TSDOS TRANSMISSION & SUBSTATION DESIGN & OPERATION SYMPOSIUM

THE UNIVERSITY OF TEXAS AT ARLINGTON

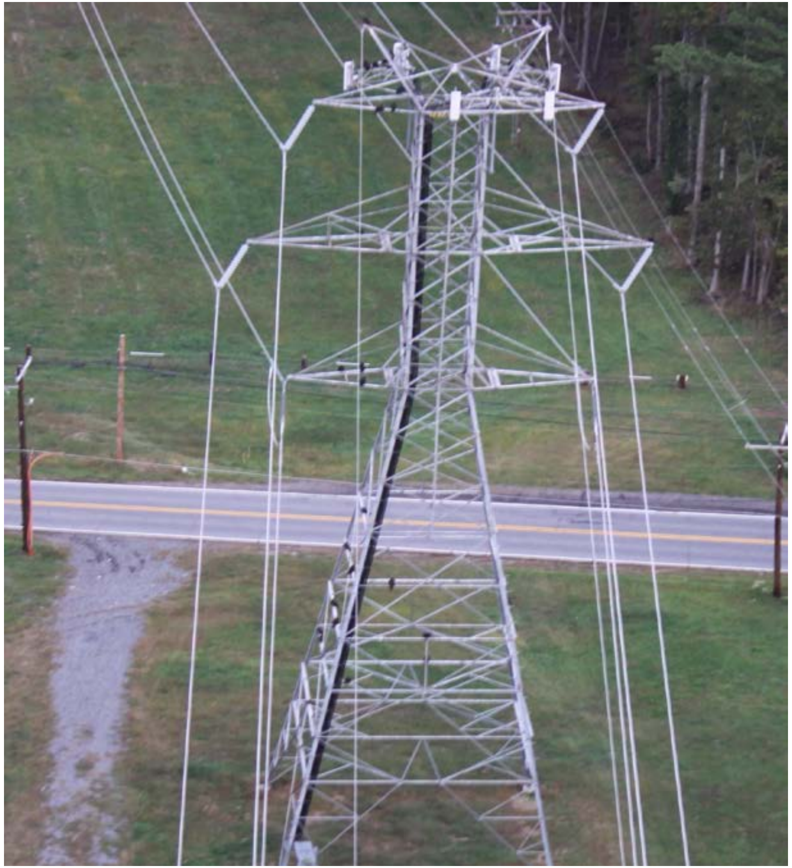
Performance Evaluation of Joint-Use Transmission Structures

Aaron Haithcock, PE Civil-Structural Engineer (Presenter) *

Sriram Kalaga PE, Ph.D., F.ASCE Principal Civil-Structural Engineer *

Jason Kilgore, PE, SE Structural Program Manager *

* MESA Associates Inc., 629 Market Street, Suite 200, Chattanooga, TN 37402



Primary Function:

- To serve as a supporting structure for the electrical transmission system, insulators, wires

Secondary Function:

- To also serve as a supporting structure for the communication antennae, frames and comm cables

Fig. 1. Typical Joint Use Lattice Steel Transmission Tower

Objectives:

- To discuss Performance Criteria for Joint-Use Structures
  - Strength → Ability to withstand imposed loads without Overstress
  - Stiffness → Ability to resist Deflections and comply with Limits
- To discuss Reliability Requirements
- To highlight Conflicts with Different Design Approaches
- To explore means to Simplify the analysis
- To illustrate the argument with a small Example
- To Provide suggestions for Extending the idea

Performance Criteria

- Performance Criteria for Joint-Use Structures
  - Strength → Ability to withstand imposed loads without Overstress
    Vertical, Transverse and Longitudinal Loads
  - Stiffness → Ability to resist Deflections and comply with Limits
    For Transmission Structures:
      - Maintain Phase Separation
      - Resist P – Delta moments

    For Communication Structures:
      - Maintain Signal Integrity

Joint Use Structures must satisfy both of the above requirements

Reliability Requirements

- Reliability Requirements for Joint-Use Structures
  - Provide Reliability under various climatological events (wind and ice)
  - Reliability levels are defined for specified Return Periods (years)
  - Transmission Structures comply with Reliability demands of ASCE and NESC-C2 usually for a default RP of 50 years.
  - Communication Structures comply with Demands of TIA-222-H with RP's of 700 years (wind) and 500 years (ice and wind)

ASCE/NESC needs are very different from those of TIA-222!

