AN ASSESSMENT OF ACSR CONDUCTOR SAG AT HIGH TEMPERATURE

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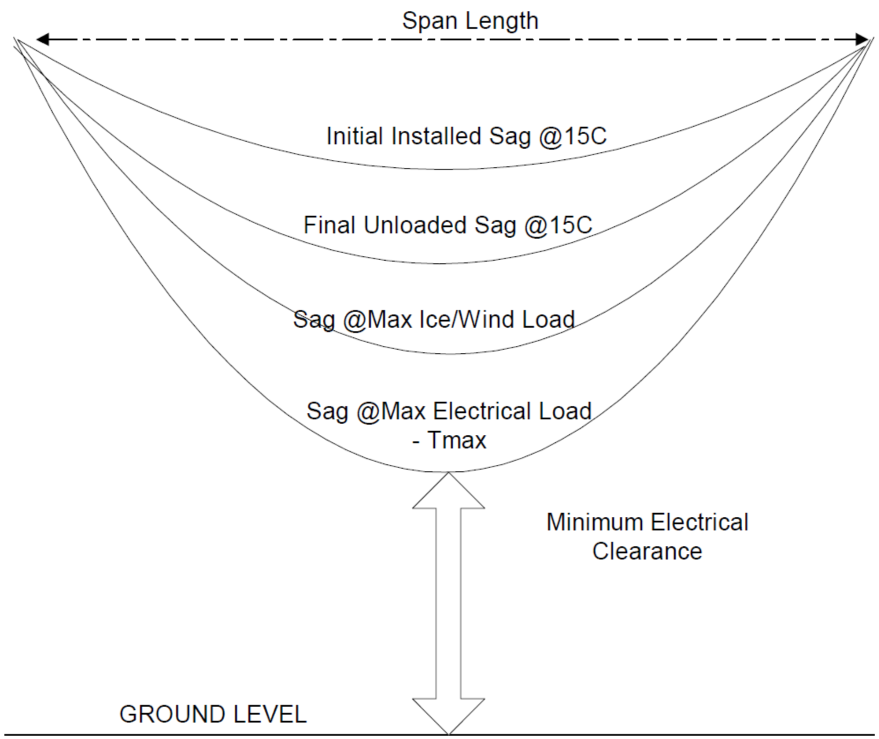
Introduction

1. Conductor Sag and Tension data used for line design
    1. Based on Stress/Strain data

2. Important to maintain clearances over the lifetime of the transmission line

3. Important to accurately model the mechanical performance of conductors

4. In a bimetallic conductor such as ACSR, mechanical behavior governed by both the steel and aluminum components



Catenary Curve

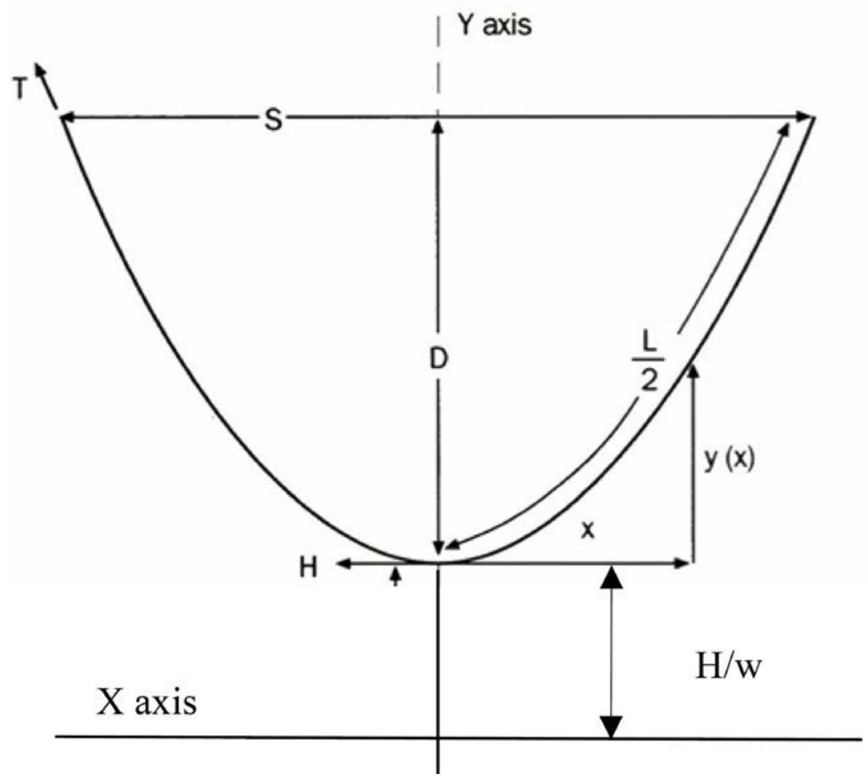
1. Models the shape of an overhead transmission line span

