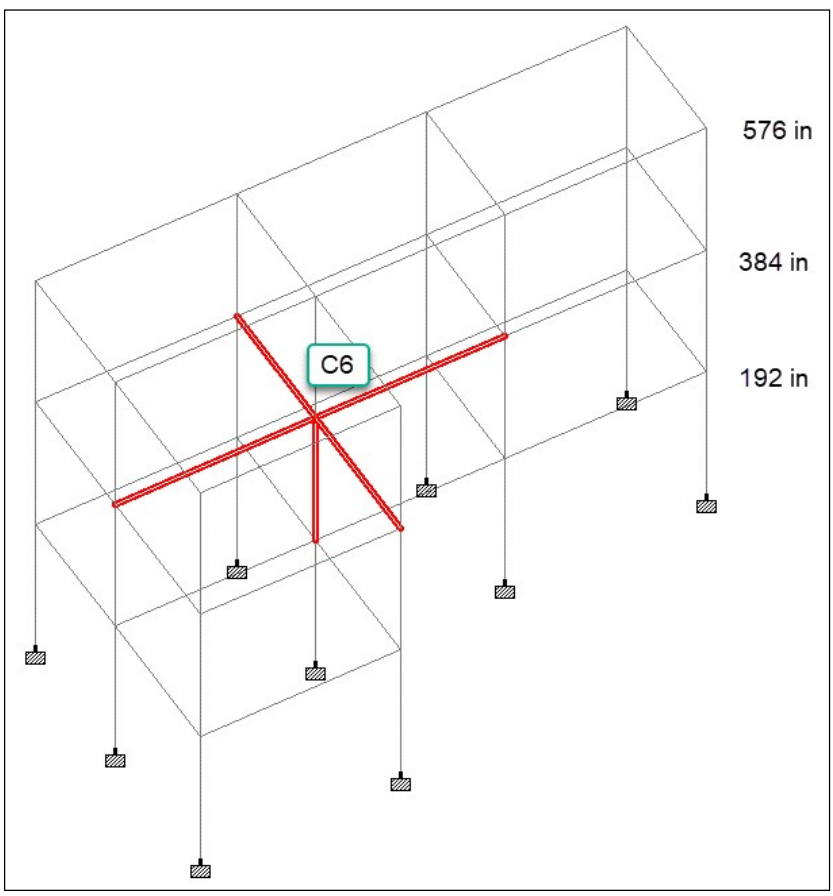
# EFFECTIVE LENGTH FACTOR CALCULATION

**Calculation of Stability Index:**

| | | | | |
|---|---|---|---|---|
| Bottom Level of Column | = | 16 | ft | |
| Top Level of Column | = | 32 | ft | |
| Column | = | C6 | | |
| Column Width | = | 15 | in | |
| Column Depth | = | 24 | in | |
| Concrete Grade for Column, fck-c | = | 7 | ksi | |
| Reinforcement Grade for Column, fy-c | = | 80 | ksi | |
| Concrete Grade for Beam, fck-b | = | 7 | ksi | |
| Reinforcement Grade for Beam, fy-b | = | 80 | ksi | |
| Height of Column,H | = | (32-16)x12 | | |
| | = | 192 | in | |
| Elastic Modulus of fck-c | = | 57000xSQRT(7x 1000)/1000 | | |
| | = | 4769 | ksi | Clause 6.2.3.1 |
| Elastic Modulus of fck-c | = | 57000xSQRT(7x 1000)/1000 | | Clause 6.2.3.1 |
| | = | 4769 | ksi | |

**COLUMN LOCATION AND LEVELS**



**Sway Calculation (Stability Index)**

For Global X direction

| Level | Load Combination Analysis | Storey Height (ft) | Gravity Load P (kip) | Relative Displacements (in) | Storey Shear (kip) | Stability Index (Q) | Sway Condition |
|---|---|---|---|---|---|---|---|
| | | A | B | C | D | B x C / (A x D) | |
| 0 ft to 16 ft | 10 | 16 | 4641.71 | 1.18 | 360.14 | 0.079 | Sway |
| 16 ft to 32 ft | 12 | 16 | 3070.46 | 0.95 | 240.1 | 0.063 | Sway |
| 32 ft to 48 ft | 10 | 16 | 1499.22 | 0.48 | 120.05 | 0.031 | Non Sway |

| | | | |
|---|---|---|---|
| Story Height (A) | = | 16 ft | |
| Gravity Load,p (B) | = | 3070 kip | |
| Relative Displacement (Eq-X) (C) | = | 0.95 in | |
| Story Shear (D) | = | 240.1 kip | |
| Stability Index,Q | = | 3070.46 x 0.95 / (16 x 12 x 240.1) | |
| | = | 0.0633 | Clause 6.6.4.3 |
| Check | = | Sway | Clause 6.6.4.3 |

