | STEEL1 | 0.000174 | -16.1% |
| 11 | 150.8 | CONC1 | 0.0123 | 17.9% |
| 12 | 117.5 | CONC1 | 0.0096 | -15.6% |
| 13 | 92.7 | CONC1 | 0.0076 | -15.8% |

# SAP2000-STAGE03

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

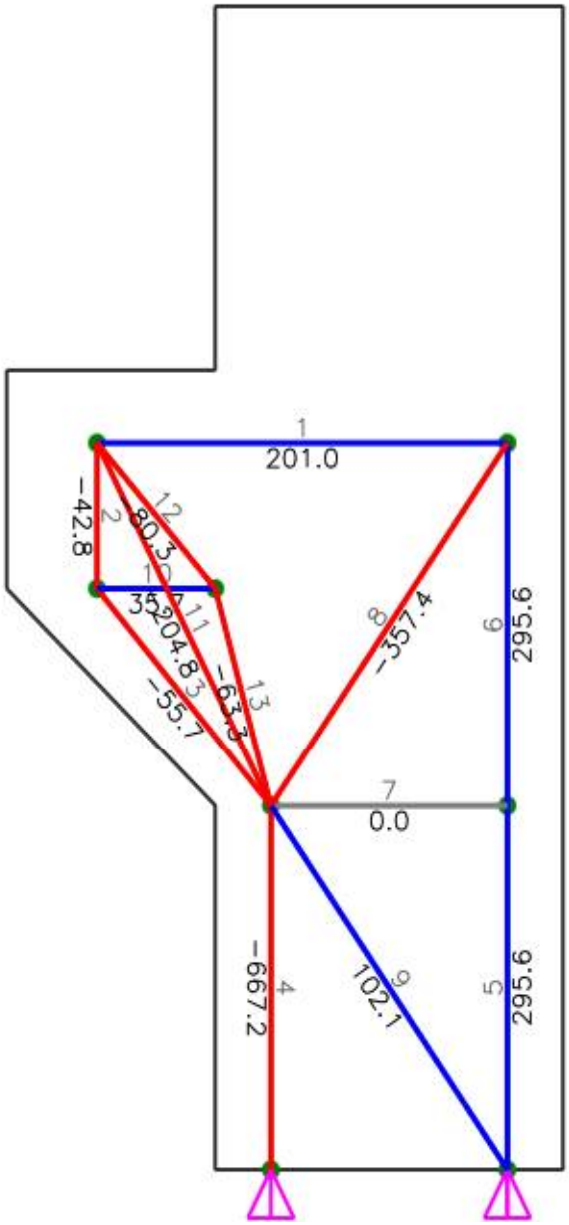


# STAGE03

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 52.6 | CONC1 | 0.0043 | -18.6% |
| 03 | 68.5 | CONC1 | 0.0056 | -19.6% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 43.8 | STEEL1 | 0.000146 | -19.2% |
| 11 | 178.2 | CONC1 | 0.0146 | 15.8% |
| 12 | 98.6 | CONC1 | 0.0081 | -18.5% |
| 13 | 77.8 | CONC1 | 0.0064 | -18.8% |

