Show Your Work!
Documenting Engineering Calculations with PLS

Engineers and Consultants

Show Your Work!

Mesa Associates, Inc.
Engineers and Consultants

I. Show your work!

- Some of the tools included with PLS that help fully document a PLS deliverable.

- Component Library Notes
- Criteria Notes
- Project Report
- Reference Manager

Showing Your Work in PLS

Mesa Associates, Inc.
Engineers and Consultants

II. Do the work!

- No Red = OK!   …Right?
- Did you find the weakest link? Are you sure?
- Tools and methods to create accurate PLS Models

- Manual Calcs: Exporting Data
- Foundation
- Dead Loads & Drag Areas
- Connections and Anchors (CAN)
- Capacities and Overrides
- Rupture
- Quality Control Checks

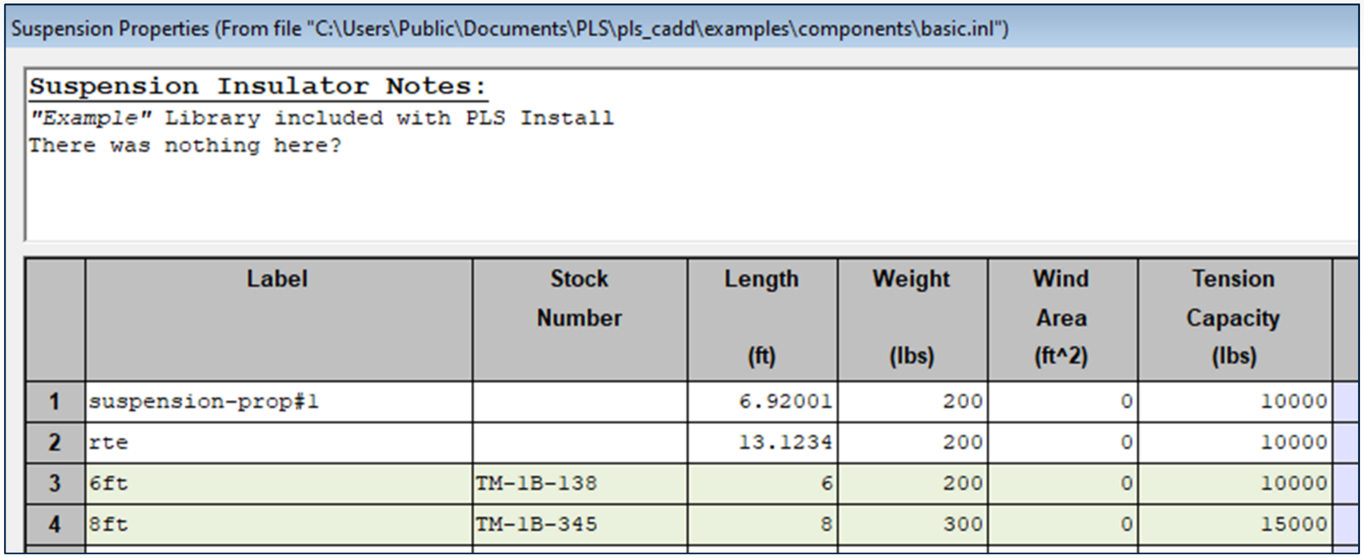
Showing Your Work in PLS

I. **Show Your Work!**

- Component Library Notes

Show Your Work: Component Library

- Tower & Pole
- Easy to find
- CAN be "rich text" formatted



Suspension Properties (From file "C:\Users\Public\Documents\PLS\pls_cadd\examples\components\basic.inl")

Suspension Insulator Notes:

"Example" Library included with PLS Install

There was nothing here?

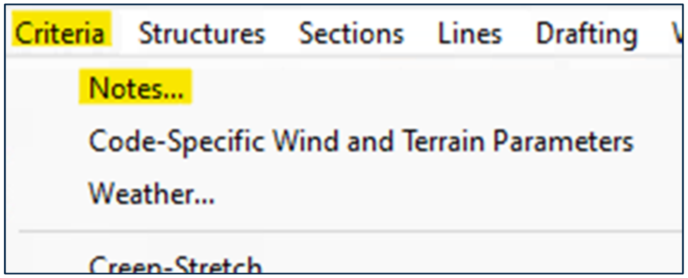
	Label	Stock Number	Length (ft)	Weight (lbs)	Wind Area (ft^2)	Tension Capacity (lbs)
1	suspension-prop#1		6.92001	200	0	10000
2	rte		13.1234	200	0	10000
3	6ft	TM-1B-138	6	200	0	10000
4	8ft	TM-1B-345	8	300	0	15000

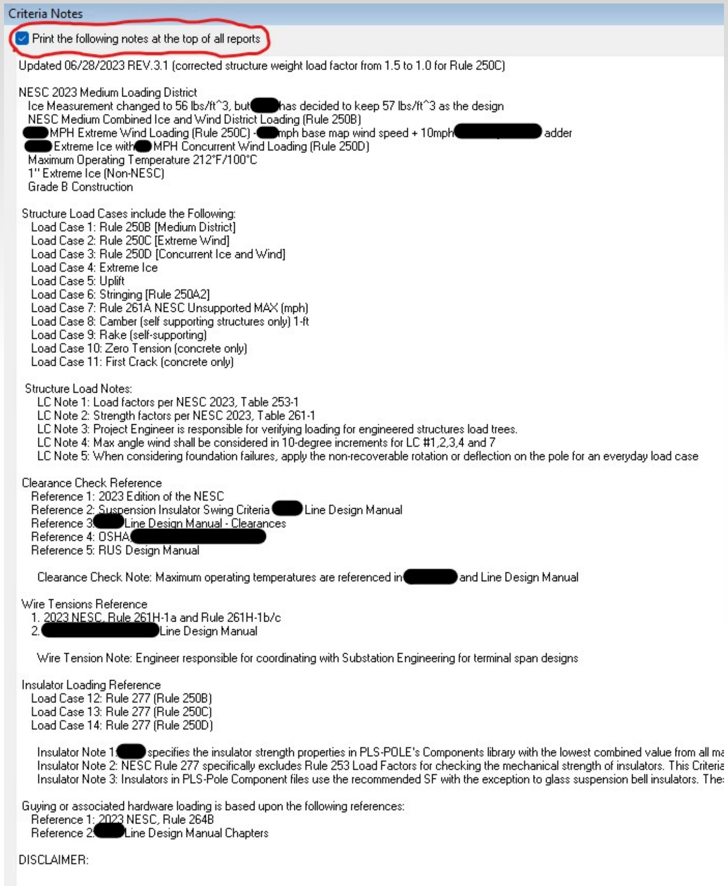
Showing Your Work in PLS

I. **Show Your Work!**
- Component Library Notes
- Criteria Notes

Show Your Work: Criteria Notes

- **PLS-CADD Only**
- **Can NOT be formatted**
- **Can be added to all reports**
  - Lots of notes will clutter short reports





Showing Your Work in PLS

Mesa Associates, Inc.
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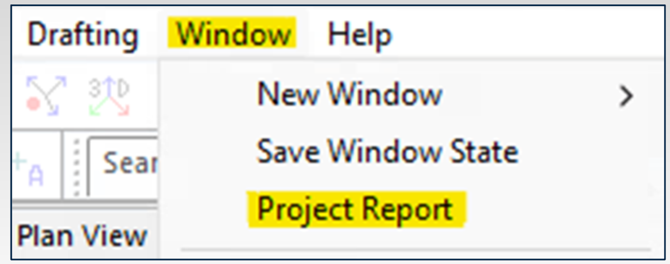
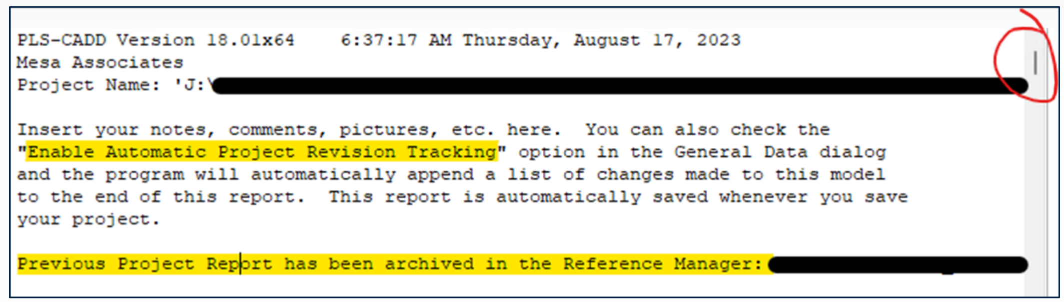
I. Show Your Work!

- Component Library Notes
- Criteria Notes
- Project Report

Show Your Work: Project Report

- **CADD, Pole, Tower**
- **CAN be “rich text” formatted**
- **This is one good option for general model notes**
  - What, When, Who, Why?
  - Engineering notes and calcs
  - References used for creation
  - Standards and deviations
- **“Enable Automatic Project Revision Tracking”**





Show Your Work: Project Report

Build Notes
[redacted] 500kV Type [redacted] Tower
Light tangent V-String Suspension

Model prepared for [redacted]
By MVRK Engineers, Inc., and Mes

Revision 0, 5/08/2024, Tower v.1
Non-Family-Managed model created

Extensions: N/A
Legs: N/A
Engineers:
Originator: Tony Cuñha, PE
Checkers: Robert Smith a

Additional information:
A file called "[redacted] Detailed Repo
the .bak file. It contains much
Project Report.

Reference drawings:
Design Criteria: [redacted] Shts 12
Design Diagrams: [redacted] to [redacted]
Erection Drawings: [redacted] to [redacted]

General Data:
Tension-only members were limited to 90% of maximum compression capacity.
Member Strength & Crossing Diagonal checks per ASCE 10.
Connection Rupture, Included Angles, and Climbing Loads are NOT checked per client r

Redundant braces:
All redundant members are included in the model.
Redundant members are checked against the actual force in the member.

Joints:
Tower Geometry defined using the Engineering Work Points identified on the Detail dr
the Masts, the engineering work points hav
knock-down format. Thus, the joints of th
dimension of the main leg members from the
Drawing.

Bolt Properties:
ASTM A394 T-0, 3/4" dia.
Shear strength 16.65 kips per ASTM A394
Holes are assumed drilled for member thick
dimension). Otherwise, holes are assumed p
Ultimate Stress F_{ub} = 74ksi.

Steel Material Properties:
ASTM A36: F_y = 36ksi, F_u = 58ksi
ASTM A572 Gr.50: F_y = 50ksi, F_u = 65ksi

Angle Properties:
All angle properties were taken from the A
w/t ratios were calculated per ASCE 10
Accurate strength properties for the Weldm
are loaded axially. Similarly, the member

Sections Table:
Dead load factors:
10% of tower weight added to account fo
XARM and BRIDGE sections have an extra

Wind Drag Area:
10% is assumed to account for gusset
SWING ARM and BRIDGE sections have an e
Face, All, and SAPS Angle columns we
Only one face is considered for Wind

Member Face Overrides:
Member face overrides were assigned to the
only assigned the members of the Windward
masts is explicitly described in the origi

Automatic Change Documentation:
Any text after the line below was automati
saved. Any changes should be reviewed then
incorporated in a new revision. If any cha
add appropriate dates, notes, etc. Once th
should be deleted (Note: At least one save
project report are saved. No changes are r
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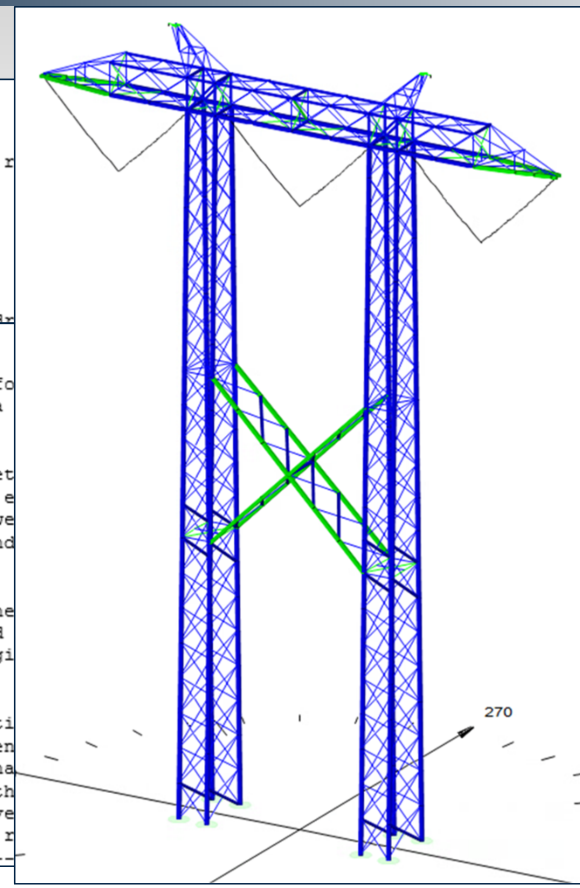

Show Your Work: Project Report

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Tower Version 19.01x64

[CLIENT] [V]kV [Double/Single] Circuit Tower Type [TYPE] - Build Notes

Received from [CLIENT] on [DATE]
This model was originally created on [DATE] in Tower version [V], by [CREATOR/ENGINEER/CHECKER/UTILITY/ETC].

