Appendix D Example 14 – Diagonal Bracing of Single Tier Framed Bent – Nailed Connections

Refer to *Falsework Manual,* Section 6-3, *Diagonal Bracing* and Section 5-3, *Timber Fasteners*. This example demonstrates how to determine if the bracing system of a single tier framed bent is adequate. All connections are nailed.

Given Information

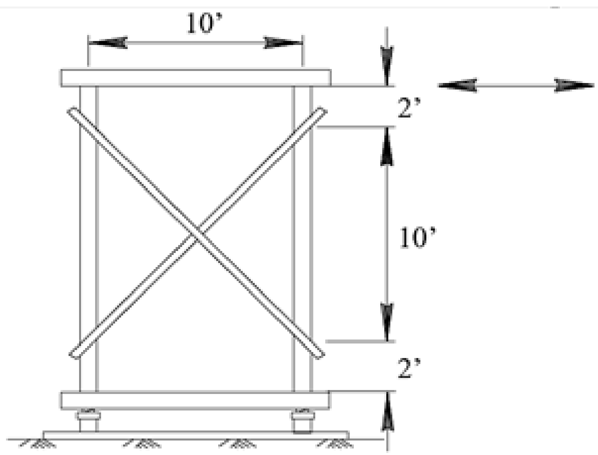


Figure D-14-1. Single Tier Framed Bent with Diagonal Bracing

2% Dead Load = 1900 lb
Wind Load = 1800 lb

Posts:
12 x 12 Rough Douglas Fir-Larch #1 (G=0.50)

Diagonal Braces:
2x8 Douglas Fir-Larch #2 (G=0.50)

Connectors:
Brace to Post 10-20d common nails
Intersection of Brace 4-16d common nails

Determine if the Bracing System is Adequate

1. **Determine the connection capacity between the brace and post:**

   10-20d Common Wire Nails
   Length = 4″
   Diameter (D) = 0.192″
   Penetration = 4″-1.5″ = 2.5″
   Minimum penetration for full tabular value = 10D = 10(0.192”) = 1.92”
   Minimum penetration = 6D = 6(0.192”) = 1.15”
   Reference lateral design value (Z) from NDS table 12N = 170 lb

Adjustment factors from NDS Table 11.3.1:

C_D = 1.25	*Duration Factor for 2% lateral loading*
C_M = 1.0	*Wet Service Factor NDS 11.3.3 (Assume < 19% moisture content)*
C_t = 1.0	*Temperature Factor NDS 11.3.4 (Temp up to 100ºF)*
C_g = 1.0	*Group Action Factor NDS 11.3.6*
C_Δ = 1.0	*Geometry Factor NDS 12.5.1*
C_{eg} = 1.0	*End Grain Factor NDS 12.5.2*
C_{di} = 1.0	*Diaphragm Factor NDS 12.5.3*
C_{tn} = 1.0	*Toe Nail Factor NDS 12.5.4*

Adjusted lateral design value $Z' = Z(C_D)(C_M)(C_t)(C_g)(C_\Delta)(C_{eg})(C_{di})(C_{tn})$ = 213 lb

Connection capacity = nZ' = 10(213 lb) = 2130 lb (n equals number of nails)

2. **Determine the capacity of the diagonal brace in tension:**

Reference design value in tension F_t = 575 psi (NDS supplement table 4A)

Adjustment factors from NDS table 4.3.1:

C_D = 1.25	*Duration Factor for 2% lateral loading*
C_M = 1.0	*Wet Service Factor NDS table 4A (Assume < 19% moisture content)*
C_t = 1.0	*Temperature Factor NDS table 2.3.3 (Temp up to 100ºF)*
C_F = 1.2	*Size Factor NDS Table 4A*
C_i = 1.0	*Incising Factor NDS 4.3.8*

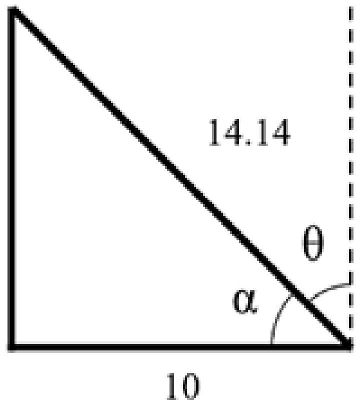
Adjusted design value $F_t' = F_t (C_D)(C_M)(C_t)(C_F)(C_i)$ = 863 psi