2. The shape is determined by the following equation

$$y(x) = \frac{H}{w} \cdot \left[\cosh\left(\frac{w \cdot x}{H}\right) - 1\right]$$

3. Sag = $D \cong \dfrac{w \cdot S^2}{8 \cdot H}$

4. Higher operating temperatures result in lower horizontal tension = more sag



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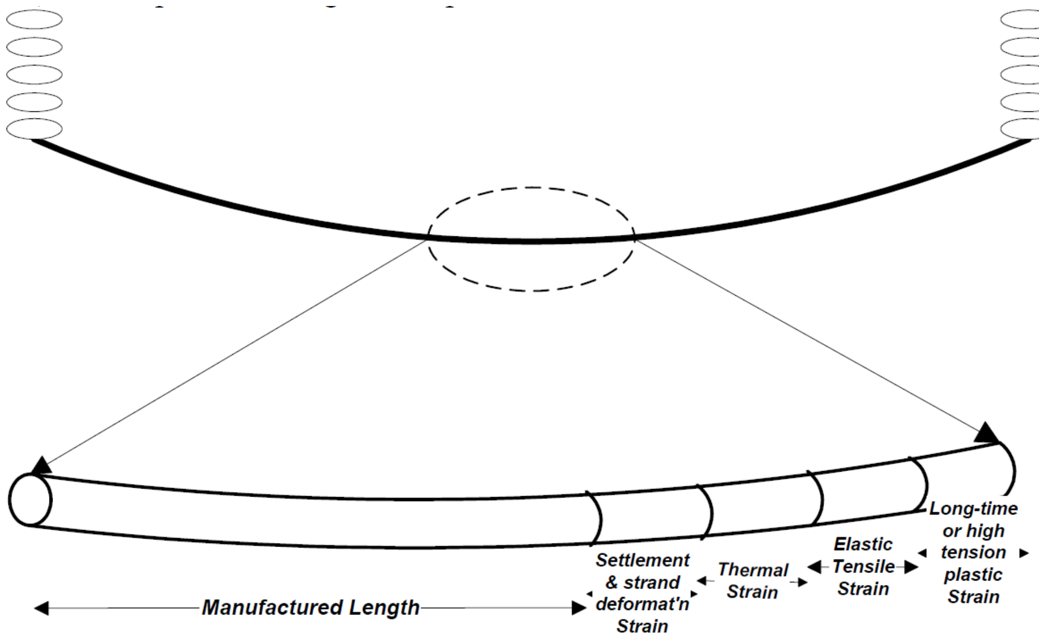
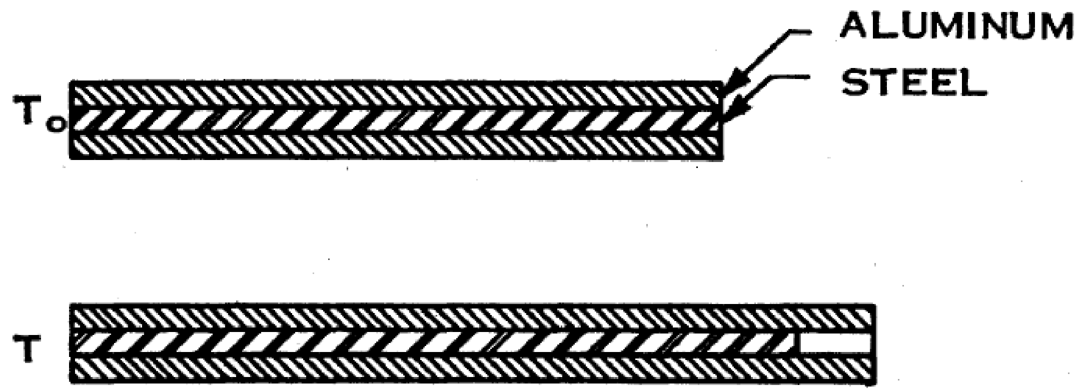
Conductor Elongation

