# Cold Form Steel Design Report

| | | | |
|---|---|---|---|
| **Element:** | \\server18\home\khuntley\Documents\CSTCL Files\CFSD_Column_Design.rtf | **Company:** | |
| **Description:** | | **User:** | |
| **Date:** | 12/May/2021 03:55:50 PM | **Software:** | Cold Formed Steel Design 1.0 |

## GENERAL INFORMATION

| Description | Value | Description | Value |
|---|---|---|---|
| Run Mode | Design Mode | Ky | 2.00 |
| Design Code | AISI 17th Edition LRFD | $K_z$ | 1.00 |
| Beam-Column Length | 10.33 Ft | Total Load Deflection Limit | L / 120 |
| Steel Yield Stress | 8640000.00 Lb/Ft^2 | Live Load Deflection Limit | L / 240 |
| $C_b$ Calculation | $12.5M_{max}$ / ( $2.5M_{max}$ + $3M_a$ + $4M_b$ + $3M_c$ ) | Lateral Torsional Braced(LTB) Length | 10.33 Ft |
| $C_{mx}$ Calculation | Always use 1.0 (conservative) | Section shape | C-Section with lip |
| $C_{my}$ Calculation | Always use 1.0 (conservative) | Maximum Section Depth | 1.00 Ft |
| $L_x$ | 10.33 Ft | Minimum Section Depth | 0.33 Ft |
| $L_y$ | 10.33 Ft | Section Width | 4.00 in |
| $L_z$ | 10.33 Ft | Check Section List | - |
| $K_x$ | 2.00 | Maximum Stress Ratio | 1.000 |

## LOAD INFORMATION

| Ref. No. | Description | Load Case | Load Type | Dir | Begin Value | Begin Position | End Value | End Position |
|---|---|---|---|---|---|---|---|---|
| 1 | DL1 | Dead | Concen | Z | -2.300 (Lb) | 10.330 (Ft) | - | - |
| 2 | DL2 | Dead | EndMom | Y | -0.730 Lb-Ft | 10.330 Ft | - | - |
| 3 | DL3 | Dead | EndMom | X | -2.040 Lb-Ft | 10.330 Ft | - | - |
| 7 | LL1 | Live | Concen | Z | -5.180 (Lb) | 10.330 (Ft) | - | - |
| 8 | LL2 | Live | EndMom | Y | -1.900 Lb-Ft | 10.330 Ft | - | - |
| 9 | LL3 | Live | EndMom | X | -4.020 Lb-Ft | 10.330 Ft | - | - |
| 10 | WL1 | Wind | Concen | Z | 1.720 (Lb) | 10.330 (Ft) | - | - |
| 11 | WL2 | Wind | EndMom | Y | 18.340 Lb-Ft | 10.330 Ft | - | - |
| 12 | WL3 | Wind | EndMom | X | -1.650 Lb-Ft | 10.330 Ft | - | - |
| 13 | WL4 | Wind | Linear | X | -0.062 (Lb/Ft) | 0.000 (Ft) | -0.062 (Lb/Ft) | 10.330 (Ft) |
| 4 | SL1 | Snow | Concen | Z | -2.510 (Lb) | 10.330 (Ft) | - | - |
| 5 | SL2 | Snow | EndMom | Y | -0.770 Lb-Ft | 10.330 Ft | - | - |
| 6 | SL3 | Snow | EndMom | X | -3.670 Lb-Ft | 10.330 Ft | - | - |