Table 1. Adjustment Factors for Wind for Various Return Periods

Load Return Period RP (years)	Relative Reliability Factor	Probability that Load is exceeded in 50 years *	Wind Load Adjustment Factor ** Υ_w
25	0.50	0.87	0.85
50 (Default)	1.0	0.64	1.00
100	2.0	0.39	1.15
200	4.0	0.22	1.30
400	8.0	0.12	1.45
500 ***	10.0	0.095	1.53
700 ***	14.0	0.07	**1.60**

(Source: ASCE-74) * Probability = $1 – (1 – 1/RP)^{50}$

** To be applied to wind load or force *** Extrapolated

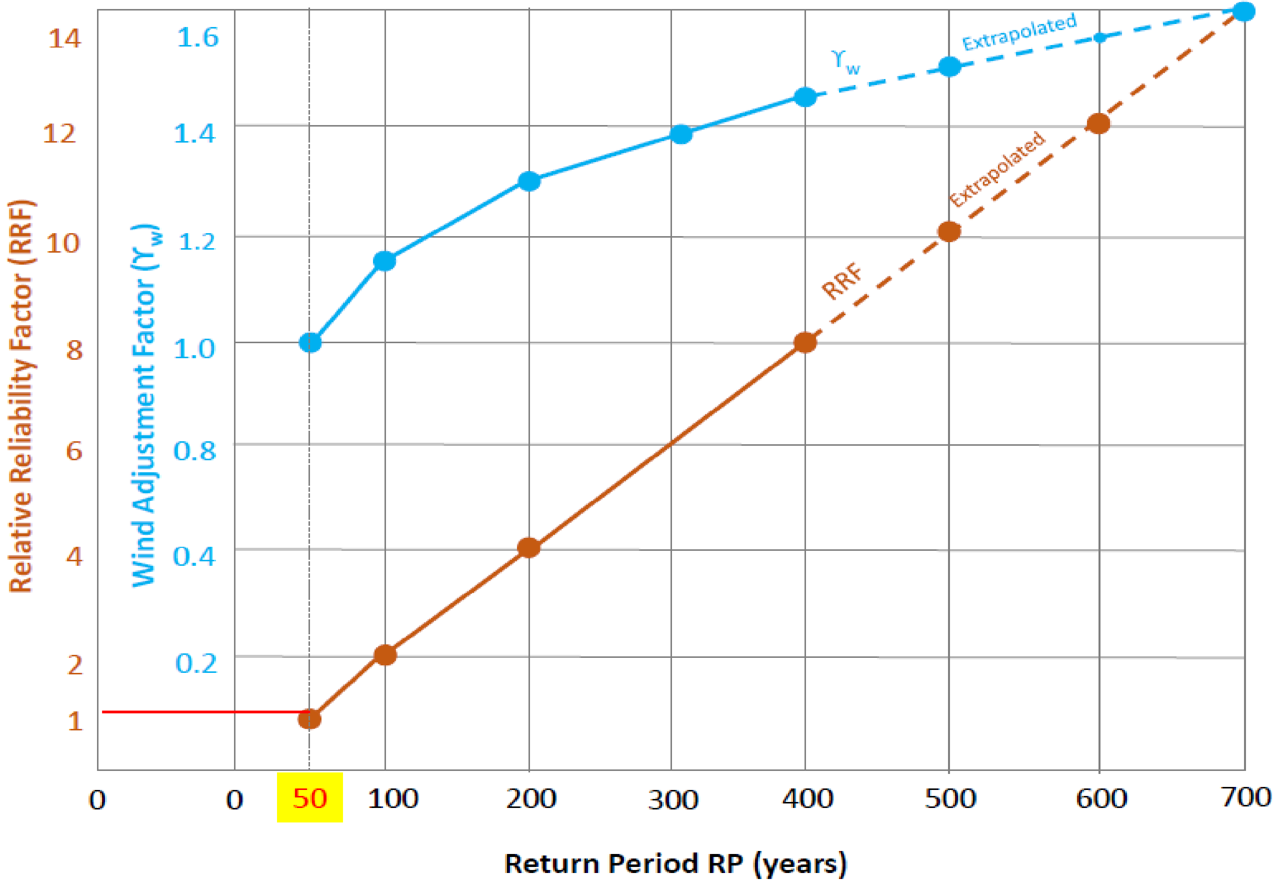


Fig. 1. Relationship Between Reliability, Wind and Return Period

Reliability Requirements