# SAP2000-STAGE04

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

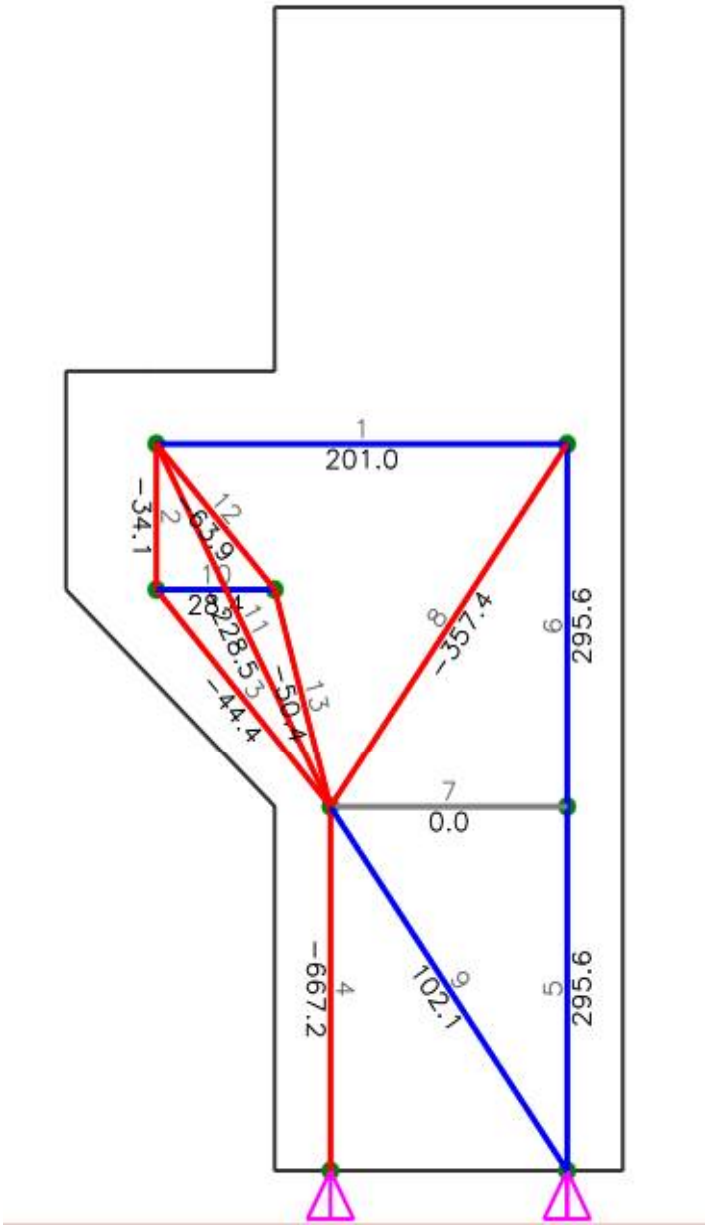


# STAGE04

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 42.8 | CONC1 | 0.0035 | -22.9% |
| 03 | 55.7 | CONC1 | 0.0046 | -21.7% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 35.7 | STEEL1 | 0.000119 | -22.7% |
| 11 | 204.8 | CONC1 | 0.0167 | 12.6% |
| 12 | 80.3 | CONC1 | 0.0066 | -22.7% |
| 13 | 63.3 | CONC1 | 0.0052 | -23.1% |

# SAP2000-STAGE05

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

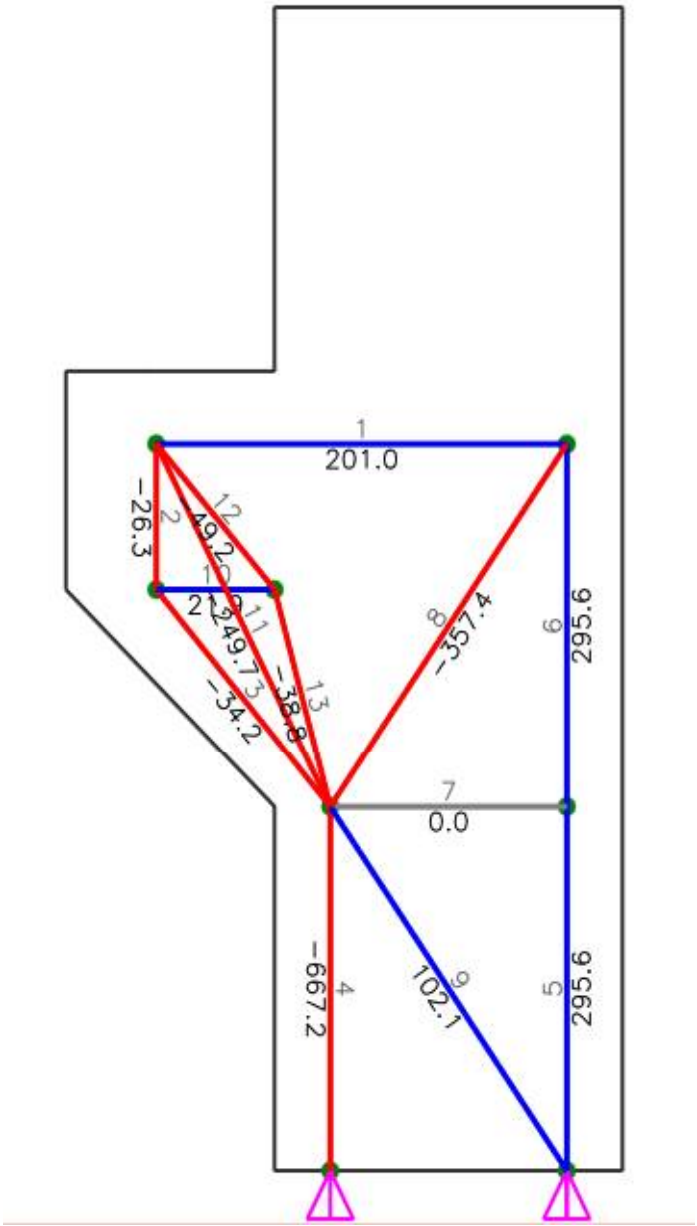


# STAGE05

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 34.1 | CONC1 | 0.0028 | -25.0% |
| 03 | 44.4 | CONC1 | 0.0036 | -27.8% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 28.4 | STEEL1 | 9.47E-05 | -25.7% |
| 11 | 228.5 | CONC1 | 0.0187 | 10.7% |
| 12 | 63.9 | CONC1 | 0.0052 | -26.9% |
| 13 | 50.4 | CONC1 | 0.0041 | -26.8% |

