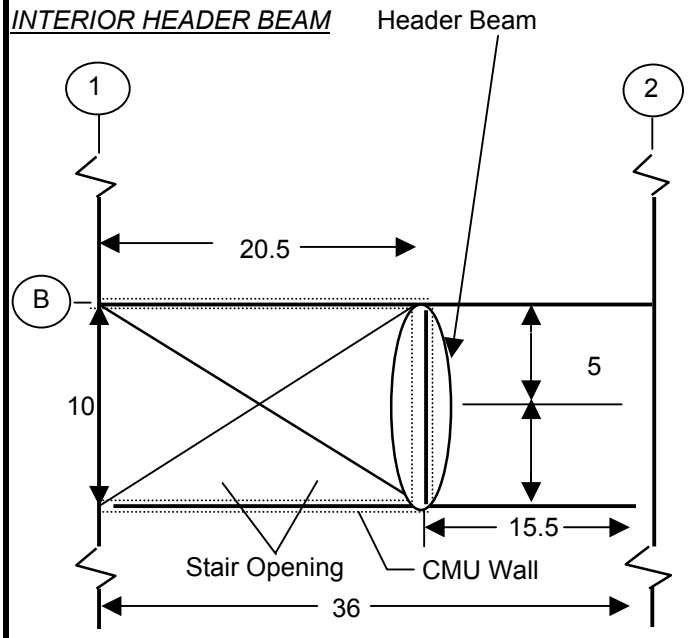
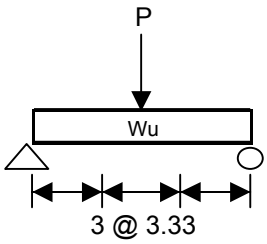
## *INTERIOR HEADER BEAM SELECTION - Bay length = 36 ft. (stairwell)*

*INTERIOR HEADER BEAM*




| | | | Tributary width | |
|---|---|---|---|---|
| Total Bay Length = | 36 | (ft) | | |
| Total Bay Width = | 10 | (ft) | | |
| Fill Beam Fy = | 50 | (ksi) | | |
| DL $_{CMU\ wall}$ = | 51.0 | ($lb/ft^2$) | 0.7 | (ft) |
| DL $_{beam}$ = | 2.5 | ($lb/ft^2$) | 18.0 | (ft) |
| LL $_{stairs}$ = | 100.0 | ($lb/ft^2$) | 10.3 | (ft) |
| DL $_{joist}$ = | 56.5 | ($lb/ft^2$) | | |
| LL $_{joist}$ = | 80.0 | ($lb/ft^2$) | | |
| WDL $_{joist}$ = | 282.5 | (lb/ft) | | |
| WLL $_{joist}$ = | 400 | (lb/ft) | | |
| PDL $_{joist}$ = | 2189.4 | (lb) | | |
| PLL $_{joist}$ = | 3100 | (lb) | | |
| $W_{DL(CMU)}$ = | 34.0 | (lb/ft) | | |
| $W_{DL(beam)}$ = | 45.0 | (lb/ft) | | |
| $W_{LL(stair)}$ = | 1025.0 | (lb/ft) | | |

Loading Diagram




| | | | |
|---|---|---|---|
| Factored Load = Wu = | 1734.8 | (lb/ft) | |
| **Factored Max. Moment (Mu) =** | 21.7 | **(k-ft)** ← | **distributed loads** |
| factored load =P = | 7587.3 | (lb) | |
| **Factored Max. Moment (Mu) =** | 29.4 | **(k-ft)** ← | **2 equal, concentrated** |
| **TOTAL Factored Max. Moment (Mu) =** | **51.1** | **(k-ft)** | **symmetrically placed** |

*SELECT SECTION*

| | | | |
|---|---|---|---|
| **LRFD p5-40 - Choose** | **W12x14** | | |
| Beam Weight (k/ft) | 0.014 | <than 85 plf assmd, sheet6 | |
| Mu = | 51.1 | (k-ft) | |
| ϕMp = | 65 | (k-ft) | |
| | **OK** | ← | **ϕMp > Mu ?** |

