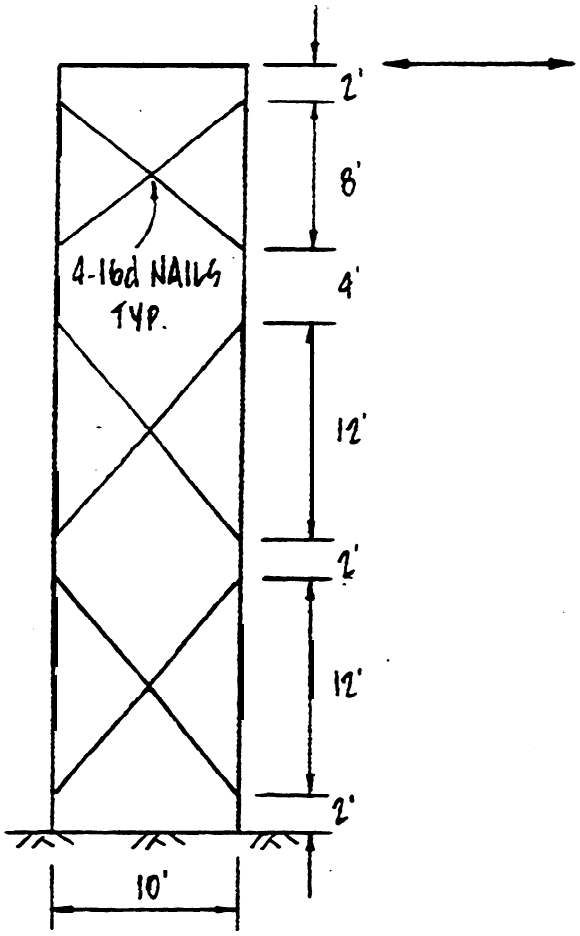
EXAMPLE NO. 5
ADEQUACY OF DIAGONAL BRACING
MULTI-TIERED FRAMED BENT



2% DEAD LOAD = 2100 #
WIND LOAD = 2800 #

POSTS: 12 x 12 ROUGH

DIAGONAL BRACES: 2 x 8 S4S

CONNECTORS: TOP BRACES 1-7/8" ϕ BOLT
MIDDLE BRACES 1-1" "
BOTTOM BRACES 1-1" "
ALL BOLTS IN SINGLE SHEAR

IS THE BRACING SYSTEM ADEQUATE

ANALYZE THE TOP TIER

1. DETERMINE THE STRENGTH OF THE CONNECTION BETWEEN BRACE AND POST:

CHECK BOLT CAPACITY IN THE SIDE MEMBER. FROM SECT. 4-3.02 OF FALSEWORK MANUAL, ENTER CHART FOR A MEMBER SIZE = 2 x THICKNESS OF SIDE MEMBER.

2 x 1.5" = 3" P = 3220 # x 0.75 FOR SINGLE SHEAR = 2415 #

CHECK BOLT CAPACITY IN THE MAIN MEMBER. FROM SECT 4-3.02 OF FALSEWORK MANUAL, ENTER CHART FOR MEMBER SIZE = 12"

P = 3900 # Q = 2060 #

1. CONTINUED

<u>CHECK BOLT CAPACITY IN MAIN MEMBER (CONT.)</u>

USE HANKINSON'S FORMULA:

$$R = \frac{PQ}{P\sin^2\theta + Q\cos^2\theta}$$

$\theta = \tan^{-1}\frac{10}{8} = 51.3°$

$\sin^2 51.3° = 0.61 \qquad \cos^2 61.3 = 0.39$

$$R = \frac{3900(2060)}{3900(0.61) + 2060(0.39)} = 2525\# \times 0.75 = \underline{1894\#}$$

FOR SINGLE SHEAR

$1894\# < 2415\#$ ∴ MAIN MEMBER CONTROLS CONNECTION CAPACITY

SINCE THE WIND LOAD CONTROLS THE HORIZONTAL DESIGN FORCE APPLY 1.33 LOAD DURATION FACTOR AS PER SECT. 4-3.06 OF FW MANUAL.