# SAP2000-STAGE06

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

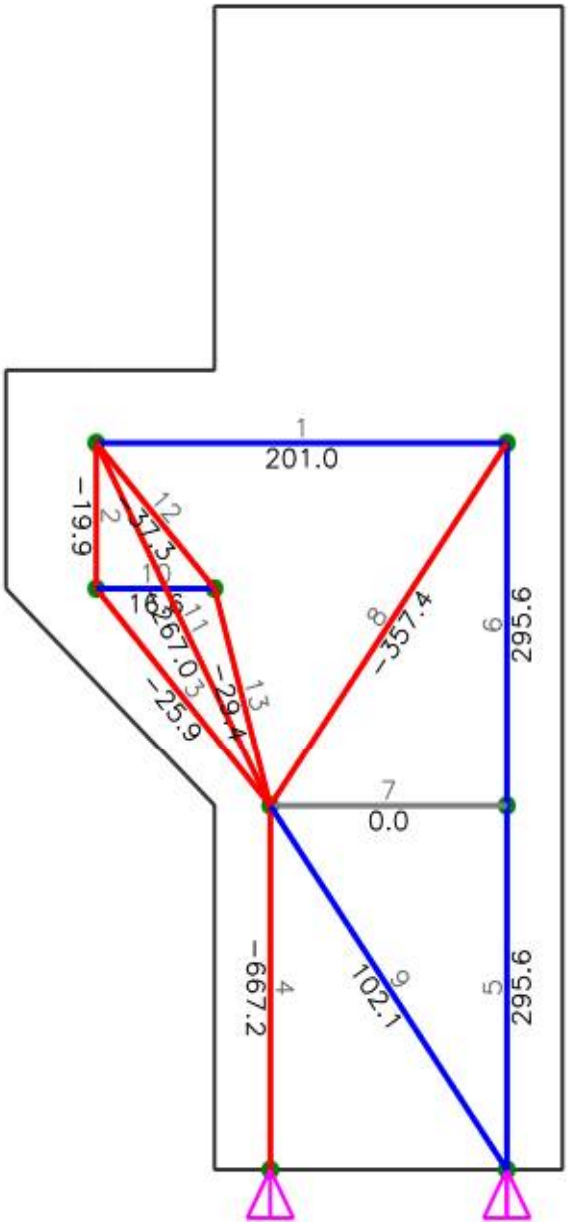


# STAGE06

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 26.3 | CONC1 | 0.0021 | -33.3% |
| 03 | 34.2 | CONC1 | 0.0028 | -28.6% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 21.9 | STEEL1 | 0.000073 | -29.7% |
| 11 | 249.7 | CONC1 | 0.0204 | 8.3% |
| 12 | 49.2 | CONC1 | 0.004 | -30.0% |
| 13 | 38.8 | CONC1 | 0.0032 | -28.1% |

# SAP2000-STAGE07

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

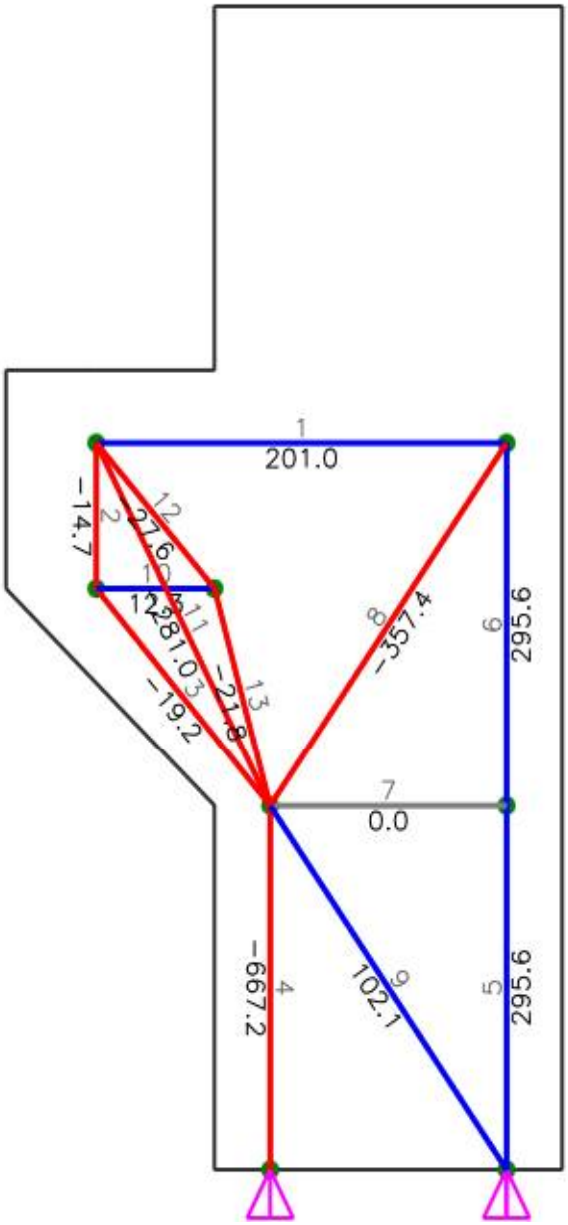


# STAGE07

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 19.9 | CONC1 | 0.0016 | -31.3% |
| 03 | 25.9 | CONC1 | 0.0021 | -33.3% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 16.6 | STEEL1 | 5.53E-05 | -32.0% |
| 11 | 267 | CONC1 | 0.0218 | 6.4% |
| 12 | 37.3 | CONC1 | 0.003 | -33.3% |
| 13 | 29.4 | CONC1 | 0.0024 | -33.3% |