Modified by Mesa Associates for [CLIENT] project [NO.], structure [NO.] on [CIRCUIT/LINE NAME]

[INSERT MESA ORIGINATOR, CHECKER, REVIEWER, EOR AS REQ'D]

Changes by Mesa: {VERIFY/UPDATE}

- [Created this Project Report. The original Project report was automatically created over time as the model was updated/saved and consisted of over NN pages of text. That report was archived to a .rtf file and attached using the Reference Manager.]
- Added existing modifications for PCS support, including center PowerMount, stem sector mounts, and additional bracing.

Reference drawings: {UPDATE}
Design Drawings:
[DESIGN DATA DRAWINGS (IF AVAILABLE)]

Erection Diagrams:
[ERECTION DRAWING NUMBER(S)]

Detail Drawings:
[DETAIL DRAWING NUMBER(S)]

Tower Modeling Specification:
[Client - Title of Spec]

Rupture: {VERIFY}
Rupture Check not included at client request.

Leg Oblique Bracing: {VERIFY}
Oblique leg bracing angles are assumed to not provide support in the out-of-plane direction.

Other Comments: {VERIFY}
The model as received from [redacted] did NOT include redundant braces, and adding redundant braces was not within the scope of this project. The section table does include factors to increase wind area to account for the missing redundant braces.

Automatic Revision Tracking is on. Any changes below this line were added automatically by PLS-Tower.
****

Show Your Work: Project Report

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What?

- Voltage(s)
- Structure Line Angle
- Family/Framing/Grid Managed vs. Single Structure
- Weather Cases
- Load Cases

When?

- When was the line / structure built?
- When was the model created / modified?
- When was LIDAR flown?
- Include model file Revision History

Show Your Work: Project Report

Who?

- Who owns the physical line/ structure?
- Who originally created the model?
- Who is modifying the model?
- Engineer, Checker, Reviewer, Company

Why?

- Why are you creating or modifying this model?
- General use structure, or site specific?
- If site specific, why?

Show Your Work: Project Report

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Other (CADD):

- Any and all Assumptions!
- List of Line Edits with descriptions
- Single or multiple circuits w/ names
- Summary of wire sizes & tensions
- Is stringing from LIDAR and weather at time of survey, or Design RS
- When was LIDAR flown and by whom
- One or multiple LIDAR flights
- Any modifications after LIDAR
- Standard or special weather cases
- What load cases are considered and why

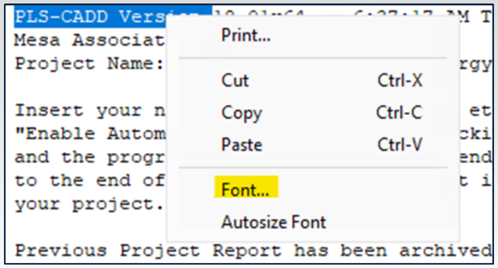
Other (Pole/Tower):

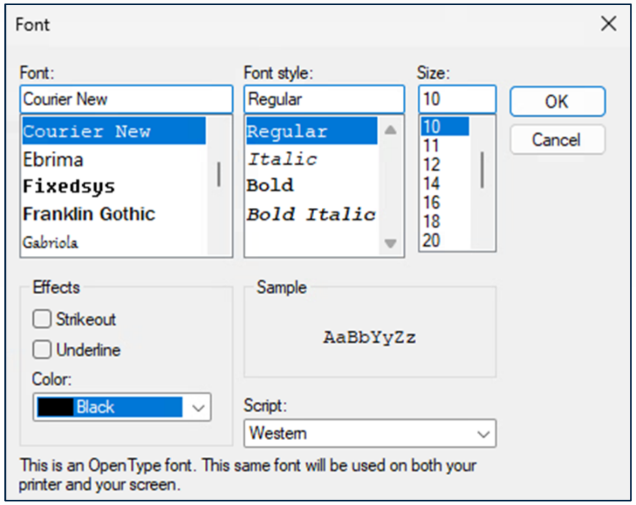
- Any and all Assumptions!!!
- List materials and how you know
  - Are materials known or assumed?
  - If known: Clear on drawings or testing?
  - Assumed: Justify assumptions
- Are all redundant braces modeled?
- Key "General" tab options:
  - % Compression in T-Only?
  - Redundant braces included in analysis?
  - Is Rupture checked, and how?
  - Which design code(s) & edition(s)
- Possibly include calculations
  - Custom Angle properties
  - Section table, rupture, net section
  - Only if short… if complicated use Reference Manager

Show Your Work: Project Report

- **Formatting**
  - Supports “Rich Text” formatting
  - Supports pasting images
  - Select text, right click on selected text, click “Font…”
  - If you right click without any text selected it selects all text automatically

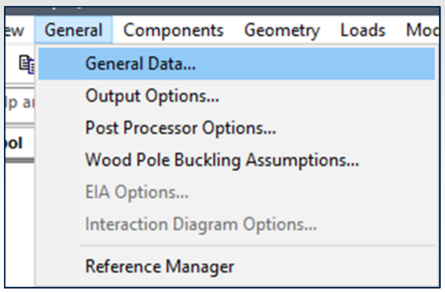
  - **Tip:** Create default formatted templates using MS Word (or similar) then copy-paste into the Project Report

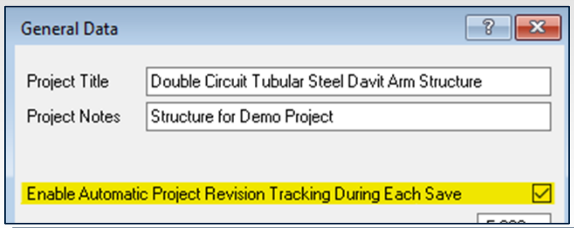


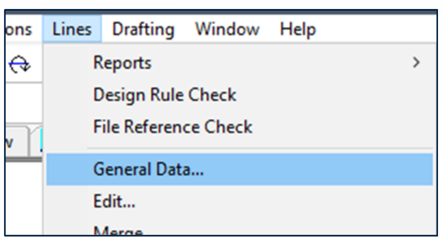


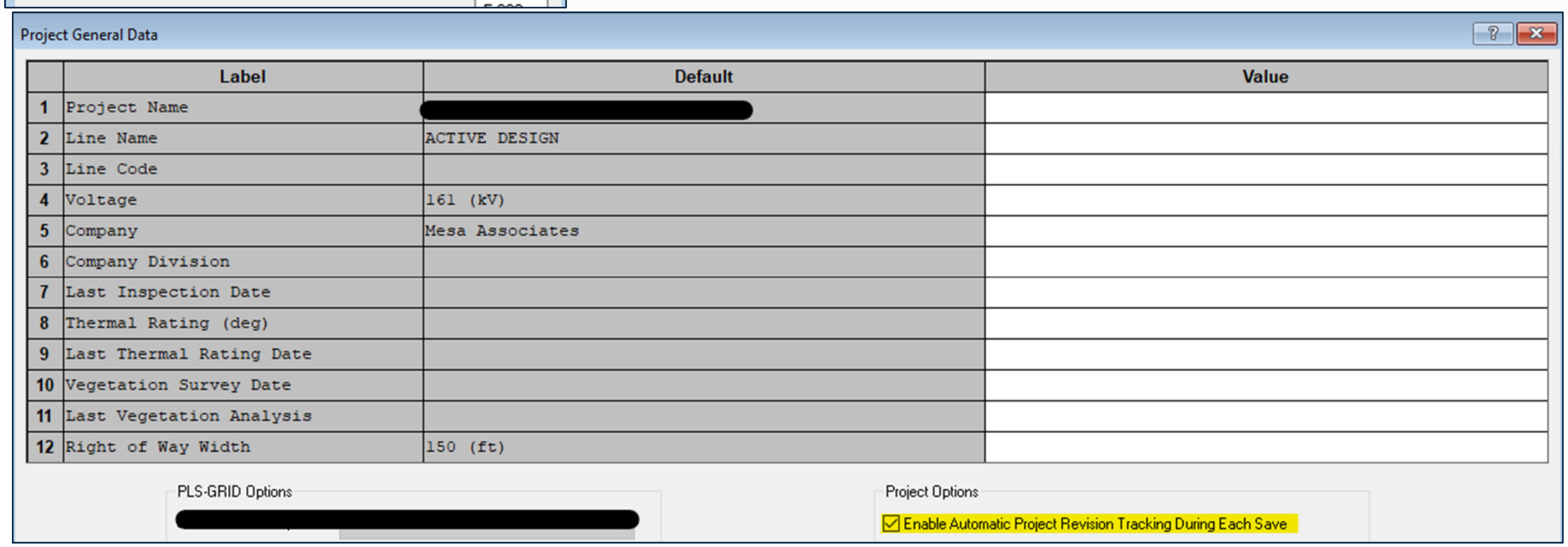
Show Your Work: Project Report

Enable Automatic Project Revision Tracking: Highly recommended!









Showing Your Work in PLS

I. **Show Your Work!**
- Component Library Notes
- Criteria Notes
- Project Report
- Reference Manager

Show Your Work: Reference Manager

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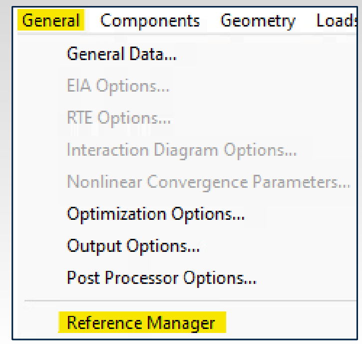
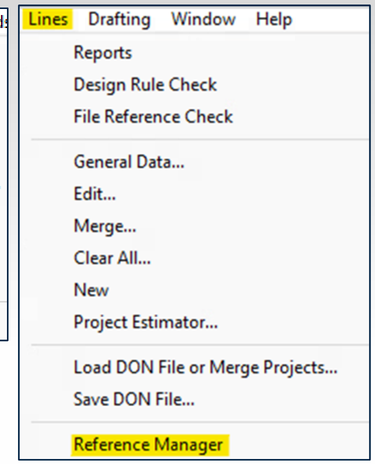
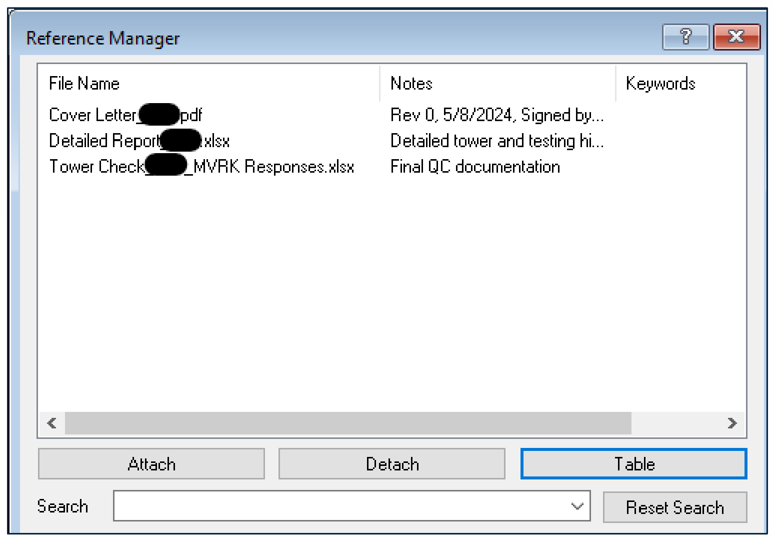
- **Different from "Attachment Manager"**
- **Any file type may be attached**
- **Examples:**
  - Cover Letter (EOR Stamp)
  - External Calculations
    - Strength, Component Properties
  - Sketches
  - Fabrication Drawings
    - Partial if too big
  - QC Documentation
  - Automatic Revision History







Doing the Work with PLS

I. Show Your Work!

- Component Library Notes
- Criteria Notes
- Project Report
- Reference Manager

II. Do the work!

- Manual Calcs: Exporting Data
- Foundation
- Dead Loads & Drag Areas
- Connections and Anchors (CAN)
- Capacities and Overrides
- Rupture
- Quality Control Checks

No Red = OK!.... Right?

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Why bother?

