610 N. Whitney Way, Suite 160
Madison, Wisconsin 53705, USA
Phone No: (608) 238-2171 Fax No: (608) 238-9241
Email: info@powline.com URL: http://www.powline.com

Loading Methods in TOWER and PLS-POLE

Introduction

Version 7 of PLS-POLE and TOWER introduces several new methods and modifies many of the existing ones for applying wind & ice loads to a structure. The new options include automatic loading as per ASCE 74-1991, ASCE 74-2009, NESC 2002, 2007, 2012, 2017, IEC 60826:2003, IS802:1995 (India), EN 50341-1:2001, EN 50341-1:2012, EN 50341-3-9:2001 (UK), EN50341-2-9:2015 (UK), EN 50341-3-17 (Portugal), EN50341-2-22:2016 (Poland), REE (Spain), Russia 7th/SNiP, ISEC-NCR-83 (Israel), TPNZ (New Zealand), ESAA C(b)1-2003, AS/NZS 7000:2010 and AS/NZS 7000:2016. The existing options that have been simplified and integrated into the new loading methodology include: Wind on All, Wind on Face, SAPS Wind, RTE Hyp1 and RTE Hyp2. TIA/EIA 222-F and ANSI/TIA 222-G have been left unchanged. Selecting a wind loading method can result in the automation of a number of calculations:

1) Calculation of the structure gust response factor
2) Adjustment of wind speed with height
3) Automatic selection of a drag coefficient for poles (as a function of number of sides or Reynolds number) and for lattice towers (as a function of solidity ratio)

To support these new methods, a new column, *Wind/Ice Model*, is now available in the vector and wire load case tables. In addition to this column we have added *Structure Ice Thickness* and *Structure Ice Density* columns so that ice may be applied to a structure. Finally, you will find a *Wind Area Factor* column which can be used to adjust the wind load on the structure in the same manner that the *Dead Load Factor* adjusts the dead load.

Revisions

Version 7.33	**ASCE 74-2006** (draft) made available Automatic calculation of K_{com} for **UK NNA** users (see the technical note for more information)
Version 8.10	**NESC 2007** added which is effectively identical to NESC 2002.
Version 10.36	**ASCE 74-2009** replaces ASCE 74-2006 (draft) now that the manual has been published.
Version 11.11	**AS/NZS 7000:2010** introduced
Version 12.04	**NESC 2012** added which is effectively identical to NESC 2007.
Version 12.35	**IS 802 : 1995** introduced

Version 12.36	**EN50341-1:2012** introduced
Version 13.03	**Russia 7th/SNiP** introduced
Version 13.09	**ISEC-NCR-83** introduced
Version 14.31	**NESC 2017** introduced (effectively identical to **NESC 2012**)
Version 14.31	**EN50341-2-9:2015 (UK)** introduced
Version 14.44	**EN50341-2-22:2016 (Poland)** introduced
Version 14.44	**AS/NZS 7000: 2016** introduced

Notes for Users of Previous Versions

Models made in previous versions open in version 7 without requiring any modifications. Any necessary translation will be performed automatically and an analysis of a structure model in version 7 will produce the same results as it did for that model in version 6. You do not need to make any changes to keep working the way you always have. However, you may want to modify your models and loading criteria to take advantage of the new options offered in version 7.

Getting Started with the New Methods

PLS-POLE models do not require any changes to use the new loading methods. Should you wish to take advantage of them, you need only select the method in the *Wind/Ice Model* column and input the appropriate *Terrain Category* in the *Loading Method Parameters* dialog reached from the *Vector Load Cases* or *Wire Load Cases* table. Please note that when using an automated method, you should input basic unadjusted wind pressures (normally at 10m or 33ft above the ground) in the *Transverse and Longitudinal Wind Pressure* columns. If you then run an analysis with the new method the following will occur: the appropriate drag coefficient will be selected based on pole shape and/or Reynolds Number (overriding whatever you input), the wind pressure will be adjusted with height, the basic input wind pressure will be adjusted by the *Wind Area Factor* and will also be adjusted by the calculated structure gust response factor and finally, ice will be applied to the pole. These effects are detailed in the ***Detailed Pole Loading Data for Load Case*** table in the *Analysis Results* report. You should carefully review this table for your preferred code as it supplies in one place all the information necessary to understand what loads the program calculated and applied to your pole. Note that ice will only be applied to your structure if you input a non-zero ice thickness and that most codes (including NESC and ASCE) do not require ice to be applied to the structure even for load cases that specify ice on conductors. If you do input an ice thickness, the ice will only be applied to equipment, cables, guys, angles and the pole itself. Due to a lack of guidance on how ice accretes on arms, braces and insulators, ice is not applied to these elements.

In order to use the new loading methods with TOWER models you may need to make some modifications. If you elect to use a method that only applies wind on the face of the structure, such as ASCE74-1991, ASCE74-2009F (but not ASCE74-2009M), NESC 2002, IEC 60826, IS802:1995, EN 50341, UK NNA, Portugal NNA, REE (Spain), Russia/SNiP, ISEC-NCR-83, TPNZ, ESAA C(b)1-2003, AS/NZS 7000:2010F and others, you should do the following:

1) Open the *General/General Data* dialog and modify these settings:
   A) Select the cross-section shape (rectangular or triangular) of the structure body.
   B) Check the *Allow separate faces for each section* checkbox. This will allow you to control the shielding effects of one portion of the structure on another and is required for delta configurations and chainette structures.
   C) Input a *Ground Elevation Shift for Wind Height Adjust* if the structure is not resting directly on the ground.