# SAP2000-STAGE08

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

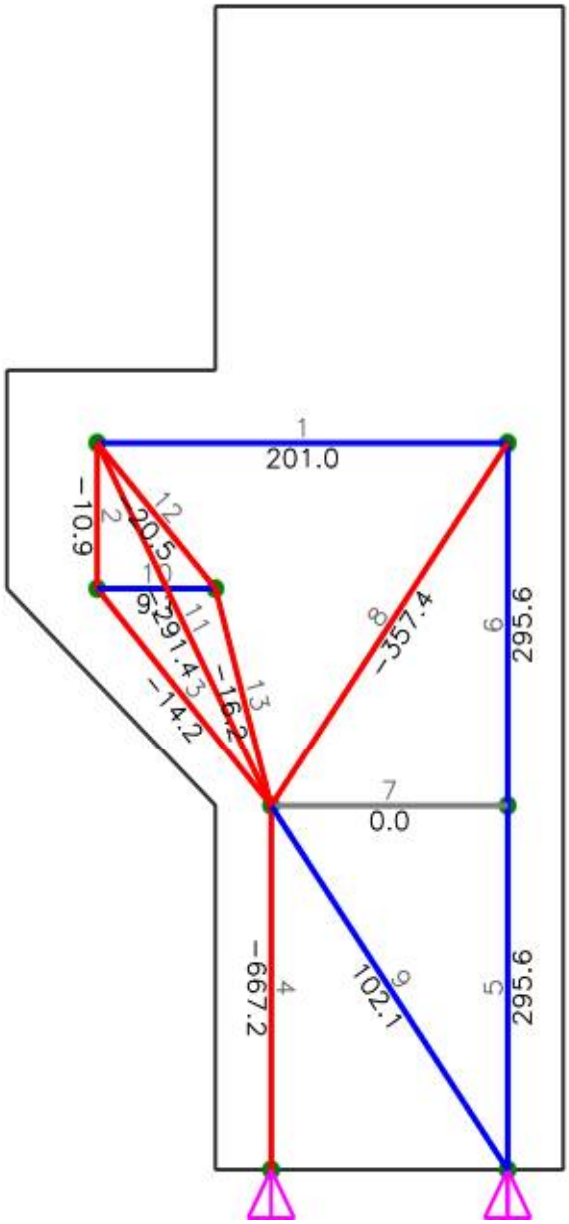


# STAGE08

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 14.7 | CONC1 | 0.0012 | -33.3% |
| 03 | 19.2 | CONC1 | 0.0016 | -31.3% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 12.3 | STEEL1 | 0.000041 | -34.9% |
| 11 | 281 | CONC1 | 0.023 | 5.2% |
| 12 | 27.6 | CONC1 | 0.0023 | -30.4% |
| 13 | 21.8 | CONC1 | 0.0018 | -33.3% |

# SAP2000-STAGE09

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

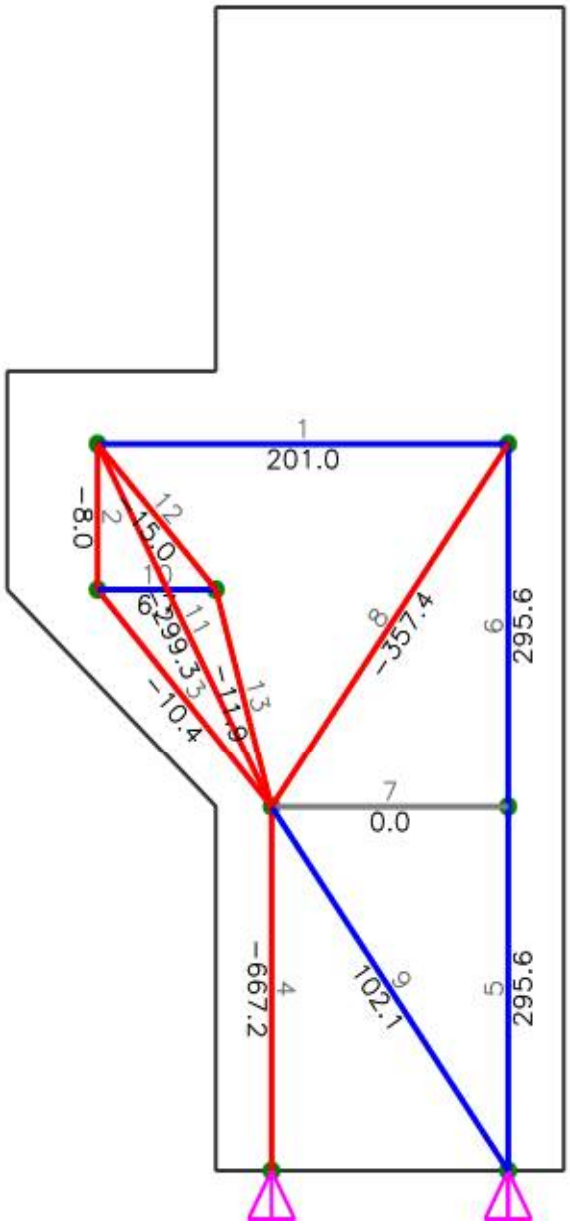


# STAGE09

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 10.9 | CONC1 | 0.0009 | -33.3% |
| 03 | 14.2 | CONC1 | 0.0012 | -33.3% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 9.1 | STEEL1 | 3.03E-05 | -35.3% |
| 11 | 291.4 | CONC1 | 0.0238 | 3.4% |
| 12 | 20.5 | CONC1 | 0.0017 | -35.3% |
| 13 | 16.2 | CONC1 | 0.0013 | -38.5% |

