Support post compressive strength and lateral resistance

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1 Introduction

This report summarizes support post compressive strength and lateral load calculations for the New Castle Steel exterior deck system.

2 Structural system

The New Castle Steel deck system is made up of cold-formed steel components. Lipped C-section joists frame into a C-section ledger at the house and a built-up beam that spans between posts.

Figure 1: New Castle Steel exterior deck with 12 ft. tall support posts

3 Post details

The New Castle Steel support post is a 6 in. x 6 in. x 1/8 in. HSS ASTM A500 Grade B&C steel member. A round ASTM A36 steel base plate is fillet welded to the post. The post is secured to the foundation with 4 - 1/2 in. wedge anchors or Simpson Titen HD screws.

A typical New Castle beam is connected to the post with front and back brackets formed from ASTM A1011 CS TYPE B steel.

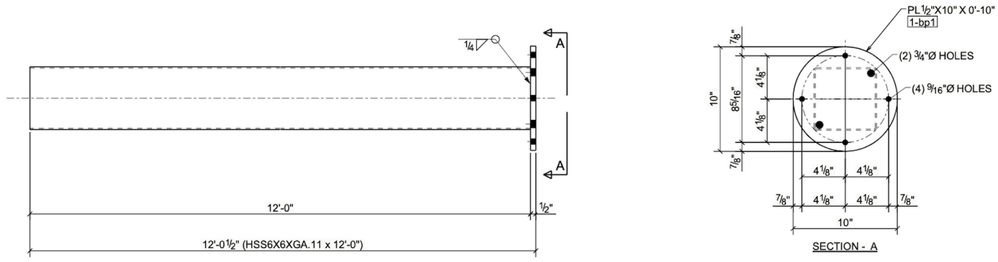

Figure 2: Support post details

4 Post section properties

```
using NewCastleSteel, Unitful, Printf, AISIS100
t = 0.116 #in.
section_dimensions = [6.0, 6.0, 6.0, 6.0] #in.
θ = [0.0, π/2, π, -π/2]
r = [3*t, 3*t, 3*t, 3*t]
n = [3, 3, 3, 3]
n_r = [3, 3, 3, 3]
E = 29500.0
ν = 0.30
fy = 55.0
design_code = "AISI S100-16 ASD"

post = NewCastleSteel.Post.properties(section_dimensions, θ, r, n, n_r, t, E, ν, fy,
design_code);

A = post.compressive_yield_strength.A * u"inch^2"
round(ustrip(A), digits = 3) * u"inch^2"
```

```
2.67 inch2
```

```
I = post.flexural_yield_strength.Ix * u"inch^4"
round(ustrip(I), digits=3) * u"inch^2"
```

```
15.215 inch2
```

5 Compressive strength

Use AISI S100-16 Section E2 to calculate the post Allowable Stress Design(ASD) compressive strength.

Assume the post is 12 ft. tall.

```
post_height = 12.0u"ft"
```

```
12.0 ft
```

Calculate the critical elastic buckling load of the column. Assume the column is fixed at the base and pinned at the top.

```
Fcre = (π^2 * E*1000*u"lbf/inch^2" * I / ((0.7 * 12.0u"ft")^2 * A)) |> u"lbf/inch^2"
round(typeof(1u"lbf/inch^2"), Fcre)
```

```
163284 lbf inch−2
```

The allowable post compressive strength P_n/Ω is:

```
Pne, ePne = AISIS100.v16.e2(Fcre=Fcre, Fy=55000.0u"lbf/inch^2", Ag = A , design_code =
"AISI S100-16 ASD")
round(typeof(1u"lbf"), ePne)
```

```
70857 lbf
```

Assume the tributary plan area for a post is 12 ft. x 12 ft.

```
A_trib = 12.0u"ft" * 12.0u"ft"
```

```
144.0 ft2
```

The maximum vertical deck pressure for the post with this tributary area is:

```
p_vertical = (ePne / A_trib) |> u"lbf/ft^2"
round(typeof(1u"lbf/ft^2"), p_vertical)
```

```
492 lbf ft−2
```

6 Lateral strength

It is assumed that this lateral loads acting perpendicular to the joists (parallel to the ledger) result from dynamic cyclic swaying of deck occupants during a lively gathering.

The lateral force coming from the occupants varies depending upon the natural frequency of the deck and the swaying frequency of the occupants. The occupant frequency for dancing at parties ranges from 1 to 3 Hz in Ginty et al. 2001. Yao et al. 2005 finds that if the occupant forcing frequency is close to the structure natural frequency, then the lateral forces generated are in the range of 3% to 7% of the occupant weight.

Approximate the natural frequency of the deck.

Calculate the lateral stiffness of the deck first assuming the support post is a cantilever with the occupant mass at its free end.

```
k = (3 * E*1000*u"lbf/inch^2" * I)/(post_height)^3 |> u"lbf/inch"
round(typeof(1u"lbf/inch"), k)
```

```
451 lbf inch−1
```

Calculate the mass associated with occupants over the tributary area. Assume each occupant takes up 7 sq. ft. and that each occupant weights 250 lbs.

```
m = (A_trib/7.0u"ft^2") * 250.0u"lbf" / ((32.2 *12) * u"inch/s^2")
round(ustrip(m), digits = 3) * u"inch^-1*lbf*s^2"
```

```
13.31 lbf s2 inch−1
```

Approximate the natural frequency of the New Castle deck.

```
ω = sqrt(k/m)
f = ω/(2π)
round(ustrip(f), digits = 2) * u"1/s"
```

```
0.93 s−1
```

The natural frequency f is similar to the dancing frequency. Assume then that the occupant lateral force is 5% of the occupant weight.

Calculate the occupant lateral demand force on a post.

```
Vu = (A_trib/7.0u"ft^2") * 250.0u"lbf" * 0.05
round(typeof(1u"lbf"), Vu)
```

```
257 lbf
```

Use AISI S100-16 Section F3.2 to calculate the post ASD flexural strength $M_{n\ell}/\Omega$.

```
eMnℓ = (post.local_buckling_flexural_strength.eMnℓ * 1000 * u"lbf*inch") |> u"lbf*ft"
round(typeof(1u"lbf*ft"), eMnℓ)
```

```
12056 ft lbf
```

The lateral force the post can carry at the deck level at its maximum height is:

```
V_allowable = eMnℓ / post_height
round(typeof(1u"lbf"), V_allowable)
```

```
1005 lbf
```

The lateral deck deflection at the occupant demand load V_u at the top of post is:

```
Δ = Vu * (1/k)
round(ustrip(Δ), digits = 2) * u"inch"
```

```
0.57 inch
```

7 Conclusions

It is clear that the support post is very strong for gravity loads at a 12 ft. height considering a 120 ft^2 tributary area.

Also, a tall 12 ft. high deck post performs well under lateral post occupant gathering sway loadings, with sufficient flexural strength in the post and a maximum top-of-post deflection of about 0.5 inches without the need for post-to-beam Y-bracing.