WORKSHOP PARA MODERNIZAÇÃO DA NORMATIZAÇÃO RELACIONADA AO SEGMENTO DE TRANSMISSÃO – BRASIL

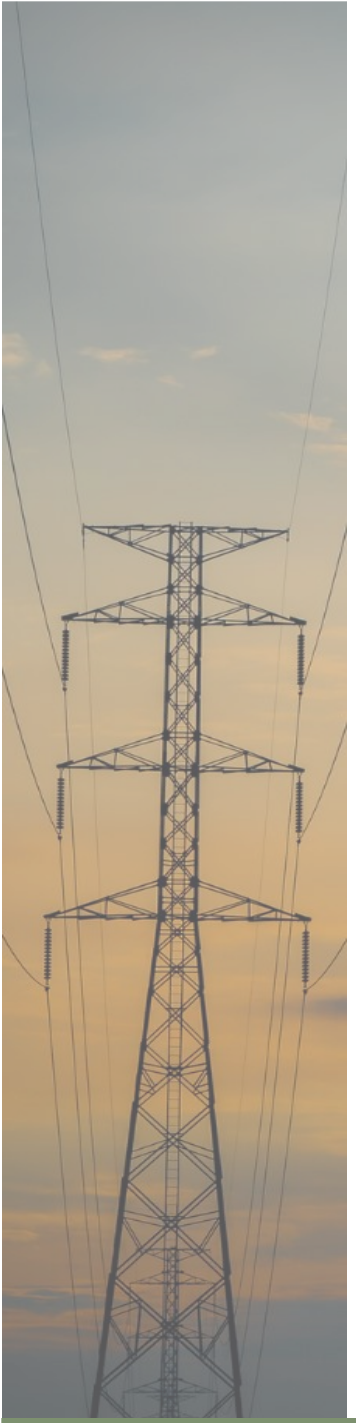
21/09/2023

Comentários para a Comissão de Norma NBR8850

João BGF da Silva/Paranaíba Transmissora de Energia

REALIZAÇÃO:

ABDIB ABRATE Instituto ABRATE ENGIE



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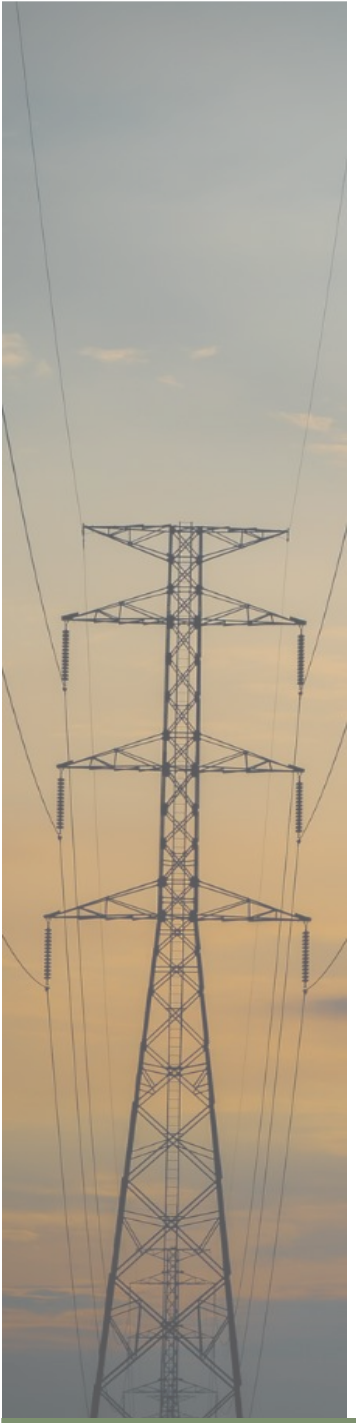
Strength Factor (ϕR) Cigré Studies

João Batista Guimarães Ferreira da Silva



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Probabilistic method for OHL: IEC 60826

$$\gamma_u \; Q_T \leq \phi_R \, R_c$$

ϕ_R = Strength Factor

- How to understand it?
- How to evaluate?

