2017 PLS-CADD Advanced Training and User Group

Why Is My Structure Failing

by

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Power Line Systems, Inc.

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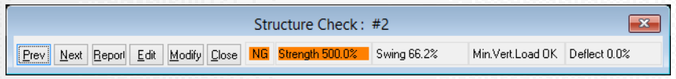
What We Will Cover

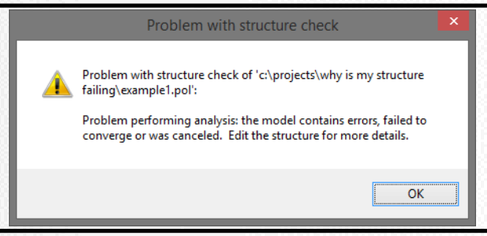
- Recognizing that your structure is failing to converge
- Discuss the non-linear debug tool
- Show what to look for when detecting instabilities
  - Show several examples of unstable structures
  - Show what to fix or change to make them stable

Recognizing Convergence Problems

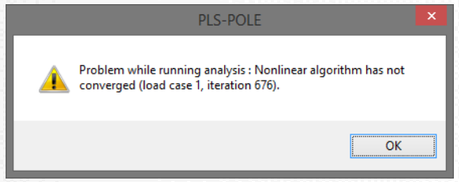
- Utilization of 500%



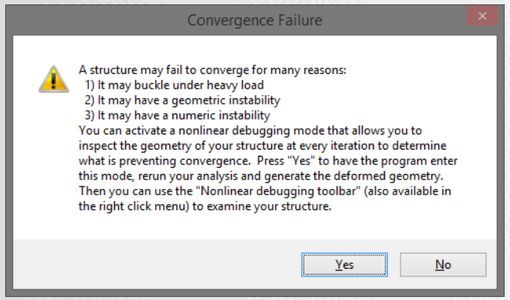
- Problem with structure check

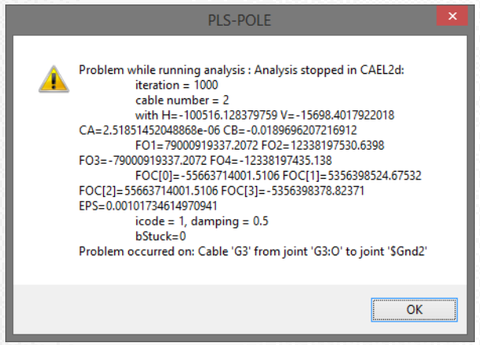


- Problems while running analysis

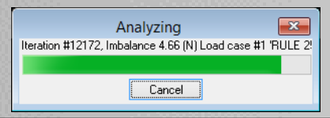


- Convergence failure notice



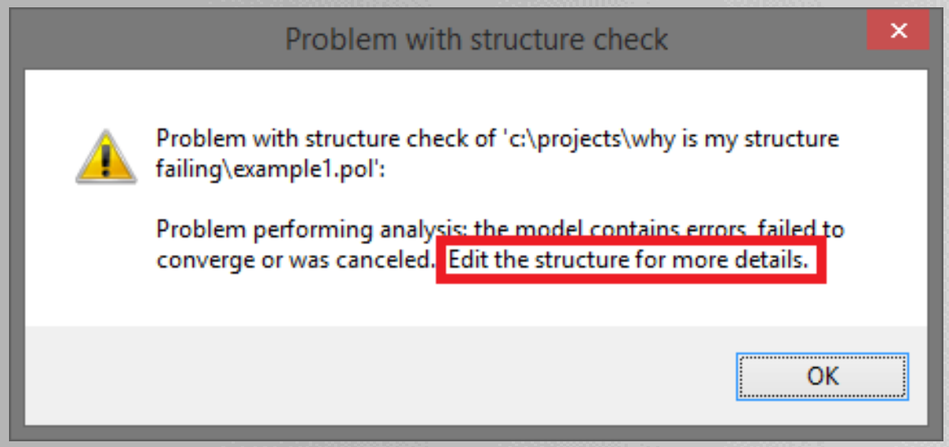


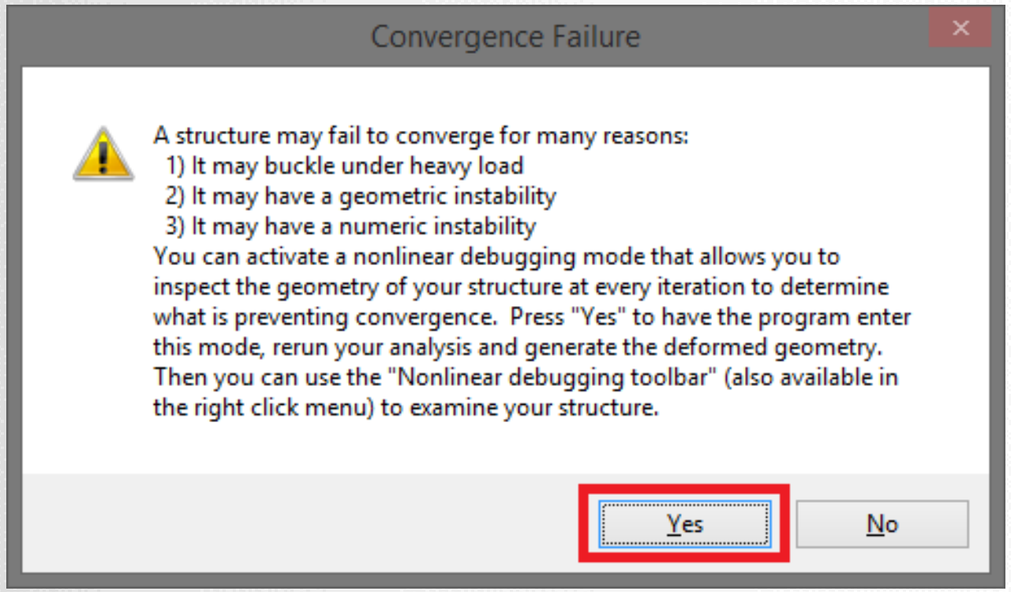
- Imbalance progress



Edit For More Details

- When convergence or analysis fails edit the structure to open it in PLS-POLE or TOWER