## SELECTED LOAD COMBINATIONS

| Load Combination | Code Check | Total | Live | Dependent | Conditional |
|---|---|---|---|---|---|
| LC1: DL+LL+WL+SL+EL | x | | | - | - |
| LC2: 1.40DL | x | | | - | - |
| LC3: 1.20DL+LL+1.6SL | x | | | - | - |
| LC4: 1.20DL+1.6LL+0.5SL | x | | | - | - |
| LC5: 1.20DL+0.5WL+1.60SL | x | | | - | - |
| LC6: 1.20DL+LL+1.0WL+0.50SL | x | | | - | - |
| LC7: 0.90DL+1.0WL | x | | | - | - |
| LC8: 0.90DL+EL | x | | | - | - |
| LC9: 1.20DL+LL+0.20SL+EL | x | | | - | - |
| LC10: DL | x | | | - | - |
| LC11: DL+LL | x | | | - | - |
| LC12: DL+SL | x | | | - | - |
| LC13: DL+0.75LL+0.75SL | x | | | - | - |
| LC14: DL+0.6WL | x | | | - | - |
| LC15: DL+0.75LL+0.45WL+0.75SL | x | | | - | - |
| LC16: 0.60DL+0.60WL | x | | | - | - |
| LC17: DL+0.70EL | x | | | - | - |
| LC17: DL+0.75LL+0.75SL+0.53EL | x | | | - | - |

## CRITICAL STRESS SUMMARY

| Ref. No. | Section Name | Opt. Mark | Governing Criteria | Stress Ratio | Load Combination | Distance (Ft) |
|---|---|---|---|---|---|---|
| 1 | 8CS4x105 | ✔ | Axial-Bending | 0.9380 | LC1: DL+LL+WL+SL+EL | 123.96 |

## CRITICAL STRESS DETAILS

**Section Name: 8CS4x105** ✔

| | Unit | Load Effects | Resistance | Ratio | Load Combination | Distance (Ft) |
|---|---|---|---|---|---|---|
| Axial | Lb | 0.0080 | 11.041 | 0.0007 | LC1: DL+LL+WL+SL+EL | 10.33 |
| Bending-X | Lb-Ft | 0.0114 | 0.0169 | 0.6741 | LC1: DL+LL+WL+SL+EL | 10.33 |
| Bending-Y | Lb-Ft | 0.0149 | 0.0568 | 0.2632 | LC1: DL+LL+WL+SL+EL | 10.33 |
| Interaction | - | - | - | 0.9380 | LC1: DL+LL+WL+SL+EL | 10.33 |
| Shear-X | Lb | 0.0033 | 23.236 | 0.0001 | LC7: 0.90DL+1.0WL | 0 |
| Shear-Y | Lb | 0.0010 | 19.774 | 0.0001 | LC17: DL+0.75LL+0.75SL+0.53EL | 10.33 |
| Total Defl-X | Ft | 0.0000 | 1.0330 | 0.0000 | - | 0 |
| Total Defl-Y | Ft | 0.0000 | 1.0330 | 0.0000 | - | 0 |
| Live Defl-X | Ft | 0.0000 | 0.5165 | 0.0000 | - | 0 |
| Live Defl-Y | Ft | 0.0000 | 0.5165 | 0.0000 | - | 0 |

## Design Procedure for 8CS4x105

*Designed according to AISI 2017 Edition (LRFD)*

*Critical load effect at distance 10.33 Ft under load combination LC1: DL+LL+WL+SL+EL*

**INPUT**

**PROPERTIES**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A ($Ft^2$) | 0.0124 | $b_f$ (Ft) | 0.3333 | $K_x$ | 2 | $S_x(Ft^3)$ | 0.0027 |
| $I_x$ ($Ft^4$) | 0.0009 | $t_f$ (Ft) | 0.0088 | $K_y$ | 2 | $S_y$ ($Ft^3$) | 0.0008 |
| $I_y$ ($Ft^4$) | 0.0002 | d (Ft) | 0.6667 | $K_z$ | 1 | | |
| $r_x$ (Ft) | 0.2692 | $t_w$ (Ft) | 0.0088 | $L_x$ (Ft) | 10.33 | | |
| $r_y$ (Ft) | 0.1208 | R (Ft) | 0.0156 | $L_y$ (Ft) | 10.33 | | |
| J ($Ft^4$) | 0 | $x_0$ (Ft) | -0.255 | $L_b$ (Ft) | 10.33 | | |
| $C_w$ ($Ft^6$) | 0 | $y_0$ (Ft) | 0 | $C_b$ | 1.67 | | |
| $\alpha$ | 0 | $x_{bar}$ (Ft) | 0.1067 | $C_{mx}$ | 1 | | |
| $\beta$ | 0 | $y_{bar}$ (Ft) | 0.3333 | $C_{my}$ | 1 | $F_y$ ($Lb/Ft^2$) | 8640 |