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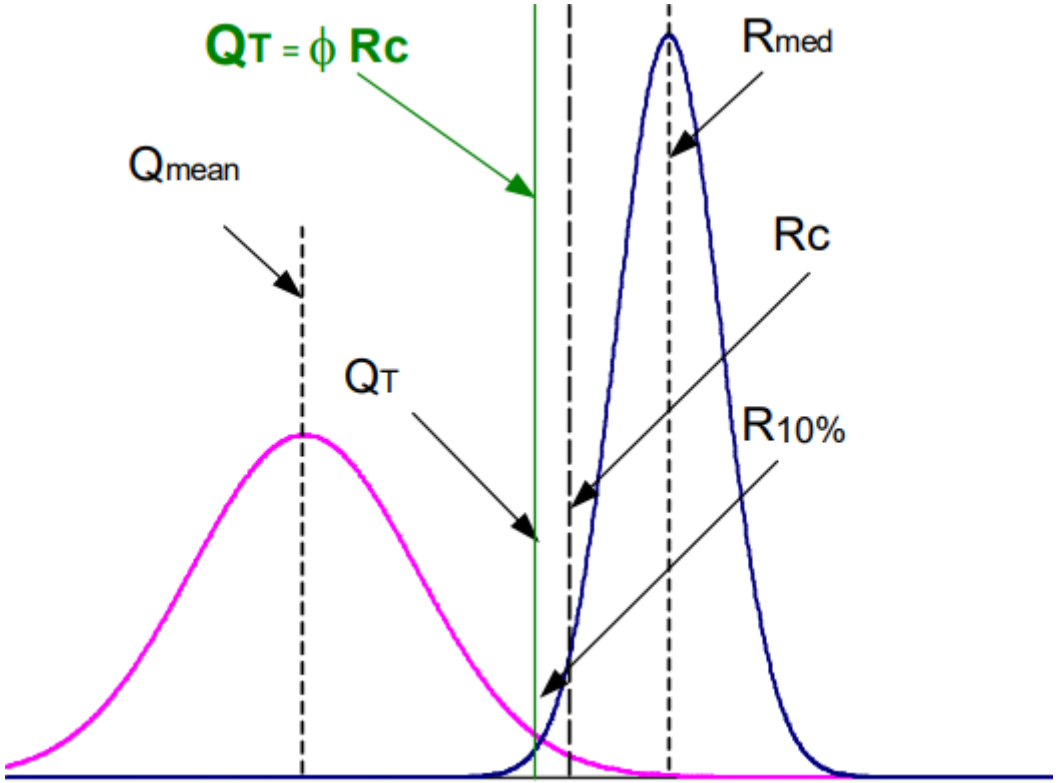
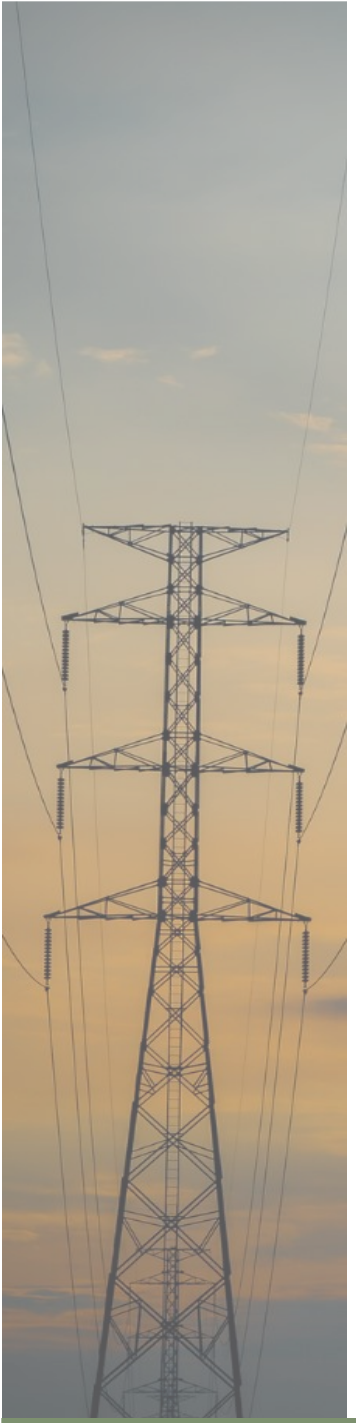
As per IEC 60826