- Run the analysis and choose the option to enable the non-linear debug mode



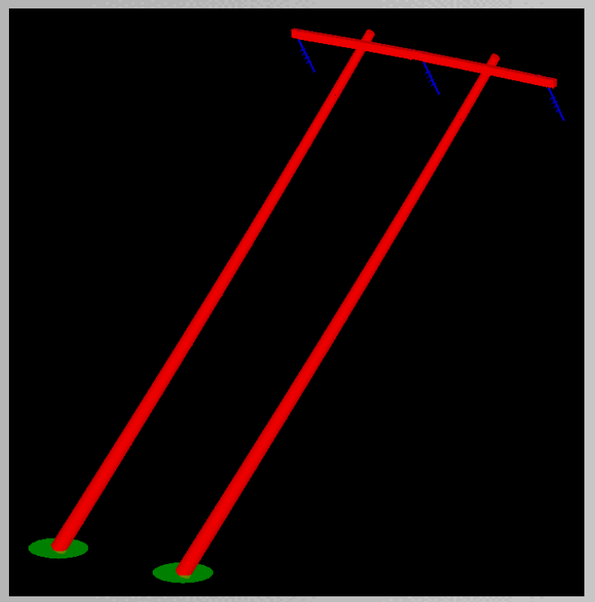


Nonlinear Debugging Toolbar

- Previous / Next allow stepping through iterations to see structure deflections
- Animate automatically steps through iterations
- Set allows for controlling load case, displacement factor, and other display settings
- If toolbar is closed it can be gotten back through right click context menu

Example 1

- Poles aren't bending but appear to rotate about ground joints indicating improper connection codes. Should be fixed, but instead were pinned.



Wood Pole Connectivity

Model Check Report

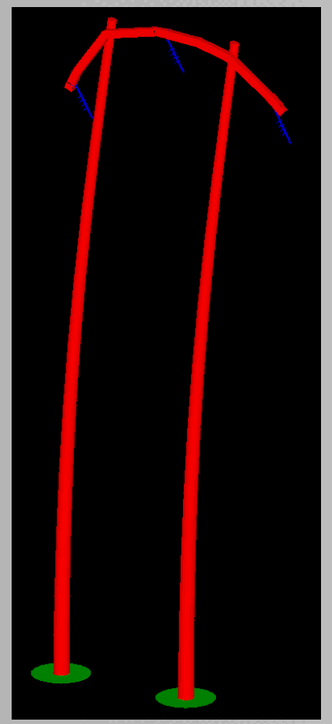
No errors or relevant warnings detected.

Note: poles may be located in one of two ways:
1) By tip and base joint. This is only appropriate for A-Frame, Y-Frame and other complicated structures.
2) By X, Y and Z of base and X, Y inclination angles. This should be used for single poles and simple frames. For example, to locate a single pole at 0,0,0 leave the tip, base, X, Y, Z and X, Y angle columns all blank.