# SAP2000-STAGE10

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

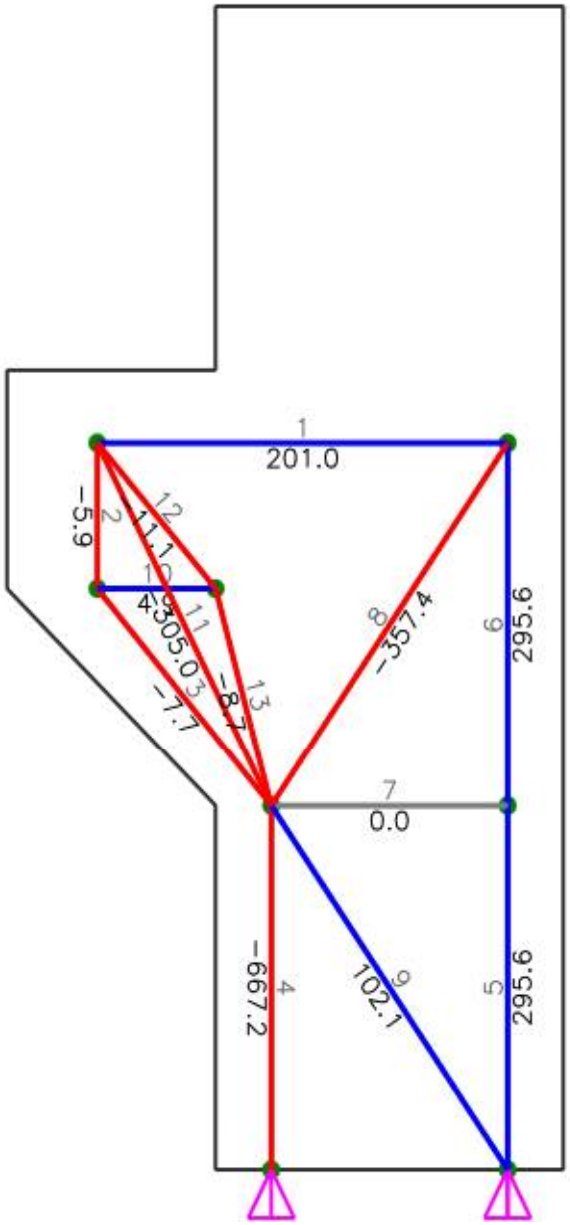


# STAGE10

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 8 | CONC1 | 0.0007 | -28.6% |
| 03 | 10.4 | CONC1 | 0.0009 | -33.3% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 6.7 | STEEL1 | 2.23E-05 | -35.9% |
| 11 | 299.3 | CONC1 | 0.0244 | 2.5% |
| 12 | 15 | CONC1 | 0.0012 | -41.7% |
| 13 | 11.9 | CONC1 | 0.001 | -30.0% |

# SAP2000-STAGE11

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

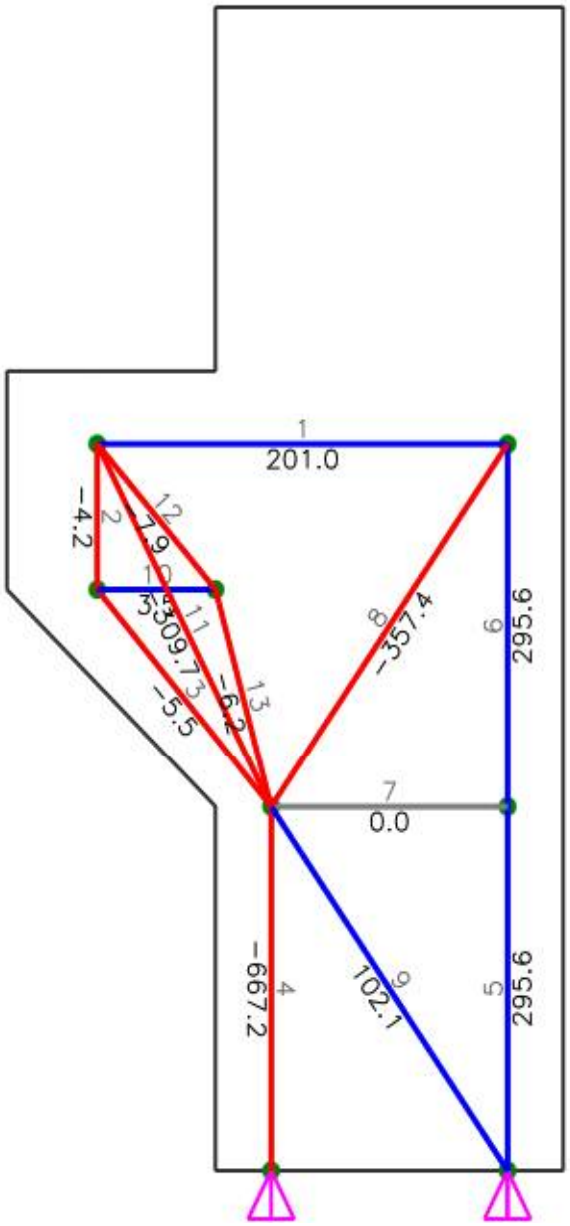


# STAGE11

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 5.9 | CONC1 | 0.0005 | -40.0% |
| 03 | 7.7 | CONC1 | 0.0006 | -50.0% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 4.9 | STEEL1 | 1.63E-05 | -36.8% |
| 11 | 305 | CONC1 | 0.0249 | 2.0% |
| 12 | 11.1 | CONC1 | 0.0009 | -33.3% |
| 13 | 8.7 | CONC1 | 0.0007 | -42.9% |