Risk: 10% Exclusion limit

$R_{10} = \phi_R \, R_c$





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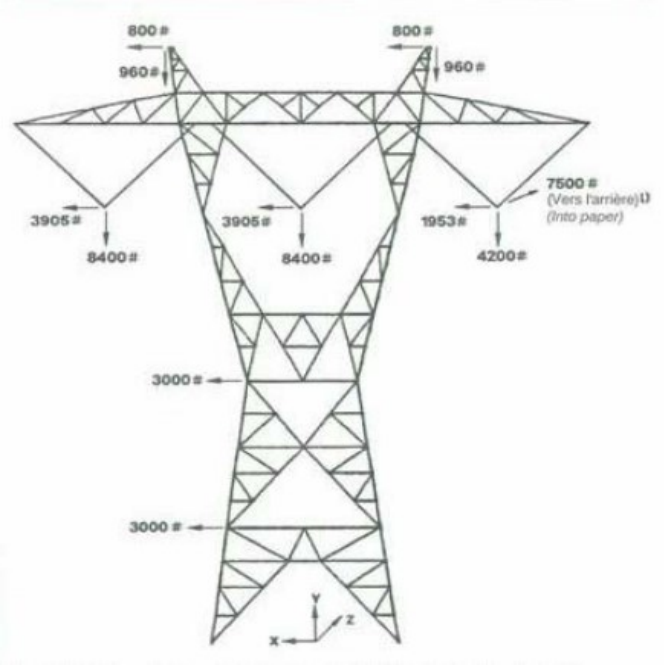
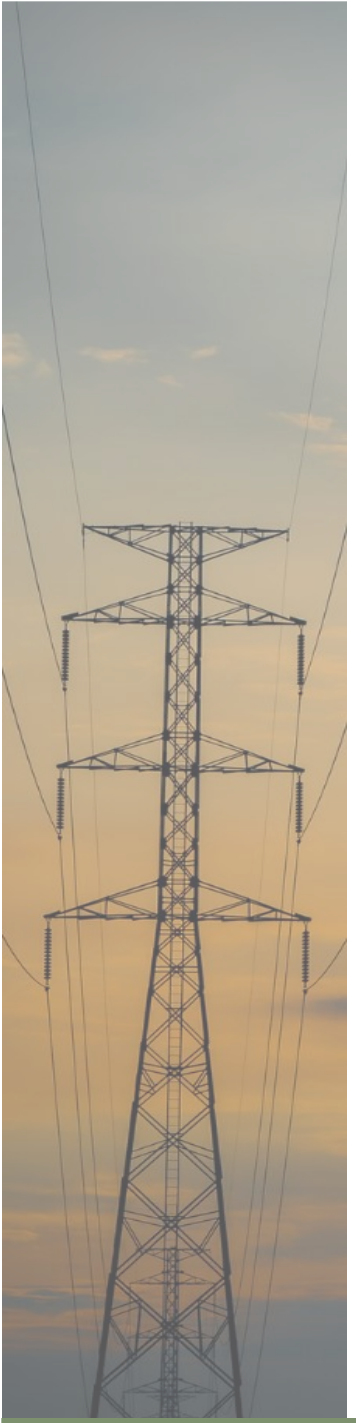
- First studies EPRI USA

Conclusions Electra 138, 1991:

- The professional assumptions (modeling), the design tools and techniques play important role for the accuracy
- Good predictions may not guarantee good test results
- Good convergence for main members, great discrepancies for some diagonals

- Why? Necessity of deeper studies





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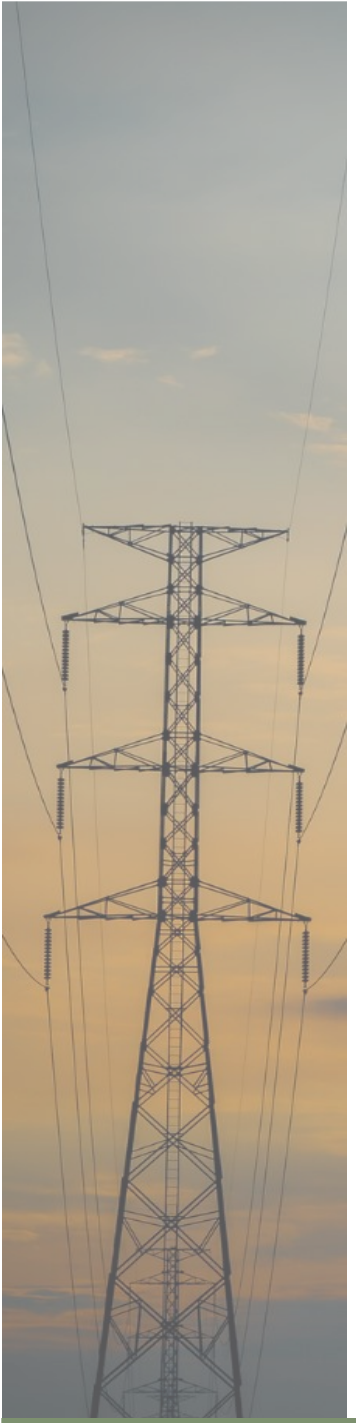
- Main causes for the discrepancies:
  - Professional knowledge: experience, design practices, modeling, software's, standards used
  - Tolerances on the material properties
  - Fabrication tolerances
  - Erection practices and techniques
  - Foundations Construction / accurence



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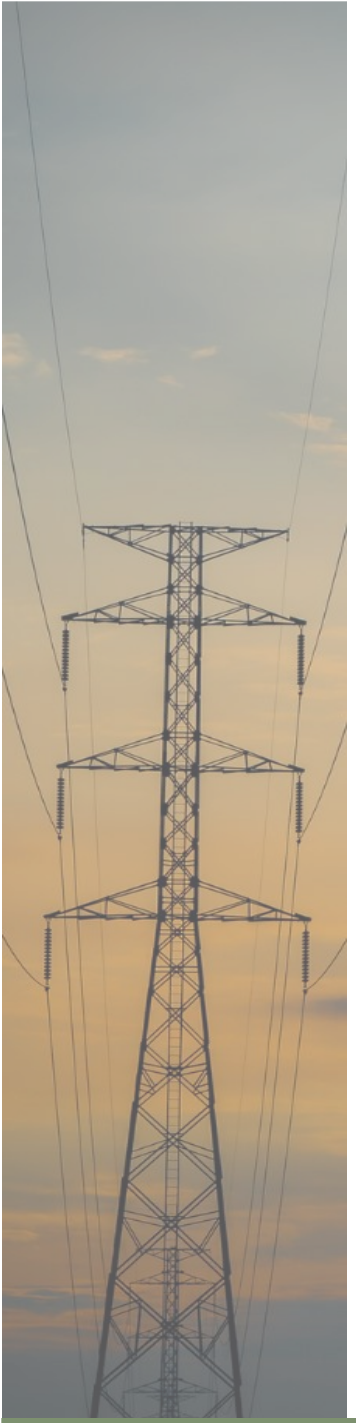
How to Understand ϕ

