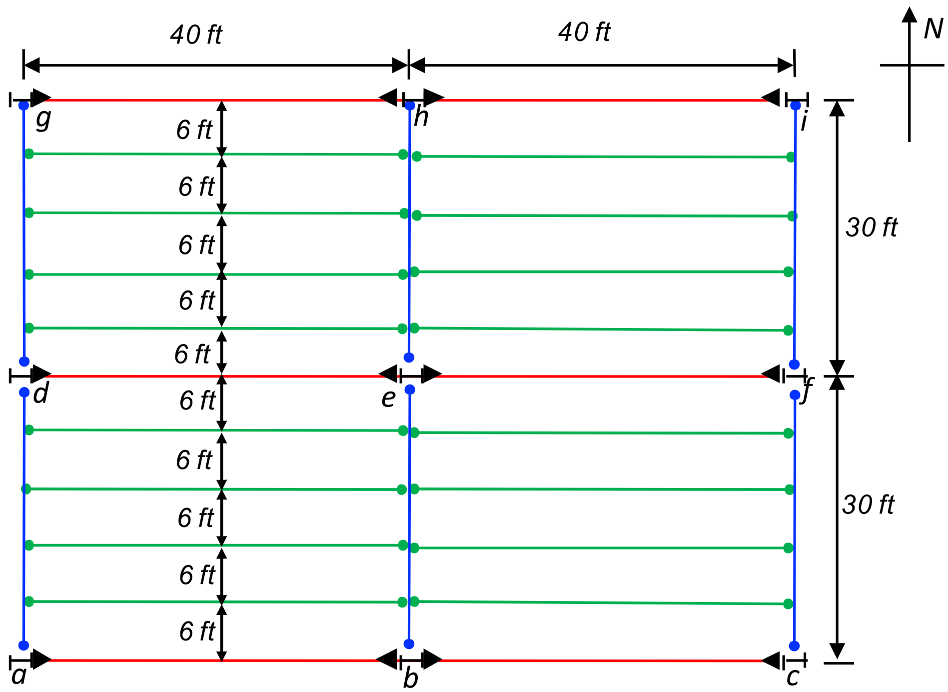
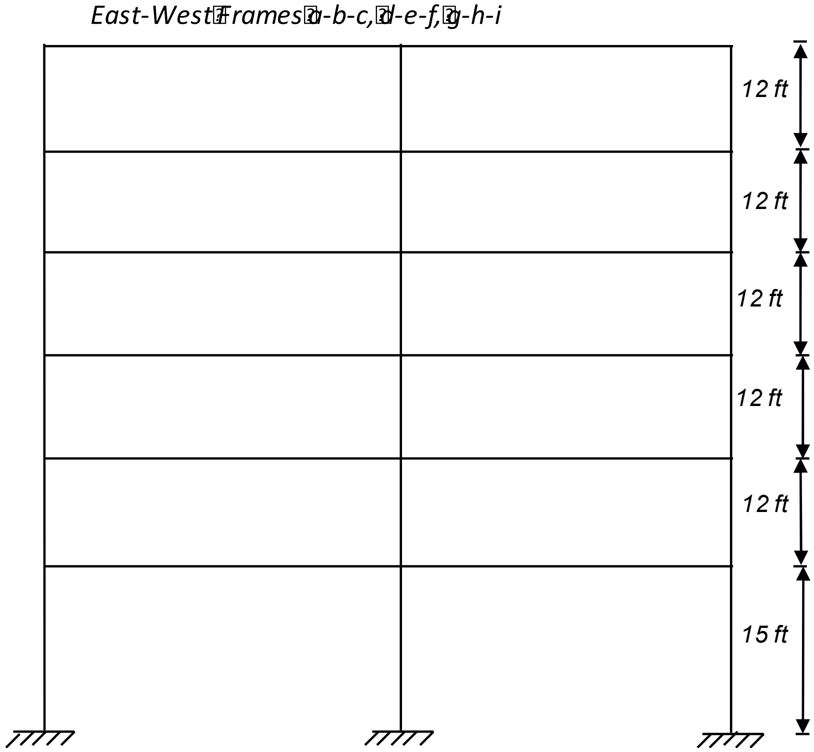
Course Project CE470 **Due Date: Friday, April 28, 2017**