*CHECK LOCAL CONDITIONS*

| | | | |
|---|---|---|---|
| $b_f$ / 2 $t_f$ (LRFD p1-29) = | 8.82 | | |
| λp = 65 / $Fy^{.5}$ = | 9.2 | | |
| | **OK** | ← | **λp > $b_f/2t_f$ ?** |

*CHECK WEB*

| | | | |
|---|---|---|---|
| h / tw (LRFD p1-29) = | 54.3 | | |
| λp = 640 / $Fy^{.5}$ = | 90.5 | | |
| | **OK** | ← | **λp > h/tw ?** |

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## *INTERIOR HEADER BEAM SELECTION - (continued)*

*CHECK SHEAR CAPACITY*

| | | | |
|---|---|---|---|
| Vu = Wu * L / 2 + P = | | 12.5 | |
| $\phi Vn = \phi_v (0.6 F_{yw}) A_w$ ($F_{yw}$ = yield strength of web) = | | 64.3 | ($\phi_v$ = .9) |
| $A_w = d * t_w$ (LRFD p1-28) = | | 2.4 | |
| d = | 12 , tw = | 0.2 | |
| | | **OK** | ← **$\phi Vn > Vu$ ?** |

*LIVE LOAD DEFLECTION CHECK*

| | | |
|---|---|---|
| $\Delta$ = L / 360 = | 0.333 | (in) - LIMIT |
| $\Delta$ (wu) = $(5*w_{LL}*L^4)/(384*E*I)$ = | 0.090 | |
| $\Delta$ (P) = $((P*a)/(24*E*I))/(3*L^2-4*a^2)$= | 0.087 | |
| | 0.177 | (in) - $\Delta_{LL}$ |
| I (moment of inertia about x-x axis, LRFD)= | 88.6 | ($in^4$) |
| | **OK** | ← **$\Delta_{limit} > \Delta_{LL}$?** |

**SECTION OK**

NOTE -- The header beam has a combination of 4 distributed loads and 2 point loads. The distributed loads are the CMU dead load, the floor dead load (same for floor and stairwell - conservative), the stair live load and floor live load. Since there are only 2 joists, these are treated as point loads. These point loads are determined by a simple analysis of the loading on each joist and determining their reactions.

| | | |
|---|---|---|
| **Cost Per Ton** | **1950** | **($)** |
| **Total Cost** | **$136.50** | |

