Purchasing Management Association of Oklahoma Electric Cooperatives
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On Behalf of the
North American Wood Pole Council

Pole Strength

- The ANSI O5.1 Pole Standard
- Concerns Raised by OAEC
  - Pole Strengths
  - Juvenile Wood
    - Stress Profiles

ANSI O5.1 - Basics

- Is Not Considered a Design Standard but Is the Customary Reference Used for Wood Pole Strengths
- Strength Values for MOR in Bending and Equivalent Class Loads
- Strength in Simple Cantilever Loading
- Cautions for Guyed or Braced Structures and Structures Where the Point of Maximum Stress is Above the Groundline

Basis of Issues Raised

- Rapidly Grown Trees – Less Dense Wood
- Juvenile Wood
- Issue Has Been Around for Many Decades - Plantation Timber
  - ANSI Added Growth Ring Requirement in Butt
- ANSI Fiber Stress Values Had Not Changed Since the 1963 Edition
- Additional Testing on Transmission Poles Was Conducted in the Early 1980s
- Recent 2000 Tests
- Are ANSI Values Still Good?

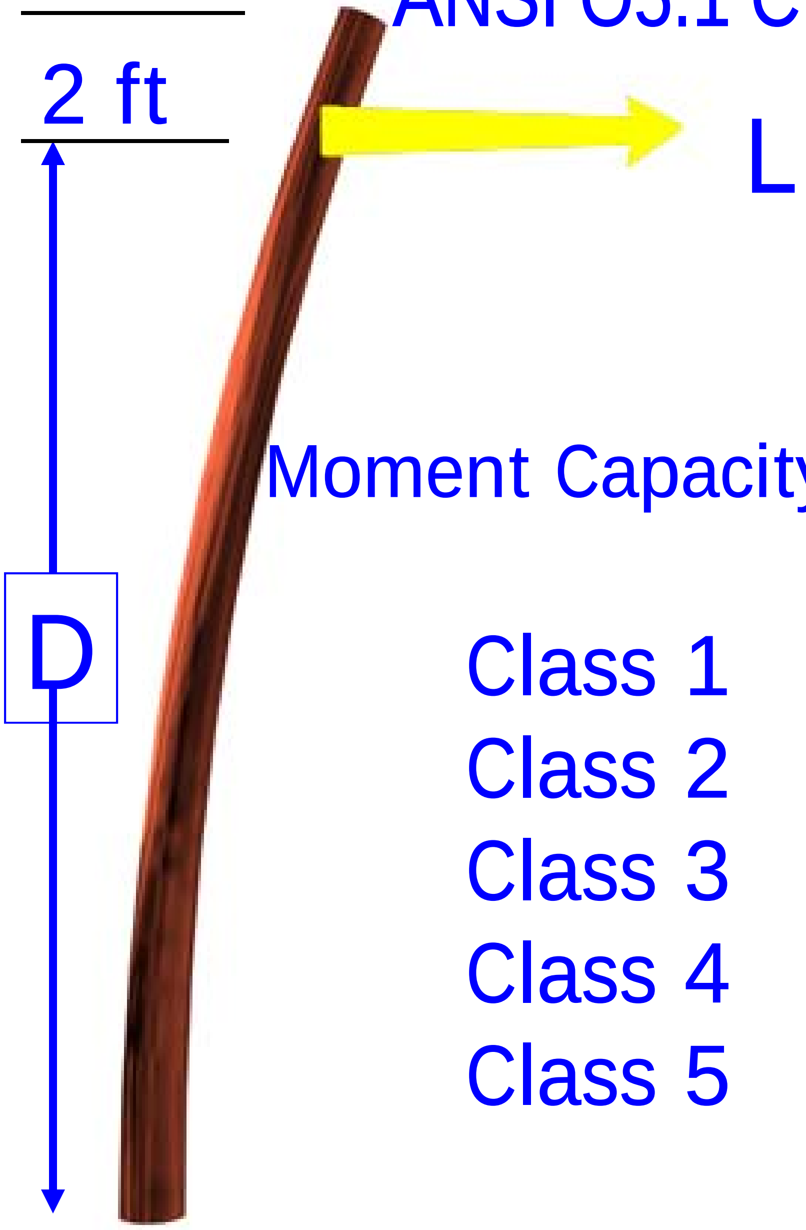
ANSI O5.1 - 2002

- Reevaluated the Entire Dataset of Full Scale Break Tests - Including Recent Data
- Concluded the Table 1 Values Were Still Valid Estimates of Mean Strength of Poles
- Recommended Reduced Design Value for Upper Portion of Poles – 6000 psi SYP

How Are Strengths Determined?