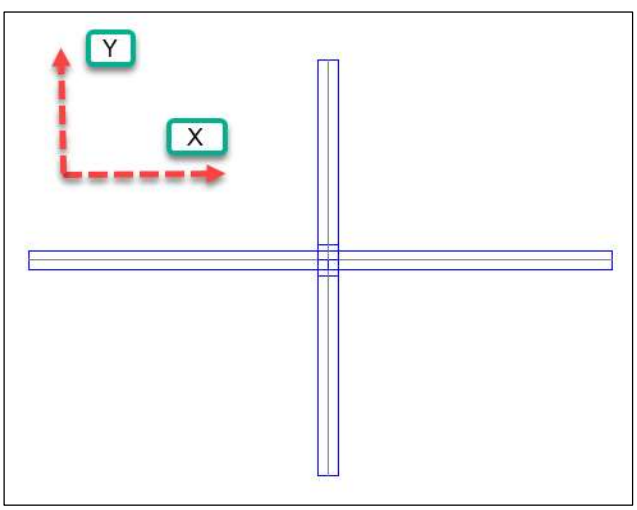
For Global X direction

| Level | Load Combination Analysis | Storey Height (ft) | Gravity Load P (kip) | Relative Displacements (in) | Storey Shear (kip) | Stability Index (Q) | Sway Condition |
|---|---|---|---|---|---|---|---|
| | | A | B | C | D | B x C / (A x D) | |
| 0 ft to 16 ft | 11 | 16 | 4641.71 | 0.55 | 360.14 | 0.037 | Non Sway |
| 16 ft to 32 ft | 11 | 16 | 3070.46 | 0.51 | 240.1 | 0.034 | Non Sway |
| 32 ft to 48 ft | 11 | 16 | 1499.22 | 0.29 | 120.05 | 0.019 | Non Sway |

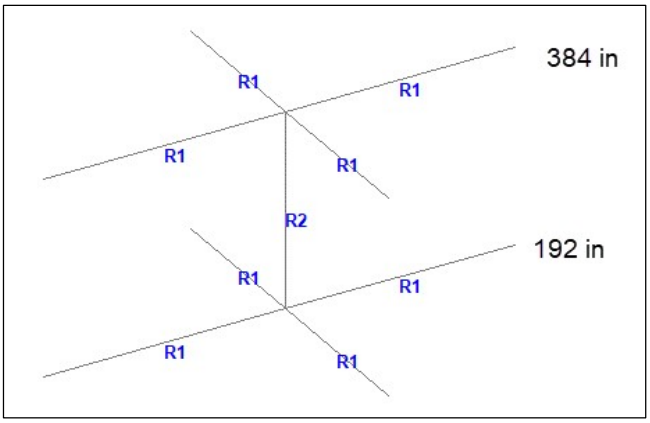
| | | | |
|---|---|---|---|
| Story Height (A) | = | 16 ft | |
| Gravity Load,p (B) | = | 3070 kip | |
| Relative Displacement (Eq-X) (C) | = | 0.51 in | |
| Story Shear (D) | = | 240.1 kip | |
| Stability Index,Q | = | 3070.46 x 0.51 / (16 x 12 x 240.1) | |
| | = | 0.034 | Clause 6.6.4.3 |
| Check | = | Non Sway | Clause 6.6.4.3 |

*Note: Validation of Values B,C and D are provided at end of this document.*

**Column Orientation W.R.T. Global Axis**



**Beam Column Layout**




**Beam Details at 192 in level**

R1 Along Major Direction of Column

| | | | |
|---|---|---|---|
| Beam Width | = | 15 | in |
| Beam Depth | = | 30 | in |
| Beam Length | = | 156 | in |
| Beam Stiffness | = | 4x15x30^3/12x4768.96/156/10^6 | |
| | = | 343.92 | lbs-ft |