In this case, deflection controls

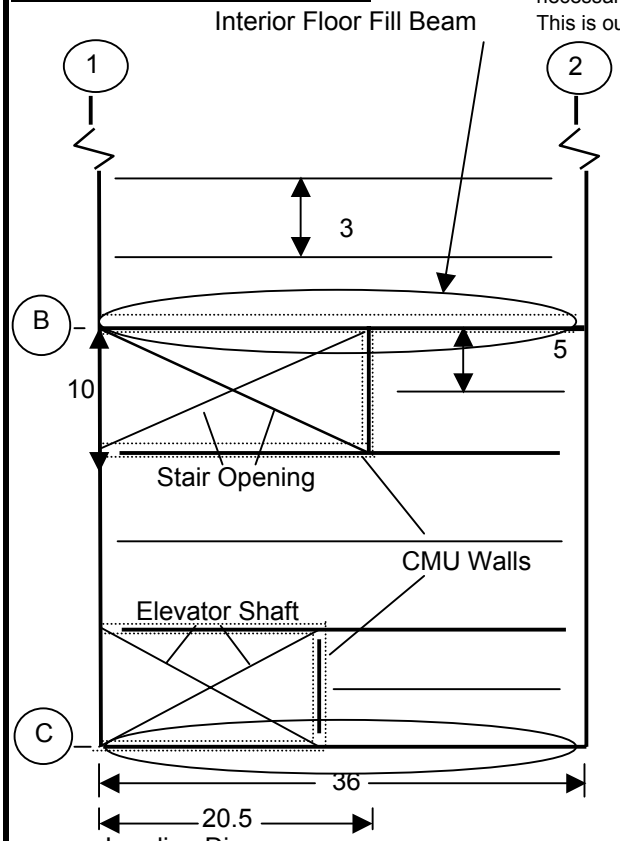
Red font indicates user input

**SECTION OK**

## *INTERIOR FLOOR FILL BEAM SELECTION - Bay length = 36 ft. (stairwell)*

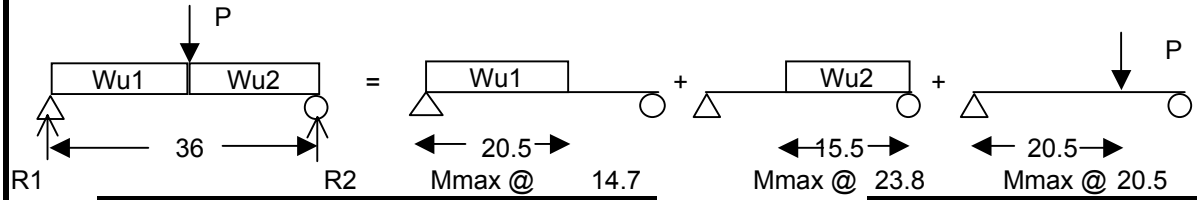
*INTERIOR FLOOR FILL BEAM*

Note: Shear studs along the beams that are part of the lateral load-resisting truss are necessary to transfer the lateral loads from the floor diaphragms to the resisting members. This is outside the scope of this case study.




| | | | Tributary width | |
|---|---|---|---|---|
| Total Bay Length = | 36 | (ft) | | |
| Total Bay Width = | 30 | (ft) | | |
| Fill Beam Fy = | 50 | (ksi) | | |
| $DL_{CMU\ wall}$ = | 51.0 | ($lb/ft^2$) | 0.7 | (ft) |
| $DL_{beam1}$ = | 59.0 | ($lb/ft^2$) | 4.0 | (ft) |
| $DL_{beam2}$ = | 59.0 | ($lb/ft^2$) | 1.5 | (ft) |
| $LL_{stairs}$ = | 100.0 | ($lb/ft^2$) | 5.0 | (ft) |
| $LL_{office1}$ = | 80.0 | ($lb/ft^2$) | 1.5 | (ft) |
| $LL_{office2}$ = | 80.0 | ($lb/ft^2$) | 4.0 | (ft) |
| $WDL_{CMU\ wall}$ = | 34 | (lb/ft) | | |
| $WDL_{beam1}$ = | 236.0 | (lb/ft) | | |
| $WDL_{beam2}$ = | 88.5 | (lb/ft) | | |
| $WLL_{stairs}$ = | 500 | (lb/ft) | | |
| $WLL_{office1}$ = | 120 | (lb/ft) | | |
| $WLL_{office2}$ = | 320 | (lb/ft) | | |
| $PDL_{header\ beam}$ = | 2584.4 | (lb) | | |
| $PLL_{header\ beam}$ = | 8225.0 | (lb) | | |
| Wu1 = | 1.139 | (k/ft) | | |
| Wu2 = | 0.8 | (k/ft) | | |
| P = | 16.3 | (k) | | |

Loading Diagrams




| | Moment by superposition (k-ft) | | | |
|---|---|---|---|---|
| | at 14.7' | at 18' | at 20.5' | at 23.8' |
| Wu1 | 122.4 | 116.1 | 103.0 | 81.1 |
| Wu2 | 39.0 | 47.8 | 54.4 | 58.8 |
| P | 102.9 | 126.0 | 143.5 | 113.0 |
| Total | 264.4 | 289.9 | ***301.0*** | 252.9 |