- **Structure Check -> No Red? Yay! -> Move on**

- **Many pole models only accurately model the tubes, but often other things "control"**

- **Lattice Towers are complex 3-Dimensional structures**
  - Full-scale testing often reveals unexpected failure points
  - Framing eccentricities can have a *huge* effect on strength
  - **The only loads that you *know* work are the full-scale test loads**

- **If you don't locate the weak spot gravity *WILL* do it for you**

No Red = OK!.... Right?

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Item	Pole	Tower	ASCE 48-19	ASCE 10-15
Vang tear-out	X	X	Sec. 6.2.7	Sec. 4.6, C4.6
Anything welded	X	X	Sec. 6.3	
Foundation capacity	X	X		
Concrete anchorage	X	X	Sec. 9.3, App. D	Sec. 7.4-7.6
Bolts combined Tens. and Shear	X	X	Sec. 6.2.4	Sec. 4.3.4
Bolt spacing, end dist., edge dist[1]		X		Sec. 4.5
Block Shear[1]		X		Sec. 3.10.2
Bending / Moment		X		Sec. 3.12-3.14, Comm.
Non-standard shapes		X		Sec 3.8-3.9
Anything not steel		X		
Component Connections	X		Sec. 6.2, App. H	
Some Holes in Tubes	X		???	
Baseplate capacity[2]	X		App. F, I, J	

Notes:

1. Can be checked using “Rupture”, sometimes.
2. Can be checked, but method is limited to the version in the Appendices of the referenced version of ASCE 48. This is the “bend line” method for -05 and the “Wedge” method for -11 and -19. Many fabricators use their own proprietary baseplate design methods.

No Red = OK!.... Right?

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Item	Pole	Tower	Solution?
Vang tear-out	X	X	CAN
Anything welded	X	X	CapOver or CAN
Foundation capacity	X	X	Foundation or CAN
Concrete anchorage	X	X	Foundation or CAN
Bolts in combined Tens. and Shear	X	X	CapOver or CAN
Bolt spacing, end dist., edge dist		X	Rupture, CapOver or CAN
Block Shear		X	Rupture, CapOver or CAN
Bending / Moment		X	CAN?
Non-standard shapes		X	CapOver or CAN
Anything not steel		X	CapOver
Component Connections	X		CAN
Some Holes in Tubes	X		Manual
Baseplate capacity	X		Baseplate, Foundation, or CAN

No Red = OK!…. Right?

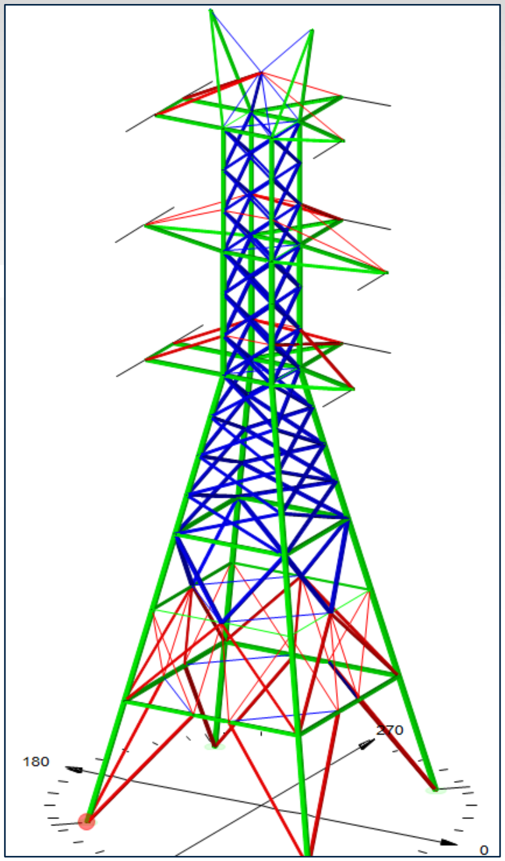
- **Bending moment in Tower: NOT CHECKED under ASCE 10!**
  - X and Y Bending moments now respect Beta angle
  - Belgian NNA code DOES check bending stress

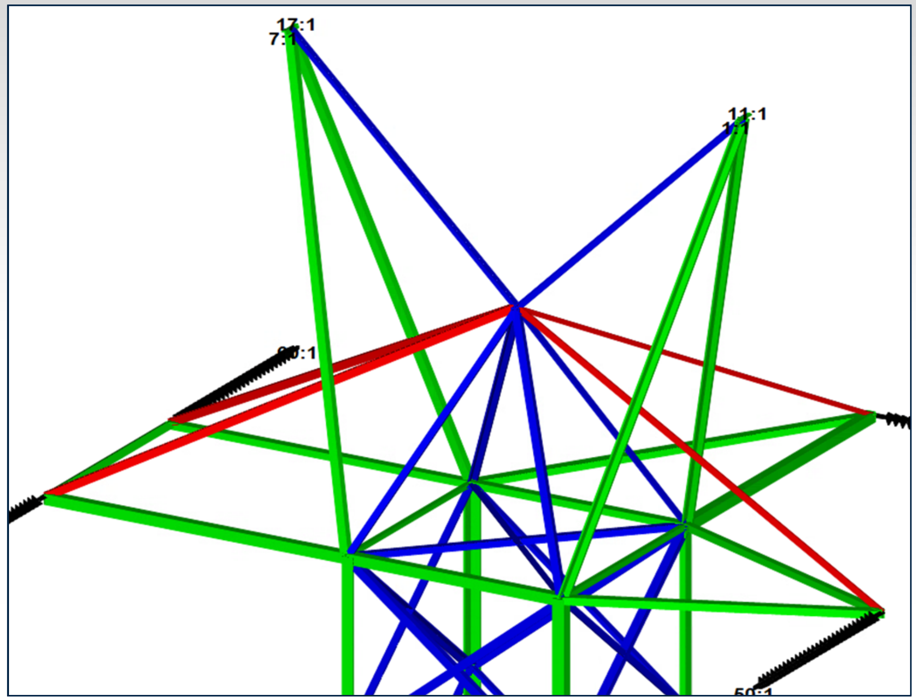
- **ASCE 10: Any load resisted by bending is**
  - Excessive Moment Warning

- **The effect of beams is minimal in a well-triangulated tower**

- **Beams in a poorly-triangulated tower can mask a critical modeling error**

No Red = OK!…. Right?





Doing the Work with PLS

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I. **Show Your Work!**
- Criteria Notes
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II. **Do the work!**
- Manual Calcs: Exporting Data

Doing the Work with PLS

- **Copy-paste from tables to a spreadsheet**
  - Output Report: Right click in report, "Table View"
  - Left click upper-left cell
  - "Copy" or "Copy with Column and Row Headings"

- **XML Export**
  - Output Reports or "Input Echo" report
  - Right click in report -> XML Export
  - Individual tables from a report or "Export All"

- **Direct data mining**
  - All PLS files are basic text
  - Not suggested unless you know what you are doing

Doing the Work with PLS

I. **Show Your Work!**
- Criteria Notes
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II. **Do the work!**
- Manual Calcs: Exporting Data
- Foundation

No Red = OK? Foundations

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Everyone **designs foundations, baseplates, concrete anchorage, etc. to the max capacity of the structure… right?**

- **Unless the owner wants to save money:**

A Foundation Cost Comparison: Alternate Methods of Specifying Loads for the Design of Rigid Base Tower Foundations

For [redacted] 500kV transmission line, the estimated foundation costs made up 21% of the total estimated construction cost for the entire project. Although [redacted] has historically designed foundations using the tower's ultimate design loads, this was identified as an area of potentially significant cost savings. With sophisticated transmission line design software and minimal additional effort by the engineer, the foundations could, in effect, be optimized when designed using site or leg specific tower loads.

No Red = OK? Foundations

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***Everyone* designs foundations, baseplates, concrete anchorage, etc. to the max capacity of the structure… right?**

- **Unless strength doesn't control the structure design:**

160-ft 2/c DE Monopole, 105.25" B.C.
Anchor for major crossing span
High-visibility, high traffic location
Maximum Design Data GLM = 10,655 ft-kip
Design was controlled by deflection limits
Maximum Design Data Pole Stress = 27.9%

NOTES:

1. MAXIMUM DESIGN REACTION AT BASE (INCLUDES 1 OLF).
MAXIMUM MOMENT TAKEN FROM 50% POLE MOMENT CAPACITY.
MAXIMUM FORCES TAKEN FROM BACK SPAN DEAD-END GO-95 LIGHT LOAD.

	TRAN-X	LONG-Y	AXIAL-Z
MOMENTS (FtKips)	0.0	14646.0	0.0
FORCES (Kips)	22.49	46.8	94.35
RESULTANT MOMENTS:	14646.0	FtKips	

No Red = OK? Foundations

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- **Pole: Geometry -> Miscellaneous -> Foundation Strength**
- **Tower: Geometry -> Foundation Strength**

Foundation Strength

	Restrained Joint Label	Long. Shear Capacity (lbs)	Trans. Shear Capacity (lbs)	Horz. Shear Capacity (lbs)	Comp. Capacity (lbs)	Uplift Capacity (lbs)	Resultant Capacity (lbs)	Trans. Moment Capacity (ft-lbs)	Long. Moment Capacity (ft-lbs)	Bending Moment Capacity (ft-lbs)	Torsional Moment Capacity (ft-lbs)	Long. Stiffness (lbs/ft)	Trans. Stiffness (lbs/ft)	Vertical Stiffness (lbs/ft)	Long. Rotational Stiffness (ft-lbs/deg)	Trans. Rotational Stiffness (ft-lbs/deg)	Vertical Rotational Stiffness (ft-lbs/deg)	Run CAISSON Design and Analysis
1	P1:g	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	No

- **Round Conc. Pier: Horiz. Shear, Compression, Uplift, Moment Capacities**

- **If you add Foundation Strength: Show Your Work!**

No Red = OK? Baseplates

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- **Added as part of pole definition**

Steel Pole Property Label	Stock Number	Length (ft)	Default Embedded Length (ft)	Base Plate	Shap
DE-135		135.00		Edit (6 bolts)	12T

- **Design limited to commentary in code specified in General tab**
- **Current code doesn't do well with clustered anchor bolts**
- **Many vendors qualify baseplates with their own testing**

Base Plate - [DE-135]

Enter 0 for the thickness if you want the program to design your base plate; otherwise, it will check the plate with the thickness you input.

Plate shape		12T	Steel density (lbs/ft^3)	490
Plate diameter	(in)	75.5	Bolt pattern diameter (in)	69.5
Hole shape		122	Bolt diameter (in)	2.25
Hole diameter	(in)	55	Plate steel yield stress (ksi)	50
Plate thickness (if 0 program will determine by ASCE/SEI 48)			(in)	3
Bend line length override			(in)	0

Enter the coordinates (like you describe a steel shape) or the angle of the anchor bolts in a single quadrant. The program assumes the pattern is doubly symmetric and will multiply these coordinates by the bolt pattern radius (1/2 the diameter above).

	Bolt X Coord.	Bolt Y Coord.	Bolt Angle (deg)
1	0	0	0
2	0	0	18
3	0	0	36
4	0	0	54
5	0	0	72
6	0	0	90
7			

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- Dead Loads & Drag Areas

Features: Dead Loads & Drag Areas

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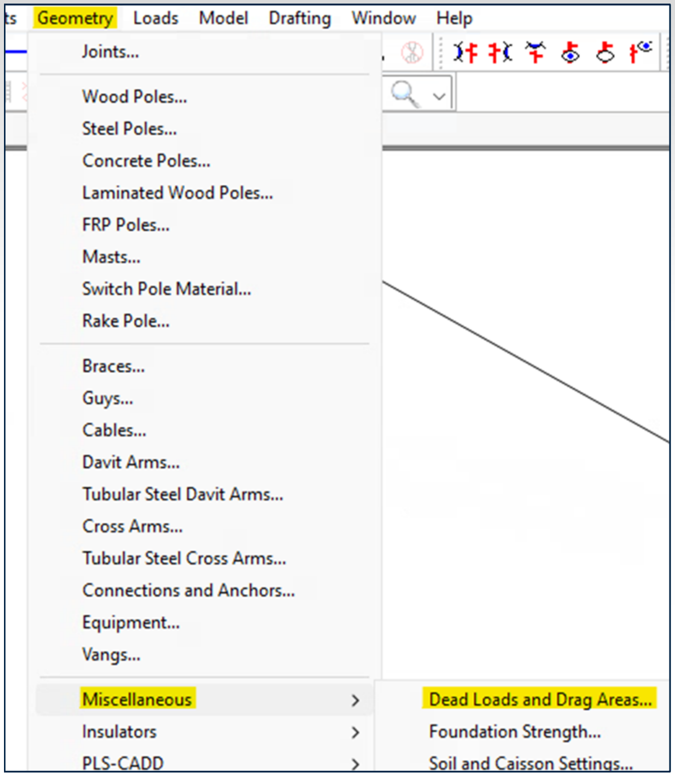
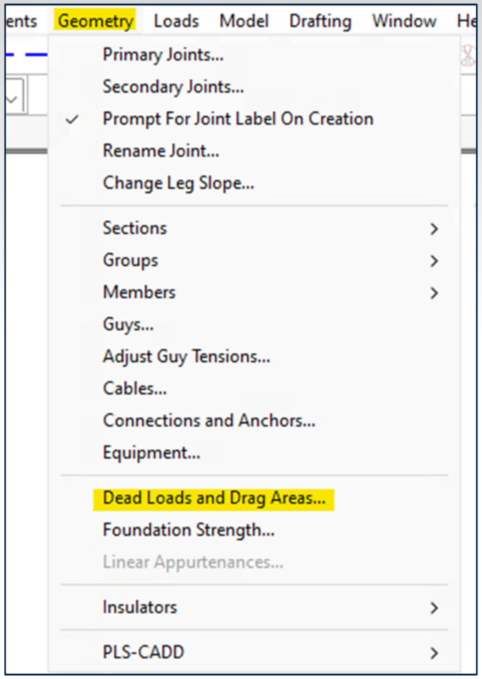
- **Used to add point weights and wind areas**
  - More precise than modifying the Sections table
  - Similar to the Equipment Library, but more flexible
- **Example uses**
  - Ladders, stairs, platforms
  - Signs, solar panels, lights
  - Antennas / “Joint Use” attachments
- **Are part of the base model**
  - Can complicate Tower Family Managed models
  - Must take care if redundants are excluded from FEA model
- **If DL&DA are added to a model: Show Your Work!**