- Cigré publications:
  - "An Experiment to Measure the Variation in Lattice Tower Strength Due to Local Design Practice". Electra nº138, 1991
  - "Statistical Analysis of Structural Data of Transmission Line Steel Towers". Electra nº 208, 2005
  - "Variability of the Mechanical Properties of Materials for Transmission Line Steel Towers." Electra nº189, 2000
  - "On the Failure Load of Transmission Line Steel Towers Considering Uncertainties Arising from Manufacturing & Erection Processes". Cigré SC B2 Web Site
  - "The Effect of Fabrication and Erection Tolerances on the Strength of Lattice Steel Transmission Towers". Electra 252, Oct 2010 – TB 428



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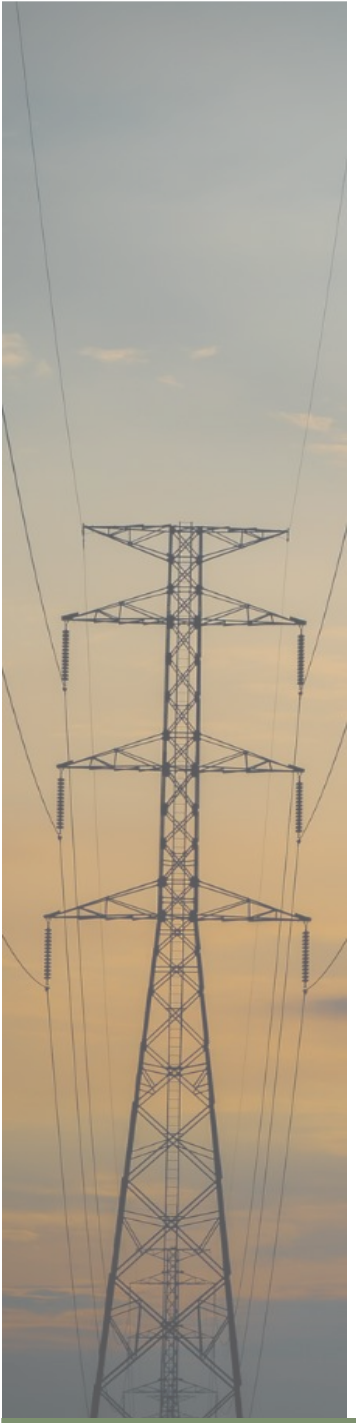
How to Understand ϕ_R

- Cigré publications:
  - "Influence of the hyperstatic modeling on the behavior of transmission line lattice structures". Electra 245, Aug 2009, TB 387
  - "Diaphragms for Lattice Steel Supports".TB 196, Electra 199, Dec 2001
  - "Improvement on the Tower Testing Methodology". Electra 247, Dec 2009 – TB 399
  - "Comparison of General Industry Practices for the Lattice Tower Design and Dettaling", TB 384, Electra 244, June 2009
  - "Investigation on the Structural Interaction between Transmission Line Towers and Foudations", TB 395, Electra 246, October 2009



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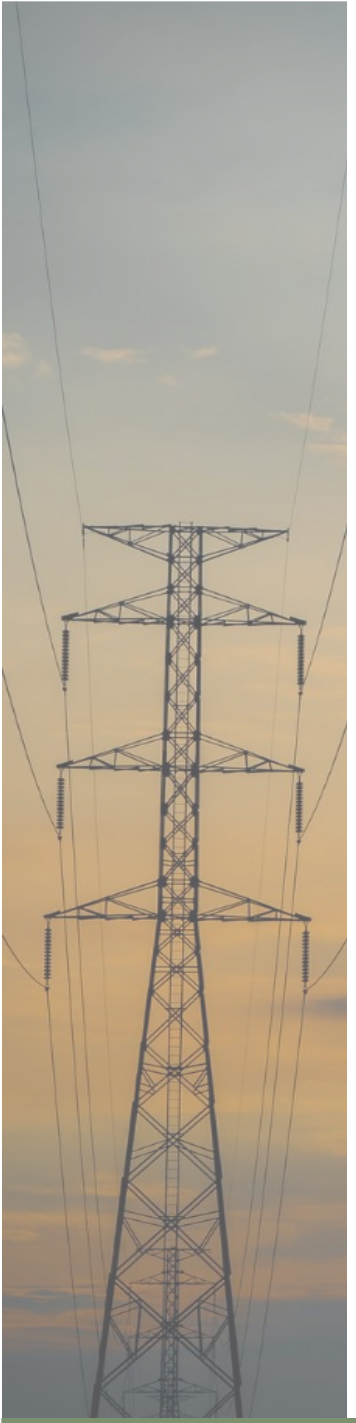
How to Estimated it?