STRENGH OF CONNECTION = $1.33 \times 1894 = \underline{2519\#}$

2. DETERMINE THE STRENGTH OF THE DIAGONAL BRACES IN TENSION.

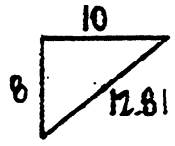
USE NET AREA OF MEMBER - $1.5"(1.25" - 0.94") = 9.41\ IN^2$

$F_T = 1200\ PSI\ (9.41\ IN^2) = \underline{11\,364\#}$

3. DETERMINE THE STRENGTH VALUE OF THE TENSION MEMBERS.

$11364\# > 2519\#$ ∴ CONNECTION CONTROLS TENSION

4. CALCULATE THE HORIZONTAL COMPONENT OF THE STRENGTH VALUE FOR THE TENSION MEMBERS.



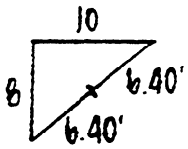
$$T = 2519 \times \frac{10}{12.81} = 1967\#$$

5. DETERMINE THE STRENGTH OF THE DIAGONAL BRACES IN COMPRESSION.

CONNECTION = $\underline{2519\#}$ FROM ABOVE

5. CONTINUED

ALLOWABLE COMPRESSION IN 2×8



CHECK ADEQUACY OF CONNECTION TO REDUCE UNSUPPORTED LENGTH OF COMPRESSION MEMBER.

REF.: N.D.S. TABLE 8.8B

ASSUME SPECIFIC GRAVITY G = 0.51

16d BOX NAILS

WITHDRAWAL CAPACITY = 35 #/INCH OF PENETRATION

CAPACITY OF 4 EA 16d = 4 × 35# × 1.5" × 1.33 = 279 # > 250# OK

LOAD DURATION

SEE FW MANUAL SECT. 5-1.03

$$\frac{480{,}000}{(L/d)^2} = \frac{480{,}000}{(6.40 \times 12/1.5)^2} = 183.1 \text{ PSI}$$

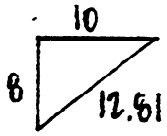
183.1 PSI (1.5" × 1.25") = <u>1991 #</u>

6. DETERMINE THE STRENGTH VALUE OF THE COMPRESSION MEMBERS

1991 # < 2519 # ∴ 2×8 BRACE CONTROLS COMPRESSION

ALLOW ½ THEORETICAL FOR COMPRESSION VALUE. ½ (1991) = 996 #

7. CALCULATE THE HORIZONTAL COMPONENT OF THE STRENGTH VALUE FOR THE COMPRESSION MEMBER.



$$C = 996 \times \frac{10}{12.81} = 778 \#$$

8. CALCULATE THE TOTAL RESISTING CAPACITY OF THE TOP TIER OF BRACING.

TOTAL = C + T = 778 # + 1967 # = 2745 #

ANALYZE THE MIDDLE TIER

1. DETERMINE THE STRENGTH OF THE CONNECTION BETWEEN BRACE AND POST.

CHECK BOLT CAPACITY IN THE SIDE MEMBER. FROM SECT. 4-3.02 OF FW MANUAL

1. CONTINUED

ENTER CHART FOR A MEMBER SIZE = 2 × THICKNESS OF SIDE MEMBER.

$2 \times 1.5" = 3"$ $\quad P = 3750\# \times 0.15$ FOR SINGLE SHEAR $= 2813\#$

<u>CHECK BOLT CAPACITY IN THE MAIN MEMBER.</u> FROM SECT. 4-3.02 OF FW MANUAL, ENTER CHART FOR MEMBER SIZE = 12".