Features: Dead Loads & Drag Areas





Dead Loads and Drag Areas

	Load Point Label	Attach Point	Vertical Dead Load (kips)	Transverse Wind Area (ft^2)	Longitudinal Wind Area (ft^2)
1	Sign	11S	0.253	4	0.68
2					
3					

Show Your Work!

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II. **Do the work!**
- Manual Calculations
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- Dead Loads & Drag Areas
- Connections and Anchors (CAN)

Features: Connections and Anchors

- **Used to establish strength of manually calculated or test-verified properties**
  - Vangs
    - Tear-out strength
    - Limit a M4 model to full-scale test loads
  - Pole arm connections
  - Bolts in combined tension/shear
  - Multi-member connections
  - Swing bracket attachments
  - Non-axial forces in Tower
  - Many other possibilities

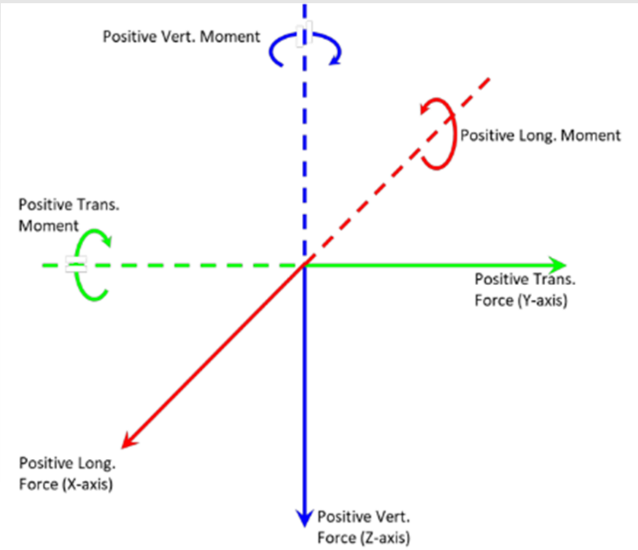


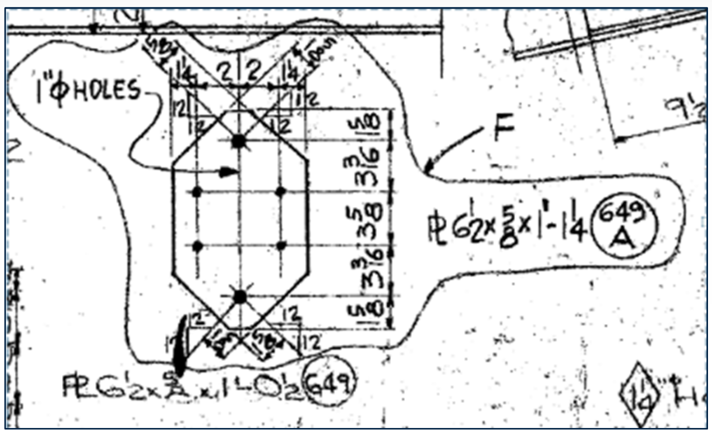
Figure 3.7-1 CAN Coordinate System

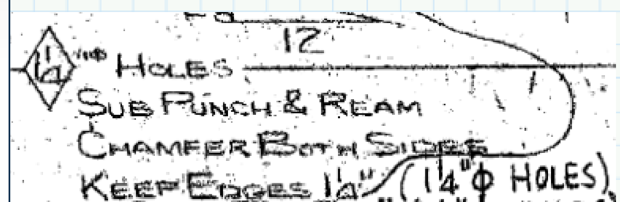
Features: Connections and Anchors

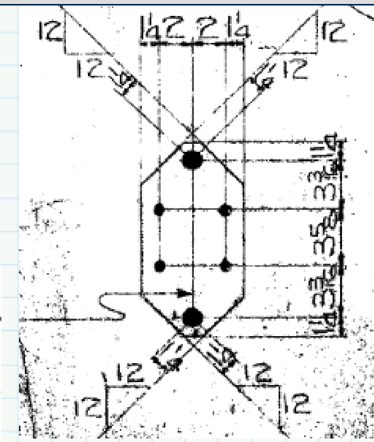
- **Component Library must be defined first**
  - Moment Capacities only usable in Pole
- **Assign Labels so failure is easily identified**
- **Multiple CANs may be required to check a single point**
- **Provide Ultimate Strength, then Strength Factor**
- **If you create a CAN: Show Your Work!**

Features: Connections and Anchors

Vang Tearout: Manual Calc







$L := 1.25\ in$ $\quad d_h := 1.25\ in$ $\quad F_u := 60\ ksi$

$t := 0.625\ in$ $\quad d := 1.0\ in$ $\quad C_h := 0.125\ in$

$$P_T := 0.75 \cdot \left(L - 0.5\ d_h - \frac{2 \cdot C_h^{\ 2}}{t} \right) t \cdot F_u = 16.172\ kip$$

$$P_B := 1.35 \cdot d \cdot (t - 2 \cdot C_h) \cdot F_u = 30.375\ kip$$

$$P := min(P_T, P_B) = 16.172\ kip$$

Features: Connections and Anchors

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Engineers and Consultants

Vang Tearout CAN

CAN roperty Labe	Stock Number	Strength Factor	Strength Check	Resultant Capacity (kips)	Long. Shear Cap. (kips)	Tran. Shear Cap. (kips)	Vert. Shear Cap. (kips)	Long. Pos. Cap. (kips)	Long. Neg. Cap. (kips)	Tran. Pos. Cap. (kips)	Tran. Neg. Cap. (kips)	Vert. Pos. Cap. (kips)	Vert. Neg. Cap. (kips)	M-Long. Pos. :apacity (ft-k)	M-Long. Neg. :apacity (ft-k)	M-Tran. Pos. Capacity (ft-k)	M-Tran. Neg. :apacit (ft-k)	M-Vert. Pos. :apacit (ft-k)	M-Vert. Neg. :apacit (ft-k)
Vang566		Steel	Independent	16.172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vang624		Steel	Independent	16.172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vang650		Steel	Independent	16.172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CAN Label	Attach Label	CAN Property Set	Azimuth (deg)	zimuth/Connect Member Type	Azimuth/Connect1 Member Label	Connect2 Member Type	Connect2 Member Label	Connect3 Member Type	Connect3 Member Label	Connect4 Member Type	Connect4 Member Label	Connect1 Insulator Type	Connect1 Insulator Label
Vang-ShldB	4TS	Vang566	0									Strain	1-1
Vang-ShlA	4TS	Vang566	0									Strain	11-1
Vang-ShldT	4P	Vang566	0									Strain	26-1
Vang-ShldB2	4P	Vang566	0									Strain	12-1
Vang-CTLB	7P	Vang624	0									Strain	3-1
Vang-CTLA	7P	Vang624	0									Strain	13-1

Features: Connections and Anchors

Mesa Associates, Inc.
Engineers and Consultants

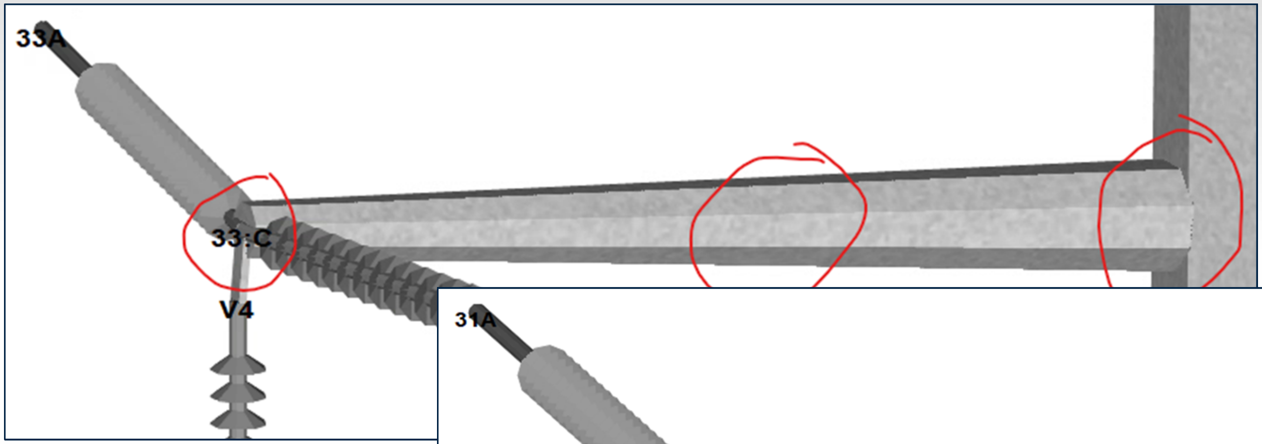
Vang: Original Design Data Loads

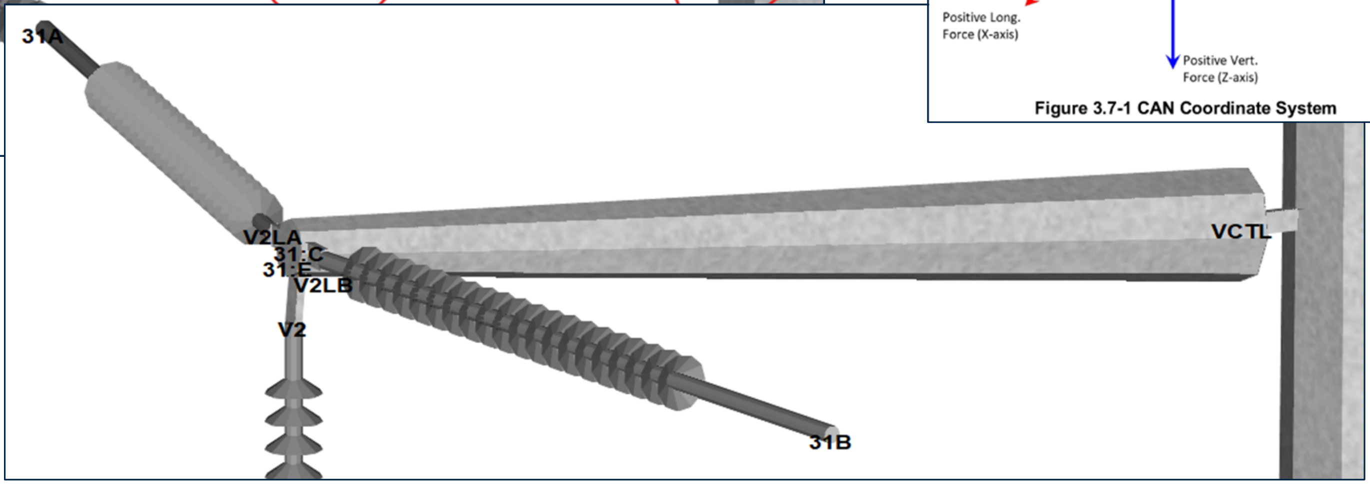
	CAN Property Label	Stock Number	Strength Factor	Strength Check	Resultant Capacity (kips)	Long. Shear Cap. (kips)	Tran. Shear Cap. (kips)	Vert. Shear Cap. (kips)	Long. Pos. Cap. (kips)	Long. Neg. Cap. (kips)	Tran. Pos. Cap. (kips)	Tran. Neg. Cap. (kips)	Vert. Pos. Cap. (kips)	Vert. Neg. Cap. (kips)	M C
1	Cond_Long		Steel	Independent	0	0	0	0	0.5	0.5	0	0	0	0	
2	Cond_Trans		Steel	Independent	0	0	0	0	0	0	9.75	9.75	0	0	
3	Cond_Vert		Steel	Independent	0	0	0	0	0	0	0	0	22.5	22.5	
4	Shld_Long		Steel	Independent	0	0	0	0	0.5	0.5	0	0	0	0	
5	Shld_Trans		Steel	Independent	0	0	0	0	0	0	1.5	1.5	0	0	
6	Shld_Vert		Steel	Independent	0	0	0	0	0	0	0	0	2.55	2.55	