R1 Along Major Direction of Column

| | | | |
|---|---|---|---|
| Beam Width | = | 15 | in |
| Beam Depth | = | 30 | in |
| Beam Length | = | 168 | in |
| Beam Stiffness | = | 4x15x30^3/12x4768.96/168/10^6 | |
| | = | 319.35 | lbs-ft |

R1 Along Minor Direction of Column

| | | | |
|---|---|---|---|
| Beam Width | = | 15 | in |
| Beam Depth | = | 30 | in |
| Beam Length | = | 216 | in |
| Beam Stiffness | = | 4x15x30^3/12x4768.96/216/10^6 | |
| | = | 248.38 | lbs-ft |

R1 Along Minor Direction of Column

| | | | |
|---|---|---|---|
| Beam Width | = | 15 | in |
| Beam Depth | = | 30 | in |
| Beam Length | = | 228 | in |
| Beam Stiffness | = | 4x15x30^3/12x4768.96/228/10^6 | |
| | = | 235.31 | lbs-ft |

**Beam Details at 384 in level**

R1 Along Major Direction of Column

| | | | |
|---|---|---|---|
| Beam Width | = | 15 | in |
| Beam Depth | = | 30 | in |
| Beam Length | = | 156 | in |
| Beam Stiffness | = | 4x15x30^3/12x4768.96/156/10^6 | |
| | = | 343.92 | lbs-ft |

R1 Along Major Direction of Column

| | | | |
|---|---|---|---|
| Beam Width | = | 15 | in |

| | | | |
|---|---|---|---|
| Beam Depth | = | 30 | in |
| Beam Length | = | 168 | in |
| Beam Stiffness | = | 4x15x30^3/12x4768.96/168/10^6 | |
| | = | 319.35 | lbs-ft |

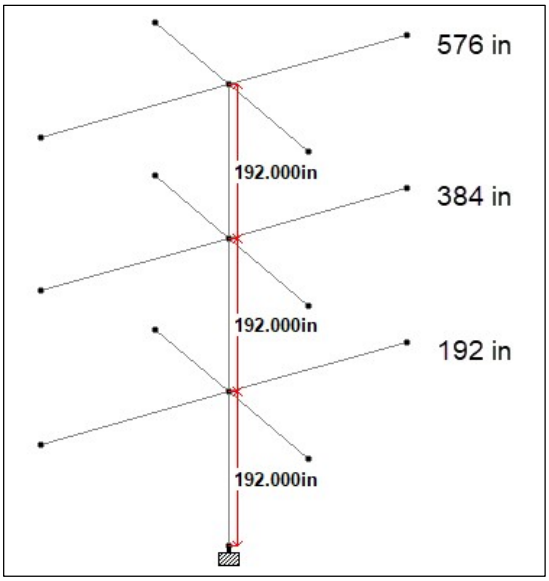
R1 Along Minor Direction of Column

| | | | |
|---|---|---|---|
| Beam Width | = | 15 | in |
| Beam Depth | = | 30 | in |
| Beam Length | = | 216 | in |
| Beam Stiffness | = | 4x15x30^3/12x4768.96/216/10^6 | |
| | = | 248.38 | lbs-ft |

R1 Along Minor Direction of Column

| | | | |
|---|---|---|---|
| Beam Width | = | 15 | in |
| Beam Depth | = | 30 | in |
| Beam Length | = | 228 | in |
| Beam Stiffness | = | 4x15x30^3/12x4768.96/228/10^6 | |
| | = | 235.31 | lbs-ft |

**Column Layout**




**For Global X direction**

Column Details above 384 in level

| | | | |
|---|---|---|---|
| Column Width | = | 15 | in |
| COlumn Depth | = | 24 | in |
| Column Length | = | 192 | in |
| Column Stiffness | = | 4x15x24^3/12x4768.96/192/10^6 | |
| | = | 143.07 | lbs-ft |

Column Details below 384 in level

| | | | |
|---|---|---|---|
| Column Width | = | 15 | in |
| COlumn Depth | = | 24 | in |
| Column Length | = | 192 | in |
| Column Stiffness | = | 4x15x24^3/12x4768.96/192/10^6 | |
| | = | 143.07 | lbs-ft |