	Pole Label	Tip Joint	Base Joint	X of Base (m)	Y of Base (m)	Z of Base (m)	Inclin. About X (deg)	Inclin. About Y (deg)	Wood Pole Property Set	Material Property Set	Attach. Labels	Push Brace	Base Connect	Embed % Override	Embed C. Override (m)	Top Cut Length (m)	Bot. Cut Length (m)
1	Pole			0	-1.6002	0	0	0	DF-2-60	DF-Douglas Fir		No	Pinned	0.000	0	0.000	0.000
2	Pole1			0	1.6002	0	0	0	DF-2-60	DF-Douglas Fir		No	Pinned	0.000	0	0.000	0.000
3																	
4																	
5																	
6																	

Example 2

- Drooping x-arm indicates bad property values for MOE. Should be 1920 ksi, but 19.20 ksi was entered.

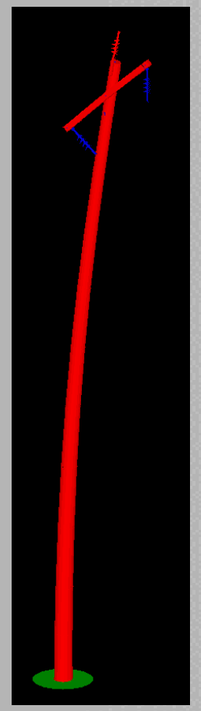


X-Arm Properties (From file "c:\projects\fe sag tension demo\structures\demo.xrm")

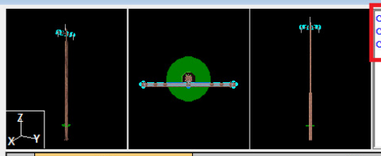
	Cross Arm Property Label	Stock Number	Cross Section Area (in^2)	X Inertia (in^4)	Z Inertia (in^4)	Weight (lbs)	Depth (in)	Width (in)	Length (ft)	Modulus of Elasticity (ksi)	Drag Coef.	Geometry	Strength Check Type	Use Steel S.F.	Vertical Capacity (lbs)	Trans. Capacity (lbs)	Long. Capacity (lbs)	Design Normal Stress (psi)	X Section Modulus (in^3)	Z Section Modulus (in^3)
1	Type 41 - 22		39.875	174.66081	100.51823	304.21875	7.375	5.625	22	1920	1.6	Edit (11 po:	Calculated	No	NA	NA	NA	7400	48.182	36.552
2	Type 41 - 22*		39.875	174.66081	100.51823	304.21875	7.375	5.625	22	19.2	1.6	Edit (11 po:	Calculated	No	NA	NA	NA	7400	48.182	36.552
3	Type 22 - 10		24.75	62.390625	41.765625	86.71875	5.625	4.625	10	1920	1.6	Edit (9 poi	Calculated	No	NA	NA	NA	7400	22.688	18.563
4	TPS-1-BAY		5	1000	1000	20	2	2	1.5	1920	1.6		Calculated	Yes	NA	NA	NA	9999.1	9998.7	9998.7
5	Type 14 - 8		24.75	62.390625	41.765625	69.375	5.625	4.625	8	1920	1.6	Edit (7 poi	Calculated	No	NA	NA	NA	7400	22.688	18.563
6	DAPLATE-15in		16.765625	1e+10	1e+10	44.708333	5.625	4.625	1.25	2900000	1.6	Edit (1 poi	Nominal	Yes	100000	100000	100000	NA	NA	NA
7	DAPLATE-15in*		16.765625	1000	1000	44.708333	5.625	4.625	1.25	29000	1.6	Edit (1 poi	Nominal	Yes	100000	100000	100000	NA	NA	NA
8	Type 04 - 8		16.765625	29.8856	18.359233	44.708333	4.625	3.625	8	1920	1.6	Edit (11 po:	Calculated	No	NA	NA	NA	15000	12.924	10.129
9	Type 03 - 8		16.765625	29.8856	18.359233	44.708333	4.625	3.625	8	1920	1.6	Edit (11 po:	Calculated	No	NA	NA	NA	15000	12.924	10.129
10	Type 03 - 8A		16.765625	29.8856	18.359233	44.708333	4.625	3.625	8	1920	1.6	Edit (11 po:	Calculated	No	NA	NA	NA	7400	12.924	10.129
11															NA	NA	NA	NA	NA	NA

Example 3

- Cross arm spins about connection point like a propeller. This is due to having no braces and a connection code of pinned X.



