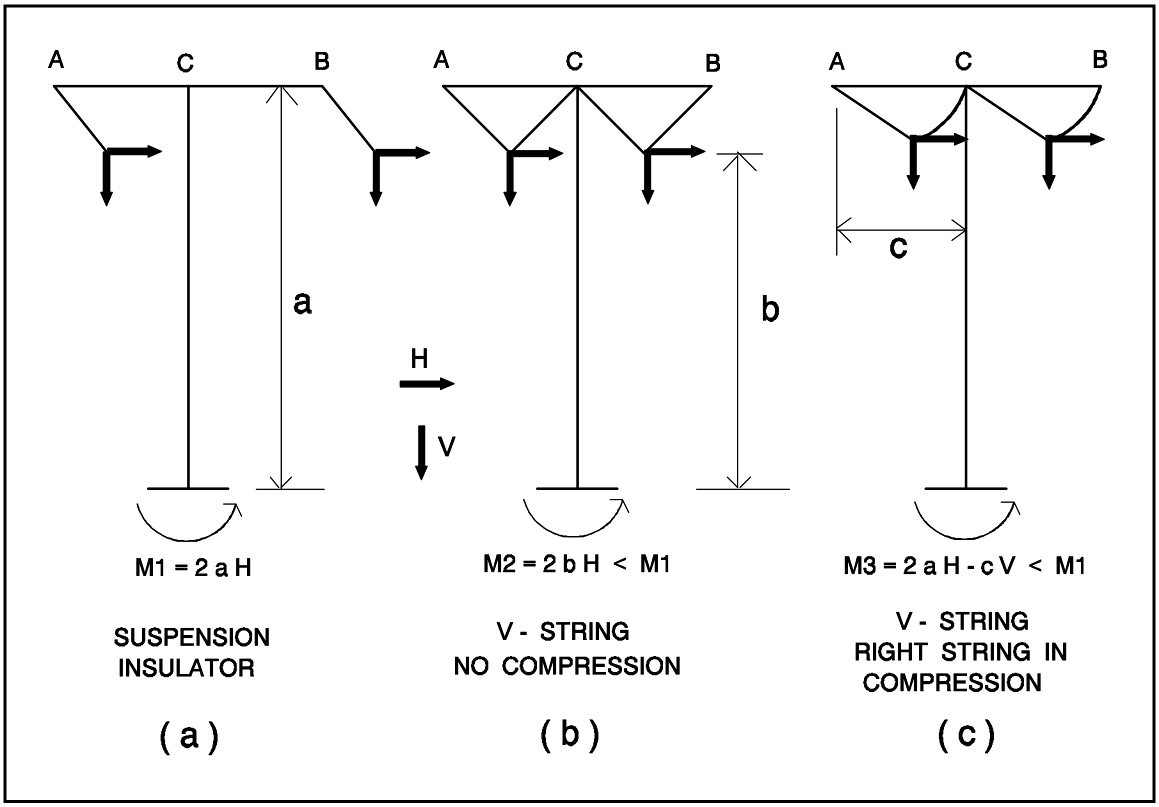
STRUCTURAL ADVANTAGE OF USING V-STRINGS

When comparing the relative advantages and disadvantages of using suspension insulators vs. 2-parts insulators such as V-strings, the most common cited benefit of the V-string is the control of conductor position and its effect on clearance to the supporting structure. However, as will be demonstrated in this technical note, there is a substantial structural advantage (reduction in overturning moment) of using V-strings. This structural advantage is in addition to the reduced torsional load in case of broken conductor.

Consider the simplistic situation of a two-phase DC pole in the figure below.