- Bienal Cigré Papers
  - Pachen, R., Pezard, J. Zago, P “Probabilistic Evaluation on Test Results of Transmission Line Towers”, Cigré International Conference on Large High Voltage Electrical Systems, Paris, Report 22-13, 1988
  - Riera, J.D., Ramos de Menezes, R.C., Silva, V.R., Ferreira da Silva, J.B.G., “Evaluation of the Probability Distribution of the Strenght os Transmission Line Steel Towers Based on Tower Test Results”, Cigré International Conference on Large High Voltage Electrical Systems, Paris, Report 22-13, 1990



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Dynamic Loading Considerations

From Cigré TB 809

João Batista Guimarães Ferreira da Silva

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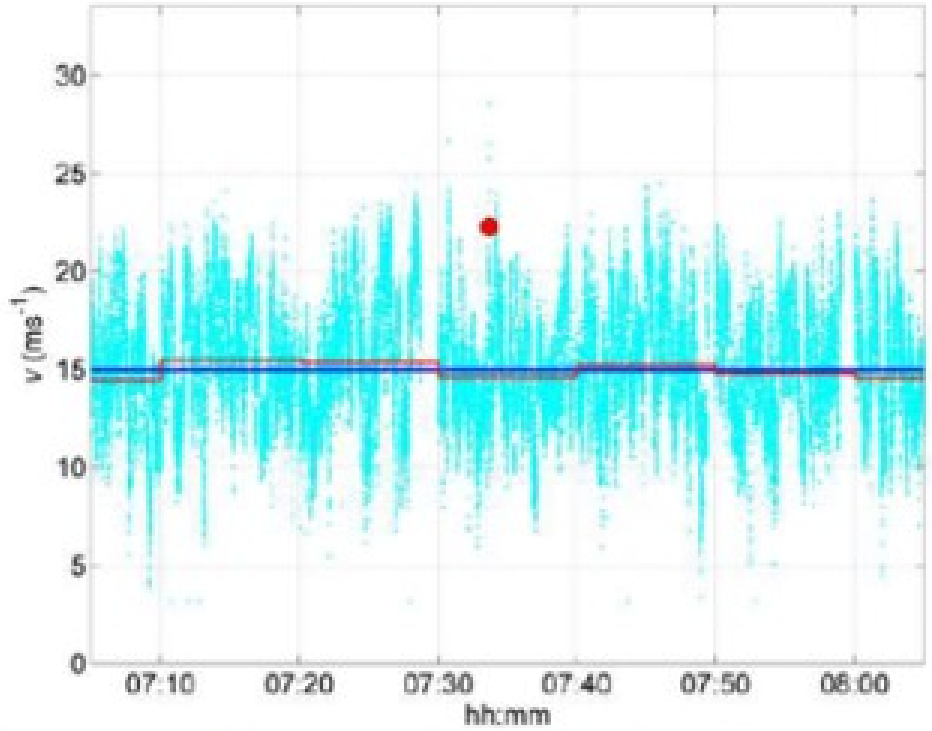

Figure 4.2: Typical record of wind velocity during a synoptic storm

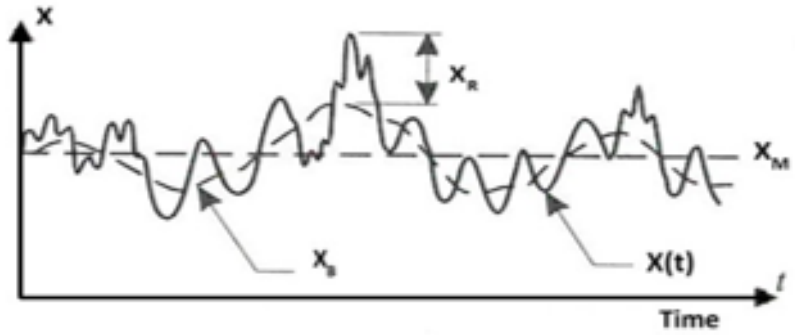

Figure 4.3: Typical time history of the structural response in terms of member forces