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Conflicts with Different Design Approaches: ASCE vs TIA

- ASCE and TIA = Apples and Oranges
- A Good Dog can have only 1 Master! Not 2 Lords ☺
- Differences:
  - Definitions of Wind load and parameters such as C_f, C_A, C_d etc..
  - Definitions of Limit States (TIA) and Performance Criteria (NESC)
  - Definitions of Serviceability Deflections

    NESC *usually* at no wind no ice 60^{o}F condition, TIA at 60 mph wind
  - Wind + Ice (TIA) often has an ice thickness of 1” or more!

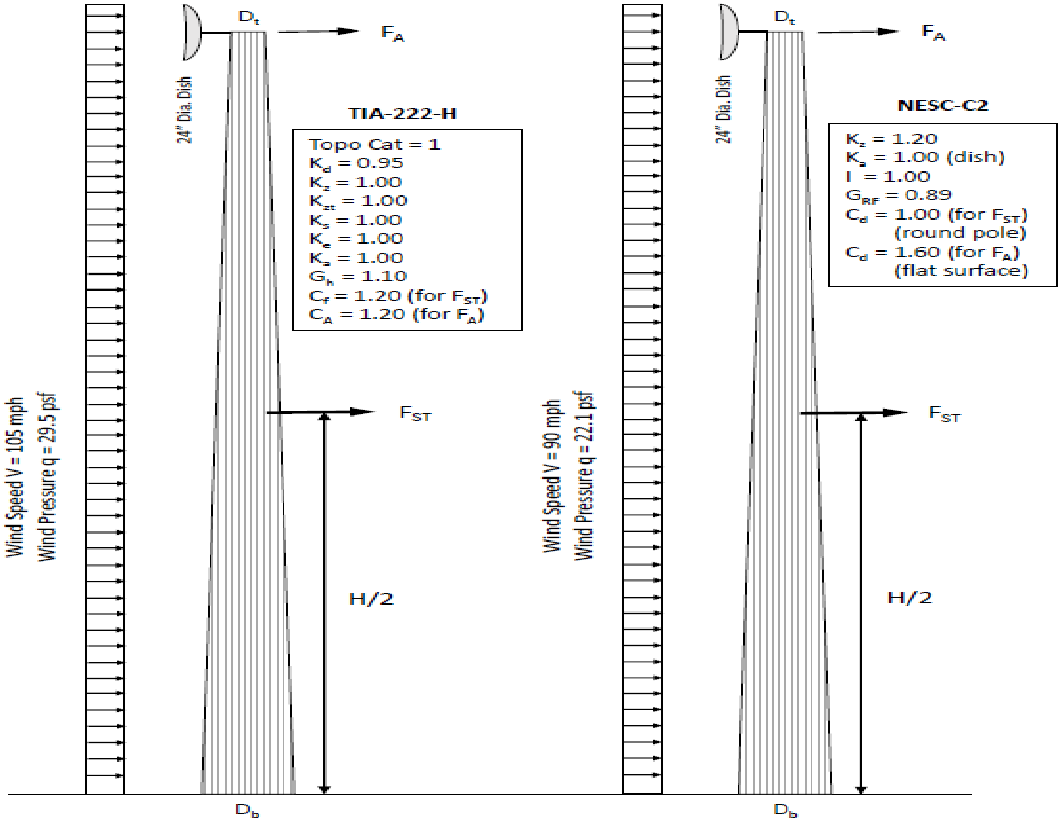
    Large ice thickness in NESC is usually associated with little wind!