Continuing with the six-story building structure used in Homework No. 2, 3.
(i) Design all the members of frame b-e-h
(ii) Design the bracing connection at the first story of the frame



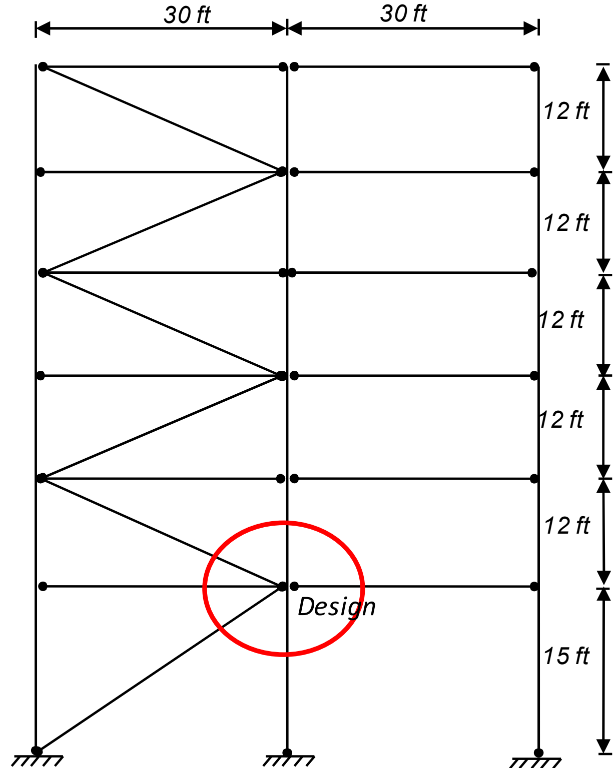
(a) Structural floor plan

East-West Frames a-b-c, d-e-f, g-h-i



(b) Elevation View

North-South Frames a-d-g, b-e-h, and c-f-i



(c) Side View,

PROJECT REPORT

The final design project report must be a concise, organized, and easy-to-read document. The exact layout and table of contents of the final design project report is up to the individual. The report should have enough information to assess the accuracy and the approach used for the design. Relevant AISC Specifications should be cited using their Specification numbers. *The report should not be too verbose.* Attach the computer results as an appendix to the report. The report must *at-least* address the following issues:

- Analysis
  - Model of the structural system
  - Summary of results from the analysis of the structural model
  - Emphasis on member design forces and corresponding governing load combination.
  - Displaced shapes of the frames for *critical* load combinations.
- Structural Design - Members
  - Summarize the results of the design process
  - Emphasis on selected material, member, strength (resistance), and controlling limit state.
  - Sample design calculations for some *critical* columns, beams, and bracing members.
- Structural Design - Connections
  - Summary of calculations for the design of bracing connection at first story.
  - Engineering drawings of the designed connections.
- Structural Weight, Fabrication Cost, and Design Cost
  - Determine the weight of each member and the total weight of steel in the structure.
  - Assuming a fabricated steel cost of $1.50 per pound, determine the total fabrication cost of the project.
  - Assuming a cost of $60.00 per person-hour, determine the cost of designing the project.

OLD HANDOUT TO HELP CONNECTION DESIGN IN THE DESIGN PROJECT

This handout discusses the design of connections at joints S and G, shown in the figure below. It is similar but not identical to the connection design for the design project.