**Mmax = 301.0 (K-ft)**

| Shear by Superposition (k) | | |
|---|---|---|
| | R1 | R2 |
| Wu1 | 16.7 | 6.6 |
| Wu2 | 2.7 | 9.7 |
| P | 7.0 | 9.3 |
| Total | 26.4 | 25.6 |

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## *INTERIOR FLOOR FILL BEAM (continued)*

*SELECT SECTION*

| | | |
|---|---|---|
| **LRFD p5-40 - Choose** | **W24x62** | |
| Beam Weight (k/ft) | 0.062 | <than 85 plf assmd, sheet6 |
| Mu = | 301.0 | (k-ft) |
| $\phi$Mp = | 578 | (k-ft) |
| | **OK** | ← **$\phi$Mp > Mu ?** |

*CHECK LOCAL CONDITIONS*

| | | |
|---|---|---|
| $b_f / 2\ t_f$ (LRFD p1-17) = | 5.97 | |
| $\lambda p = 65 / Fy^{.5}$ = | 9.2 | |
| | **OK** | ← **$\lambda p > b_f/2t_f$ ?** |

*CHECK WEB*

| | | |
|---|---|---|
| h / tw (LRFD p1-17) = | 49.7 | |
| $\lambda p = 640 / Fy^{.5}$ = | 90.5 | |
| | **OK** | ← **$\lambda p > h/tw$ ?** |

*CHECK SHEAR CAPACITY*

| | | |
|---|---|---|
| Vu = Wu * L / 2 P*a/L = | 26.4 | |
| $\phi Vn = \phi_v (0.6\ F_{yw})\ A_w$ ($F_{yw}$ = yield strength of web) = | 226.8 | ($\phi_v$ = .9) |
| $A_w = d * t_w$ (LRFD p1-16) = | 8.4 | |

d = 24 , tw = 0.4

**OK** ← **$\phi$Vn > Vu ?**

## *LIVE LOAD DEFLECTION CHECK*

$\Delta$ max= L / 360 = 1.200 (in) - LIMIT

Deflection at Mmax :

| | | |
|---|---|---|
| $\Delta$( P) = (P*b*x)*(L^2 - b^2 - x^2) / (6*E*I*L) = | 0.294 | |
| $\Delta$( Wu1) = W*a^2 *(L-x)*(4*L*x - 2*x^2 - a^2) / (24* E * I * L) = | 0.555 | |
| $\Delta$( Wu2) = W*a^2 *(L-x)*(4*L*x - 2*x^2 - a^2) / (24* E * I * L) = | 0.262 | |
| | 1.110 | (in) - $\Delta_{LL}$ |
| I (moment of inertia about x-x axis, LRFD)= | 1560 | ($in^4$) |
| | **OK** | ← **$\Delta_{limit} > \Delta_{LL}$?** |

**SECTION OK**

NOTE -- The fill-beam has a combination of several uniform and partially distributed loads and 2 concentrated loads. The dead load for the floor and stair is uniformly distributed as well as the floor live load. The CMU dead load is only particially distrubuted along the length of the member PLUS 1/2 of the distance along the header (the fill beam picks up half this load). This fill-beam also picks up 2 partially distributed live loads for the floor and stair. There is one concentrated dead and live load at the point where the header frames into the fill beam.