Can We Simplify?

- Simplifications must entail the same level of reliability in both TIA and NESC approaches
- Should address both wind (and ice) parameters
- Upward Adjustment of NESC to meet TIA's High RPs?

We Illustrate the argument with a small Example.

- Tubular Steel Pole located in Chattanooga, Tennessee
- Investigate the High Wind load case
- Compare moments, shears and deflections for both TIA and NESC and evaluate the contrast



Tubular Pole: Height H = 90' D_t = 20" D_b = 32" t = ¼" 12-sided - 65 ksi

Fig. 3. Example Steel Pole with Dish Antenna – Extreme Wind Case

Table 2: Numerical Results for Steel Pole

Code	Basic Wind Speed V (mph)	Basic Wind Pressure q (psf)	Total GL Shear S (kips)	GL Moment M (kip-ft)	Bending Stress f_b (ksi)	Tip Deflection (ft)
NESC	90	22.1	4.42	203.9	11.63	0.76
TIA-222	105 *	29.5	7.01	320.5	18.28	1.18
Ratio: TIA/NESC	1.166	1.335	1.586	1.571	1.571	1.553

* From ASCE 7 Hazard Tool

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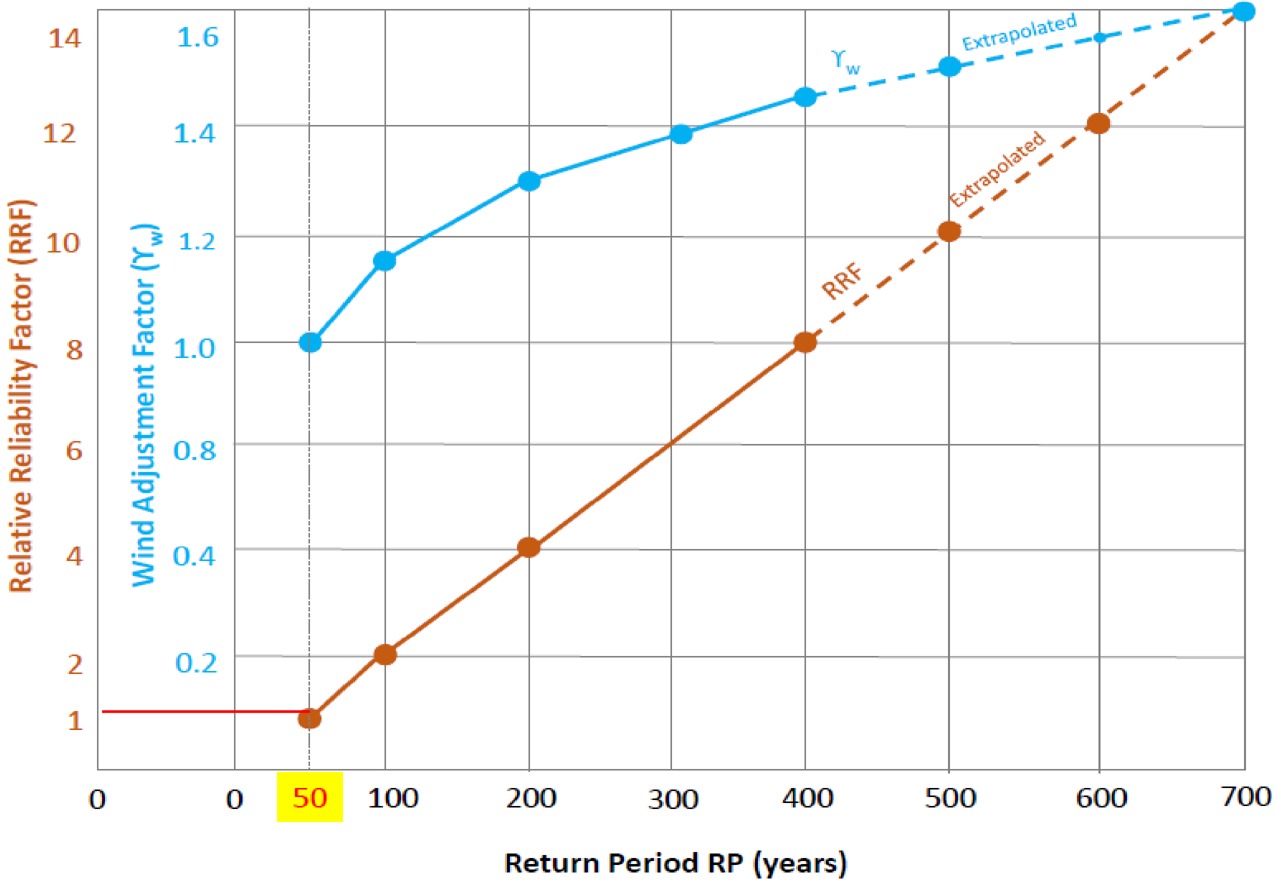