<u>Note:</u> Currently can only be attached to a structure joint, so doesn't work with V-Strings or chained insulators

Features: Connections and Anchors

Pole / Arm Connection





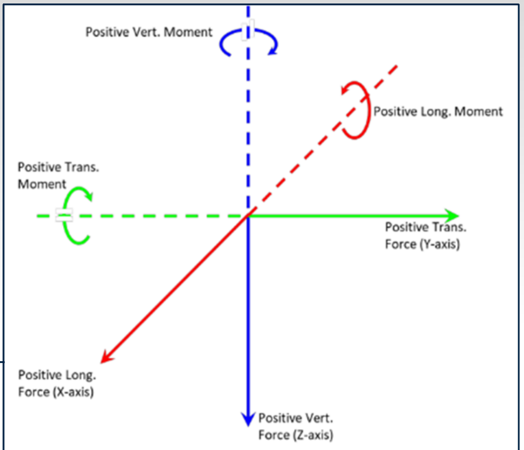


Figure 3.7-1 CAN Coordinate System

Features: Connections and Anchors

Pole / Arm Connection

CAN Property Label	Stock Number	Strength Factor	Strength Check	Resultant Capacity (kips)	Long. Shear Cap. (kips)	Tran. Shear Cap. (kips)	Vert. Shear Cap. (kips)	Long. Pos. Cap. (kips)	Long. Neg. Cap. (kips)	Tran. Pos. Cap. (kips)	Tran. Neg. Cap. (kips)	Vert. Pos. Cap. (kips)	Vert. Neg. Cap. (kips)	M-Long. Pos. Capacity (ft-k)	M-Long. Neg. Capacity (ft-k)	M-Tran. Pos. Capacity (ft-k)	M-Tran. Neg. Capacity (ft-k)	M-Vert. Pos. Capacity (ft-k)	M-Vert. Neg. Capacity (ft-k)
12ftArmConn		Steel	Interaction	0	0	0	0	0	0	0	0	0	0	150	150	0	0	200	200

CAN Label	Attach Label	CAN Property Set	Azimuth (deg)	Azimuth/Connect1 Member Type	Azimuth/Connect1 Member Label
12ftBrkt_Lt	VCTL	12ftArmConn		Tubular Davit	41
12ftBrkt_Rt	VCTR	12ftArmConn		Tubular Davit	41

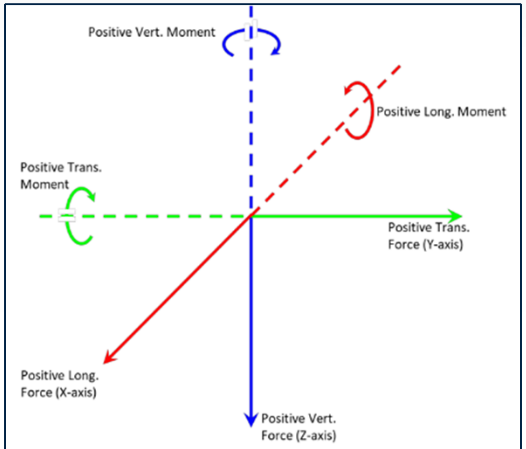
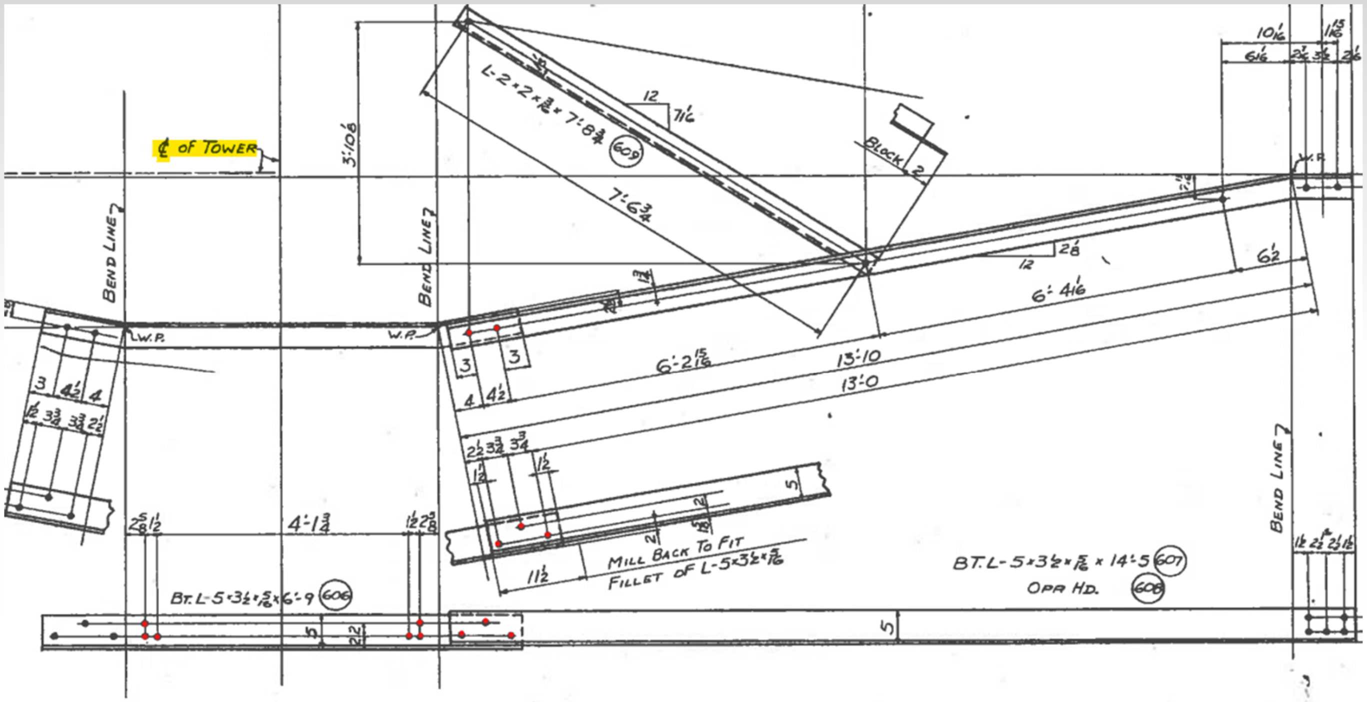


Figure 3.7-1 CAN Coordinate System

Arm is along Positive Trans axis (Green Arrow)

- M-Long: From Vertical Load
- M-Trans: Torsion
- M-Vert: From Longitudinal Load

Features: Connections and Anchors



MIDDLE CROSS ARM

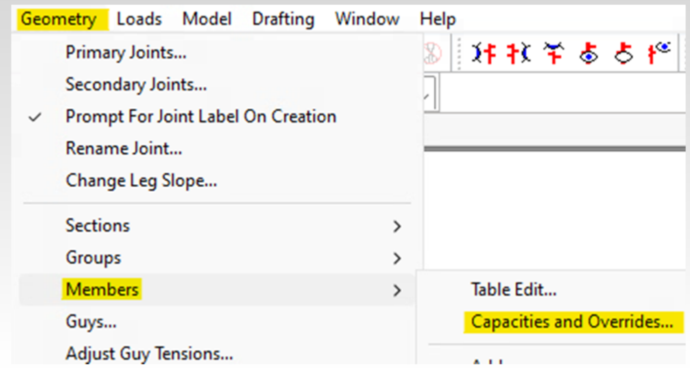
Doing the Work in PLS

I. **Show Your Work!**
- Component Library Notes
- Criteria Notes
- Project Report
- Reference Manager

II. **Do the work!**
- Manual Calcs: Exporting Data
- Foundation
- Dead Loads & Drag Areas
- Connections and Anchors (CAN)
- Capacities and Overrides

Features: Capacities and Overrides

- **Only checks axial forces**
- **Required if Tower cannot calculate capacities**
  - Rupture, if Rupture isn't checked
  - Non-Standard Shapes
  - Anything not Steel
  - Welded connections
  - Axial load limited by bending



Features: Capacities and Overrides

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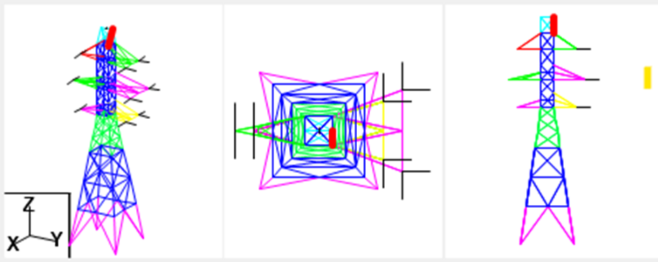
Member Capacities and Overrides




```
Model Check Report

No errors or relevant warnings detected.
```

	Member Label	Group Label	Design Comp. Capacity (kips)	Comp. Control Criterion	Des Ten Cap (ki	Override Comp. Capacity (kips)	Override Comp. Capacity Unsup. (kips)	Override Comp. Control Criterion	Override Tension Capacity (kips)	Override Tension Control Criterion	Override Face Member ship	Override Climbing Status	Override Climbing Load (lbs)	Override RL Climb	Heuristic Beta (deg)	Override Beta (deg)	Note	
143	674P	674	21.6888	L/r		9.3	NA		19.9		Trans.	Automatic	0	0	180	0	Limit to test load	Rupt
144	674Y	674	21.6888	L/r		9.3	NA		19.9		oth	Automatic	0	0	270	0	Limit to test load	Rupt
145	677P	677	20.9165	L/r	2	0	NA		0	Net Sect	rans.	Automatic	0	0	180	0		
146	677Y	677	20.9165	L/r	2	0	NA		0	Shear Bearing	rans.	Automatic	0	0	180	0		
147	65-2P	65-2	38.9216	L/r	41.	0	NA		0	Rupture RTE End	rans.	Automatic	0	0	270	0		
148	65-2Y	65-2	38.9216	L/r	41.	0	NA		0	RTE Edge	oth	Automatic	0	0	180	0		
149	65-2AP	65-2	38.9216	L/r	41.	0	NA		0		Automatic	Automatic	0	0	180	0		
150	65-2AY	65-2	38.9216	L/r	41.	0	NA		0		Automatic	Automatic	0	0	270	0		
151	615P	615	).0885752	L/r	11.	0	NA		0		Trans.	Automatic	0	0	188.314	0		
152	615Y	615	).0885752	L/r	11.	0	NA		0		Both	Automatic	0	0	261.686	0		