Strength Values Based on Full-Size Break Tests

ANSI O5.1 Class Loads



Moment Capacity = L x D (ft-lb)

Class 1	4,500 lb
Class 2	3,700 lb
Class 3	3,000 lb
Class 4	2,400 lb
Class 5	1,900 lb

Will Poles Today Still Meet These Class Loads?

Yes!!!

Two Sets of Recent Data

	Penta and CCA Treated						
	Southern Pine Pole Break Test						
	20 - 35 foot Class 5						
		March 28, 1996					
Pole #	**Circ. @ 6'**	**Circ. @ Top**	**Ultimate Load - Pounds**	**Failure Location from Butt**	**Observed Stress At Groundline - PSI**	**Stress Based on ANSI Dimensions - PSI**	
1P	30.25	21.75	2250	11'	8318	9440	
1C	30	21.75	2760	10'	10460	11580	
2P	30	22.5	2130	6'	8073	8937	
2C	30.75	24.5	2500	6'	8798	10489	
3P	30	22.5	2900	6'	10991	12167	
3C	30.25	23.5	2410	6'	8909	10112	
4P	30.25	23.25	1750	9'	6469	7342	
4C	30	23.25	2560	12'	9702	10741	
5P	30	23.5	2600	6'	9854	10909	
5C	30.25	23.5	1630	14'	6026	6839	
6P	30	22.25	2390	6.5'	9058	10028	
6C	30	22.25	2940	8'	11142	12335	
7P	30	24	2300	15'	8717	9650	
7C	30.5	22.25	2420	6'	8728	10154	
8P	30	24	2530	6'	9589	10615	
8C	30.5	23.25	2830	15'	10207	11874	
9P	30	23	2400	8'	9096	10070	
9C	30.5	21.75	1870	8'	6744	7846	
10P	30.5	22.5	2500	9'	9016	10489	
10C	30.25	22.75	2520	6'	9316	10573	
		AVERAGES	2409.5		8961	10109	
		ANSI Class Load	**1900**			**8000**	**ANSI Table 1 Fiber Stress Value**

RESULTS OF BREAKING TESTS OF PILING MEETING POLE SPECIFICATIONS - 2000

	Number of Tests	Observed Groundline Stress	Adjusted to Min. ANSI Dimensions	Avg. Rings per Inch
Year 2000 Tests	97	9787	10981	9.4
Old ASTM Tests	143		10190	13.6

For the poles tested in 2000 the rings per inch in the butt varied from a minimum of 4 to a maximum of 18

This does not indicate any significant change from the 1960's data to the 2000 data.

What About Juvenile Wood?

Juvenile Wood

- Generally First 10 Growth Rings from Pith
- Therefore, Every Pole Top is Largely Juvenile Wood
- No Clear Demarcation
- Has Lower Density and Therefore Lower Strength
- Some Other Cellular Differences
- Should It Be an Issue in Normal Cantilever Loading?

Should Juvenile Wood Be an Issue?

No, If Proper Design Practices Are Followed

Data Needed to Answer

- Strength of Juvenile Wood
- Stress Profile in Poles Under Expected Load Conditions

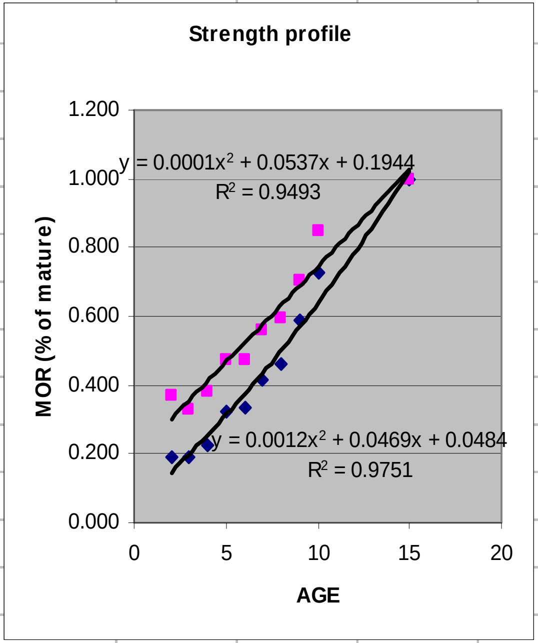
How Strong Is Juvenile Wood?