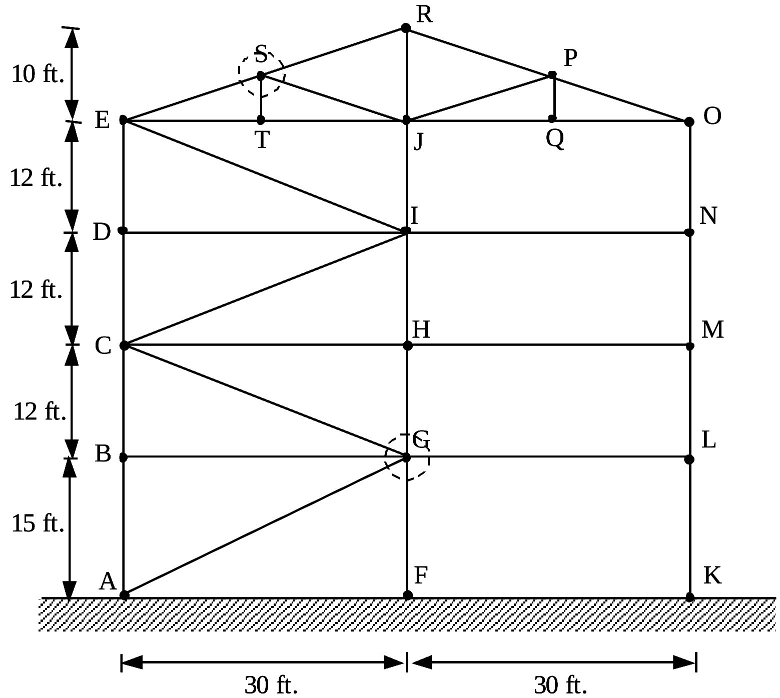


Figure 1. Structural elevation of Frame A-A

- Working point: The working point for a connection is defined as the point of intersection of the centroidal axes of all members connected at the joint.

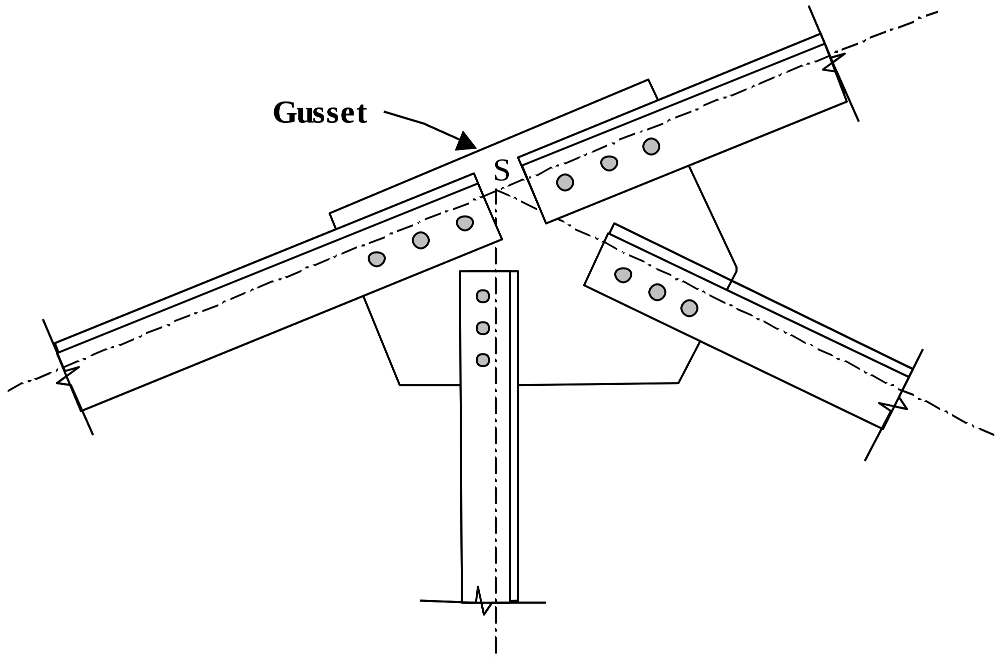
- The working point (W.P) for all connections should correspond to the joints shown in the line sketches and assumed in the analysis & design.