Features: Capacities and Overrides

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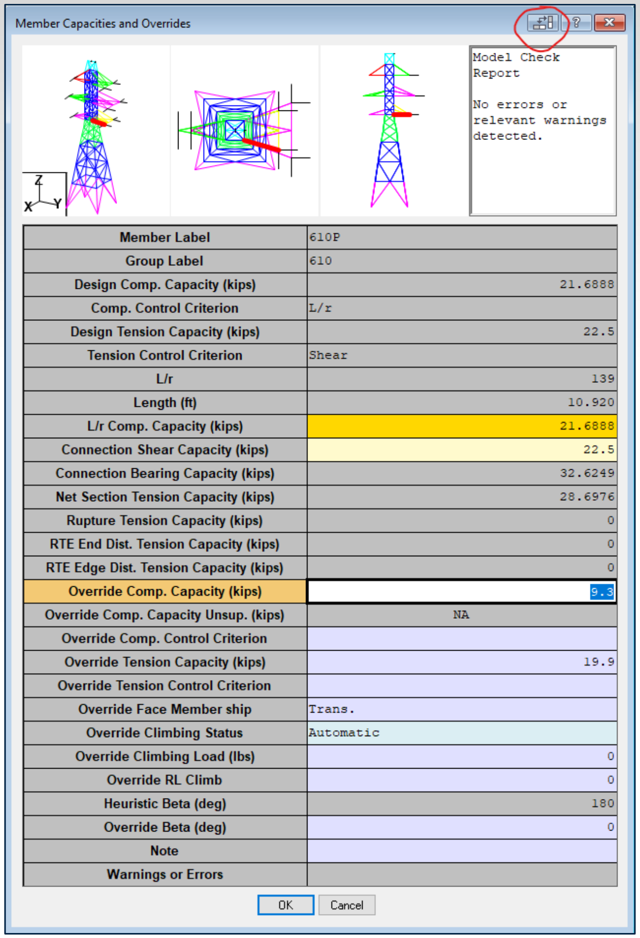
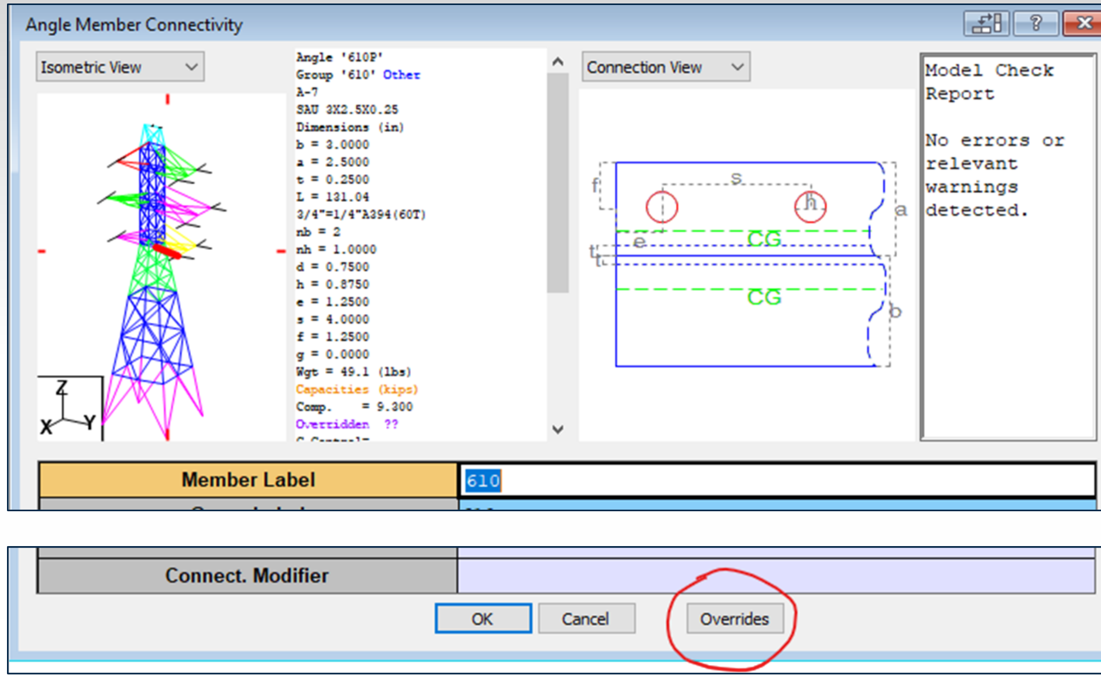


Member Label	610P
Group Label	610
Design Comp. Capacity (kips)	21.6888
Comp. Control Criterion	L/r
Design Tension Capacity (kips)	22.5
Tension Control Criterion	Shear
L/r	139
Length (ft)	10.920
L/r Comp. Capacity (kips)	21.6888
Connection Shear Capacity (kips)	22.5
Connection Bearing Capacity (kips)	32.6249
Net Section Tension Capacity (kips)	28.6976
Rupture Tension Capacity (kips)	0
RTE End Dist. Tension Capacity (kips)	0
RTE Edge Dist. Tension Capacity (kips)	0
Override Comp. Capacity (kips)	9.3
Override Comp. Capacity Unsup. (kips)	NA
Override Comp. Control Criterion	
Override Tension Capacity (kips)	19.9
Override Tension Control Criterion	
Override Face Member ship	Trans.
Override Climbing Status	Automatic
Override Climbing Load (lbs)	0
Override RL Climb	0
Heuristic Beta (deg)	180
Override Beta (deg)	0
Note	
Warnings or Errors	

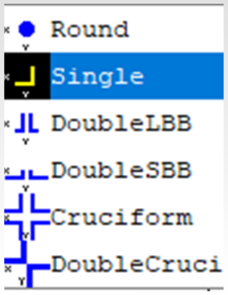
OK Cancel

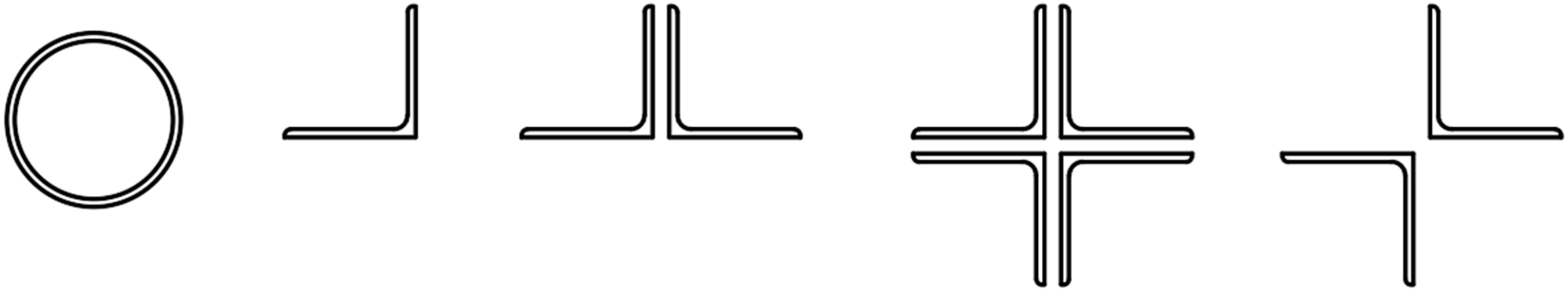


<u>Note:</u> This version ONLY edits the "Primary" member. Click the Transpose button to update members created by symmetry.

Features: Capacities and Overrides

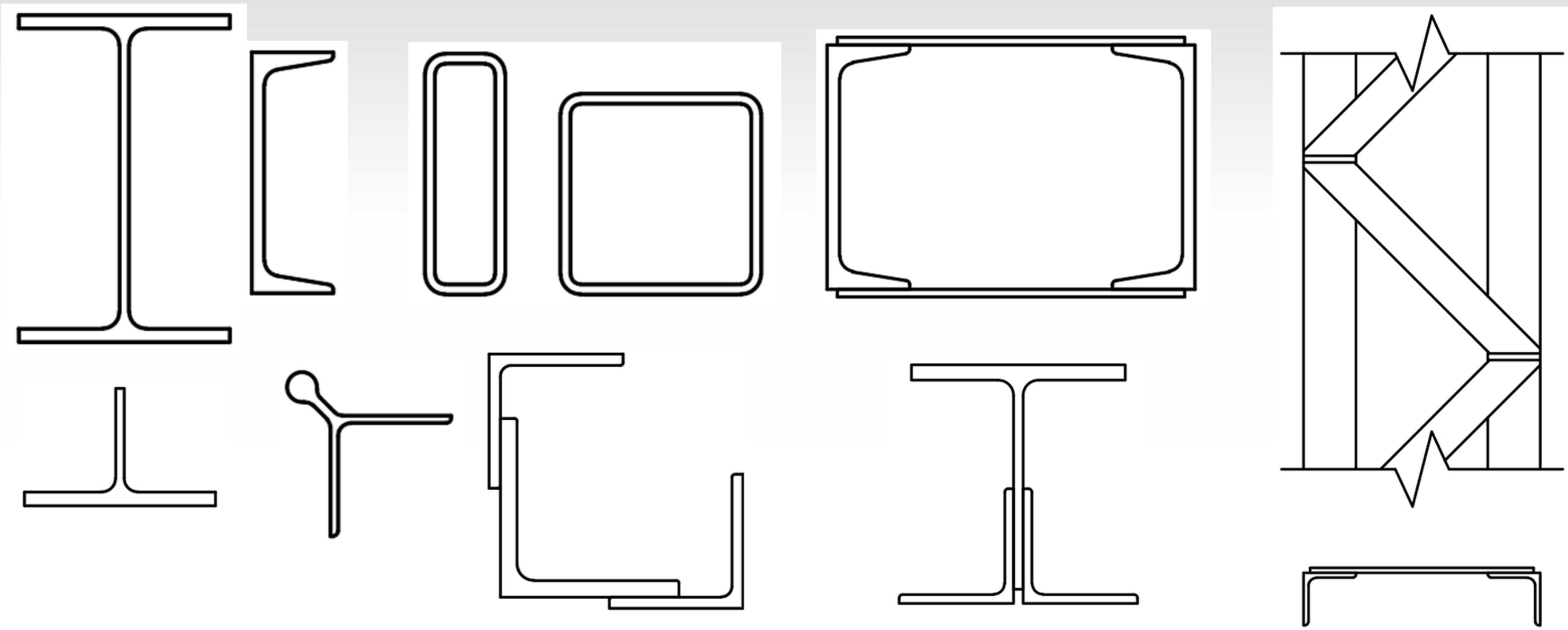
Tower can only calculate strengths using these shapes





Features: Capacities and Overrides

Tower CANNOT calculate strengths of these shapes:



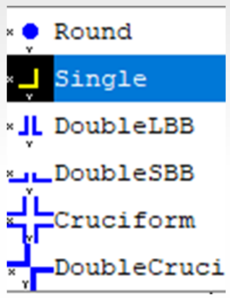
Features: Capacities and Overrides

With the excluded shapes, Tower CANNOT calculate strengths of:

- **L/r Buckling**
- **Rupture**

If varying thicknesses:

- **Net Section**
- **Bolt Bearing**



Tower CAN calculate:

- **Bolt Shear**

Features: Capacities and Overrides

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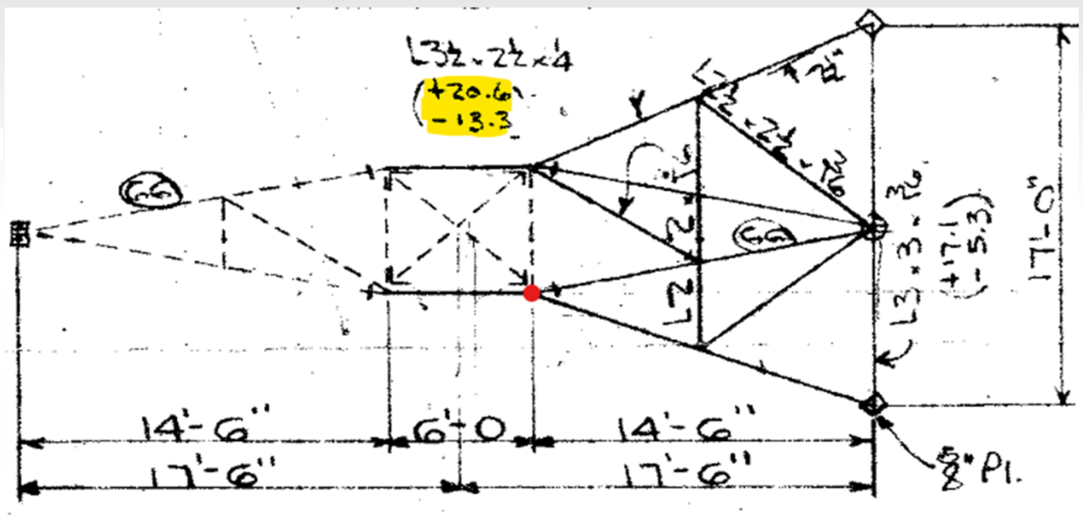
Limit load to original design value



SECTION B-B

```
Capacities (kips)
Comp.      = 17.983
C-Control= L/r
Tension    = 22.500
T-Control= Shear
```