**SECTION OK**

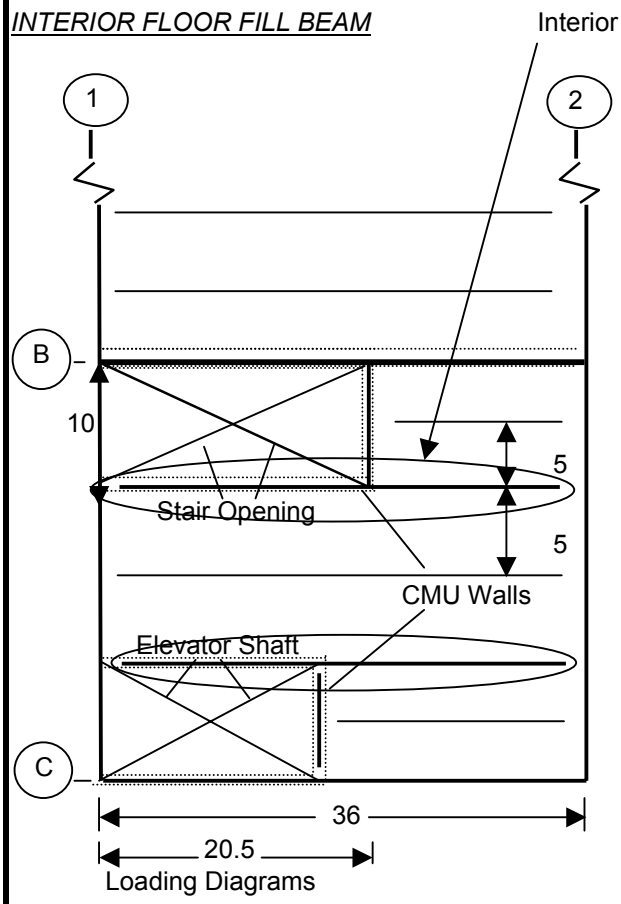
| | | |
|---|---|---|
| **Cost Per Ton** | **1950** | **($)** |
| **Total Cost** | **$2,176.20** | |

In this case, deflection controls

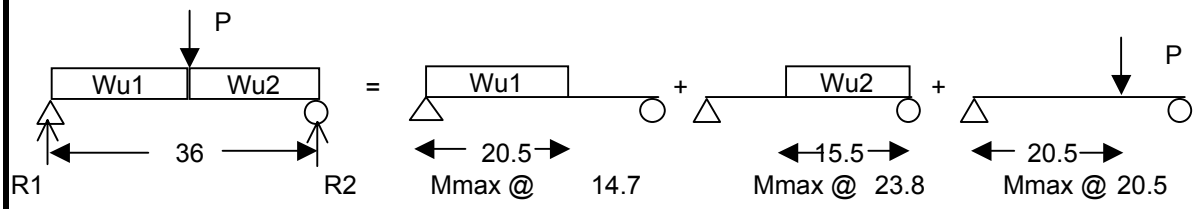
Red font indicates user input

## *INTERIOR FLOOR FILL BEAM SELECTION - Bay length = 36 ft. (stairwell)*

*INTERIOR FLOOR FILL BEAM*




| | | | ibutary width | |
|---|---|---|---|---|
| Total Bay Length = | 36 | (ft) | | |
| Total Bay Width = | 30 | (ft) | | |
| Fill Beam Fy = | 50 | (ksi) | | |
| $DL_{CMU\ wall}$ = | 51.0 | ($lb/ft^2$) | 0.7 | (ft) |
| $DL_{beam1}$ = | 59.0 | ($lb/ft^2$) | 5.0 | (ft) |
| $DL_{beam2}$ = | 59.0 | ($lb/ft^2$) | 2.5 | (ft) |
| $LL_{stairs}$ = | 100.0 | ($lb/ft^2$) | 5.0 | (ft) |
| $LL_{office1}$ = | 80.0 | ($lb/ft^2$) | 2.5 | (ft) |
| $LL_{office2}$ = | 80.0 | ($lb/ft^2$) | 5.0 | (ft) |
| $WDL_{CMU\ wall}$ = | 34 | (lb/ft) | | |
| $WDL_{beam1}$ = | 295.0 | (lb/ft) | | |
| $WDL_{beam2}$ = | 147.5 | (lb/ft) | | |
| $WLL_{stairs}$ = | 500 | (lb/ft) | | |
| $WLL_{office1}$ = | 200 | (lb/ft) | | |
| $WLL_{office2}$ = | 400 | (lb/ft) | | |
| $PDL_{header\ beam}$ = | 2584.4 | (lb) | | |
| $PLL_{header\ beam}$ = | 8225.0 | (lb) | | |
| Wu1 = | 1.3378 | (k/ft) | | |
| Wu2 = | 1.0 | (k/ft) | | |
| P = | 16.3 | (k) | | |