SYP Juvenile Wood Strength

- 4000 psi in Early Years
- 10,000 psi by Year 10
- ANSI Table 1 Value 8000 psi

Larson P.R., D.E.Kretschmann, A.Clark III, J.G. Isebrands, 2001. Formation and propertiew of Juvenile Wood in Southern Pines: A synopsis
Forest Products Lab FPL GTR 129

AGE	R	E	MOR	MOE	R'
1	0.363	0.188	4200	0.289	0.248
2	0.366	0.191	4240	0.294	0.302
3	0.328	0.190	3800	0.293	0.356
4	0.380	0.226	4400	0.349	0.409
5	0.473	0.323	5470	0.498	0.463
6	0.475	0.334	5490	0.514	0.517
7	0.559	0.417	6470	0.642	0.570
8	0.592	0.461	6848	0.71	0.624
9	0.705	0.587	8160	0.904	0.678
10	0.849	0.727	9820	1.12	0.731
15	1.000	1	11570	1.541	1.000



$$4.4179\frac{(540\cdot A + 45\cdot B + 4\cdot C)}{GR^3}\cdot\frac{E_m}{R}$$

A = 0.0001
B = 0.0537
C = 0.1944
IF
GR = 4 rpi
R = 6
sigma = 1.5408
12326.4 17827.06

$$\boxed{EI = E_m\cdot\pi\cdot R^4\cdot\left(2\cdot 10^{-4}\cdot GR^2\cdot R^2 + 9.3810^{-4}\cdot GR\cdot R + 1.2\cdot 10^{-2}\right)}$$

fb=.0001*(GR*R)^2+.0537*GR*R+.1944

Specific Gravity- Loblolly Pine
based on 100 tree sample by Zoble et al (1972)

10	0.385
15	0.409
20	0.425
25	0.438
30	0.449
40	0.466

What Are Expected Stresses?