$P = 5080\#$ $\quad Q = 2710\#$

USE HANKINSON'S FORMULA:

$$R = \frac{PQ}{P\sin^2\theta + Q\cos^2\theta}$$

$$\theta = \tan^{-1}\frac{10}{12} = 39.8°$$

$\sin^2 39.8° = 0.41$ $\quad \cos^2 39.8° = 0.59$

$$R = \frac{5080(2710)}{5080(0.41) + 2710(0.59)} = 3139\# \times 0.15 = \underline{2804\#}$$

FOR SINGLE SHEAR

$2804\# < 2813\#$ $\quad \therefore$ MAIN MEMBER CONTROLS CONNECTION CAPACITY

SINCE THE WIND LOAD CONTROLS THE HORIZONTAL DESIGN FORCE APPLY 1.33 LOAD DURATION FACTOR AS PER SECTION 4-3.06 OF FW MANUAL.

STRENGTH OF CONNECTION $= 1.33 \times 2804 = \underline{3729\#}$

2. DETERMINE THE STRENGTH OF THE DIAGONAL BRACES IN TENSION

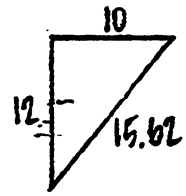
USE NET AREA OF MEMBER - $1.5"(1.25" - 1.06") = 9.28\ IN^2$

$F_T = 1200\ PSI\ (9.28\ IN^2) = \underline{11136\#}$

3. DETERMINE THE STRENGTH VALUE OF THE TENSION MEMBERS.

$11136\# > 3729\#$ $\quad \therefore$ CONNECTION CONTROLS TENSION

4. CALCULATE THE HORIZONTAL COMPONENT OF THE STRENGTH VALUE FOR THE TENSION MEMBERS.

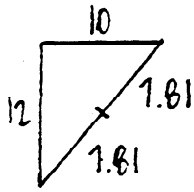


$$T = 3729 \times \frac{10}{15.62} = 2388\#$$

5. DETERMINE THE STRENGTH OF THE DIAGONAL MEMBERS IN COMPRESSION

CONNECTION = 3129 # FROM ABOVE

ALLOWABLE COMPRESSION IN 2×8



(FROM STEP 5 OF TOP TIER CALCS, CONNECTION FOUND ADEQUATE TO REDUCE UNSUPPORTED LENGTH.)

$$\frac{480\,000}{(L/d)^2} = \frac{480\,000}{(1.81 \times 12/1.5)^2} = 123.0 \text{ PSI}$$

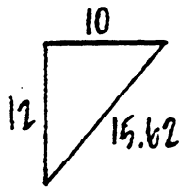
$$123.0 \text{ PSI } (1.5'' \times 1.25'') = 1338\#$$

6. DETERMINE THE STRENGTH VALUE OF THE COMPRESSION MEMBERS

1338 # < 3129 # ∴ 2×8 BRACE CONTROLS COMPRESSION

ALLOW ½ THEORETICAL FOR COMPRESSION VALUE. ½ (1338) = 669 #

7. CALCULATE THE HORIZONTAL COMPONENT OF THE STRENGTH VALUE FOR THE COMPRESSION MEMBER



$$C = 669 \times \frac{10}{15.62} = 428\#$$

8. CALCULATE THE TOTAL RESISTING CAPACITY OF THE MIDDLE TIER OF BRACING.

TOTAL = C + T = 428 # + 2388 # = 2816 #

ANALYZE THE BOTTOM TIER

SINCE THE BOTTOM TIER IS IDENTICAL TO THE MIDDLE TIER, THE RESISTING CAPACI
IS EQUAL TO THE MIDDLE TIER. BY INSPECTION, C + T = 2816 #

SUMMARY

TIER	RESISTING CAPACITY	COLLAPSING FORCE = 2800 #
TOP	2145 #	NO GOOD → ∴ THE BRACING SYST
MIDDLE	2816	OKAY IS INADEQUATE
BOTTOM	2816	OKAY