Column Details below 192 in level

| | | | |
|---|---|---|---|
| Column Width | = | 15 | in |

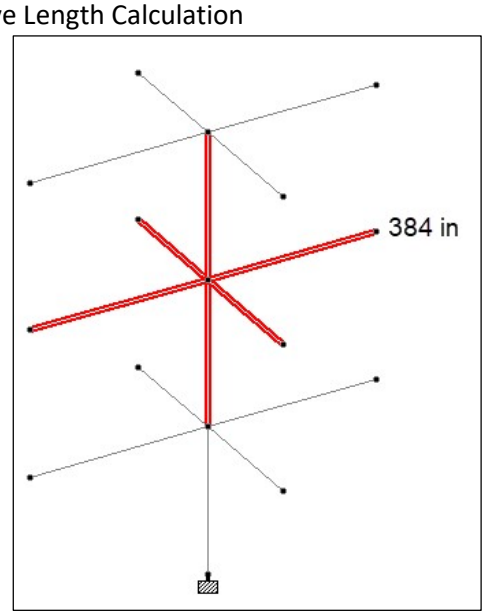
| | | | |
|---|---|---|---|
| COlumn Depth | = | 24 | in |
| Column Length | = | 192 | in |
| Column Stiffness | = | 4x15x24^3/12x4768.96/192/10^6 | |
| | = | 143.07 | lbs-ft |

**For Global Y direction**

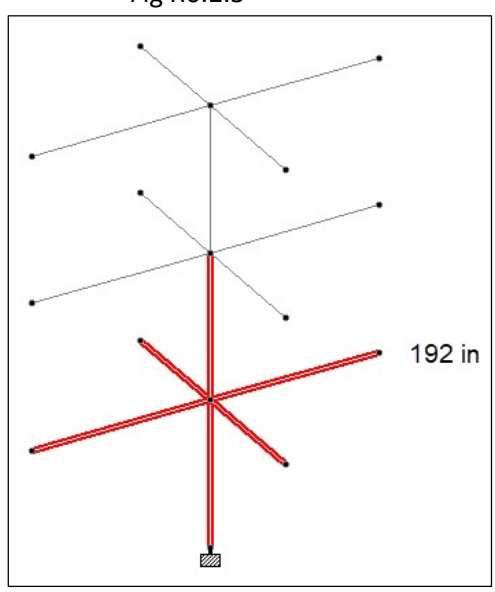
| | | | | |
|---|---|---|---|---|
| Column Details above | 384 | in level | | |
| Column Width | | | = | 24 in |
| COlumn Depth | | | = | 15 in |
| Column Length | | | = | 192 in |
| Column Stiffness | | | = | 4x24x15^3/12x4768.96/192/10^6 |
| | | | = | 55.89 lbs-ft |
| Column Details below | 384 | in level | | |
| Column Width | | | = | 24 in |
| COlumn Depth | | | = | 15 in |
| Column Length | | | = | 192 in |
| Column Stiffness | | | = | 4x24x15^3/12x4768.96/192/10^6 |
| | | | = | 55.89 lbs-ft |
| Column Details below | 192 | in level | | |
| Column Width | | | = | 24 in |
| COlumn Depth | | | = | 15 in |
| Column Length | | | = | 192 in |
| Column Stiffness | | | = | 4x24x15^3/12x4768.96/192/10^6 |
| | | | = | 55.89 lbs-ft |

Effective Length Calculation

Fig R6.2.5




Beam and Column for Top Joint




Beam and Column for Bottom Joint

Calculation of Ψ Factor Along Major Axis Of Column

| | | |
|---|---|---|
| Top | = | (143.07+143.07)/(343.92+319.35) |
| | = | 0.431 |
| Bottom | = | (143.07+143.07)/(343.92+319.35) |

= 0.431

Calculation of Beta Factor Along Minor Axis Of Column

Top = (55.89+55.89)/(248.38+235.31)

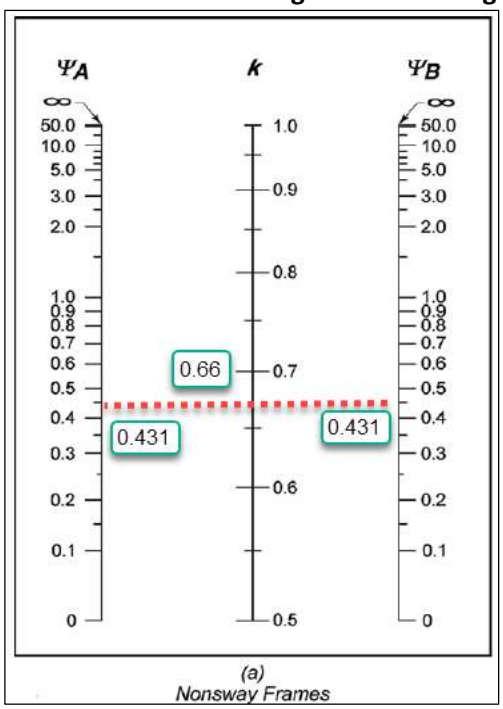
= 0.231

Bottom = (55.89+55.89)/(248.38+235.31)