- Design the connections using either bolts or welds. Note that welds will be much easier. If you have assumed bolted connections during member design, then you will find that they will still be adequate for welded connections.

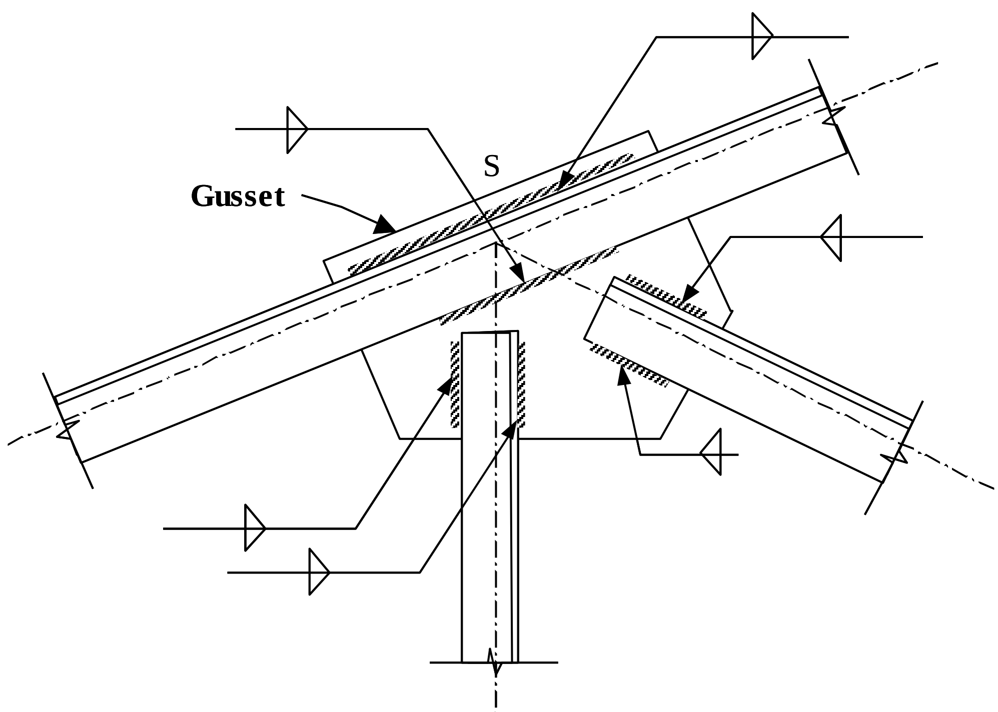
- Example details of connection S and G are shown in the attached sheets. Additional references include the AISC manual pages 13-11 to 13-17 for truss connections and 13-3 to 13-11 for bracing member connections. See Example 13.2 (case b on page 13-35) for bracing connection examples. See Example 13.3 (page 13-38) for truss connection examples. These page numbers need to be fixed for the newer version of the manual.

- A sample gusset plate design is also shown. Additional reference for gusset plate design can be downloaded from: http://www.aisc.org/documents/dec_98.pdf