| | Moment by superposition (k-ft) | | | |
|---|---|---|---|---|
| | at 14.7' | at 18' | at 20.5' | at 23.8' |
| Wu1 | 143.8 | 136.4 | 121.0 | 95.3 |
| Wu2 | 48.8 | 59.7 | 68.0 | 73.5 |
| P | 102.9 | 126.0 | 143.5 | 113.0 |
| Total | 295.5 | 322.1 | ***332.6*** | 281.8 |

| Shear by Superposition (k) | | |
|---|---|---|
| | R1 | R2 |
| Wu1 | 19.6 | 7.8 |
| Wu2 | 3.3 | 12.1 |
| P | 7.0 | 9.3 |
| Total | 29.9 | 29.2 |

**Mmax = 332.6 (K-ft)**

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## *INTERIOR FLOOR FILL BEAM (continued)*

*SELECT SECTION*

| | | |
|---|---|---|
| **LRFD p5-40 - Choose** | **W21x83** | |
| Beam Weight (k/ft) | 0.083 | <than 85 plf assmd, sheet6 |
| Mu = | 332.6 | (k-ft) |
| $\phi$Mp = | 735 | (k-ft) |
| | **OK** | ← **$\phi$Mp > Mu ?** |

*CHECK LOCAL CONDITIONS*

| | | |
|---|---|---|
| $b_f / 2\ t_f$ (LRFD p1-17) = | 5 | |
| $\lambda p = 65 / Fy^{.5}$ = | 9.2 | |
| | **OK** | ← **$\lambda p > b_f/2t_f$ ?** |

*CHECK WEB*

| | | |
|---|---|---|
| h / tw (LRFD p1-17) = | 36.4 | |
| $\lambda p = 640 / Fy^{.5}$ = | 90.5 | |
| | **OK** | ← **$\lambda p$ > h/tw ?** |

*CHECK SHEAR CAPACITY*

| | | |
|---|---|---|
| Vu = Wu * L / 2 P*a/L = | 29.9 | |
| $\phi Vn = \phi_v (0.6\ F_{yw})\ A_w$ ($F_{yw}$ = yield strength of web) = | 226.8 | ($\phi_v$ = .9) |
| $A_w = d * t_w$ (LRFD p1-16) = | 8.4 | |

d = 21 , tw = 0.5

**OK** ← **$\phi$Vn > Vu ?**

## *LIVE LOAD DEFLECTION CHECK*

$\Delta$ max= L / 360 = 1.200 (in) - LIMIT

Deflection at Mmax :

| | | |
|---|---|---|
| $\Delta$( P) = (P*b*x)*(L^2 - b^2 - x^2) / (6*E*I*L) = | 0.250 | |
| $\Delta$( Wu1) = W*a^2 *(L-x)*(4*L*x - 2*x^2 - a^2) / (24* E * I * L) = | 0.555 | |
| $\Delta$( Wu2) = W*a^2 *(L-x)*(4*L*x - 2*x^2 - a^2) / (24* E * I * L) = | 0.279 | |
| | 1.085 | (in) - $\Delta_{LL}$ |
| I (moment of inertia about x-x axis, LRFD)= | 1830 | ($in^4$) |
| | **OK** | ← **$\Delta_{limit} > \Delta_{LL}$?** |

**SECTION OK**

NOTE -- The fill-beam has a combination of several uniform and partially distributed loads and 2 concentrated loads. The dead load for the floor and stair is uniformly distributed as well as the floor live load. The CMU dead load is only particially distrubuted along the length of the member PLUS 1/2 of the distance along the header (the fill beam picks up half this load). This fill-beam also picks up 2 partially distributed live loads for the floor and stair. There is one concentrated dead and live load at the point where the header frames into the fill beam.