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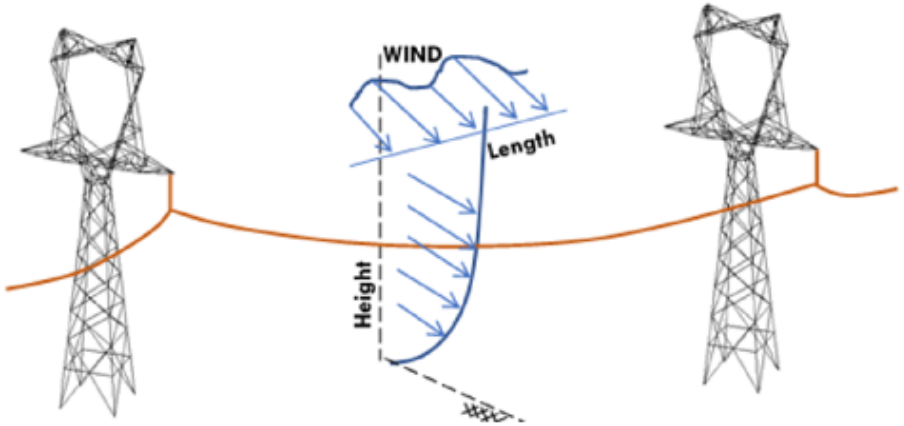
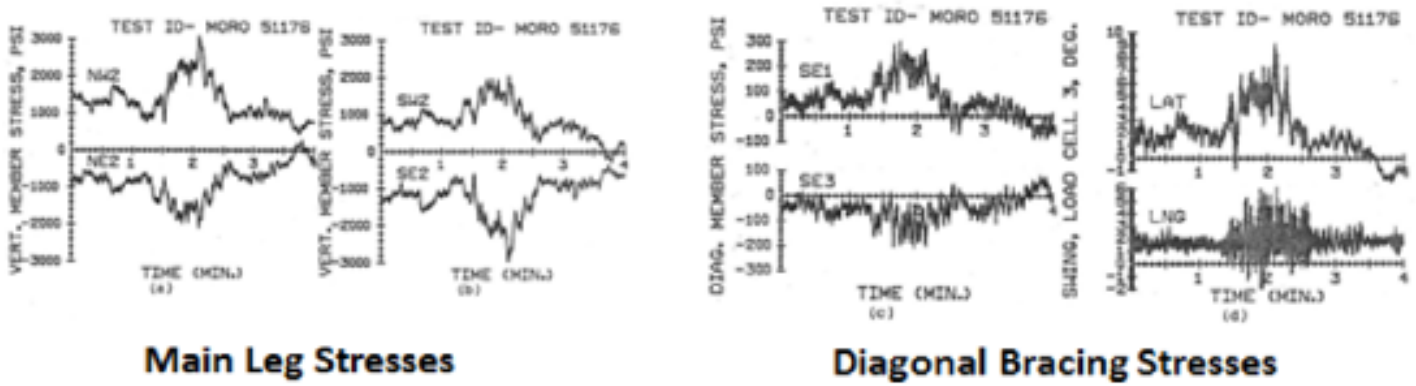


Figure 4-1: Wind loads on transmission lines



Main Leg Stresses **Diagonal Bracing Stresses**

Figure 4-2: Tower response to wind [68, 69, 70]

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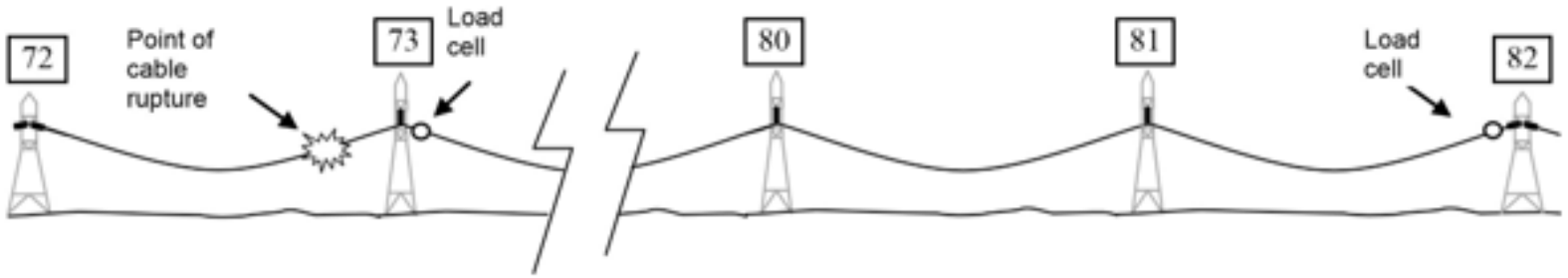
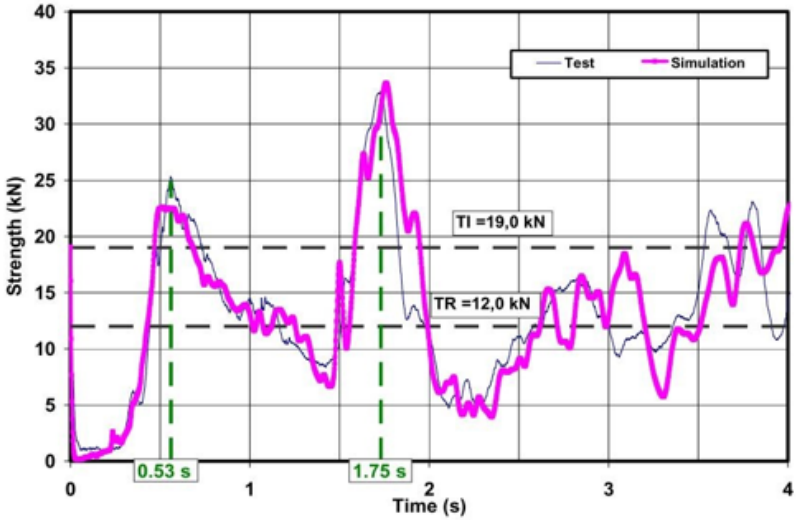
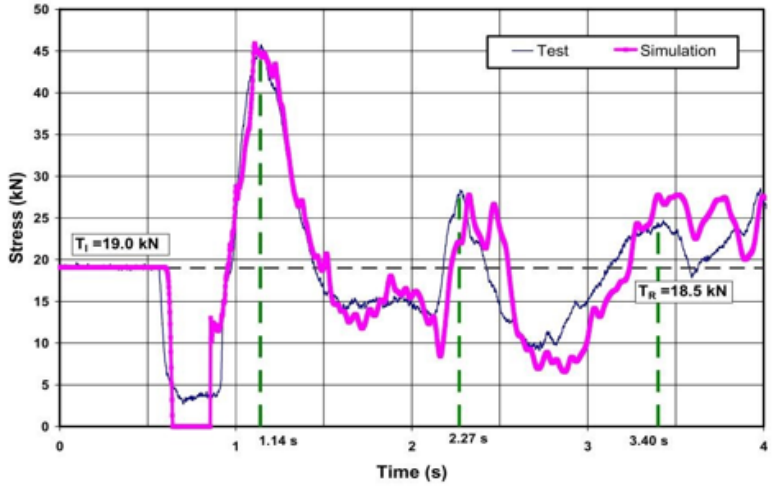