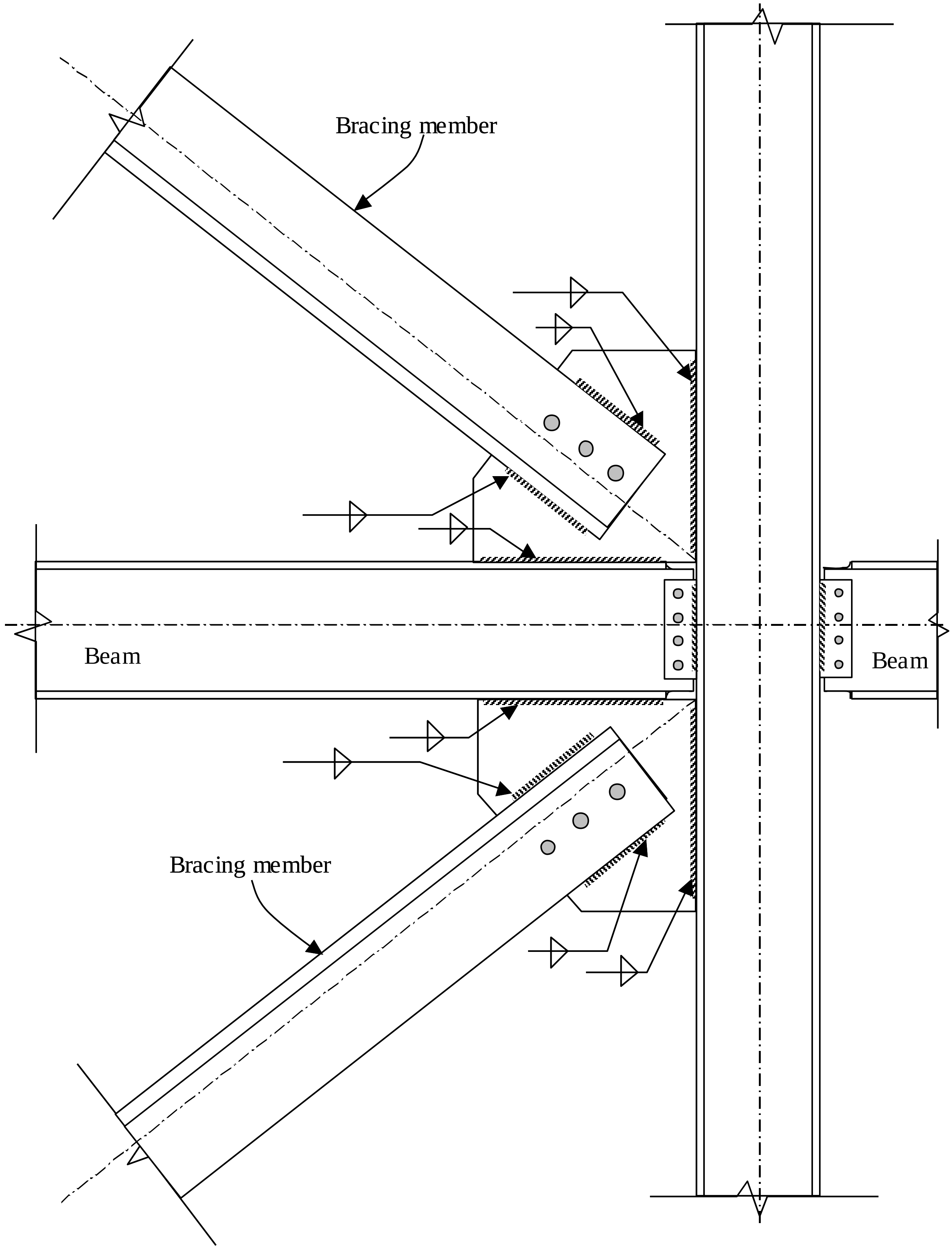
- Example of Connection S - Bolted



- Example of Connection S - Welded



- Example of Connection - G (Bolted and Welded options shown together)



Bracing connection design example (very brief, many steps omitted)

Given:

Bracing member, $L_x = L_y = 34$ ft.

$K_x = K_y = 1.0$

$P_u = 90$ kips (tension and compression).

Design member

- Select double angle section 8 x 6 x 1/2 in. with long legs back-to-back, made from 50 ksi material
- See AISC manual page 4-127: $\phi P_n = 120$ kips for x-axis buckling
  $\phi P_n = 95.5$ kips for y-axis buckling

  y-axis buckling governs, need two connectors along the member length (student design).

Design Connection of member to gusset plate

- If a bolted connection is desired,

  No. of bolts required = four 3/4 in. A325 bolts

  $\phi R_n = 127$ kips.

  Design, edge distance (L_e) = 1.5 in. and spacing (s) = 3.0 in.

