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Allowable Wind & Weight Spans vs. Real Structure Models

Introduction

For more than three decades many PLS-CADD users have taken advantage of Power Line Systems' advanced structural analysis solutions. Fully modeling structures in our TOWER and PLS-POLE programs provides many benefits over traditional wind & weight span approaches. These benefits accrue because TOWER and PLS-POLE model the intrinsic (physical) properties of the structure separately from the allowable strength of the structure.

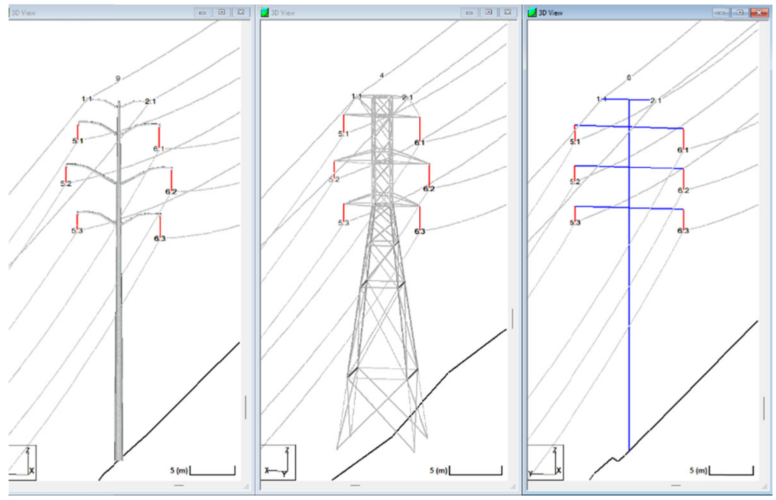

Figure 1 - Full structure models from PLS-POLE and TOWER compared to an Allowable Span file

With our structure programs, a load is applied to a structure model and a relevant design code is then used to check the structure strength. With wind & weight spans the strength definition has embedded within it the load that was applied (the type and tension of the conductor) and the code that was used to check. Modeling the intrinsic properties of a structure separately as opposed to combining these properties with the wires attached to the structure and the code used to check it enables:

1. **Generation of allowable wind & weight spans:**

   Allowable wind & weight span values or an interaction of these (which we call interaction diagrams) are still necessary for the optimum spotting of a line by PLS-CADD. With TOWER and PLS-POLE models, you can derive these values with the click of a mouse and have the freedom to rapidly experiment with many different structure and conductor configurations. The initial spotting of a line is the only time we see a need to use allowable wind & weight spans. However, even then we recommend the use of the more sophisticated interaction diagrams method as it can lead to substantially more efficient designs.

2. **Reconductoring:**

   When you are using PLS-POLE and/or TOWER structures you simply change the wire or tension and use the Structure/Check command. With wind & weight span structures you need to create new structure files for every combination of conductor and tension scenario you want to consider before you can check structures.

3. **Structure upgrades:**

   When you check a PLS-POLE or TOWER structure, the program checks each piece of the structure. It will tell you which, if any, parts of the structure are failing. A wind & weight span check will tell you if a structure is failing based on the allowable wind & weight spans but doesn't give you any idea why or what could be done to fix the problem. For example: Suppose you are to perform an uprating study that involved reconductoring a lattice tower line. A simple analysis of wind and weight spans indicates that these structures do not have sufficient strength for the heavier conductor. A more detailed analysis in TOWER generates color coded graphics showing the overstressed members. Many of the structures can be made to withstand the increased load by simply replacing specific members on the towers. The identification of the members needing reinforcement is not possible with a wind & weight span analysis and in this case could result in substantial savings over replacing an entire structure.

4. **Changing ruling span:**

   Sometimes, through unusual terrain or clearance requirements you end up with a design that doesn't match the design ruling span very well. Once again, this isn't a problem for PLS-POLE/TOWER structures as you just use the ***Structure/ Check*** command. For wind & weight span structures you need to rederive your allowable spans if you really want to get the most accurate allowable strength of your structures.

5. **Underbuild/Joint Use:**

   For PLS-POLE/TOWER structures, you add attachment points to the structures if they aren't already there, string whatever additional wires are needed at the appropriate tensions and use the ***Structure/ Check*** command. For wind & weight spans you need a different set of allowable wind & weight spans for each different underbuild scenario.

6. **Unbalanced ice, broken conductors, slack removal/shift for extra clearance:**

   These techniques/events leave you with a longitudinal imbalance. With PLS-POLE and TOWER it is very easy to figure out if the structures can withstand this imbalance and how they influence the structure strength. The programs can even supply structure flexibility information to PLS-CADD to account for structure deflection when calculating sag-tension and loading. Allowable wind & weight spans are useless in these cases.

7. **Change of Codes**

   Various revisions of the NESC redefined wind pressures as a function of span length and attachment elevation: Those who had modeled their structures in PLS-POLE or TOWER simply switched to the latest NESC wind adjustments in PLS-CADD's ***Criteria/ Weather*** table and performed a structure check. If your standards were based on wind & weight span, you would need to rederive them. In fact, the very concept of being able to compute an allowable wind span for a structure seems at odds with the new NESC where you can't even compute the wind unless you know the heights of the ahead and back structures.