- Conductor Creep
- Mechanical Loading
- Conductor Temperature Changes



ACSR Thermal Elongation and Sag

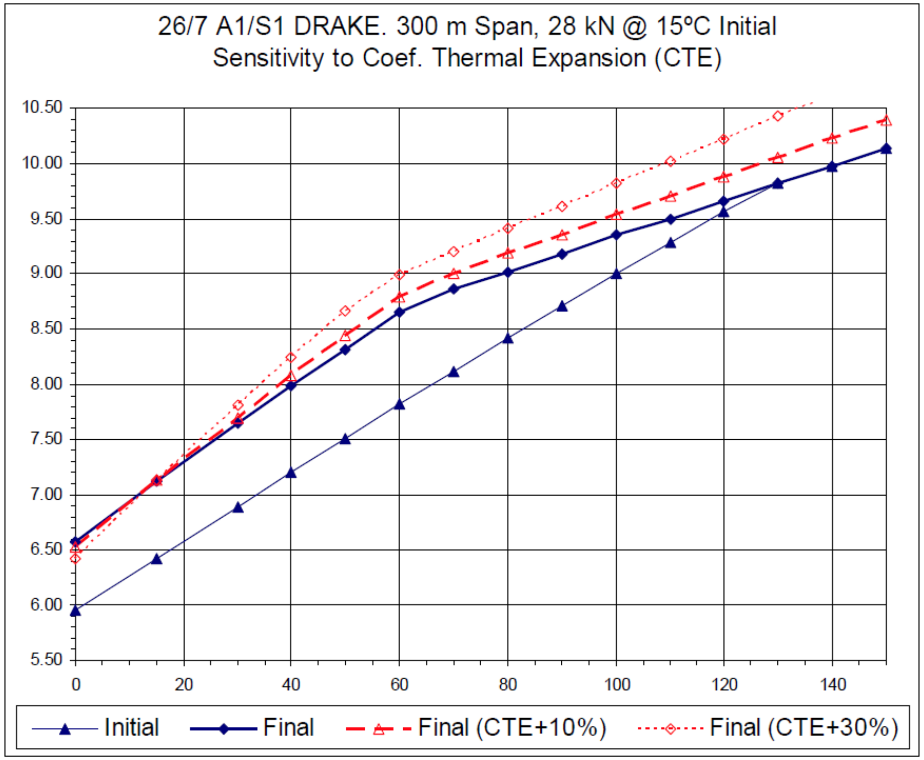
- Bimetallic Mode of Expansion
  1. Steel
  2. Aluminum



- Drake ACSR Conductor Coefficient of Thermal Expansion
  1. Steel = 11.5 x 10^{-6}m/m/°K
  2. Aluminum = 23 x 10^{-6}m/m/°K
  3. Entire conductor = 18.8 x 10^{-6}m/m/°K

- Well understood below ~ 75°C (Knee-point)