**LOAD EFFECTS:**

| P (Lb) | $M_x$ (Lb - Ft) | $M_y$ (Lb - Ft) | $V_x$ (Lb) | $V_y$ (Lb) |
|---|---|---|---|---|
| 0.008 | 0.0009 | 0.0012 | 0.0011 | 0.001 |

**SOLUTION**

**1. CHECK AXIAL STRENGTH**

(a). Flexural & Local Buckling

| Description | Formula | Value | Code |
|---|---|---|---|
| KL / r | $\max(K_xL_x / r_{x\,K,y}L_y / r_y)$ | 170.98 | |
| $F_e$ ($Lb/Ft^2$) | $F_e = (F_{ey} + F_{ez}) / (2H)\ (1 - (1 - 4F_{ey}F_{ez}H / (F_{ey} + F_{ez})^2)^{0.5})$ | 1.2 | E2.2-1 |
| $F_{cr}$ ($Lb/Ft^2$) | (for $F_e < 0.44\ F_y$) $F_{cr} = 0.877\ F_e$ | 1.05 | E2-3 |

Axial Capacity: $P_n = F_{cr}\ A = 12.99$ Lb : $P_c = P_n = 11.04$ Lb

**2. CHECK FLEXURAL STRENGTH**

(a). Strong Axis Yielding

| Description | Formula | Value | Code |
|---|---|---|---|
| $M_{nx}$ (Lb-Ft) | $M_{px} = F_y\ Z_x$ | 26550 | F2-1-1 |

(b). Lateral-Torsional-Buckling (LTB)

| Description | Formula | Value | Code |
|---|---|---|---|
| $L_p$ (Ft) | $L_p = 1.1\ r_t\ (E/F_y)^{0.5}$ | 4.72 | F2-5 |
| $L_r$ (Ft) | $L_r = r_t\ (E/(0.7\ F_y))^{0.5}$ | | F2-6 |
| $M_n$ (Lb-Ft) | $M_n = 0.9\ E\ k_cS_x/\lambda_f^2$ where $R_{pc} = M_p/M_y - (M_p/M_y - 1)((\lambda_w - \lambda_{pw}) / (\lambda_{rw} - \lambda_{pw})) <= M_p/M_y = 1.06$ | 18.76 | F4-14, F4-9b |

(c). Flange Local Buckling

| Description | Formula | Value | Code |
|---|---|---|---|
| $M_n$ | $M_n = 0.9\ E\ k_c\ S_x / \lambda_f^2$ | 3350.53 | F3-2 |

Note: 1). $0.35 < k_c = 4 / (h/t_w)^{0.5} < 0.76 \Rightarrow k_c = 0.4613$ (F3.2)

(d). Web Local Buckling

| Description | Formula | Value | Code |
|---|---|---|---|
| $\lambda$ | $(d - 2k)/t_w$ | 72.62 | Table B4.1-1 |
| $\lambda p$ | $3.76\ (E / F_y)^{0.5}$ | 83.37 | Table B4.1-1 |
| $\lambda r$ | $5.7\ (E / F_y)^{0.5}$ | 126.39 | Table B4.1-1 |
| $M_n$ | Web is compact | 26550 | NA |

(e). Web Crippling

| Description | Formula | Value | Code |
|---|---|---|---|
| $P_n$ | $P_n = Ct^2\ f_y \sin((1 - C_r\ (R/t)^{0.5})\ (1 + C_n\ (N/t)^{0.5})\ (1 - C_h\ (h/t)^{0.5}))$ | 150668.18 | Eq. G5-1 |

(f). Weak Axis Yeilding

| Description | Formula | Value | Code |
|---|---|---|---|
| $M_{ny}$ (Lb-Ft) | $M_{py} = F_y\ Z_y <= 1.6\ F_y\ S_y$ | 5775 | F6-1-1 |

(g). Weak Axis Flange Local Buckling

| Description | Formula | Value | Code |
|---|---|---|---|
| $M_n$ | Web is compact | 63.09 | Eq. G5-1 |