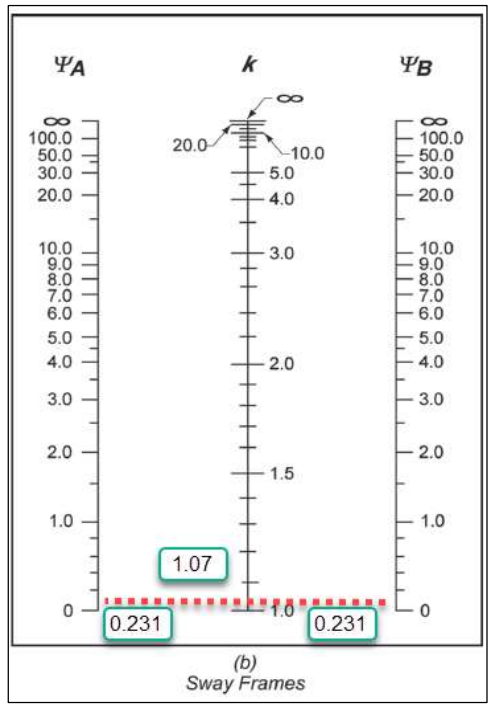
= 0.231

Note: For the calculation of the Ψ factor, all members connected to the joint at the level are considered. Ψ Factor is calculated at top and bottom joint of the column.

**Calculation of Effective length factors Using Fig. R6.2.5**




**Along Major Axis Of Column**




**Along Minor Axis Of Column**

**Calculation Along Major Axis Of Column**

| Joint | Column Stiffness | Beam Sizes | | Beam Stiffness | | ψ |
|---|---|---|---|---|---|---|
| | | Beam 1 (Length x Width x Depth) | Beam 2 (Length x Width x Depth) | Beam 1 | Beam 2 | |
| | lbs-ft x 10^6 | in | in | lbs-ft x 10^6 | lbs-ft x 10^6 | |
| Bottom | 142.07 | 156 x 15 x 30 | 168 x 15 x 30 | 341.51 | 317.11 | 0.431 |
| Top | 142.07 | 156 x 15 x 30 | 168 x 15 x 30 | 341.51 | 317.11 | 0.431 |

Sway Condition (as per Stability Index) = Non Sway

Effective Length Factor along Major Axis = 0.66

**Calculation Along Minor Axis Of Column**

| Joint | Column Stiffness | Beam Sizes | | Beam Stiffness | | ψ |
|---|---|---|---|---|---|---|
| | | Beam 1 (Length x Width x Depth) | Beam 2 (Length x Width x Depth) | Beam 1 | Beam 2 | |
| | lbs-ft x 10^6 | in | in | lbs-ft x 10^6 | lbs-ft x 10^6 | |
| Bottom | 55.49 | 216 x 15 x 30 | 228 x 15 x 30 | 246.64 | 233.66 | 0.231 |
| Top | 55.49 | 216 x 15 x 30 | 228 x 15 x 30 | 246.64 | 233.66 | 0.231 |