Tension capacity = 863 psi(1.5")(7.25") = 9385 lb

3. **Determine the strength value of the tension members:**

9385 lb > 2130 lb ∴ Connection strength controls

4. **Calculate the horizontal component of the strength value for the tension members**



$$T = 2130\ \text{lb}\left(\frac{10}{14.14}\right) = 1506\ \text{lb}$$

Figure D-14-2. Geometric Components of Tension Strength Value

5. **Determine the capacity of diagonal brace in compression:**

First check adequacy of the connection to reduce the unsupported length of compression member (See section 6-3.02 Wood cross bracing):

4-16d Common Wire Nails

Reference withdrawal design value W = 40 lb/inch of penetration (NDS table 12.2C)

Adjustment factors from NDS Table 11.3.1:

C_D = 1.25	*Duration Factor for 2% lateral loading*
C_M = 1.0	*Wet Service Factor NDS 11.3.3 (Assume < 19% moisture content)*
C_t = 1.0	*Temperature Factor NDS 11.3.4 (Temp up to 100ºF)*
C_{eg} = 1.0	*End Grain Factor NDS 12.5.2*
C_{tn} = 1.0	*Geometry Factor NDS 12.5.4*

Adjusted withdrawal design value W' = $W(C_D)(C_M)(C_t)(C_{eg})(C_{tn})$ = 50 lb/inch

Penetration p = 1.5"

Connection capacity = n(p)(Z') = 4(1.5")(50 lb/inch) = 300 lb (n equals number of nails)

300 lb > 250 lb (minimum required per section 6-3.02)

Check cross brace capacity in compression:

Reference design value in compression F_c = 1350 psi (NDS supplement table 4A)

Adjustment factors from NDS table 4.3.1:

C_D = 1.25	*Duration Factor for 2% lateral loading*
C_M = 1.0	*Wet Service Factor NDS table 4A (Assume < 19% moisture content)*
C_t = 1.0	*Temperature Factor NDS table 2.3.3 (Temp up to 100ºF)*
C_F = 1.05	*Size Factor NDS Table 4A*
C_i = 1.0	*Incising Factor NDS 4.3.8*
C_P = 0.083	*Column Stability Factor NDS 3.7.1 (unsupported length =* $\frac{14.14}{2}$= *7.07')*

Adjusted design compression value $F_c' = F_c\,(C_D)(C_M)(C_t)(C_F)(C_i)(C_P)$ = 147 psi

Compression brace capacity = 147 psi (1.5")(7.25") = 1599 lb

6. **Determine the strength value of the compression members:**

Connection capacity = 2130 lb

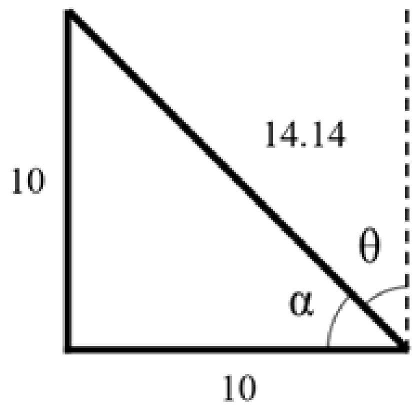
(See step 1. Capacity in tension and compression are the same)

1599 lb < 2130 lb ∴ 2x8 brace controls compression

Limit to ½ theoretical strength for compression values: See section 6-3.02, *Wood Cross Bracing.*

Reduced compression brace capacity = $\frac{1599\ \text{lb}}{2}$ = 800 lb

7. **Calculate the horizontal component of the strength value for the compression member**:



$$C = 800\ \text{lb}\left(\frac{10}{14.14}\right) = 566\ \text{lb}$$

Figure D-14-3. Geometric Components of Compression Strength Value

8. **Calculate the total resisting capacity of the diagonal bracing system:**

Summarize Result for 2% Dead Load

Total resisting capacity = C + T = 566 lb + 1506 lb = 2072 lb

Resisting Capacity = 2072 lb > Horizontal Demand Force = 1900 lb

Bracing system is adequate for 2% Dead Load

Summarize Result for Wind Load

Repeat above process for wind load to calculate the Resisting Capacity, using C_D = 1.6 rather than 1.25. All other factors are the same.

The Resisting Capacity for wind load can also be derived by multiplying the resisting capacity for 2% Dead Load (above) by the ratio $\frac{C_D\ \text{wind}}{C_D\ 2\%} = \frac{1.6}{1.25}$

Resisting Capacity = 2072 lb $\left(\frac{1.6}{1.25}\right)$ = 2652 lb > Horizontal Demand Force = 1800 lb

Bracing system is adequate for Wind Load