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Pole Deflection Check in PLS-POLE and PLS-CADD

Introduction

PLS-CADD and **PLS-POLE** allow you to specify a Pole Deflection Check (PDC) for any load case. In **PLS-CADD** you specify the check in *Criteria/Structure Loads (method 4)*... and in **PLS-POLE** in the *Loads/Vector Loads (LCA File)*... or *Loads/Wire Loads (LIC File)*... tables. In all cases you specify the check in the *Pole Deflection Check* and *Pole Deflection Limit* columns.

Unless you select *No Limit*, **PLS-POLE** will use one of eight methods for checking the pole tip deflection for the selected load case. Only **PLS-POLE** (method 4) structures can be checked for deflection. **TOWER** structures will ignore the PDC and will never have a deflection usage

For each load case that specifies a PDC the deflection measured at the tip of a pole will be compared to an allowable deflection to develop a Deflection Usage (DU).

$$DU = \frac{(100 \times deflection)}{(allowable \ deflection)}$$

Where:

Deflection is measured using either one of the two approaches indicated in Figure 1:



Figure 1 – The two approaches to measuring deflection

For the first four methods it is the exact distance in 3-d between the pole tip position in its unloaded configuration and its position in the deflected shape for the load case, as shown on the left of Figure 1.

The deflection for the last four methods which contain the suffix VA, is the exact distance in 3-d between the projected position of the pole tip on the vertical axis based on the length of pole above the point of fixity based on the coordinates of the base of the pole and its position in the deflected shape for the load case, as shown on the right of Figure 1.

Allowable deflection is computed based on the value of the PDC which can be one of the 8 methods mentioned below or set with No Limit:

No Limit - the deflection check is skipped for this load case, all old files will default to this setting

% Pole Height - Allowable Deflection is calculated as a specified percentage of the pole height above the fixity point (typically height above ground).

% Pole Length - Allowable Deflection is calculated as a specified percentage of the total pole length (including any embedded portion, but excluding any cuts).

% Pole Tip Diameter - Allowable Deflection is calculated as a specified percentage of the pole tip diameter.

Input Limit - Allowable Deflection is input directly by the user (for example 3 ft or 1m).

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PLS-POLE treats the *Deflection Usage* separately from the *Strength Usage* of its components. It considers the *Deflection Usage* as an additional constraint when it determines *Allowable Spans* or *Allowable Spans Interaction Diagrams* as one of the last four **Analysis Options** selectable in the General/General Data dialog. **PLS-POLE** also considers the *Deflection Usage* constraint when it uses one of the automatic design features, such as Tubular Steel Pole Shaft Optimizer.

Example Results

To see the results of the deflection check, let's look at Structure #9, the *demtan3.pol* steel pole model that is in the *demo.xyz* **PLS-CADD** example project that ships with our software^{*}. The Structure loading criteria (*Criteria/Structure Loads (method 4)...*) for the "RULE 250C" Load cases specify a deflection limit of 6% of Pole *Height*.

When checking the structures usage in PLS-CADD, by running the command *Structures/Check* and clicking on Structure #9, the calculated usage includes a deflection check as shown below:

Structure Check : #9									
Prev Next Edit Modify	Close OK	Strength 75.9%	Swing 52.6%	Min.Vert.Load OK	Deflect 97.4%				
- Available Reports									
Standard Summary	🗌 <mark>Analysis</mark>	Geometry	Overview	Configure	Report				

Figure 2 - Structure Check results showing Deflection Usage for a PLS-POLE modelled structure

If you need a bit more information about the **PLS-POLE** models results, you can create either a Summary or Analysis Results Report. For example, below is an example showing what you see for this structure in the *Summary Results Report*. The calculated Tip Deflections are presented first for each Load Case. With the *Resultant Deflection* being used in the following check for the Deflection Usage based on the entered deflection limits.

		Load Case	Joint Label	Long. Defl. (mm)	Tran. Defl. (mm)	Vert. Defl. (mm)	Resultant Defl. (mm)	Long. Rot. (deg)	Tran. Rot. (deg)	Twist (deg)
	RULE 250B	NA+,I NA+	P:t	0.44	2173.64	-86.65	2175.36	0.00	-6.43	0.01
	RULE 250B	NA-,I NA-	P:t	2.16	-1436.69	-35.61	1437.14	0.01	3.73	-0.01
RULE	250B Uplift	NA+, I NA+	P:t	0.46	1944.13	-68.34	1945.33	0.00	-5.66	0.01
RULE	250B Uplift	NA-,I NA-	P:t	2.03	-1480.32	-37.88	1480.81	0.01	3.95	-0.01
	RULE 250C	NA+,I NA+	P:t	0.87	2346.98	-97.07	2348.99	0.00	-6.58	0.01
	RULE 250C	NA-,I NA-	P:t	3.49	-1967.91	-65.99	1969.02	0.01	5.17	-0.01
	RULE 250D	NA+,I NA+	P:t	0.89	990.57	-19.52	990.77	0.00	-3.11	0.00
	RULE 250D	NA-,I NA-	P:t	1.30	-357.41	-3.03	357.43	0.00	0.78	-0.00
RULE 277	Insulators	NA+,I NA+	P:t	0.93	923.81	-16.44	923.96	0.00	-2.80	0.00
RULE 277	Insulators	NA-,I NA-	P:t	1.56	-448.60	-3.95	448.62	0.00	1.05	-0.00
	Extreme Ice	NA+, I NA+	P:t	1.00	276.20	-2.54	276.21	0.00	-1.01	-0.00
	Extreme Ice	NA-,I NA-	P:t	1.00	276.20	-2.54	276.21	0.00	-1.01	-0.00
	Up	lift,I NA+	P:t	0.97	205.62	-1.57	205.63	0.00	-0.76	-0.00
	RULE 261A	Back, I BI+	P:t	259.16	0.00	-1.37	259.16	0.62	-0.00	-0.00
	RULE 261A A	head, I BI-	P:t	-259.16	-0.00	-1.37	259.16	-0.62	0.00	-0.00

Summary of Tip Deflections For All Load Cases

Pole Deflection Usages For All Load Cases

Pole Label	Load Case	Deflection Check	Deflection Limit %	Height (m)	Length (m)	Tip Diameter (mm)	Allowable Deflection (m)	Actual Deflection (m)	Deflection From Vertical Axis (m)	Usage %
P RULE	250C NA+,I NA+	% Pole Height	6.00	40.21	40.21	304.80	2.41	2.35	2.35	97.37
P RULE	250C NA-,I NA-	% Pole Height	6.00	40.21	40.21	304.80	2.41	1.97	1.97	81.62

Figure 3 - Summary Results Report showing the "Pole Deflection Usages For All Load Cases"

^{*} this project is typically stored at C:\Users\Public\Documents\PLS\pls_cadd\examples\projects

The Deflection Usage also appears on the Structure Usage Graph that is generated when running the *Lines/Reports/Structure Usage*. In this case the bar chart representing the Deflection Usage is the bright green bar.



Figure 4 - Structure Usage Graph for the demo.xyz PLS-CADD Project

Limitations

PLS-POLE models are sometimes comprised by stacking elements on top of each other by using tip and base joints. This is called Method A if you read Section 4.4.1 of the PLS-POLE User's Manual. This is often done to model unusual arrangements like poles with reverse taper, hybrid steel/concrete poles among others.

Unfortunately, there is not a way to define a deflection limit for the entire "stacked" structure when it is comprised of different pole segments connected to joints. PLS-POLE treats each pole segment individually for the deflection limits in this case.