Sway Condition (as per Stability Index) = Sway

Effective Length Factor along Minor axis = 1.07

**Table showing calculation of Gravity Load**

| Beam | L/C | Node | Axial Force kip | Shear-Y kip | Shear-Z kip | Torsion kN-m | Moment-Y kN-m | Moment-Z kN-m |
|---|---|---|---|---|---|---|---|---|
| 57 | 12 | 28 | 191.031 | 13.383 | 4.609 | -0.474 | 47.569 | -156.743 |
| 51 | 12 | 24 | 191.56 | 13.162 | -4.388 | -0.462 | -45.17 | -154.334 |
| 59 | 12 | 30 | 218.43 | 15.447 | 8.416 | -0.606 | 94.399 | -178.414 |
| 41 | 12 | 21 | 256.525 | 27.943 | -6.26 | -0.158 | -68.611 | -313.447 |
| 45 | 12 | 29 | 277.078 | 30.337 | 5.574 | -0.573 | 59.985 | -335.583 |
| 43 | 12 | 25 | 351.052 | 28.226 | -1.753 | -0.668 | -19.216 | -315.985 |
| 47 | 12 | 22 | 376.957 | 27.04 | -6.157 | -0.301 | -65.731 | -298.504 |
| 49 | 12 | 23 | 381.55 | 29.083 | -4.776 | -0.536 | -49.386 | -317.77 |
| 55 | 12 | 27 | 383.036 | 29.034 | 4.157 | -0.479 | 42.973 | -316.859 |
| 53 | 12 | 26 | 442.016 | 26.345 | 0.579 | -0.644 | 8.605 | -290.902 |
| | | SUM | 3069.24 | kip | | | | |

| Beam | L/C | Node | Axial Force kip | Shear-Y kip | Shear-Z kip | Torsion kN-m | Moment-Y kN-m | Moment-Z kN-m |
|---|---|---|---|---|---|---|---|---|
| 51 | 11 | 24 | 162.699 | -7.565 | 19.314 | -1.095 | 223.12 | 81.506 |
| 41 | 11 | 21 | 180.296 | 7.211 | 14.352 | -0.707 | 171.795 | -77.573 |
| 57 | 11 | 28 | 281.339 | -7.232 | 28.322 | -1.081 | 315.951 | 77.834 |
| 45 | 11 | 29 | 283.558 | 8.186 | 25.923 | -0.404 | 298.619 | -86.429 |
| 59 | 11 | 30 | 297.807 | -7.272 | 28.571 | -0.271 | 330.234 | 76.135 |
| 49 | 11 | 23 | 319.412 | 0.676 | 18.136 | -1.511 | 210.9 | -5.806 |
| 43 | 11 | 25 | 321.749 | 7.478 | 30.45 | -0.625 | 334.288 | -80.208 |
| 47 | 11 | 22 | 334.364 | -1.347 | 14.866 | -1.238 | 178.519 | 13.257 |
| 55 | 11 | 27 | 430.748 | 1.141 | 27.425 | -1.564 | 306.519 | -10.793 |
| 53 | 11 | 26 | 457.263 | -1.276 | 32.641 | -1.012 | 360.203 | 12.495 |
| | | SUM | 3069.24 | kip | | | | |

**Table showing calculation of Story Drift**

For Global-X Direction

Deflection at 384 in level

| Node | L/C | X-Trans in | Y-Trans in | Z-Trans in | Absolute in | X-Rotan rad | Y-Rotan rad | Z-Rotan rad |
|---|---|---|---|---|---|---|---|---|
| 29 | 12 | -2.15 | -0.123 | -0.022 | 2.154 | 0 | 0 | 0 |
| 30 | 12 | -2.15 | -0.089 | -0.014 | 2.152 | -0.001 | 0 | 0.002 |
| 26 | 12 | -2.133 | -0.189 | -0.015 | 2.142 | 0 | 0 | 0.001 |
| 25 | 12 | -2.134 | -0.155 | -0.022 | 2.139 | 0 | 0 | 0 |
| 27 | 12 | -2.133 | -0.165 | -0.007 | 2.139 | 0 | 0 | 0.001 |
| 28 | 12 | -2.133 | -0.079 | 0.003 | 2.134 | 0 | 0 | 0.003 |
| 23 | 12 | -2.125 | -0.165 | -0.008 | 2.131 | 0 | 0 | 0.001 |
| 22 | 12 | -2.125 | -0.159 | -0.015 | 2.131 | 0 | 0 | 0.001 |
| 21 | 12 | -2.125 | -0.114 | -0.022 | 2.128 | 0 | 0 | 0 |
| 24 | 12 | -2.125 | -0.079 | 0.003 | 2.126 | 0 | 0 | 0.003 |
| | Average | 2.1333 | in | | | | | |