X-Arm Connectivity



Cross arm element "ARM" only has a single pinned connection which will be unstable unless braced ??
Cross arm element "ARM" only has a single pinned connection which will be unstable unless braced ??
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	X-Arm Label	X-Arm Property Set	Azimuth (deg)	Slope (deg)	Attach. Labels	Connects
1	BAY	TPS-1-BAY	0	0	Edit (2 points)	Edit (4 points)
2	ARM	Type 22 - 10	0	0		Edit (11 points)
3						
4						
5						
6						
7						
8						
9						
10						

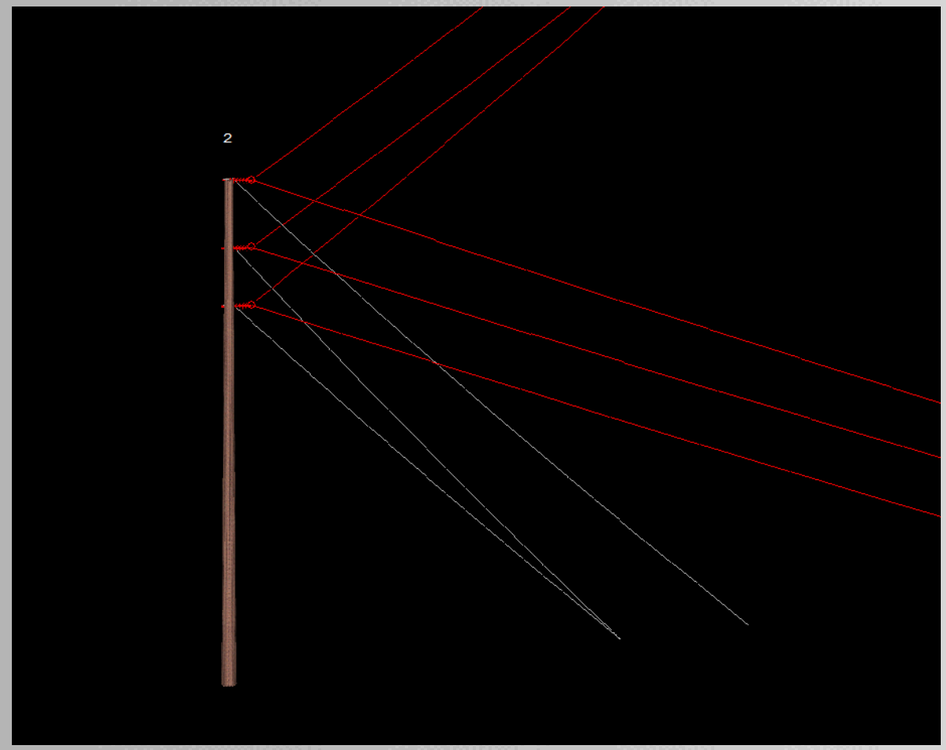
X-Arm Connections - [ARM]

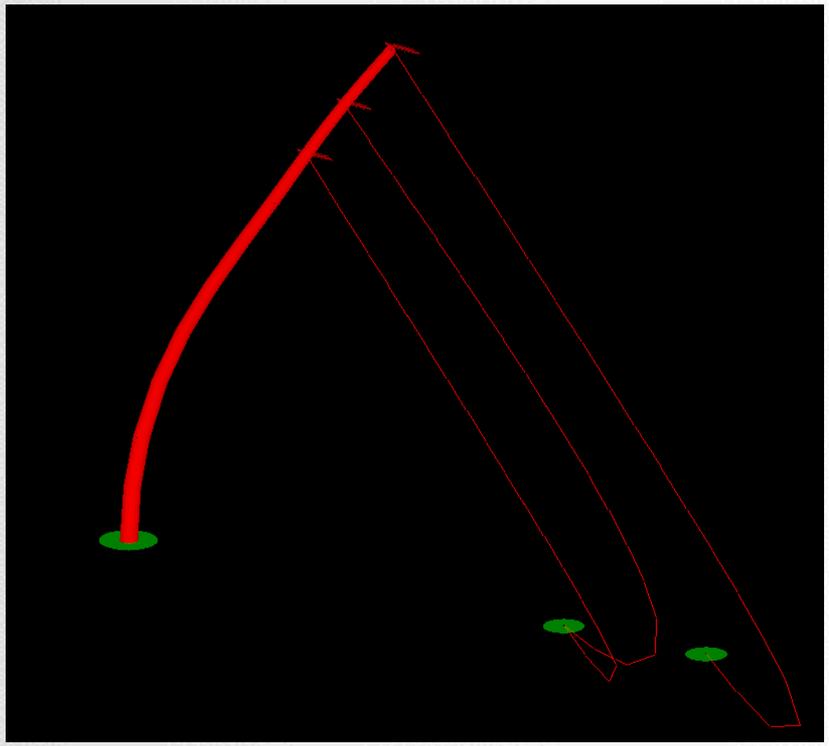
	Attach Label	Offset (m)	Connect At	Connection Code Type
1	ARM:O	0.000		Pinned X
2	ARM:L57H	0.076		Pinned X
3	ARM:L54V	0.152		Pinned X
4	ARM:L42V	0.457		Pinned X
5	ARM:L30V	0.762		Pinned X
6	ARM:PH	1.524	Pole:F1-Arm	Pinned Face
7	ARM:R30V	2.286		Pinned X
8	ARM:R42V	2.591		Pinned X
9	ARM:R54V	2.896		Pinned X
10	ARM:R57H	2.972		Pinned X
11	ARM:E	3.048		Pinned X