*Flexural Capacity - Strong Axis: Mnx = 18.76Lb-Ft: Mcx = φ Mnx = 0.0014 Lb-Ft*

*Flexural Capacity - Weak Axis: Mny = 63.09Lb-Ft: Mcyφ Mny = 0.0047 Lb-Ft*

**3. CHECK AXIAL AND FLEXURAL INTERACTION**

| Description | Formula | Value | Code |
|---|---|---|---|
| $P_{e1w}$ (Lb) | $P_{e1w} = EI_w^2 / (MIN(1, K_x)L_x)^2$ | 352.43 | C1.2.1.1-5 |
| $B_{1w}$ | $B_{1w} = C_{mx} / (1 - \alpha P_r / P_{e1w}) >= 1.0$ | 1 | C1.2.1.1-3 |
| $M_{rw}$ (Lb-Ft) | $B_{1w}M_{rw}$ | 0.0009 | C1.2.1.1-1 |
| $P_{e1z}$ (Lb) | $P_{e1z} = EI_z^2 / (MIN(1, K_y)L_y)^2$ | 71.24 | C1.2.1.1-5 |
| $B_{1z}$ | $B_{1z} = C_{my} / (1 - \alpha P_r / P_{e1z}) >= 1.0$ | 1 | C1.2.1.1-3 |
| $M_{rz}$ (Lb-Ft) | $B_{1z}M_{rz}$ | 0.0012 | C1.2.1.1-1 |

Note:

1). Moment magnification factor $B_1$ is conservatively applied to overall moment

2). Moment magnification factor $B_2$ is assumed to have been taken care of by P-Delta Analysis

3). a = 1

4). The user shall input values of L, K and $C_m$ appropriate for the principle axes, W and Z

**4. CHECK SHEAR STRENGTH**

| Description | Formula | Value | Code |
|---|---|---|---|
| $L_v$ (Ft) | the distance from maximum to zero shear force | 0 | G6 |
| $F_{cr}$ (Lb/Ft$^2$) | | | |
| $V_{ny}$ (Lb) | $V_{ny} = 0.6 F_y A_w C_v$ | 21.97 | G2.1-5 |

| Description | Formula | Value | Code |
|---|---|---|---|
| $L_v$ (Ft) | the distance from maximum to zero shear force | 0 | G6 |
| $F_{cr}$ (Lb/Ft$^2$) | | | |
| $V_{nx}$ (Lb) | $V_{nx} = 0.6 F_y A_w C_v$ | 25.82 | G2.1-5 and G7 |

$V_{cy} = \varphi V_{ny} = 19.77$

$V_{ry} = 0.001$

$V_{ry} / V_{cy} = 0.0001$

***SHEAR-Y STATUS: OK***

$V_{cx} = \varphi V_{nx} = 23.24$

$V_{rx} = 0.0011$

$V_{rx} / V_{cx} = 0$

***SHEAR-X STATUS: OK***

*5. CHECK TOTAL LOAD DEFLECTIONS (Load Combination: δx - Not Applicable, δy - Not Applicable)*

| Description | Formula | Value | Code |
|---|---|---|---|
| *Allowable δx* | L/120 | 1.03 | Not Applicable |
| *Allowable δy* | L/120 | 1.03 | Not Applicable |

Note:

*δx(Act.) / δx(All.) = 0 / 1.03 = 0*

***TOTAL LOAD DEFLECTION-X STATUS: OK***

*δy(Act.) / δy(All.) = 0 / 1.03 = 0*

***TOTAL LOAD DEFLECTION-Y STATUS: OK***

*6. CHECK LIVE LOAD DEFLECTIONS (Load Combination: δx - Not Applicable, δy - Not Applicable)*

| Description | Formula | Value | Code |
|---|---|---|---|
| *Allowable δx* | L/240 | 0.5165 | Not Applicable |
| *Allowable δy* | L/240 | 0.5165 | Not Applicable |

Note:

*δy(Act.) / δy(All.) = 0 / 0.5165 = 0*

***LIVE LOAD DEFLECTION-X STATUS: OK***

*δy(Act.) / δy(All.) = 0 / 0.5165 = 0*

***LIVE LOAD DEFLECTION-Y STATUS: OK***