Features: Capacities and Over Rides

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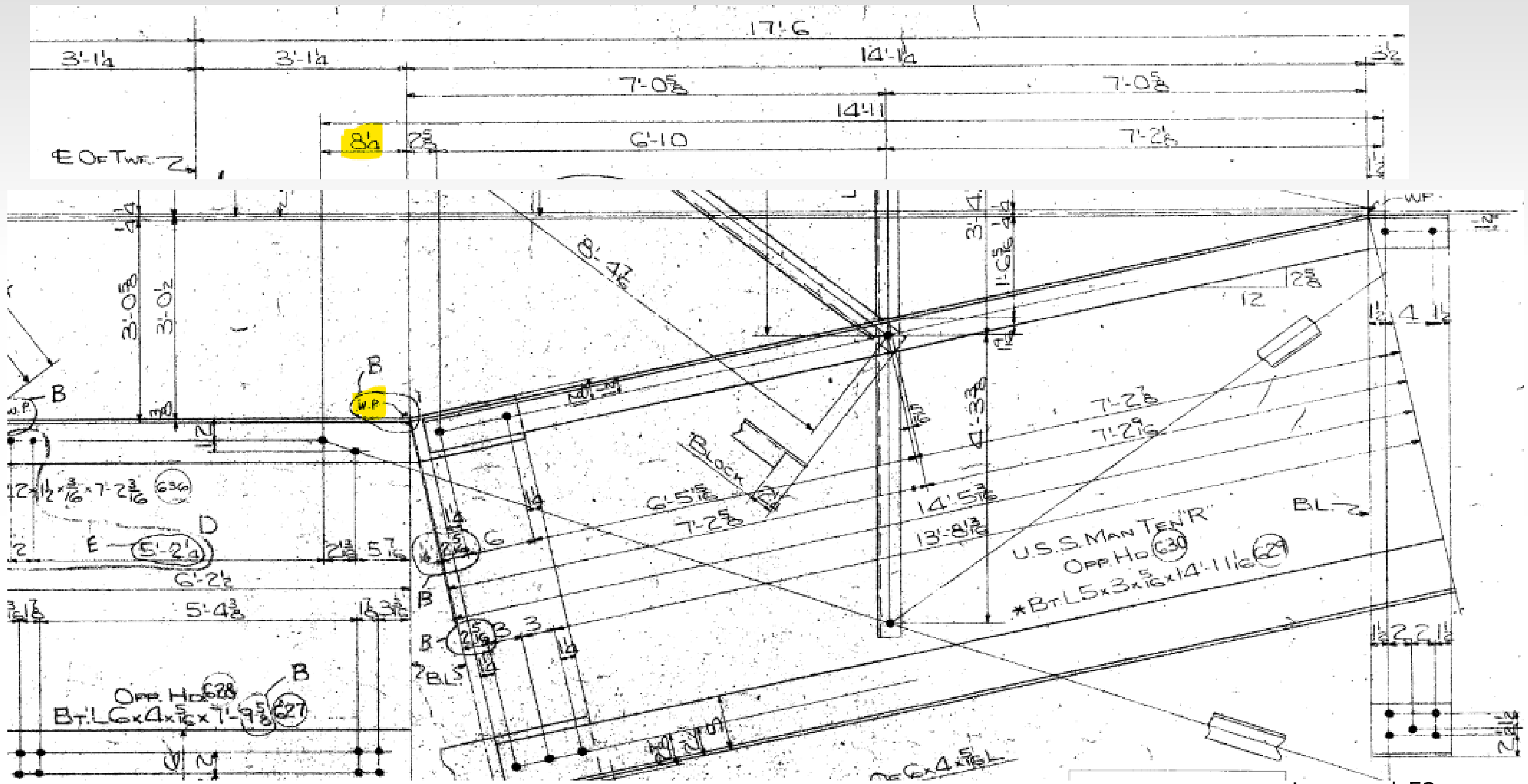
Limit load to original design value



Features: Capacities and Overrides

If you override the capacities, face membership, or heuristic beta of any members…

Show Your Work!

Doing the Work in PLS

Mesa Associates, Inc.
Engineers and Consultants

I. **Show Your Work!**
- Criteria Notes
- Project Report
- Reference Manager

II. **Do the work!**
- Manual Calculations
- Foundation
- Dead Loads & Drag Areas
- Connections and Anchors (CAN)
- Capacities and Overrides
- Rupture

Features: Rupture

Mesa Associates, Inc. Engineers and Consultants

- **More than just Block Shear**
- **End Distance, Edge Distance, Bolt Spacing**
  - Current ASCE 10 requires reducing the strength of ALL bolts if any ONE bolt is too close to the end, edge, or another bolt
  - Can be entered as default values in the Angle and Bolt libraries
  - If short edge distance is entered into both bolt and angle tables, the angle table value is used.

Bolt Label	Bolt Diameter (in)	Hole Diameter (in)	Ultimate Shear Capacity (kips)	Default End Distance (in)	Default Bolt Spacing (in)	Shear Capacity Hyp. 1 (kips)	Shear Capacity Hyp. 2 (kips)	Ultimate Stress Fub (ksi)	Short Edge Dist. (in)

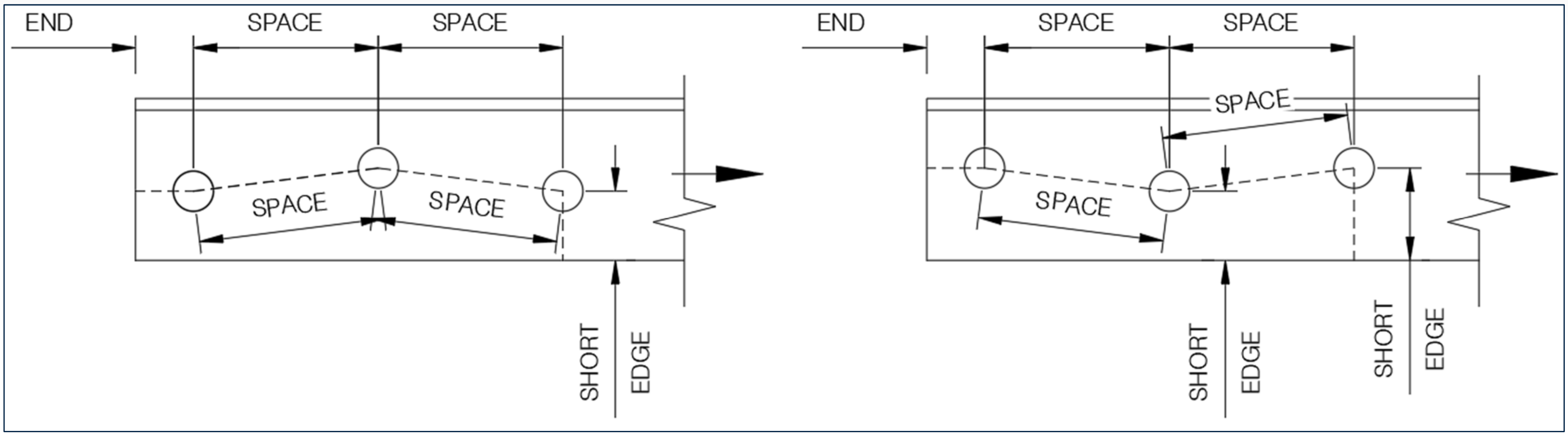
Angle Type	Angle Size	Long Leg (in)	Short Leg (in)	Thick. (in)	Unit Weight (lbs/ft)	Gross Area (in^2)	w/t Ratio	Radius of Gyration Rx (in)	Radius of Gyration Ry (in)	Radius of Gyration Rz (in)	Angle Cross Section	Wind Width (in)	Short Edge Dist. (in)	Long Edge Dist. (in)

Features: Rupture

"Single" gage line

- **Tower can handle**
  - Multiple gages requires entering Shear and Tension path lengths

Short Edge Dist. (in)	1.5
Long Edge Dist. (in)	0
End Dist. (in)	1.25
Bolt Spacing (in)	2.6875
Shear Path Length (in)	0
Tension Path Length (in)	0
Rest. Coef.	0

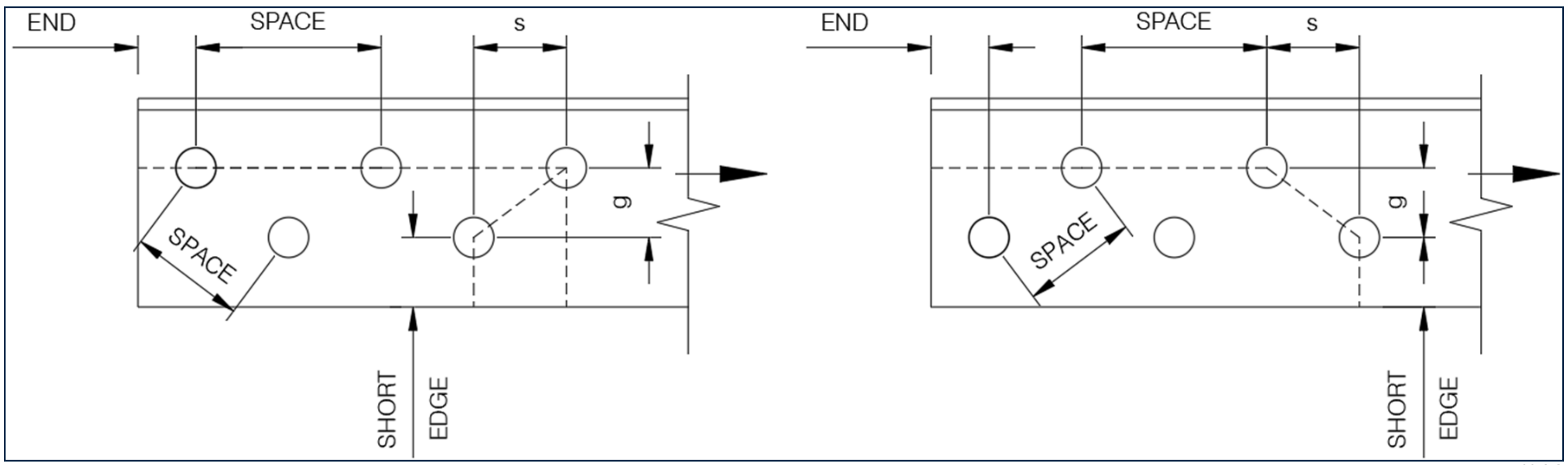


Features: Rupture

Multiple gage lines: Regular

- ***<u>MUST</u>*** **enter Shear and Tension Path Length values**
  - These must be manually calculated

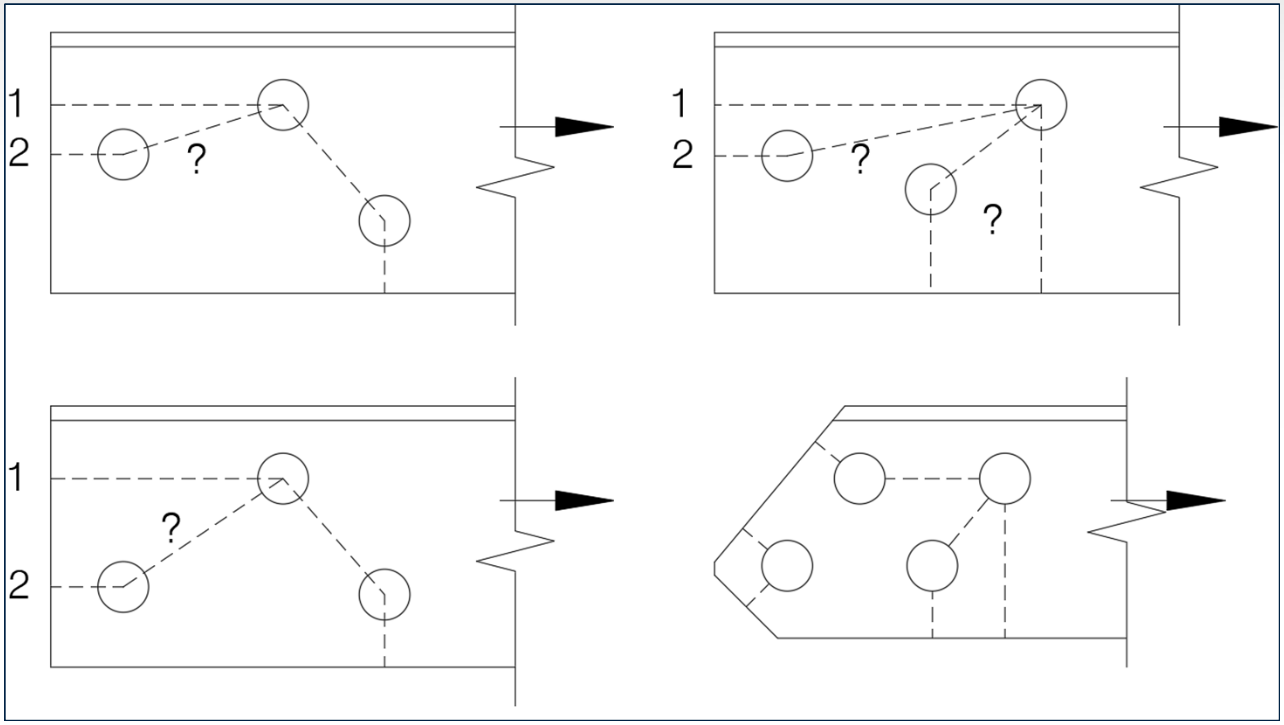
- **For "sloped" tension segments use net section modification:**
  - Horizontal distance, minus extra bolt hole, plus (s^2/4g)
  - For left condition, also check straight horizontal path without hole



Features: Rupture

Multiple gage lines: The really fun ones

- **Engineering judgement, and VPL and TPL are required**



Doing the Work in PLS

Mesa Associates, Inc.
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I. Show Your Work!