OK Cancel

Example 4

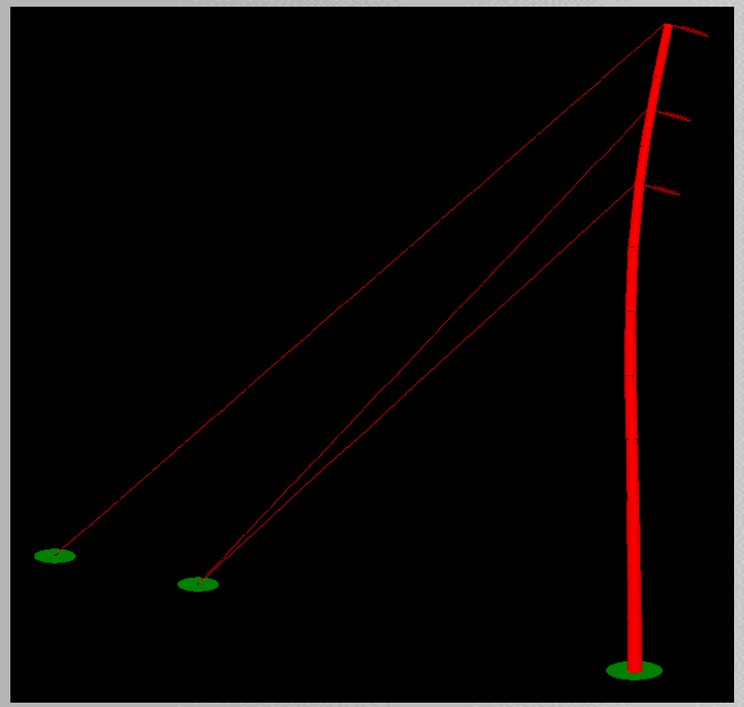
- Guy wires are pointed in the wrong direction. Apply 180 Degree orientation angle or rotate framing.



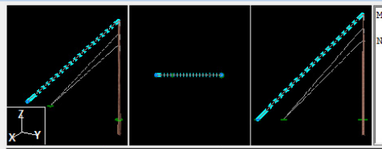


Example 5

- Guy wire install tension too high. Typical values are 2-5% of ultimate



Guy Connectivity



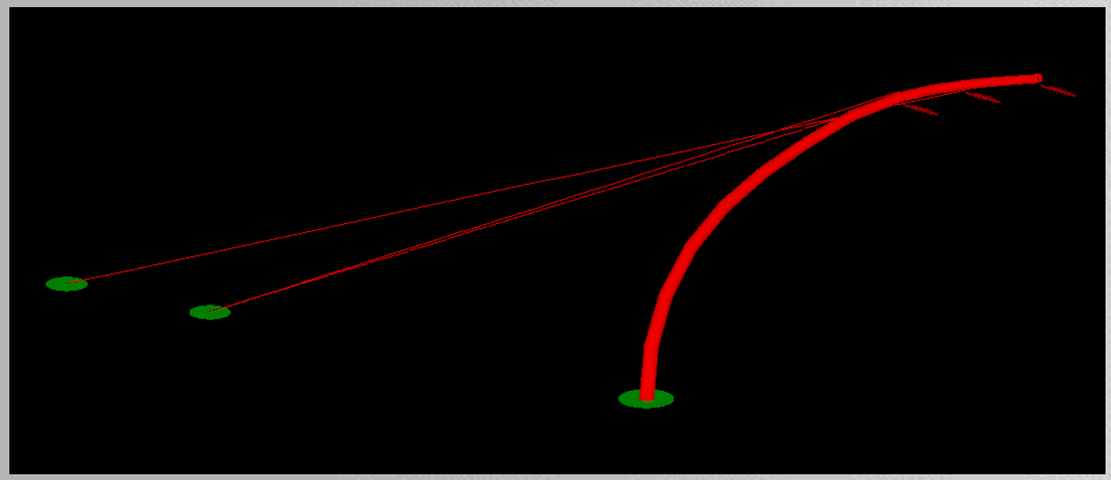
Model Check Report

No errors or relevant warnings detected.