- If welded connection is required,

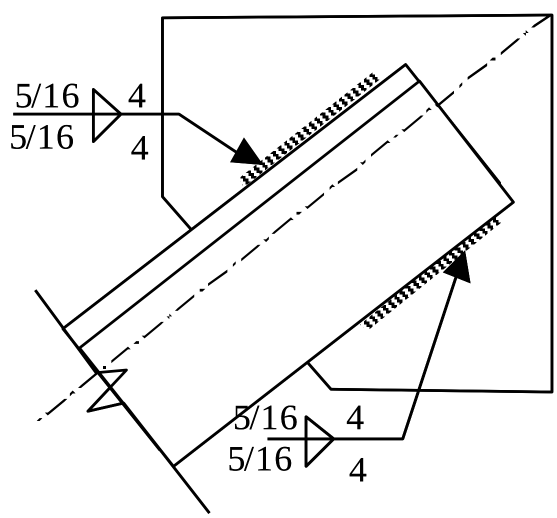
  Let a = 5/16 in. (check with a_{min} and a_{max})

  Design with E70XX electrode

  $\phi R_n = 0.75 \times 0.6 \times 70 \times 0.707 \times 5/16 \times L = 6.96\ L$ kips > 90 kips

  Therefore, L > 12.93 in.

  Design, L = 16 in. - (8 in. on either sides of the gusset plate)

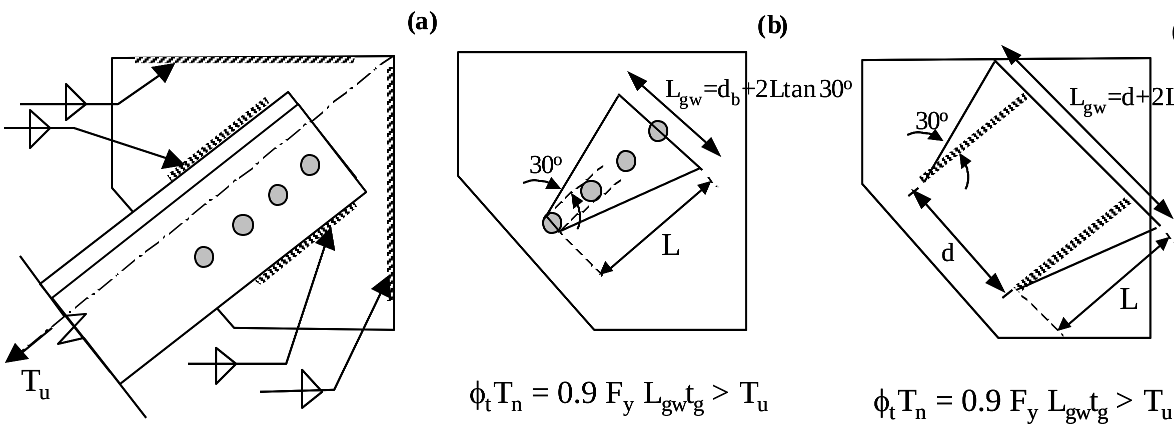


Gusset Plate Design

- Gusset plate design is governed by the length of the critical section subjected to *direct* tension or compression. The length of the critical section can be estimate using the Whitmore gage-length method, shown in the Figure below.

- The Whitmore gage-length method assumes that the critical section is located at the *last* fastener long the line of force. The length (L_{gw}) of the critical section is estimated assuming 30° angles of spread from the length of the plate in *direct* tension or compression at the *first* fastener.

- The area of the critical section is equal to L_{gw} multiplied by the thickness (t_g) of the gusset.
- The thickness (t_g) of the gusset plate must be designed so that the gross yielding and net section fracture strength of the critical section are greater than factored tension force.
- *Usually*, the limit state of gusset plate *buckling* due to compression forces is also considered in the design process. However, this is beyond the scope of the current course.
- Therefore, design the thickness (t_g) of the gusset plate so that the gross yield strength in compression, with a ϕ factor of 0.85, is greater than the factored compressive force.