Fig. 1. Relationship Between Reliability, Wind and Return Period

Discussion Recap:

- Table 2 contained the ratio of the TIA value/NESC value of all parameters. This was due to the conflicting design approaches of the TIA and NESC. One can easily see the apples and oranges analogy therein.

While the basic wind pressure ratio is 1.335 the ratios of moments, shears and deflections were 1.56 to 1.59. Note that the TIA wind pressure of 29.5 psf does not include the C_f (or C_A) factor of 1.20. If this is included, then the wind pressure ratio becomes 1.335 x 1.20 = 1.601.

- (For a 12-sided pole, the corresponding C_d factor is taken as 1.00).
- Figure 1 & Table 1: this corresponds to a wind adjustment factor (Υ_w) of 1.60 associated with a RP of 700 years!

Discussion Recap (cont.):

The above discussion leads to an interesting possibility:

- Adjusting the nominal (default) 50-year NESC/ASCE winds using a Υ_w factor of 1.60 gives us a means of "upwards adjusting" NESC wind loads to get them closer to TIA loads.

(Note: This factor should be applied to the wind pressure and NOT to the wind speed!)

- Multiplying NESC loads by appropriate ASCE adjustment factors can help bring them on par with TIA requirements?

Further Work:

1. Explore extending the adjustment argument to other NESC Weather Cases including:
   - Ice with Concurrent Wind (250B or 250D)
   - Serviceability Deflections
2. The goal, in summary, is to perform one single analysis with one set of weather and load cases which comply with both NESC and TIA rules.

Is it Possible? We need to explore it further.

References:

1. NSEC-C2, National Electrical Safety Code, IEEE, 2017.
2. TIA-222-H, Structural Standard for Antenna-Supporting Structures, Antennas and Small Wind Turbine Support Structures, 2017.
3. ASCE MoP 74, Guidelines for Transmission Line Structural Loading, 2012.
4. ASCE 7-16, Minimum Design Loads for Buildings and Other Structures, 2016.
5. ASCE 48-11, Design of Steel Transmission Pole Structures, 2011.
6. ASCE 10-15, Design of Latticed Steel Transmission Structures, 2015.
7. Hopkins, R.B., Design Analysis of Shafts and Beams, Mc-Graw-Hill, 2004.
8. PLS-Pole ™, Computer Program for Analysis of Transmission Poles, 2012.

THANK YOU FOR WATCHING THIS PRESENTATION!

If you have any questions related to this presentation , please feel free to contact the following:

Aaron Haithcock, PE

ahaithcock@mesainc.com

Sriram Kalaga PE, Ph.D., F.ASCE

skalaga@mesainc.com

Jason Kilgore, PE, SE

jkilgore@mesainc.com