	Guy Label	Attach Label	Property Set	Anchor Type	Anchor X or Offset (ft)	Anchor Y (ft)	Anchor Z (ft)	Anchor Lead Length (ft)	Azimuth (deg)	Slope (deg)	Reference Anchor	Installed Tension At Top (% of Ult.)	Design Tension Capacity (kips)	Ultimate Tension Capacity (kips)
1	G1	Pole:t	07/16" 7 Strand HS*	Slope	NA	NA	0	NA	180	45	NA	100	200	200
2	G3	Pole:F1-R	07/16" 7 Strand HS*	Slope	NA	NA	0	NA	180	45	NA	100	200	200
3	G2	Pole:F1-L	07/16" 7 Strand HS*	Shared	NA	NA	NA	NA	NA	NA	G3	100	200	200
4					NA	NA	NA	NA	NA	NA	NA			
5					NA	NA	NA	NA	NA	NA	NA			

Example 6

- Guy wires have MOE too low. Set at 2.57 e+05, should be 2.57 e+07



Cable Properties (From file "c:\projects\fe sag tension demo\structures\guy.cab")

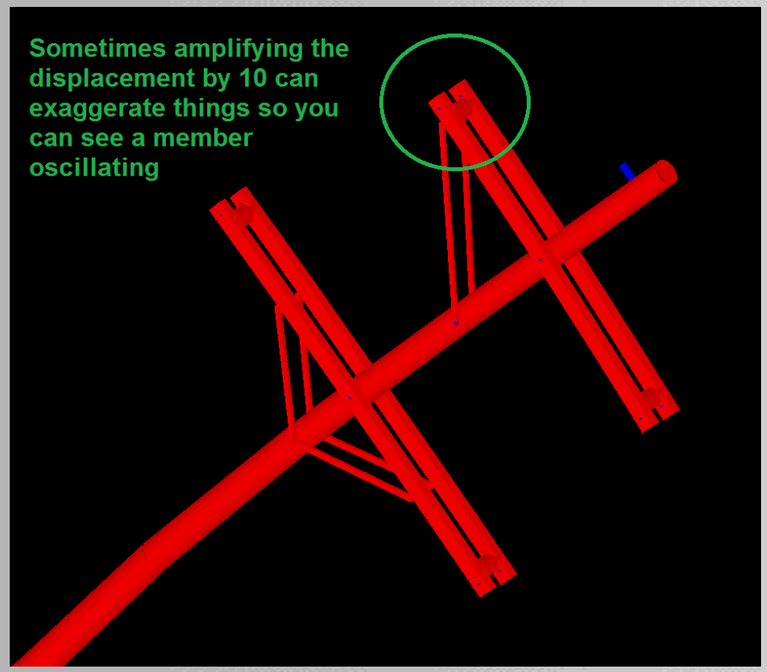
Based on publicly available ASTM A363 and A475 data.
Created June 27, 2001

Please note that the *Allowable % of Ultimate* values have been set to 100% since the 0.9 strength factor is normally accounted for in the Structure Loads tables (as done in the sample NESC Criteria files).