# SAP2000-STAGE12

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

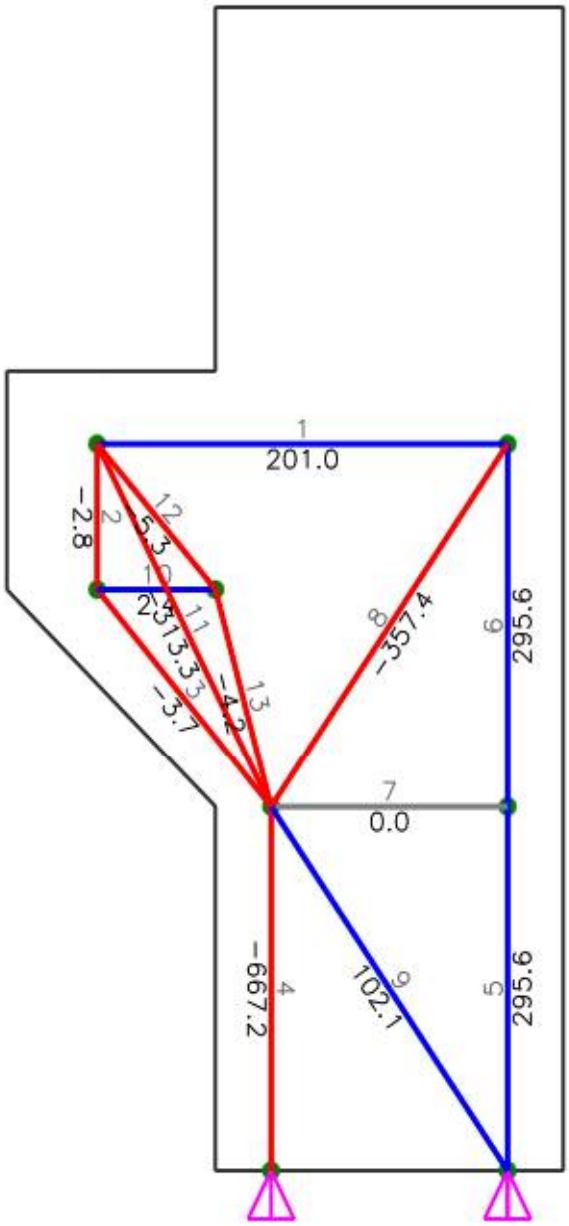


# STAGE12

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 4.2 | CONC1 | 0.0003 | -66.7% |
| 03 | 5.5 | CONC1 | 0.0004 | -50.0% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 3.5 | STEEL1 | 1.17E-05 | -39.3% |
| 11 | 309.7 | CONC1 | 0.0253 | 1.6% |
| 12 | 7.9 | CONC1 | 0.0006 | -50.0% |
| 13 | 6.2 | CONC1 | 0.0005 | -40.0% |