$\phi_t T_n = 0.9\ F_y\ L_{gw} t_g > T_u$ $\qquad$ $\phi_t T_n = 0.9\ F_y\ L_{gw} t_g > T_u$

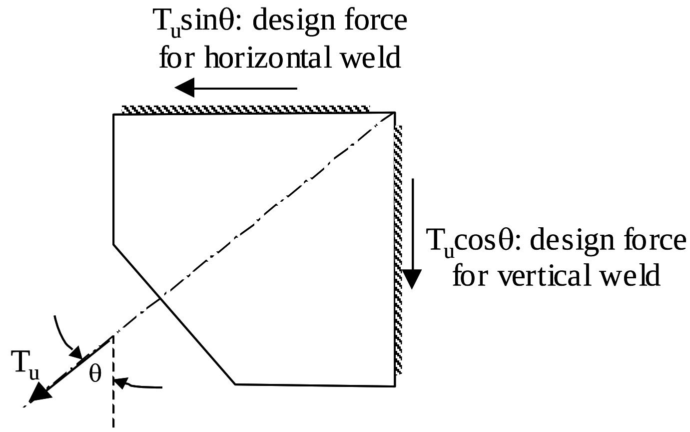
$\phi_t T_n = 0.75\ F_u\ (L_{gw} - n\ (d_b + 1/8))\ t_g > T_u$

Whitmore gage length and design of gusset plates: (a) member with bolts or welds; (b) Whitmore gage length for bolted conn.; (c) Whitmore gage length for welded conn.

<u>*Design Gusset Plate*</u>

- $L_{gw} = 3/4 + 2 \times 9 \times \tan 30^o = 11.14$ in. - for bolted connection
- $\phi_t T_n > T_u$ - gross yielding in tension
  $0.9 \times L_{gw} \times t_g \times 50 > 90$ - gross yielding in tension
  Therefore, $t_g > 0.18$ in.
- $\phi_t T_n > T_u$ -net section fracture in tension
  $0.75 \times (11.14 - 0.875) \times t_g \times 65 > 90$
  Therefore, $t_g > 0.18$ in.
- $\phi_t T_n > P_u$ - gross yielding in compression (approx.)
  $0.85 \times (11.14) \times t_g \times 50 > 90$
  Therefore, $t_g > 0.19$ in.
- Assume t_g = either 3/8 in. or 1/2 in. or 3/4 in. for bolted connection gusset plate. All of these values are greater than that required. The final choice will be based on the designer. The instructor would prefer a 1/2 in. thick gusset plate.
  - $L_{gw} = 8 + 2 \times 4 \times \tan 30^o = 12.6$ in.
  - $\phi_t T_n > T_u$ - gross yielding in tension
    $0.9 \times 12.6 \times t_g \times 50 > 90$
    Therefore, $t_g > 0.16$ in.
  - $\phi_t T_n > T_u$ - gross yielding in compression.
    $0.85 \times 12.6 \times t_g \times 50 > 90$
    Therefore, $t_g > 0.17$ in.
  - Design t_g = 1/2 in. for the gusset plate.

Design gusset plate to beam and column connection.



θ – angle between the vertical and the line joining the corners of the gussets at the top and bottom levels

- The weld joining the gusset to the beam must be designed for a design force of T_u x sinθ

- The weld joining the gusset to the column must be designed for a design force of T_u x cosθ

- These values come from AISC Manual. Note that there are three other methods of designing these connections. However, the recommended method is the simplest.

- θ is the angle between the vertical and the line joining the corners of the gussets at the top and bottom level. Thus, θ is not exactly equal to the angle of the diagonal bracing member.

- In order to use the recommended simple design method for the connection, the bracing member centroidal axis should pass through the corners of the gusset plates as shown. Thus, the working point for the bracing member should be located at the corner of the gusset.

- This will cause some additional end moment in the beam due to the eccentricity of the working point with respect to its centroidal axis. This should have to be accounted for in the design process. *However, it is beyond the scope of this course and design project.*