- Component Library Notes
- Criteria Notes
- Project Report
- Reference Manager

II. Do the work!

- Manual Calcs: Exporting Data
- Foundation
- Dead Loads & Drag Areas
- Connections and Anchors (CAN)
- Capacities and Overrides
- Rupture
- Quality Control Checks

Doing the Work in PLS

Mesa Associates, Inc.
Engineers and Consultants

Every company here has an official QC Procedure, right?

Member Label XML	Member Label	Group Label	Section Label	Symmetry Code	Origin Joint	End Joint	Ecc.	Rest.	Ratio	Ratio	Ratio	Bolt Type	# Bolt	# Bolt H	# Shear P	Connect Leg	Short Edge Di	Long Edge Di	End Dist.	Bolt Spacing	Shear Path Le	Tension Path Le	Rest. Coef.	Connect. Modifi
203iP	203i	203	GWP	XY-Symmetry	2P	10S	1	4	1	1	1	3/4 A394-T0_Punched	6	2	1	Both	0	0	0	0	0	0	0	
203iiP	203ii	203	GWP	XY-Symmetry	10S	100P	1	4	1	1	1	3/4 A394-T0_Punched	2	2	1	Short only	0	0	0	0	0	0	0	
201iP	201i	201	GWP	XY-Symmetry	3P	11S	1	4	1	1	1	3/4 A394-T0_Punched	6	2	1	Both	0	0	0	0	0	0	0	
201iiP	201ii	201	GWP	XY-Symmetry	11S	110P	1	4	1	1	1	3/4 A394-T0_Punched	2	2	1	Short only	0	0	0	0	0	0	0	
207P	207	207	GWP	XY-Symmetry	3P	10S	3	4	1	1	1	3/4 A394-T0_Punched	1	1	1	Long only	0	0	0	0	0	0	0	
209P	209	209	GWP	XY-Symmetry	10S	11S	3	4	1	1	1	3/4 A394-T0_Punched	1	1	1	Long only	0	0	0	0	0	0	0	
210P	210	210	GWP	XY-Symmetry	11S	100P	3	4	1	1	1	3/4 A394-T0_Punched	1	1	1	Long only	0	0	0	0	0	0	0	
211P	211	211	GWP	Across-Rot	2P	10Y	3	4	1	1	1	3/4 A394-T0_Punched	1	1	1	Long only	0	0	0	0	0	0	0	
212P	212	212	GWP	Across-Rot	10Y	10S	3	4	1	1	1	3/4 A394-T0_Punched	1	1	1	Long only	0	0	0	0	0	0	0	
213P	213	213	GWP	Across-Rot	10S	100Y	3	4	1	1	1	3/4 A394-T0_Punched	1	1	1	Long only	0	0	0	0	0	0	0	
205P	205	205	GWP	Across-Rot	3Y	11S	3	4	1	1	1	3/4 A394-T0_Punched	1	1	1	Long only	0	0	0	0	0	0	0	
206P	206	206	GWP	Across-Rot	11S	11Y	3	4	1	1	1	3/4 A394-T0_Punched	1	1	1	Long only	0	0	0	0	0	0	0	
217P	217	217	GWP	Across-Rot	11Y	110P	3	4	1	1	1	3/4 A394-T0_Punched	1	1	1	Long only	0	0	0	0	0	0	0	
218aP	218a	218bm	GWP	XY-Symmetry	2P	3P	1	4	1	1	1	3/4 A394-T0_Punched	0	0	0	Continuous	0	0	0	0	0	0	0	
218bP	218b	218bm	GWP	X-Symmetry	2P	2.5S	1	4	1	1	1	3/4 A394-T0_Punched	0	0	0	Continuous	0	0	0	0	0	0	0	
218cP	218c	218bm	GWP	X-Symmetry	2.5S	2Y	1	4	1	1	1	3/4 A394-T0_Punched	0	0	0	Continuous	0	0	0	0	0	0	0	
218dP	218d	218bm	GWP	X-Symmetry	3P	3.5S	1	4	1	1	1	3/4 A394-T0_Punched	0	0	0	Continuous	0	0	0	0	0	0	0	
218eP	218e	218bm	GWP	X-Symmetry	3.5S	3Y	1	4	1	1	1	3/4 A394-T0_Punched	0	0	0	Continuous	0	0	0	0	0	0	0	
218fP	218f	218bm	GWP	X-Symmetry	2.5S	1P	1	4	1	1	1	3/4 A394-T0_Punched	0	0	0	Continuous	0	0	0	0	0	0	0	
218gP	218g	218bm	GWP	XY-Symmetry	3P	2.5S	1	4	1	1	1	3/4 A394-T0_Punched	0	0	0	Continuous	0	0	0	0	0	0	0	
218hP	218h	218bm	GWP	XY-Symmetry	2P	3.5S	1	4	1	1	1	3/4 A394-T0_Punched	0	0	0	Continuous	0	0	0	0	0	0	0	
254iP	254i	254	XARM	XY-Symmetry	200P	240S	1	4	1	1	1	3/4 A394-T0_Punched	11	4	1	Both	0	0	0	0	0	0	0	
254iiP	254ii	254	XARM	XY-Symmetry	240S	250P	1	4	1	1	1	3/4 A394-T0_Punched	0	4	0	Continuous	0	0	0	0	0	0	0	
254iiiP	254iii	254bm	XARM	XY-Symmetry	250P	260S	1	4	1	1	1	3/4 A394-T0_Punched	0	3	0	Continuous	0	0	0	0	0	0	0	
254ivP	254iv	254bm	XARM	XY-Symmetry	260S	270S	1	4	2.2	1	1	3/4 A394-T0_Punched	0	3	0	Continuous	0	0	0	0	0	0	0	
254vP	254v	254bm	XARM	XY-Symmetry	270S	280S	1	4	2.4	1	1	3/4 A394-T0_Punched	0	3	0	Continuous	0	0	0	0	0	0	0	
254viP	254vi	254bm	XARM	XY-Symmetry	280S	300P	1	4	7.3	1	1	3/4 A394-T0_Punched	6	3	1	Both	0	0	0	0	0	0	0	
221iP	221i	221	XARM	XY-Symmetry	100P	220S	1	4	1	1	1	3/4 A394-T0_Punched	6	3	1	Both	0	0	0	0	0	0	0	
221iiP	221ii	221	XARM	XY-Symmetry	220S	230P	1	4	1	1	1	3/4 A394-T0_Punched	6	3	1	Both	0	0	0	0	0	0	0	
246iP	246i	246	XARM	XY-Symmetry	230P	260HS	2	4	1	1	1	3/4 A394-T0_Punched	2	2	1	Long only	0	0	0	0	0	0	0	
246iiP	246ii	246	XARM	XY-Symmetry	260HS	300P	2	5	1	1	1	3/4 A394-T0_Punched	2	2	1	Long only	0	0	0	0	0	0	0	
256P	256	256	XARM	XY-Symmetry	200P	240Y	2	5	0.5	0.5	0.5	3/4 A394-T0_Punched	2	1	1	Short only	0	0	0	0	0	0	0	

Row #	Member Label XML	Member Label	Group Label	Section Label	Symmetry Code	Origin Joint	End Joint	Ecc. Code	Rest. Code	Ratio RLX	Ratio RLY	Ratio RLZ	Bolt Type	# Bolts	# Bolt Hol	# Shear Plan	Connect Leg	RDS Comments	Response
0	203iP	203i	203	GWP	XY-Symmetr	2P	10S	1	4	1	1	1	3/4 A394-T0_Punche	6	2	1	Both		
4	203iiP	203ii	203	GWP	XY-Symmetr	10S	100P	1	4	1	1	1	3/4 A394-T0_Punche	2	2	1	Short only		
8	201iP	201i	201	GWP	XY-Symmetr	3P	11S	1	4	1	1	1	3/4 A394-T0_Punche	6	2	1	Both		
12	201iiP	201ii	201	GWP	XY-Symmetr	11S	110P	1	4	1	1	1	3/4 A394-T0_Punche	2	2	1	Short only		
16	207P	207	207	GWP	XY-Symmetr	3P	10S	3	4	1	1	1	3/4 A394-T0_Punche	1	1	1	Long only		
20	209P	209	209	GWP	XY-Symmetr	10S	11S	3	4	1	1	1	3/4 A394-T0_Punche	1	1	1	Long only		
24	210P	210	210	GWP	XY-Symmetr	11S	100P	3	4	1	1	1	3/4 A394-T0_Punche	1	1	1	Long only		
28	211P	211	211	GWP	Across-Rot	2P	10Y	3	4	1	1	1	3/4 A394-T0_Punche	1	1	1	Long only		
30	212P	212	212	GWP	Across-Rot	10Y	10S	3	4	1	1	1	3/4 A394-T0_Punche	1	1	1	Long only		
32	213P	213	213	GWP	Across-Rot	10S	100Y	3	4	1	1	1	3/4 A394-T0_Punche	1	1	1	Long only		
34	205P	205	205	GWP	Across-Rot	3P	11Y	3	4	1	1	1	3/4 A394-T0_Punche	1	1	1	Long only		Agreed, revision performed
36	206P	206	206	GWP	Across-Rot	11S	11Y	3	4	1	1	1	3/4 A394-T0_Punche	1	1	1	Long only		
38	217P	217	217	GWP	Across-Rot	11S	110Y	3	4	1	1	1	3/4 A394-T0_Punche	1	1	1	Long only		Agreed, revision performed
40	218aP	218a	218bm	GWP	XY-Symmetr	2P	3P	1	4	1	1	1	3/4 A394-T0_Punche	0	0	0	Continuous		
44	218bP	218b	218bm	GWP	X-Symmetry	2P	2.5S	1	4	1	1	1	3/4 A394-T0_Punche	0	0	0	Continuous		
46	218cP	218c	218bm	GWP	X-Symmetry	2.5S	2Y	1	4	1	1	1	3/4 A394-T0_Punche	0	0	0	Continuous		
48	218dP	218d	218bm	GWP	X-Symmetry	3P	3.5S	1	4	1	1	1	3/4 A394-T0_Punche	0	0	0	Continuous		
50	218eP	218e	218bm	GWP	X-Symmetry	3.5S	3Y	1	4	1	1	1	3/4 A394-T0_Punche	0	0	0	Continuous		
52	218fP	218f	218bm	GWP	X-Symmetry	2.5S	1P	1	4	1	1	1	3/4 A394-T0_Punche	0	0	0	Continuous		
54	218gP	218g	218bm	GWP	XY-Symmetr	3P	2.5S	1	4	1	1	1	3/4 A394-T0_Punche	0	0	0	Continuous		
58	218hP	218h	218bm	GWP	XY-Symmetr	2P	3.5S	1	4	1	1	1	3/4 A394-T0_Punche	0	0	0	Continuous		
62	254iP	254i	254	XARM	XY-Symmetr	200P	240S	1	4	1	1	1	3/4 A394-T0_Punche	11	4	1	Both		
66	254iiP	254ii	254	XARM	XY-Symmetr	240S	250P	1	4	1	1	1	3/4 A394-T0_Punche	0	4	0	Continuous		
70	254iiiP	254iii	254bm	XARM	XY-Symmetr	250P	260S	1	4	1	1	1	3/4 A394-T0_Punche	0	3	0	Continuous		
74	254ivP	254iv	254bm	XARM	XY-Symmetr	260S	270S	1	4	2.21	1	1	3/4 A394-T0_Punche	0	3	0	Continuous		
78	254vP	254v	254bm	XARM	XY-Symmetr	270S	280S	1	4	2.43	1	1	3/4 A394-T0_Punche	0	3	0	Continuous		
82	254viP	254vi	254bm	XARM	XY-Symmetr	280S	300P	1	4	7.35	1	1	3/4 A394-T0_Punche	6	3	1	Both		
86	221iP	221i	221	XARM	XY-Symmetr	100P	220S	1	4	1	1	1	3/4 A394-T0_Punche	6	3	1	Both		
90	221iiP	221ii	221	XARM	XY-Symmetr	220S	230P	1	4	1	1	1	3/4 A394-T0_Punche	6	3	1	Both		
94	246iP	246i	246	XARM	XY-Symmetr	230P	260HS	2	4	1	1	1	3/4 A394-T0_Punche	2	2	1	Long only		
98	246iiP	246ii	246	XARM	XY-Symmetr	260HS	300P	2	5	1	1	1	3/4 A394-T0_Punche	3	1	1	Long only	4	Agreed to Rest=4 and #bolts=3, revisions performed. #holes = 2 left unchanged because of oblique redundant at member midpoint
102	256P	256	256	XARM	XY-Symmetr	200P	240Y	2	4	0.5	0.5	0.5	3/4 A394-T0_Punche	2	1	1	Short only	one end connects to gusset	good catch, agreed.

Mesa Associates, Inc.
Engineers and Consultants

QUESTIONS?