# SAP2000-STAGE13

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

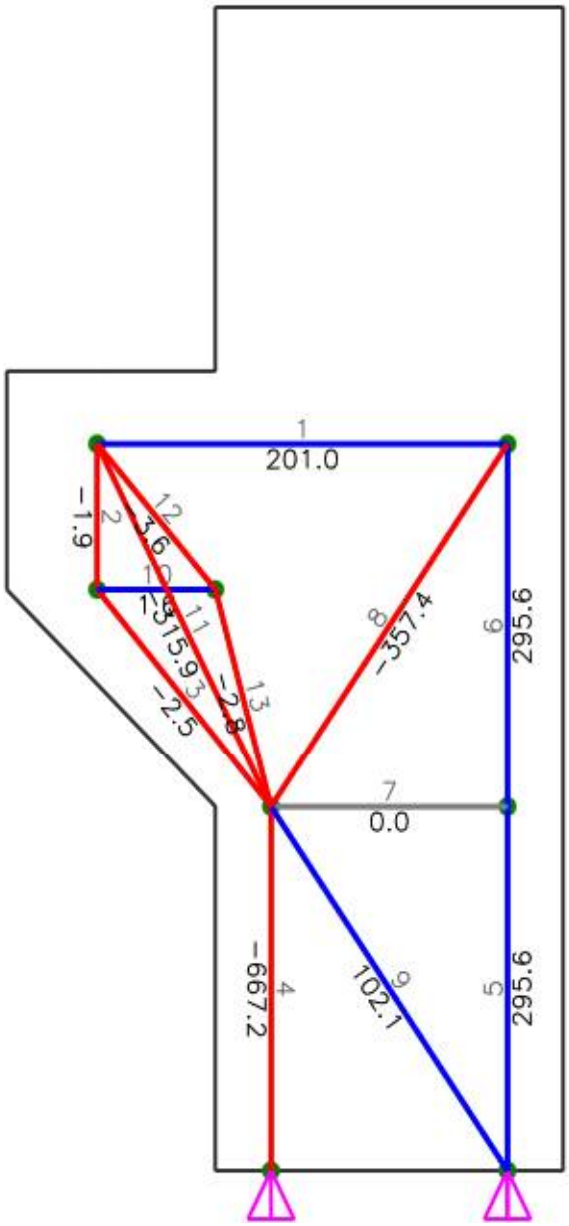


# STAGE13

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 2.8 | CONC1 | 0.0002 | -50.0% |
| 03 | 3.7 | CONC1 | 0.0003 | -33.3% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 2.4 | STEEL1 | 0.000008 | -46.3% |
| 11 | 313.3 | CONC1 | 0.0256 | 1.2% |
| 12 | 5.3 | CONC1 | 0.0004 | -50.0% |
| 13 | 4.2 | CONC1 | 0.0003 | -66.7% |

# SAP2000-STAGE14

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

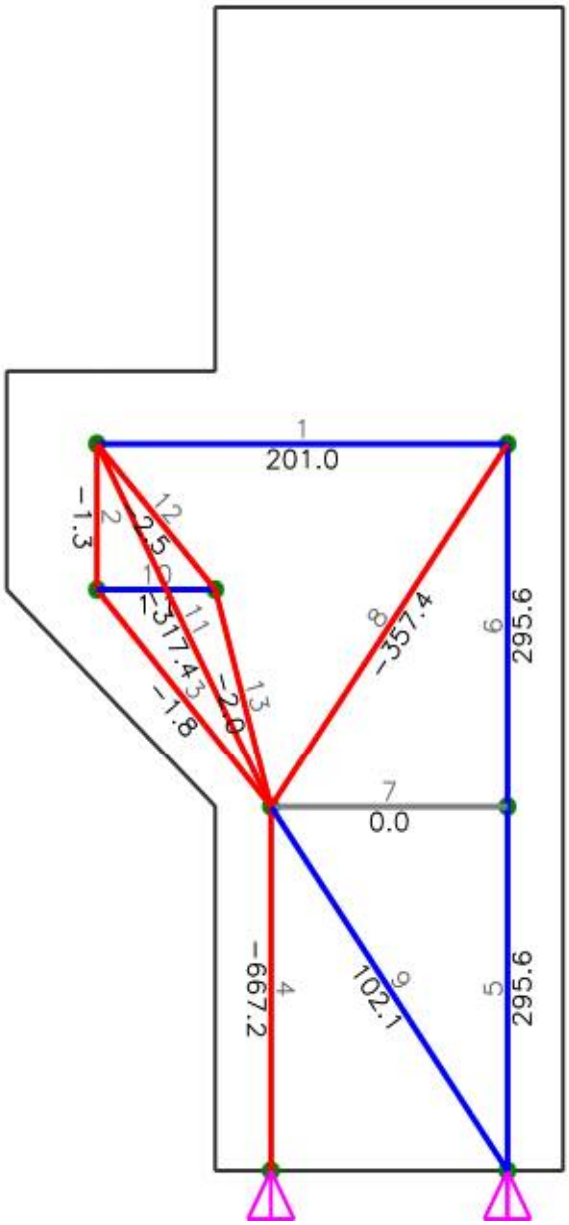


# STAGE14

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 1.9 | CONC1 | 0.0002 | 0.0% |
| 03 | 2.5 | CONC1 | 0.0002 | -50.0% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 1.6 | STEEL1 | 5.3E-06 | -50.9% |
| 11 | 315.9 | CONC1 | 0.0258 | 0.8% |
| 12 | 3.6 | CONC1 | 0.0003 | -33.3% |
| 13 | 2.8 | CONC1 | 0.0002 | -50.0% |