- Above the Knee-point temperature ACSR elongation is not well understood



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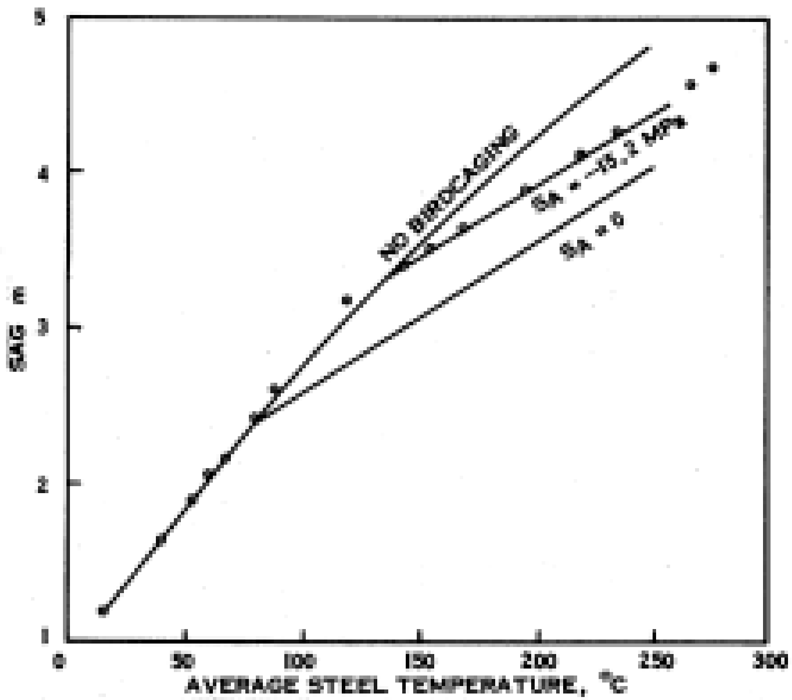
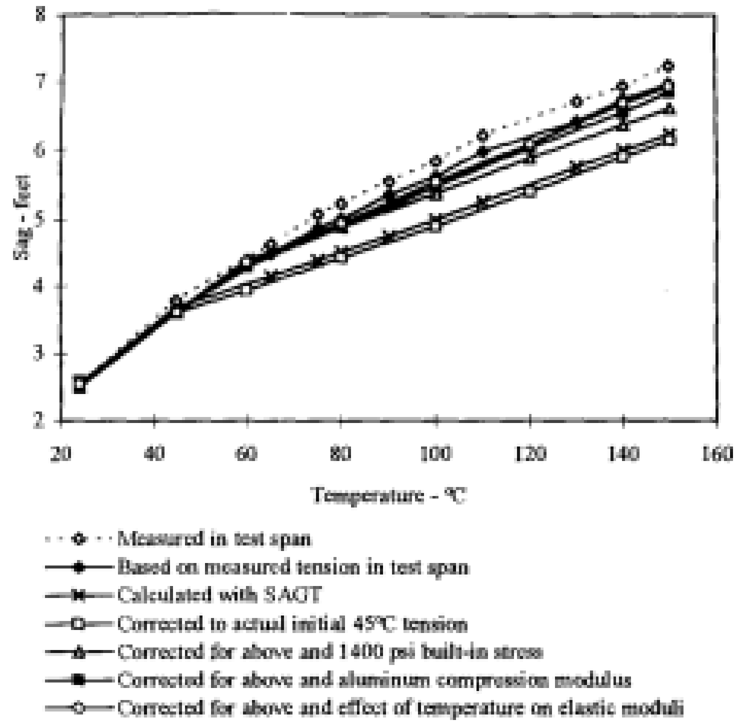
ACSR Sag Above the Knee-point

- Two Main Hypothesis
  - Aluminum strand compressive forces
  - Conductor manufacturing process effects (Mill effects)

