Solution to Sag Problem with Conductor Supports at Different Elevations (with Example)

Conductor: 795 Kcmil ACSR 26/7
Maximum Horizontal Tension (Th): 8,000 Lbs
Heavy Loading Resultant Weight + K (W): 2,510 Lbs/Ft
Span Length (S): 1800 Ft
Difference in Elevation (H): 460 Ft

1. Estimate span length, S2, or D2 sag. (See Fig. 1 & 2)
   For this example, D2 is estimated to be 463 feet.

2. Calculate span, S2, corresponding to D2 of 463 feet using catenary equation.

   \[ D_2 = \frac{T_h}{W} \times \left( \cosh \left( \frac{S_2 x W}{T_h} \right) \right) - \frac{T_h}{W} \]

   \[ S_2 = \frac{T_h}{W} \times \cosh^{-1} \left( \left( D_2 + \frac{T_h}{W} \right) \times \frac{W}{T_h} \right) \]

   \[ S_2 = \frac{8000}{2510} \times \cosh^{-1} \left( \left( \frac{463}{8000} + \frac{8000}{2510} \right) \times \frac{2510}{8000} \right) = 1697.82 \text{ Ft} \]

3. Calculate S1 (See Fig. 2)

   \[ S_1 = S - S_2 \]
   \[ S_1 = 1800 - 1697.82 = 102.18 \text{ Ft} \]

4. Calculate D1 sag using catenary equation.

   \[ D_1 = \frac{8000}{2510} \times \left( \cosh \left( \frac{102.18 \times 2.510}{8000} \right) \right) - \frac{8000}{2510} = 1.64 \text{ Ft} \]

5. D2 - D1 should equal the value of H (460 Ft).

   \[ 463 - 1.64 = 461.38 \text{ Ft} \]

   This means that span S2 is too long.

6. Reduce span length to 1695.5 Ft and recalculate D2 sag.

   \[ D_2 = \frac{8000}{2510} \times \left( \cosh \left( \frac{1695.5 \times 2.510}{8000} \right) \right) - \frac{8000}{2510} = 461.70 \text{ Ft} \]

7. Recalculate S1 span length.

   \[ S_1 = 1800 - 1695.5 = 104.5 \text{ Ft} \]

8. Recalculate D1 sag.

   \[ D_1 = \frac{8000}{2510} \times \left( \cosh \left( \frac{104.5 \times 2.510}{8000} \right) \right) - \frac{8000}{2510} = 1.71 \text{ Ft} \]
9. Recalculate difference between \( D_2 \) and \( D_1 \) sags as \( H \).
\[
H = 461.71 - 1.71 = 460 \text{ Ft}
\]

10. Calculate \( S_3 \) span length.
\[
S_3 = S / 2 - S_1
\]
\[
S_3 = 1800 / 2 - 104.5 = 795.5 \text{ Ft}
\]

11. Calculate \( D_3 \) sag using catenary equation.
\[
D_3 = \frac{8000}{2.510} \left( \cosh \left( \frac{795.5 \times 2.510}{8000} \right) \right) - \frac{8000}{2.510} = 99.79 \text{ Ft}
\]

12. Calculate \( D \) sag.
\[
D = H / 2 + D_1 - D_3
\]
\[
D = 460 / 2 + 1.71 - 99.79 = 131.92 \text{ Ft}
\]

13. Calculate \( T_1 \) and \( T_2 \) tensions.
\[
T_1 = T_h + D_1 \times W
\]
\[
T_1 = 8000 + 1.71 \times 2.510 = 8004 \text{ Lbs}
\]
\[
T_2 = T_h + D_2 \times W
\]
\[
T_2 = 8000 + 461.71 \times 2.510 = 9159 \text{ Lbs}
\]

14. Calculate tension \( Pav \). (This is the tension to be used in sag-tension calculations).
\[
Pav = (T_1 + T_2) / 2 - (D \times W) / 2
\]
\[
Pav = (8004 + 9159) / 2 - (131.92 \times 2.510) / 2 = 8416 \text{ Lbs}
\]

15. Calculate inclined span length.
\[
SL = \sqrt{S^2 + H^2}
\]
\[
SL = \sqrt{1800^2 + 460^2} = 1857.85 \text{ Ft}
\]

16. Calculate sags-tensions using inclined span, \( SL \), and heavy loading tension, \( Pav \).

Note: A starting condition other than the loaded condition may be used.
Appendix J       Inclined Span Sag Example

Fig. S1 Low Point of Sag Beyond Lower Support

Fig. S2 Span Supported at Different Levels