Working Load

4 lb.
Transverse
Wind

.50”
ICE

Heavy Loading District

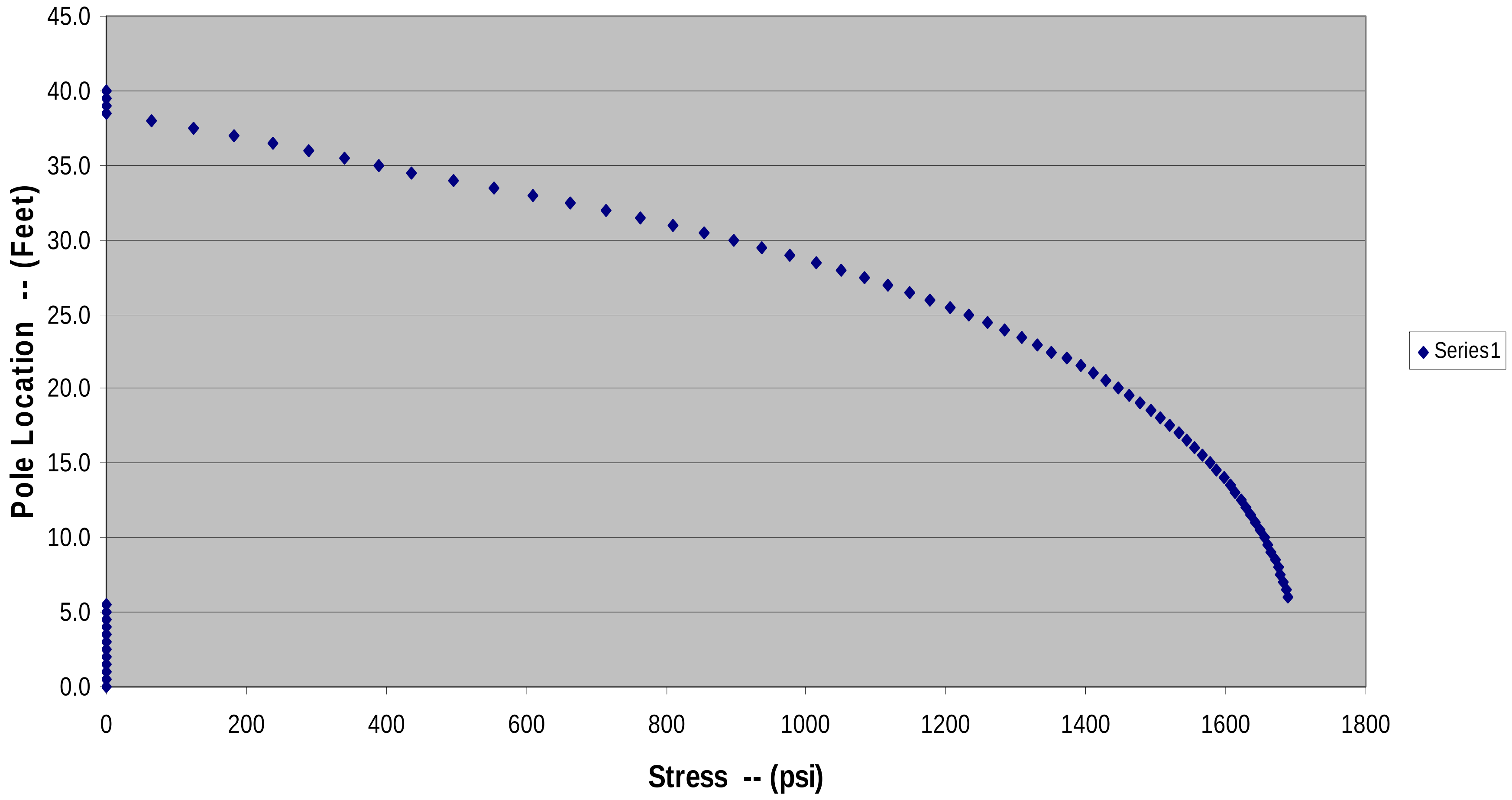
Two Load Conditions

- Simple Transverse Cantilever Load
- Fault Conditions that Impose a Moment at the Pole Top

