HW 2 SOLN

Reading:
Read “MSC Stadium Addition” posted on Stellar
Read Chapters B and D of the Spec (AISC Steel Manual Spec on website)

Northwestern University Stadium Pressbox
Read “MSC Stadium Addition” posted on Stellar and write about the framing scheme selected. This could address the loads, why the framing scheme was selected, and see if you can suggest a better alternative to the framing scheme.

A new pressbox facility has been added to the Northwestern University Stadium (Stadium Addition, 1998). This pressbox sits above the existing stadium, and the design must satisfy specific site requirements. Three floor levels were required, with height limitations specified by the city. The height restriction required tight floor-to-floor heights, and this in turn minimized the beam depths. Thus a cable support system has been used to transfer gravity loads back to the supporting truss. Some of the interesting features include the fact that serviceability governed in the supporting truss design, the limitations on the truss depth, and the use of the cables at the top. The slotted wide flange is a good solution for a continuous gusset, but it may have been more economical to use a doubler plate in the column web, also using a thinker gusset would eliminate the need for welded washers for the pin connections (bearing). Another solution is to cut the column and weld the gusset to an end plate (sketch any solution you feel would improve design…).

Problem 2

What is E for steel (Young's modulus)? *29,000 ksi*
Does it vary? *No*
What are typical values for the yield stress of steel (A36 and A992)? *36ksi for A36, and 50ksi for A992*
What does yield stress mean? *When the steel starts to undergo plastic deformation, this is typically referred to the steel strength. It is where the linear stress-strain curve goes to nonlinear and a lot of deformation occurs after. Intersection of linear elastic range to the non-linear plastic range.*
Who publishes the steel specification? *AISC*

Problem 3

Assume you want to design a square bar for a tension of 20k dead load and 80k live load, what is the size of the bar using both ASD and LRFD? Assume A36 steel. Using ASD, what is the elongation of this member if it is 30ft long?

ASD SOLUTION:
Pa = 20k + 80k = 100k
100k < Pn/Ω = AgFy/Ω = A (36ksi)/1.67 therefore, A =1.67 x 100k/(36ksi) = 4.64 in^2
Each Side = sqrt 4.64 = 2.15 in
*Elongation = PL/AE = 100k x (30ft x 12in per foot) / (4.64 * 29000ksi) = 0.27 inch*

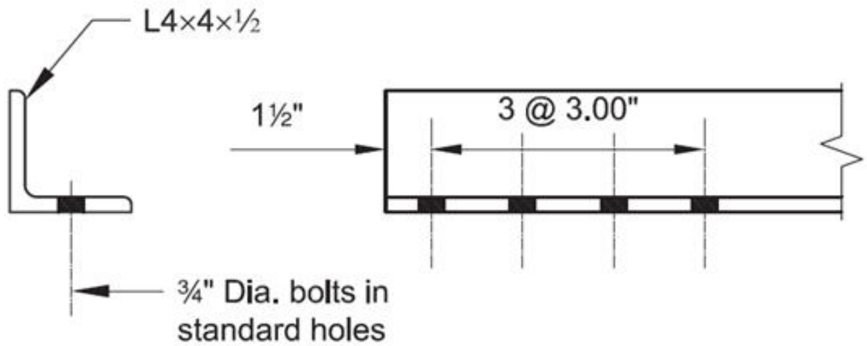
LRFD SOLUTION:
Pa = 1.2 x 20k + 1.6 x 80k = 152k
152k < φPn = φAgFy = 0.9 A (36ksi) therefore, A = 152k/(36ksi x 0.9) = 4.69 in

Area = sqrt(4.64 or 4.69) = 2.16- Say use 2 ¼ x 2 ¼ Bar or Area = 5.0625 (many answers are OK)

Elongation = PL/AE = 80k x 30ft x 12" / (5.0625in2 x 29000ksi) = about 0.2"

Problem 4

What is the net area of this angle? What is the LRFD yield strength and rupture strength? Assume A36 steel and U=0.8.



A = 3.75 in^2
F_y =36ksi
F_u = 58ksi

LRFD Yield Strength = $\varphi P_n = \varphi A_g F_y$ = 0.9 x 3.75 in^2 x 36ksi = **121.5k**

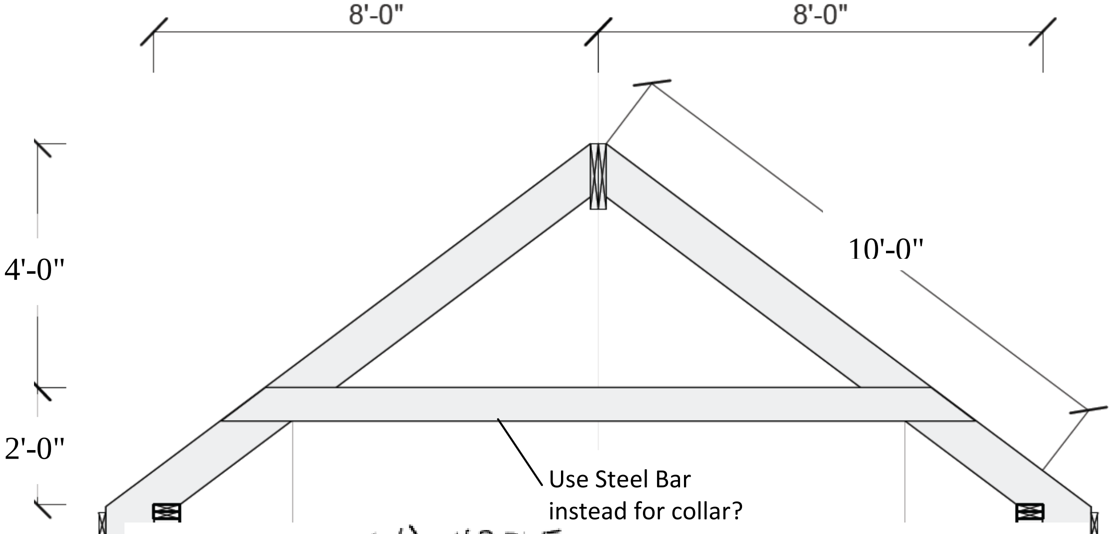
Hole Size = (3/4"dia + 1/8") x 1/2" thick = 0.4375