Deflection at 192 in level

| Node | L/C | X-Trans in | Y-Trans in | Z-Trans in | Absolute in | X-Rotan rad | Y-Rotan rad | Z-Rotan rad |
|---|---|---|---|---|---|---|---|---|
| 16 | 12 | -1.182 | -0.114 | -0.001 | 1.188 | 0 | 0 | 0.001 |
| 15 | 12 | -1.183 | -0.095 | -0.01 | 1.187 | 0 | 0 | 0.001 |
| 17 | 12 | -1.182 | -0.1 | -0.002 | 1.186 | 0 | 0 | 0.001 |
| 19 | 12 | -1.183 | -0.076 | -0.009 | 1.186 | 0 | 0 | 0.001 |
| 12 | 12 | -1.181 | -0.095 | -0.001 | 1.185 | 0 | 0 | 0.001 |
| 13 | 12 | -1.18 | -0.1 | -0.003 | 1.185 | 0 | 0 | 0.001 |
| 20 | 12 | -1.183 | -0.052 | 0 | 1.184 | -0.001 | 0 | 0.003 |
| 11 | 12 | -1.181 | -0.07 | -0.01 | 1.183 | 0 | 0 | 0.001 |
| 18 | 12 | -1.181 | -0.046 | 0.001 | 1.182 | 0 | 0 | 0.003 |
| 14 | 12 | -1.18 | -0.046 | 0.001 | 1.18 | 0 | 0 | 0.003 |

Average 1.1816 in

Story Drift = 2.1333-1.1816

= 0.952 in

For Global-Y Direction

Deflection at 384 in level

| Node | L/C | X-Trans in | Y-Trans in | Z-Trans in | Absolute in | X-Rotan rad | Y-Rotan rad | Z-Rotan rad |
|---|---|---|---|---|---|---|---|---|
| 28 | 11 | -0.006 | -0.127 | 1.117 | 1.125 | 0.001 | 0 | 0.001 |
| 24 | 11 | 0.015 | -0.065 | 1.117 | 1.119 | 0.002 | 0 | 0.001 |
| 27 | 11 | -0.006 | -0.19 | 1.078 | 1.095 | 0.001 | 0 | 0 |
| 23 | 11 | 0.015 | -0.131 | 1.078 | 1.086 | 0.001 | 0 | 0 |
| 26 | 11 | -0.006 | -0.197 | 1.038 | 1.057 | 0.001 | 0 | 0 |
| 22 | 11 | 0.015 | -0.138 | 1.038 | 1.047 | 0.001 | 0 | 0 |
| 30 | 11 | -0.021 | -0.132 | 1.039 | 1.047 | 0.001 | 0 | 0.001 |
| 25 | 11 | -0.006 | -0.139 | 1.015 | 1.024 | 0.001 | 0 | -0.001 |
| 29 | 11 | -0.021 | -0.126 | 1.015 | 1.023 | 0.001 | 0 | -0.001 |
| 21 | 11 | 0.015 | -0.073 | 1.015 | 1.017 | 0.001 | 0 | -0.001 |

Average 1.055 in

Deflection at 192 in level

| Node | L/C | X-Trans in | Y-Trans in | Z-Trans in | Absolute in | X-Rotan rad | Y-Rotan rad | Z-Rotan rad |
|---|---|---|---|---|---|---|---|---|
| 18 | 11 | -0.001 | -0.079 | 0.564 | 0.569 | 0.001 | 0 | 0.001 |
| 14 | 11 | 0.008 | -0.036 | 0.563 | 0.565 | 0.002 | 0 | 0.001 |
| 17 | 11 | -0.001 | -0.117 | 0.549 | 0.562 | 0.001 | 0 | 0 |
| 16 | 11 | -0.002 | -0.119 | 0.545 | 0.558 | 0.001 | 0 | 0 |
| 13 | 11 | 0.008 | -0.076 | 0.549 | 0.554 | 0.002 | 0 | 0 |
| 20 | 11 | -0.011 | -0.081 | 0.546 | 0.552 | 0.001 | 0 | 0.001 |
| 12 | 11 | 0.007 | -0.081 | 0.545 | 0.551 | 0.002 | 0 | 0 |
| 15 | 11 | -0.002 | -0.084 | 0.531 | 0.537 | 0.001 | 0 | -0.001 |
| 19 | 11 | -0.012 | -0.077 | 0.531 | 0.536 | 0.001 | 0 | -0.001 |
| 11 | 11 | 0.006 | -0.042 | 0.53 | 0.532 | 0.002 | 0 | -0.001 |

Average 0.5453 in

Story Drift = 1.055-0.5453

= 0.510 in