**SECTION OK**

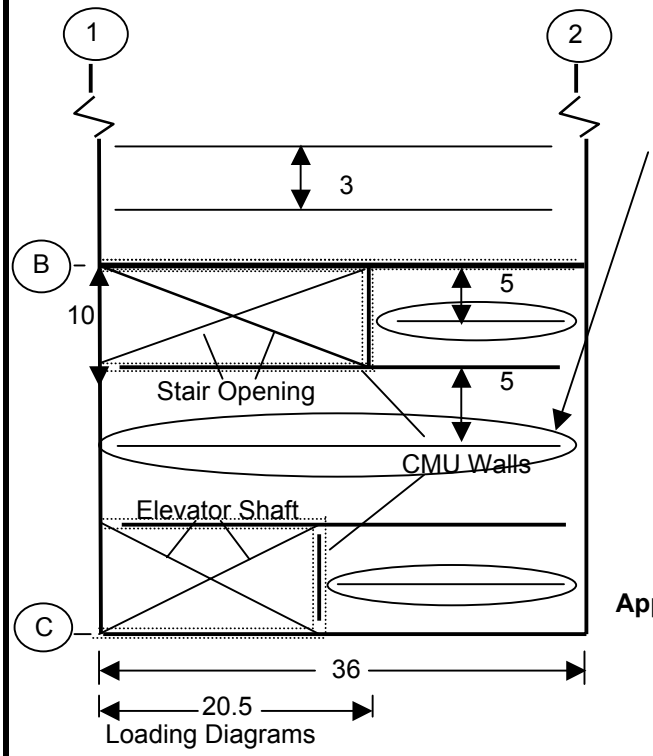
| | | |
|---|---|---|
| **Cost Per Ton** | **1950** | **($)** |
| **Total Cost** | **$2,913.30** | |

In this case, deflection controls

Red font indicates user input

***INTERIOR FLOOR FILL BEAM SELECTION - Bay length = 36 ft. (stairwell)***

*INTERIOR FLOOR FILL BEAM*




Interior Floor Fill Beam
(Braces bottom flange of girder in lateral resisting truss)

| | | |
|---|---|---|
| Spacing = | 5 | (ft) |
| DL = | 61.0 | (lb/ft$^2$) |
| LL = | 80.0 | (lb/ft$^2$) |
| $W_{DL}$ = | 305.0 | (lb/ft) |
| $W_{LL}$ = | 400.0 | (lb/ft) |
| **Applied Load - Wu =** | **705.0** | (lb/ft) |

*SELECT SECTION*

| | | |
|---|---|---|
| **LRFD p.5-48 - Choose** | **W18x35** | |
| Beam Weight (k/ft) | 0.035 | > 11 plf assumed, add Wt. |
| Mu = | 163.0 | (k-ft) |
| $\phi$Mp = | 249 | (k-ft) |
| | **OK** | **$\phi$Mp > Mu ?** |

*LIVE LOAD DEFLECTION CHECK*

| | | |
|---|---|---|
| $\Delta$ = L / 360 = | 1.200 | (in) - LIMIT |
| $\Delta = (5*w_{LL}*L^4)/(384*E*I)$ = | 1.022 | (in) - $\Delta_{LL}$ |
| I (moment of inertia about x-x axis, LRFD p.5-48)= | 510 | (in$^4$) |
| | **OK** | **$\Delta_{limit} > \Delta_{LL}$?** |

Note: Fill beam for this bay will be the same on the 2nd and 3rd floors. On the 4th and roof use interior fill beams determined previously for this bracing beam. The beam is necessary to laterally brace the W 24 x 68 framing beam. The beam is part of the North/South lateral load-resisting truss. A plate is added to brace the bottom flange against buckling out-of-plane.

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