Figure 5.7: Sketch of the line section profile used by Vincent et al. [B87]



(a) Conductor tension at support 73



(b) Conductor tension at support 82

Figure 5.8: Recorded and simulated conductor tension at supports 73 and 82 [B87]

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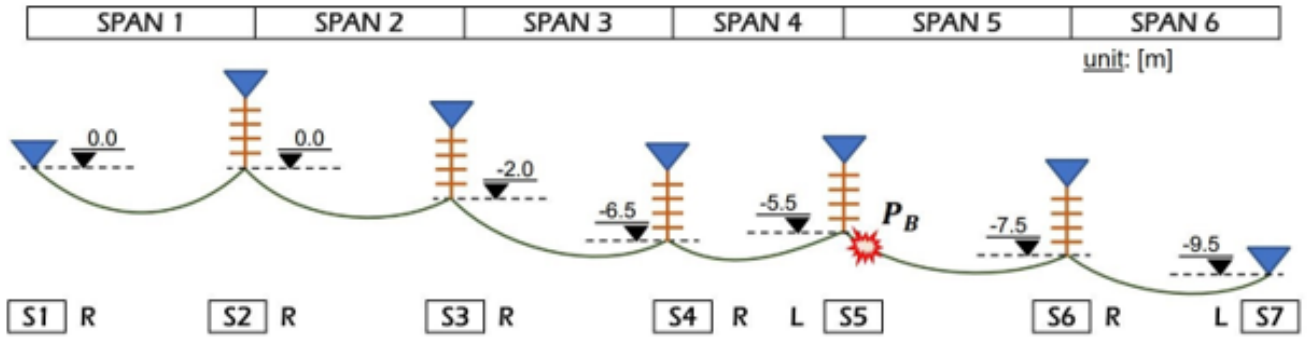

Figure 5.9: Profile of the two-dimensional model used by Lapointe [B55]

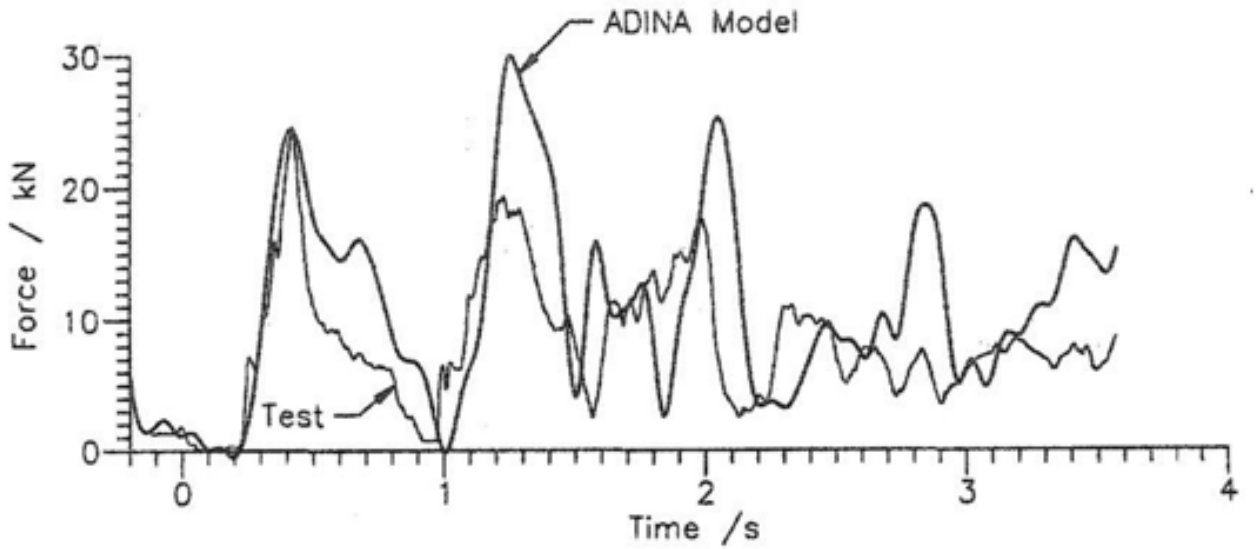

Figure 5.10: Comparison between experimental and simulated insulator tension [B64]