	Label	Stock Number	Area (in^2)	Modulus of Elasticity (psi)	Diameter (in)	Unit Weight (lbs/ft)	Drag Coef.	Thermal Expansion Coeff. (/deg F)	Ultimate Tension (kips)	Allowable % of Ultimate
1	1/2" 19 Strand EHS		0.1492	2.5e+07	0.5	0.504	1	6.4e-06	26.7	100
2	1/2" 19 Strand HS		0.1492	2.57e+07	0.5	0.504	1	6.4e-06	19.1	100
3	1/2" 7 Strand EHS		0.1497	2.5e+07	0.495	0.517	1	6.4e-06	26.9	100
4	1/2" 7 Strand HS		0.1497	2.57e+07	0.495	0.517	1	6.4e-06	18.8	100
5	1/4" 7 Strand EHS		0.031	1.68e+07	0.25	0.1	1	6.4e-06	6.65	100
6	1/4" 7 Strand HS		0.031	2.57e+07	0.25	0.1	1	6.4e-06	4.75	100
7	3/4" 19 Strand EHS		0.3358	2.5e+07	0.75	1.155	1	6.4e-06	58.3	100
8	3/4" 19 Strand HS		0.3358	2.57e+07	0.75	1.155	1	6.4e-06	40.8	100
9	3/8" 7 Strand EHS		0.07917	2.5e+07	0.36	0.273	1	6.4e-06	15.4	100
10	3/8" 7 Strand HS		0.07917	2.57e+07	0.36	0.273	1	6.4e-06	10.8	100
11	5/16" 7 Strand EHS		0.05946	2.5e+07	0.312	0.205	1	6.4e-06	11.2	100
12	5/16" 7 Strand HS		0.05946	2.57e+07	0.312	0.205	1	6.4e-06	8	100
13	5/8" 7 Strand EHS		0.2356	2.5e+07	0.621	0.813	1	6.4e-06	42.4	100
14	5/8" 7 Strand HS		0.2356	2.57e+07	0.621	0.813	1	6.4e-06	29.6	100
15	7/16" 7 Strand EHS		0.1156	2.5e+07	0.435	0.399	1	6.4e-06	20.8	100
16	7/16" 7 Strand HS		0.1156	2.57e+07	0.435	0.399	1	6.4e-06	14.5	100
17	9/16" 19 Strand EHS		0.1816	2.5e+07	0.56	0.63	1	6.4e-06	33.7	100
18	9/16" 19 Strand HS		0.1816	2.57e+07	0.56	0.63	1	6.4e-06	24.1	100
19	9/16" 7 Strand EHS		0.1943	2.5e+07	0.564	0.671	1	6.4e-06	35	100
20	9/16" 7 Strand HS		0.1943	2.57e+07	0.564	0.671	1	6.4e-06	24.5	100
21	07/16" 7 Strand HS*	TG-21A	0.115	2.57e+05	0.435	0.399	1	6.4e-06	200	100
22	07/16" 7 Strand HS**	TG-21A	0.115	257000	0.435	0.399	1	6.4e-06	14.5	100
23	07/16" 7 Strand HS	TG-21A	0.115	2.57e+07	0.435	0.399	1	6.4e-06	14.5	90

Example 7

- Analysis never converges, it just oscillates.
- Must stop analysis and manually engage non-linear debug mode through the F1 menu.



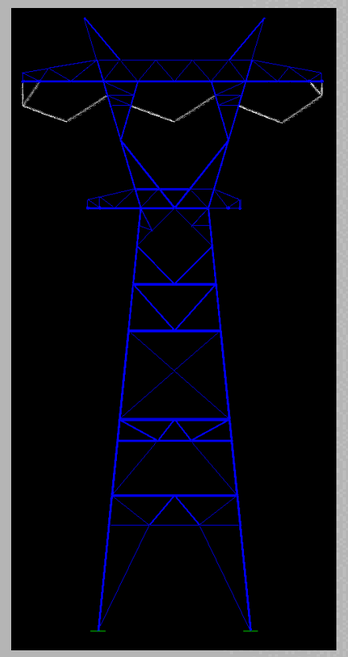
Avoid using bogus properties to make a member rigid because it can cause numerical stability problems.

X-Arm Properties (From file "c:\projects\fe sag tension demo\structures\demo.xrm")