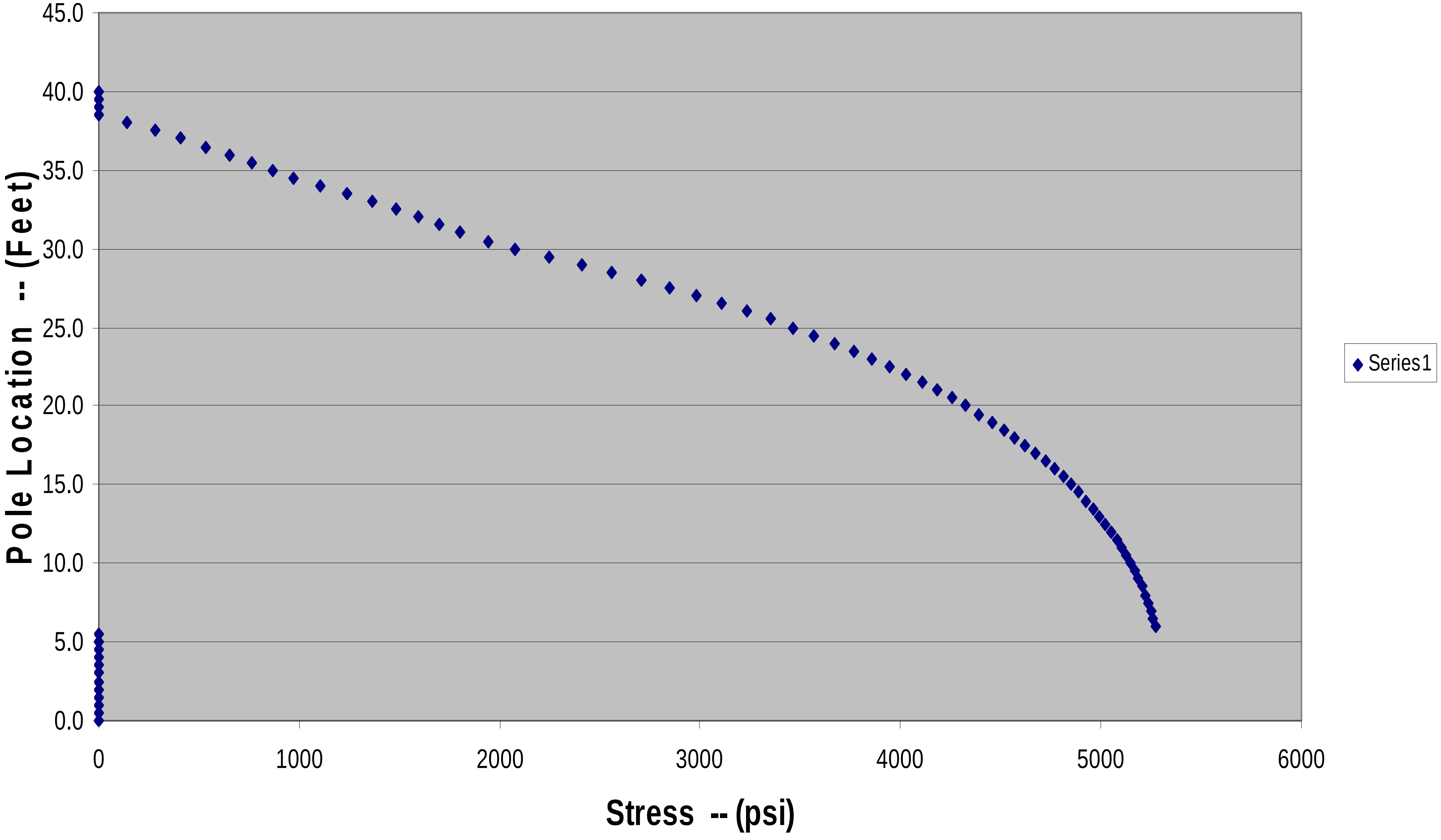
Typical Coop Design

- 40 Foot Poles
- 280 Foot Span
- 3 - 4/0 Conductors
- 1 – 4/0 Neutral
- 2 – 1.5 Inch Telecom/Cable Underbuild

Actual Stress Profile for Grade C 40 Foot Class 3 Example Under Standard NESC Heavy Loading District - 0.5 Inch Ice



Stress Profile for Grade C 40 Foot Class 3 - 3-Phase 4/0, 280 Foot Span, With Two 1.5 Inch Communication Conductors and 1.5 Inch Radial Ice