- Aluminum Compression



- Mill Effects



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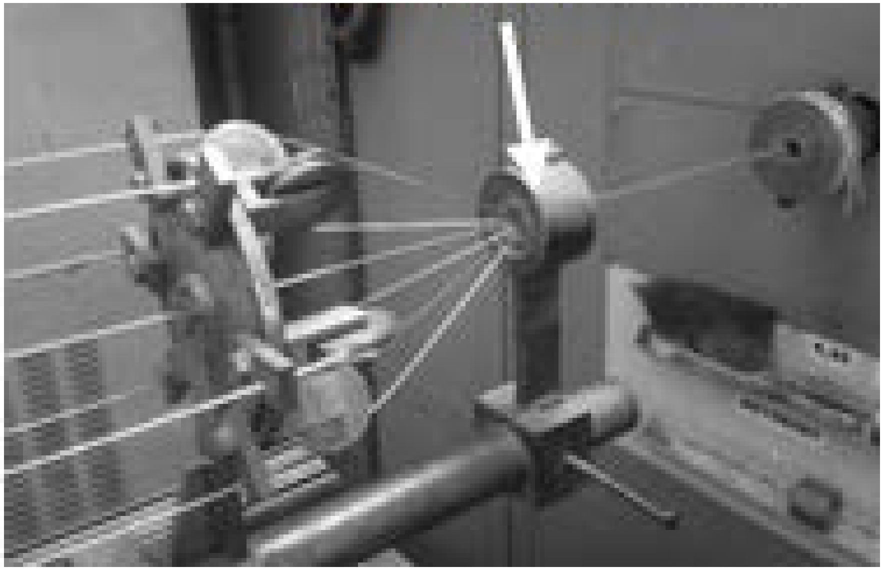
Industry Practices – No Consensus

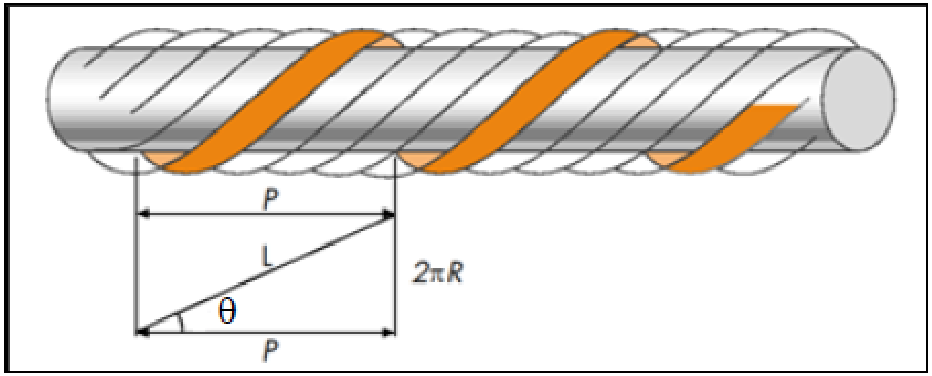
- Aluminum compression
  - Magnitude?

- Mill Effects
  - How do we know what happened during manufacturing?
  - How does this get modeled?

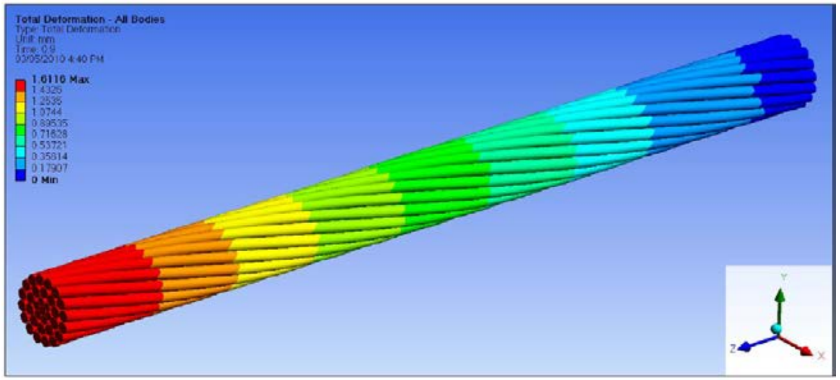


Previous Studies

- Proposed Sag Models
  - Mostly Analytical
  - Ignoring inter-strand and inter-layer friction



- Numerical Studies
  - Mostly limited to vibration studies
  - Steel Core and Aluminum Strands under tension



- No numerical modeling of ACSR conductor above the knee-point temperature

- No physical tests to determine compression forces in aluminum strands

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Conclusions

- Knowing the conductor sag under all operational conditions is important
- ACSR Sag at high temperatures is not well understood – further research is required
- Existing ACSR elongation models are not accurate at temperatures above the knee-point
- Previous analytical studies have not explained the phenomenon sufficiently
- There is a need for a better understanding of the mechanical behavior of the steel and aluminum strands
- Numerical modeling and physical tests will provide more clarity on the factors affecting ACSR sag

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