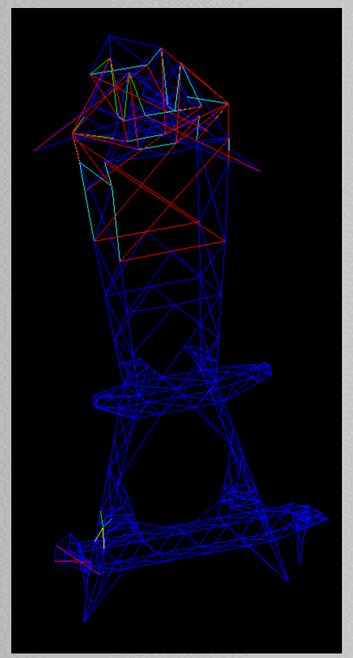
	Cross Arm Property Label	Stock Number	Cross Section Area (in^2)	X Inertia (in^4)	Z Inertia (in^4)	Weight (lbs)	Depth (in)	Width (in)	Length (ft)	Modulus of Elasticity (ksi)	Drag Coef.	Geometry	Strength Check Type	Use Steel S.F.	Vertical Capacity (lbs)	Trans. Capacity (lbs)	Long. Capacity (lbs)	Design Normal Stress (psi)	X Section Modulus (in^3)	Z Section Modulus (in^3)
1	Type 41 - 22		39.875	174.66081	100.51823	304.21875	7.375	5.625	22	1920	1.6	Edit (11 po:	Calculated	No	NA	NA	NA	7400	48.182	36.552
2	Type 41 - 22*		39.875	174.66081	100.51823	304.21875	7.375	5.625	22	19.2	1.6	Edit (11 po:	Calculated	No	NA	NA	NA	7400	48.182	36.552
3	Type 22 - 10		24.75	62.390625	41.765625	86.71875	5.625	4.625	10	1920	1.6	Edit (9 poi:	Calculated	No	NA	NA	NA	7400	22.688	18.563
4	TPS-1-BAY		5	1000	1000	20	2	2	1.5	1920	1.6		Calculated	Yes	NA	NA	NA	9999.1	9998.7	9998.7
5	Type 14 - 8		24.75	62.390625	41.765625	69.375	5.625	4.625	8	1920	1.6	Edit (7 poi:	Calculated	No	NA	NA	NA	7400	22.688	18.563
6	DAPLATE-15in		16.765625	1e+10	1e+10	44.708333	5.625	4.625	1.25	2900000	1.6	Edit (1 poi:	Nominal	Yes	100000	100000	100000	NA	NA	NA
7	DAPLATE-15in*		16.765625	1000	1000	44.708333	5.625	4.625	1.25	29000	1.6	Edit (1 poi:	Nominal	Yes	100000	100000	100000	NA	NA	NA
8	Type 04 - 8		16.765625	29.8856	18.359233	44.708333	4.625	3.625	8	1920	1.6	Edit (11 po:	Calculated	No	NA	NA	NA	15000	12.924	10.129
9	Type 03 - 8		16.765625	29.8856	18.359233	44.708333	4.625	3.625	8	1920	1.6	Edit (11 po:	Calculated	No	NA	NA	NA	15000	12.924	10.129
10	Type 03 - 8A		16.765625	29.8856	18.359233	44.708333	4.625	3.625	8	1920	1.6	Edit (11 po:	Calculated	No	NA	NA	NA	7400	12.924	10.129
11															NA	NA	NA	NA	NA	NA

Example 8

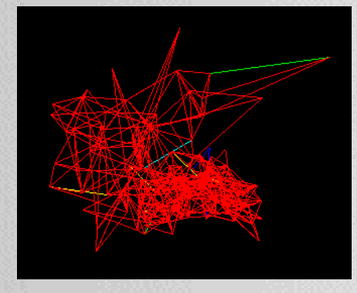
- Sometimes a structure may converge to a heavily deflected shape.
- In these instances it's best to turn on the non-linear debug mode and analyze the structure to see what joints are moving.
- In this example there are no beam elements used to stabilize the planar joints.
- Section 1.2.3.4 of the TOWER manual gives recommendations on what members to select for as beams.



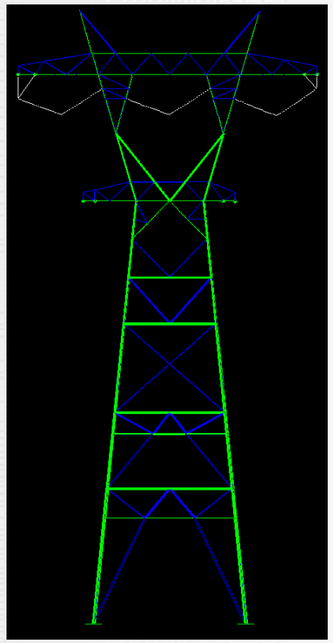
Undeformed
No Beams



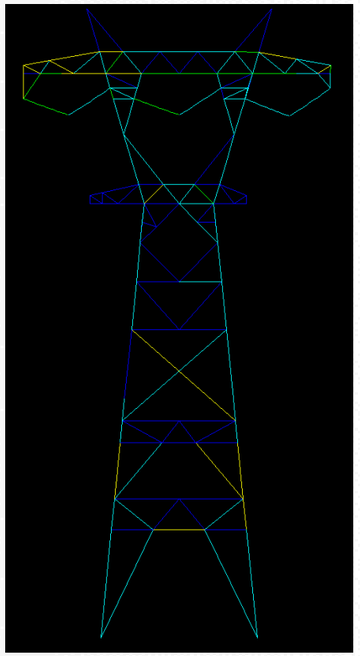
Deformed
No Beams



Deformed w/ Nonlinear Debugging
No Beams



Undeformed
With Beams



Deformed
With Beams

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