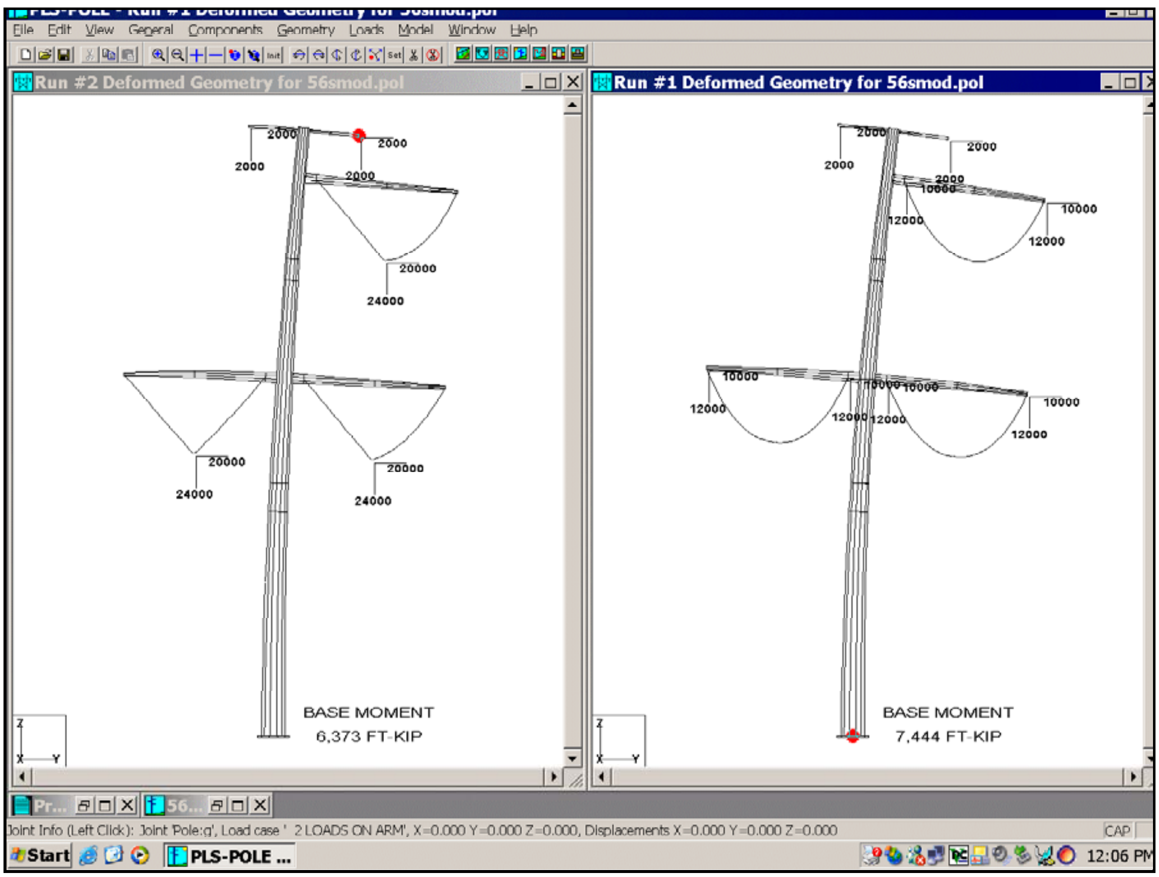


With suspension insulators (left side of figure), the horizontal load H and the vertical load V are transferred to points A and B at the tip of the arms and their effect on the base moment is 2 a H, where a is the height of the arms above the ground.

With V-strings configured so that the loads do not cause compression in either sides of the V's (center of figure), the sides of the V's can be thought of as structural members and the effect of the loads on base moment is 2 b H, where b is the height of the conductor attachment point above the ground.

With V-strings not deep enough to prevent compression in the right part of the V (right side of figure), the loads are transferred to points A and C. Therefore, their contribution to the base moment is 2 a H - V c, where c is the length of the arm. The leftward shift of the vertical load makes it counteract the moment produced by the horizontal load.

Therefore, whether one side of the V-string goes into compression or not, there is always a reduction in overturning moment with the use of V-strings. This reduction can be very subtantial as demonstrated by the example in the next figure.



The left pane shows a real tubular pole (displayed at scale) with the load correctly applied to the V-strings and the right pane shows the loads divided equally at the attachment of the V-strings to the arms. A detailed analysis of both models with PLS-POLE shows a substantial difference of 17 % between the base moment in the pole on the left and that on the right.

Automatically taking advantage of the reduction of overturning moments in latticed towers and poles is one of the reasons V-strings are always modeled as structural members (truss or cables) in TOWER and PLS-POLE. The other reason is that the distribution of forces from the conductor attachment point to the structure attachment points is complex in the presense of longitudinal loads and is affected by the deflection of the structure. You can see in the left pane of the figure that the right side of the V-strings on the right of the pole are more slack than the corresponding string on the left side of the pole. When there is longitudinal load, the distribution of load to the arm attachment points is a complicated nonlinear 3-d problem that cannot be handled by simple manual methods.

In conclusion, V-strings really behave as structural components of the structures to which they are attached and should be made part of the structure model in a competent analysis. Furthermore, the analysis should be nonlinear.