Juvenile Wood Not an Issue in Simple Cantilever Load Situation

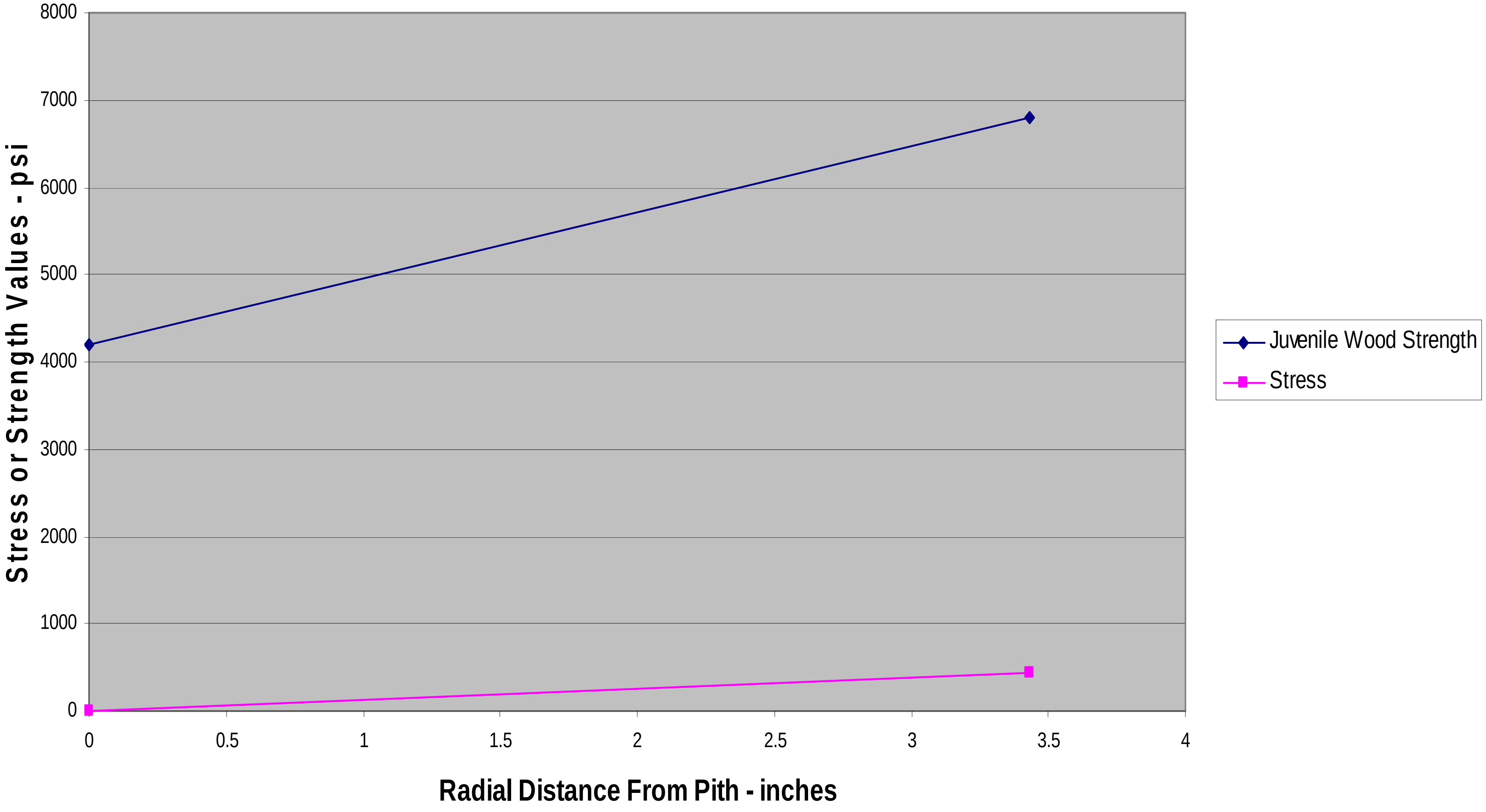
What About Fault Conditions

- What if One Conductor Fails?