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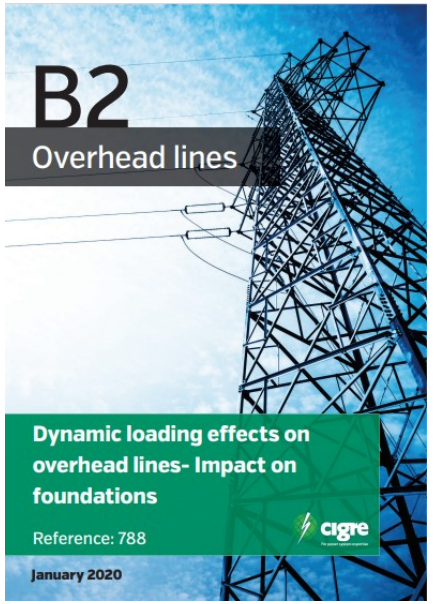
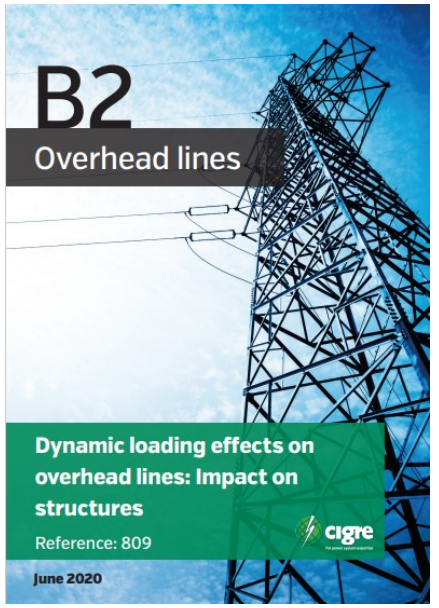
Conclusion BT 809

The current industry practice to design transmission line components does not explicitly apply structural dynamic analysis to predict their response, in terms of effects of time varying loads. Equivalent static analysis methods of dynamic loading events have provided reliable tower designs under typical conditions, fulfilling the premises about which they are derived. Therefore, within a considerable range of usual TL conditions, it is valid to say that dynamic analysis capabilities are not necessarily required for the production design of transmission line towers.

In this context, structural dynamic analysis capabilities are important to understand the structural performance of transmission line components (towers, foundations), when subjected to time-dependent loads. In some situations, such as, very high towers, specifically slender towers, in cases when the tower natural frequencies are in the range of the excitation spectrum, towers located at major crossings, in complex mountainous terrain, etc., structural dynamic analysis is a necessary tool to understand the transmission line response to loads that are time-dependent





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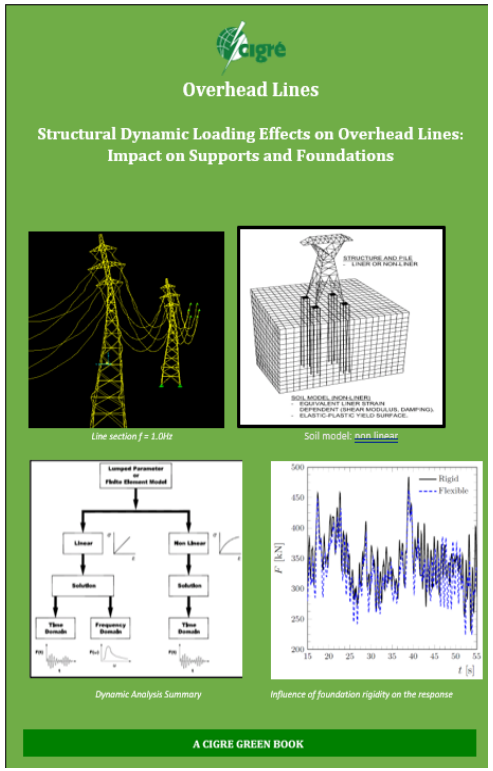

"Overhead transmission lines extend over significant distances and are exposed to dynamic loads such as wind, wind and ice storms, ice shedding, earthquakes, conductor breakage, insulator string failure which can have an impact on their performance. This book presents a comprehensive overview of the dynamic phenomena impacting transmission line supports and foundations and the dynamic analysis techniques used to obtain the response of transmission lines under time-dependent loads. Simplified approaches based on equivalent static loads are traditionally employed, however, there are special cases where the designer should consider dynamic analysis, such as for large river crossings, special long span configurations, or for new non-traditional tower/foundation designs."

Pierre / João