# SAP2000-STAGE15

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

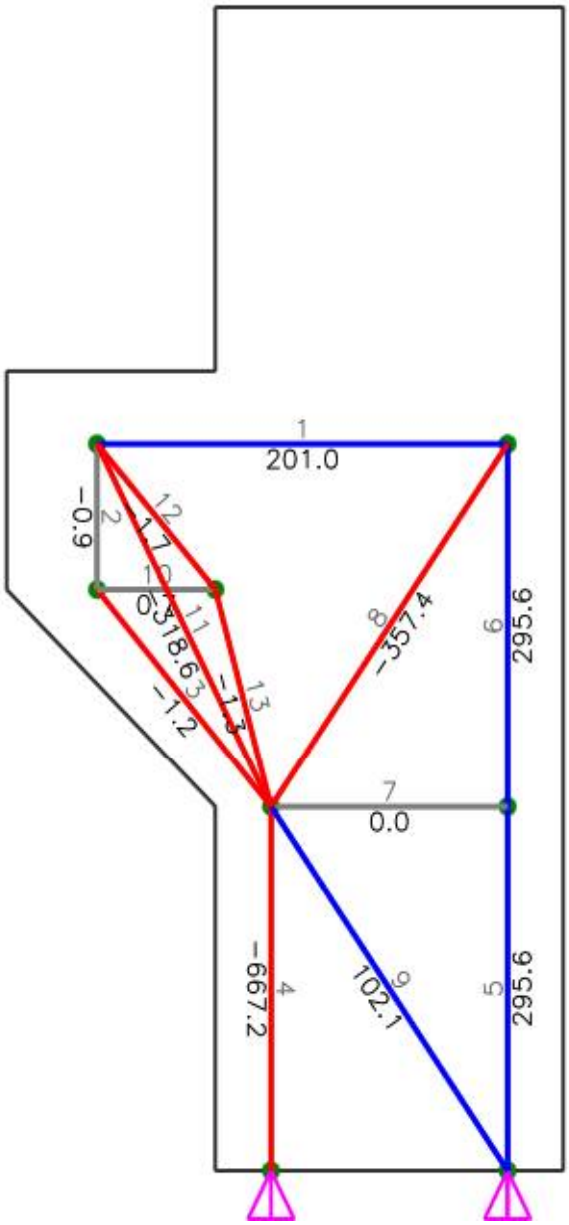


# STAGE15

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 1.3 | CONC1 | 0.0001 | -100.0% |
| 03 | 1.8 | CONC1 | 0.0001 | -100.0% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 1.1 | STEEL1 | 3.7E-06 | -43.2% |
| 11 | 317.4 | CONC1 | 0.0259 | 0.4% |
| 12 | 2.5 | CONC1 | 0.0002 | -50.0% |
| 13 | 2 | CONC1 | 0.0002 | 0.0% |

# SAP2000-STAGE16

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L

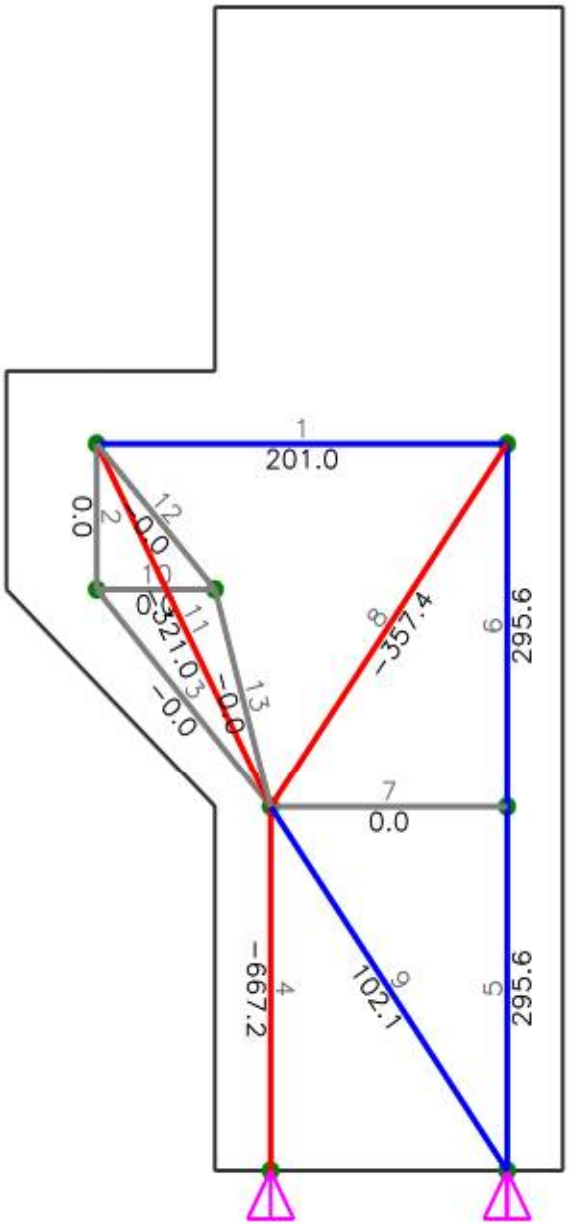


# STAGE16

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 0.9 | STEEL1 | 0 | 0.0% |
| 03 | 1.2 | CONC1 | 0.0001 | 0.0% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 0 | STEEL1 | 0 | 0.0% |
| 11 | 318.6 | CONC1 | 0.026 | 0.4% |
| 12 | 1.7 | CONC1 | 0.0001 | -100.0% |
| 13 | 1.3 | CONC1 | 0.0001 | -100.0% |

# SAP2000-STAGE17

하중조합 ULT : 1.3 SW + 1.3 D + 2.1 L



# STAGE17

| Element | Force | Material | Area | 증감율 |
|---|---|---|---|---|
| 01 | 201 | STEEL1 | 0.00067 | 0.0% |
| 02 | 0 | STEEL1 | 0 | 0.0% |
| 03 | 0 | STEEL1 | 0 | 0.0% |
| 04 | 667.2 | CONC1 | 0.0545 | 0.0% |
| 05 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 06 | 295.6 | STEEL1 | 0.000985 | 0.0% |
| 07 | 0 | STEEL1 | 0 | 0.0% |
| 08 | 357.4 | CONC1 | 0.0292 | 0.0% |
| 09 | 102.1 | STEEL1 | 0.00034 | 0.0% |
| 10 | 0 | STEEL1 | 0 | 0.0% |
| 11 | 321 | CONC1 | 0.0262 | 1.1% |
| 12 | 0 | STEEL1 | 0 | 0.0% |
| 13 | 0 | STEEL1 | 0 | 0.0% |