Eccentric Load Analysis

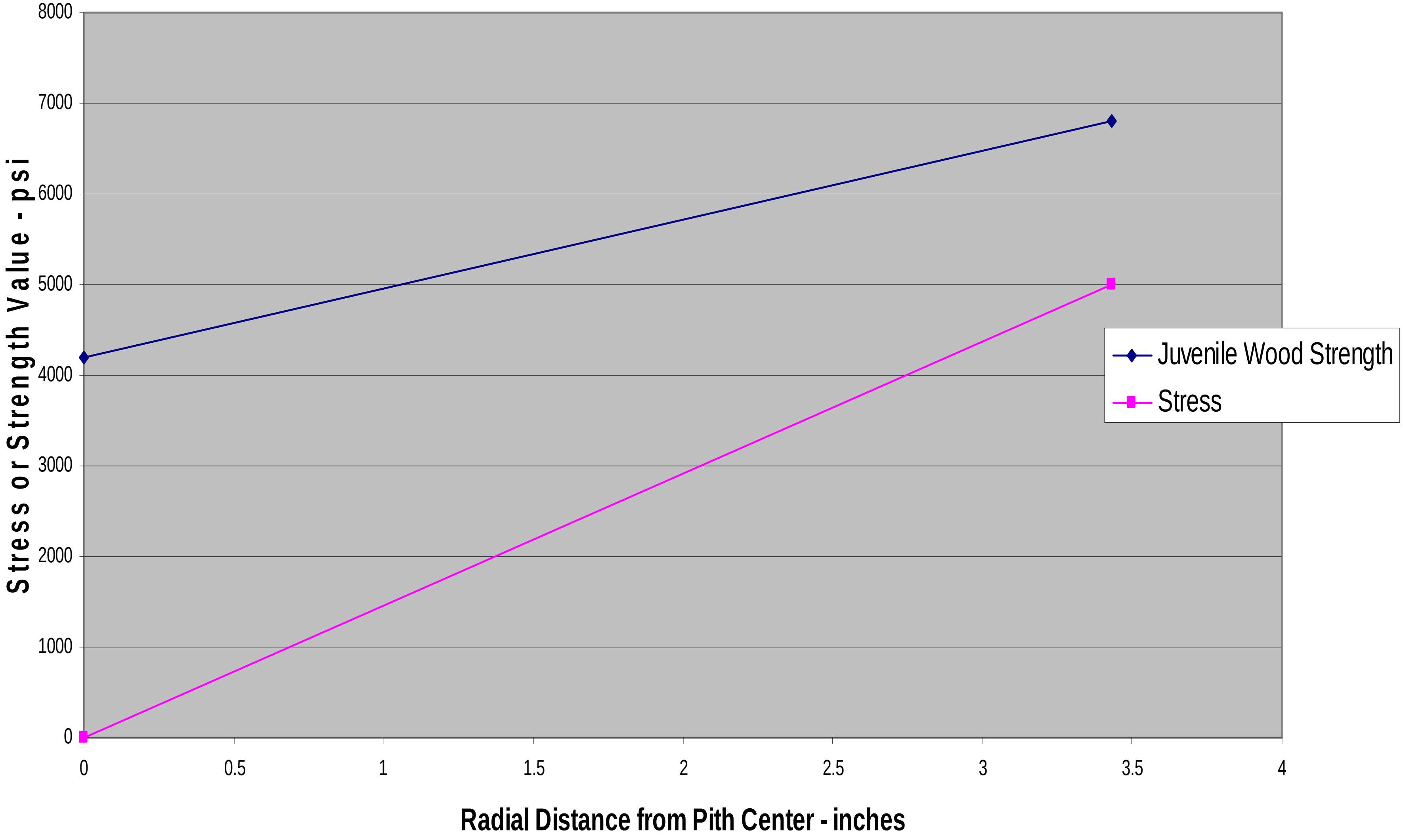
Broken Conductor on Single Conductor Side			
Oklahoma is Heavy Loading District		Ice Thickness - in.	0.5
Verical Load per Phase Equals Weight per Foot Times Span			233
Outside Conductor Offset-In.	44		
Inside Conductor Offset - In.	15		
Eccentric Moment Applied at Crossarm - ft. lbs.			1148
Stress in Pole at Crossarm Location - psi			332
Stress in Crossarm - 0.5 Inch Ice			1166
Stress n Pole with 1.5 Inches of Ice			1581
Stress in Pole with 2.5 Inches of Ice			3821
Eight Year Old Juvenile Wood Strength - psi			6800
Recommended ANSI Design Value in Upper Half of Pole - psi			6000

Appears Eccentric Load Alone Should Not Cause Failure and Crossarm Will Fail Before Pole



Stress in 40 Foot Class 4 Pole at Crossarm Location Due to Eccentric Load Caused By Failure of One Conductor with 0.5 Inches of Ice

Stress in 40 Foot Class 4 Pole at Crossarm Location Due to Eccentric Load Caused By Failure of One Conductor With 2.5 Inches of Radial Ice



Juvenile Wood Should Not Be and Issue

Conclusions

- Today’s ANSI Pole Is Expected to Meet Class Load Strengths
- Significant Juvenile Wood is Present in Every Pole Top – Always Has Been
- Under Normal NESC Load Conditions Stress in Upper Portion of Poles is Low
- ANSI Has Provisions Controlling Growth Rate
- Recommends Reduced Design Value in Upper Portion of Pole – Accounts for Juvenile Wood
- Deviation from ANSI or RUS Specifications Will Add Cost Without Any Quantifiable Benefit

Questions?

Thank You for the Opportunity to Meet With You!