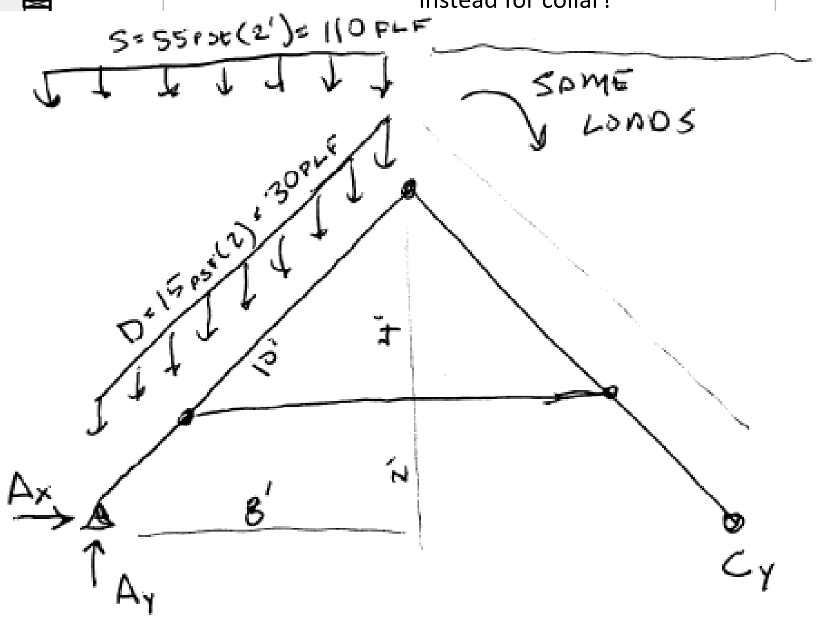
LRFD Rupture Strength = $\varphi P_n = \varphi U A_e F_u$ =0.75 x 0.8 (3.75 in^2 - 0.4375)(58ksi) = **115.3k**

Problem 5

Below is a section of a house gable roof. The rafter and tie shown is spaced at 2 ft on center in plan (so this section is 2ft on center). Suppose we want to use a round solid steel bar for the collar tie, instead of a 2x6 as shown below...what size do we need for strength? How much will it elongate? Assume 15psf for dead load of roof (ignore self weight), and 55psf of snow load since in New Hampshire (this is projected load, if applied to rafter it would be 55psf x 8/10).

Hint: Solve for reactions at top of wall first, then cut in half and crease FBD.



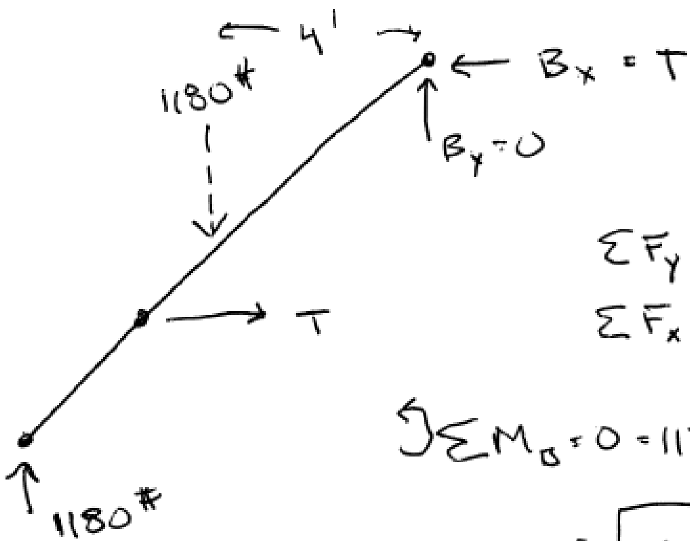


$$\Sigma F_x = 0 \rightarrow A_x = 0$$

$$\Sigma F_y = 0 = A_y + C_y - 30(10)2 - 110(8)2 = 0$$

$$A_y = C_y \quad \text{Symmetry}$$

$$A_y = \frac{30(10)(2) + 110(8)(2)}{2} = 1180^{\#}$$



$\Sigma F_y = 0 \rightarrow B_y = 0$

$\Sigma F_x = 0 \rightarrow T = B_x$

$\circlearrowleft \Sigma M_B = 0 = 1180^{\#}(4') + T(4) - 1180(8)$

$\therefore \boxed{T = 1180^{\#}}$

STEEL BAR

$A = \pi d^2/4$

$\text{CAPACITY} = \frac{P_N}{\Omega} = \frac{F_y A}{\Omega} > \text{DEMAND} = 1180^{\#}$

$A = 0.055$

$\frac{(36^{ksi})(\pi d^2/4)}{1.67} = 1.180^{K} \rightarrow \boxed{d = 0.26''}$

$\Delta = \frac{PL}{AE} = \frac{(1.18^K)(10.67')(12)}{(0.055)(29{,}000)} = \boxed{0.095'' = \Delta}$