   Three months after the 2002 NESC took effect, ANSI O5.1-2002 was released which mandated a reduction in the allowable fiber stress for wood poles. Once again, existing wind & weight span structures were rendered useless, but users of PLS-POLE simply switched to the ANSI O5.1-2002 strength check and immediately had updated results.

   These two code changes which both occurred in the same year show why it is so important to model the intrinsic properties of the structure separately from the code used to check it.

8. **Structure modification:**

   When using PLS-POLE and TOWER structures, PLS-CADD lets you customize structures by dragging guy anchors around. It also lets you move attachments and/or arms up and down on PLS-POLE structures. When you are finished with these drag/drop operations you can check the structure with a simple ***Structure/ Check***. If using allowable wind & weight spans you must once again rederive the allowable values based on the changes to the geometry.

9. **Improved graphics:**

   When using PLS-POLE/TOWER structures PLS-CADD can insert rendered images of the structure into its views. These graphics are a great help in catching structure modeling errors. With wind & weight span structures no graphical double check is available, only a simple “stick” model is shown.

10. **Clearances to structures/guys:**

    PLS-POLE/TOWER graphics are much more than just pretty pictures. These graphics contain all the information PLS-CADD needs to perform clearance checks from wires to the structure and its guys. Wind & weight span structures do not contain this information (in fact they don't even specify whether the structure is a lattice tower or a wood pole or even if it has guys).

11. **Maintenance:**

    PLS-POLE and TOWER models allow you to track changes to the structure and account for deterioration of the structure. For example, if your maintenance crew tells you that a wood pole has some shell rot you can model that with PLS-POLE and immediately check the structure to see if it needs to be replaced. With a wind & weight span structure you have no means to determine the adequacy of the structure considering the pole defect.

12. **Phase transposition:**

    When switching from a horizontal to a vertical configuration, each wire in a circuit has its own wind & weight span as well as its own induced line angle. You need to keep this in mind and manually account for it if using wind & weight spans, but it is handled automatically if you use PLS-POLE or TOWER to check your structures since the actual line geometry is used to calculate the loads acting on the structure.

The preceding scenarios illustrate the many advantages of using real structure models rather than allowable wind & weight span models. Wind & weight span models used to be popular because they enabled "structural analysis" by simply measuring a few distances on a drawing in a time when computer 3D design and analysis were not possible. Wind & weight spans were a very useful concept in the days when people spotted lines manually on paper, but they do not lend themselves well to modern demands on engineering. Nevertheless, it is surprising how many line design programs still attempt to computerize antiquated methods and how many engineers accept this substandard method. At PLS we endeavor to advance the state of the art. We do not lock you into obsolete constructs from the age of manual drawings and slide rules when we know of a better way. Because of this our customers have been taking advantage of the benefits of integrating line design and structural analysis for over three decades.

Background information on wind & weight spans

Measuring wind & weight spans

The wind & weight span method allows one to determine structure adequacy by simply measuring two distances in a profile view:

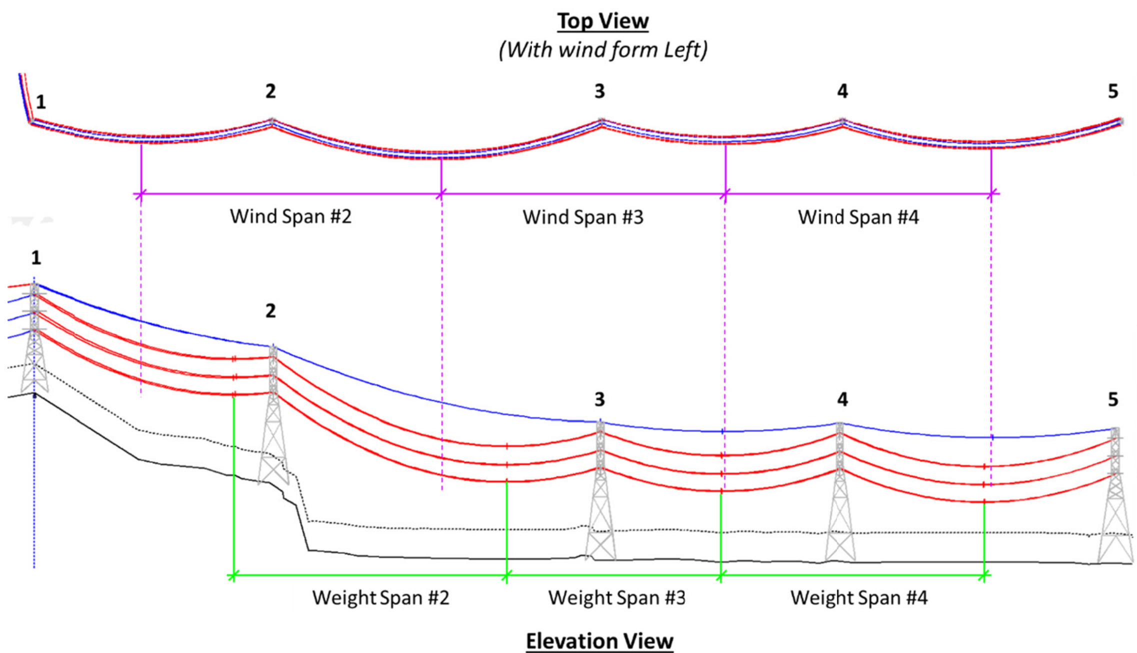

Figure 2 - Overview of Wind and Weight Spans

The first of these measurements, the wind span, is simply half the back span length plus half the ahead span length. The idea here is that this measurement is indicative of the wind load on the structure with the horizontal load on the structure being half the wind load from the back span and half the wind load from the ahead span. The weight span is the distance between the low point in the back span and the low point in the ahead span (span catenary curves may need to be extended beyond ahead and back structures if low point isn't in the span). The idea is that this distance between low points is representative of the vertical load seen by the structure. For more information on how PLS-CADD interprets and calculates Ruling Spans, Wind Spans and Weight Spans please refer to Appendix I of the PLS-CADD User's Manual.

Calculating wind spans is relatively straightforward, but when it comes to the weight spans of structures there are some complexities which become evident as you move to sloping terrain with inclined spans. This is illustrated by the following graphic (Figure 3).

The weight spans **VS** at each structure are indicated. The cable shape in Span 1-2 shows a low point. In any of the other spans, the low point is actually outside of the span. However, the definition of weight span to estimate vertical load still holds algebraically, i.e., **VS** = **VSL** + **VSR**, where **VSL** = distance from structure to low point in catenary of left span, positive if low point is to the left of structure and **VSR** = distance from structure to low point of catenary in right span, positive if low point is to the right of the structure.

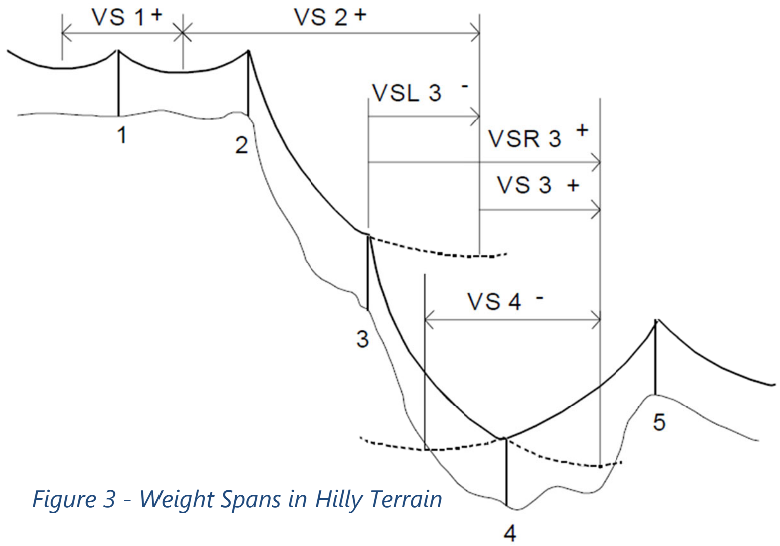

Figure 3 - Weight Spans in Hilly Terrain

For example, **VS3** is a positive quantity (vertical load down) because **VS3** = **VSL3** (a negative quantity) + **VSR3** (a larger positive quantity). **VS4** is a negative quantity, indicating uplift at Structure 4.

To add to this, the low point of the curve is not a static position. It can and does change with changes in wind pressure, temperature, and ice loading. In fact, it could even shift due to cable long term creep.

PLS-CADD is able to improve on archaic wind and weight span checks and look at the actual wind and weight spans taking into account the blown-out displacement of the conductors and the influence of the vertical change in elevation of structures that historical methods may have ignored. Please refer to our companion Technical Note on the topic of Understanding the use of Weight Spans for further information.

Checking structure wind & weight spans

If the structure's measured wind span is less than a calculated allowable wind span and its measured weight span is less than a calculated allowable weight span, then the structure is considered to have adequate strength. The implication is that structure strength is completely defined by two numbers: the allowable wind span and the allowable weight span.

The problem is that these allowable values are not intrinsic properties of the structure in that they depend on:

- the ruling span,
- the wires that are attached, and
- the safety or structure code being used.

Conclusion

While the use of wind and weight spans to evaluate structure capacity still has its place for quick estimates using structure spotting optimization, modern day software and computers are able to correctly evaluate structures taking into account the true representation of a line including unbalanced loading and the addition of other attachments or different cables or conductors using the intrinsic properties of the structure models.

We fully recommend modelling your structures in our structural applications and then using PLS-CADD/Lite to determine the allowable wind and weight spans when necessary.