2) If you have not already defined sections, do so using *Geometry/Sections/Table Edit*. In general, you should create sections at the border of a discontinuity in tower outline, to separate parts of the tower where the solidity ratio can be expected to substantially differ and for each mast of a chainette. Section heights should not exceed the maximum allowed by the code for zones over which wind pressure can be assumed constant. You should always have a clean boundary between two sections in the horizontal plane even when overriding section membership manually in the *Geometry/Angle Members* table.
   Note that loads (wind and dead) are divided evenly among all joints in a section, so placing your entire tower in a single section will result in a conservative distribution of dead load.

3) Input appropriate factors in *Geometry/Sections/Table Edit* for the *Transverse and Longitudinal Area Factor (CD From Code)* columns to account for any members that were not included in the TOWER model. The factors in these columns are used by any loading method that calculates a drag coefficient for a section as a function of the solidity ratio (ASCE74, IEC60826, IS802:1995, EN 50341, UK NNA, Portugal NNA, REE, TPNZ, ESAA C(b)1 and AS/NZS 7000:2010 methods), NESC and others. You will note that columns corresponding to the other methods also exist, such as: *Transverse and Longitudinal Drag x Area Factor for Face* (Wind on Face method), *Af and Ar Factor For Face EIA Only* (TIA/EIA 222-F and G methods), *Transverse and Longitudinal Drag x Area Factor For All* (Wind on All method), *SAPS Angle and Round Drag x Area Factor* (SAPS, ASCE74-2009M, AS/NZS 7000:2010 M, RTE Hyp1 and RTE Hyp2 methods). Finally, you may notice a new column at the end of the sections table titled *Force Solid Face*. This can be used to

override the calculated face area of a section with the gross area and can be useful for areas where the face computation is uncertain or one wishes to be conservative such as the transverse face of a crossarm. This setting only applies to section based loading methods and not to member based methods (such as Wind on All, SAPS, ASCE74-2009M, AS/NZS 7000:2010M, RTE Hyp1 and RTE Hyp2). A drag coefficient of 2 is always used with a solid face; however, you can modify this by inputting whatever *Transverse and Longitudinal Area Factor (CD From Code)* you find appropriate.

4) Inspect the transverse and longitudinal faces that TOWER automatically determined. TOWER was designed to automatically identify the faces for conventional lattice structures. If you have a chainette or otherwise unconventional structure, or simply don’t like the face that TOWER identified, you can use the new *Geometry/Members/Override Face* and *Geometry/Members/Fence Override Face* commands to define your own face. Face overrides are stored in the *Geometry/Members/Capacities and Overrides* table should you want to edit them in a tabular format.

5) Run an analysis of your model and carefully inspect the detailed sections loading table ***Section Load Case Information*** printed in the *Analysis Results* report. This table includes within it all the data you need to understand how TOWER calculated the load on this section and what that load was. For each type of tower you model, you should make sure that the gross area the program calculates using your section and face definition matches your expectations. Note that the ice load printed in this table is multiplied by the *Sections Dead Load Factor* for this section. Since the *Sections Dead Load Factor* is intended to account for the effects of members that were not included in the model, it is used to modify the ice load calculated for the section.

Note: we strongly encourage you to graphically review the member type (truss, beam or tension only), section membership and face settings of all members in your structure. To accelerate this process, we have provided a keyboard shortcut that changes the color by mode. Press the *F9* key or use the *View/Cycle Color By* command to have the program cycle through the available color by modes. A new status bar indicator (in the lower right hand corner of your screen) indicates the current mode.

Notes for PLS-CADD Users

PLS-CADD can be used to generate loads with the new methods. To do so, you will need to modify your *Criteria/Structure Loads* to select the Loading Method in the *Structure Wind Load Model* column, input the appropriate *Structure Wind Area Factor, Structure Ice Thickness and Structure Ice Density*. Users of the UK NNA will need to input K_{com} in the *Structure Wind Area Factor* column (or zero to trigger automatic calculation of K_{com}). PLS-CADD will read old projects and translate their criteria into the new format. Previous implementations of standards such as ASCE 1991, ASCE 2002 and NESC 2002 will be translated to a "Pre V7" Loading Method. For these legacy loading methods PLS-CADD will pass a wind pressure that has been adjusted by the structure gust response factor and adjusted for height as appropriate. The structure program will then apply this constant pressure to the structure. For any new loading method, PLS-CADD passes the structure program an unadjusted wind pressure and the structure program is responsible for calculating the final wind pressure per whatever code was selected. Note that prior to version 7, you could not explicitly select *Standard, Wind on Face, Wind on All, SAPS, RTE Hyp1* or *RTE Hyp2* methods; however, one of these methods was in use depending on the settings made in the structure program and elsewhere. The centralization and simplification of the selection of Loading Method is a major benefit of version 7.

Additional information is available in the *Loading Changes in Version 7 of PLS-CADD* document available at http://www.powline.com/products/PLS-CADD_version7_loads.pdf

Detailed Notes for Each Method

We have done our best to faithfully implement the following aspects of some codes: selection of gust response factor, adjustment of wind with height and selection of drag coefficient. However, not all codes define all necessary concepts for all aspects of the loading method, some codes leave wide latitude for interpretation and some are just plain wrong. We describe the automated calculations, major interpretations and deviations we may have taken for each code in the *Loading Method Parameters* dialog reached from *Loads/Vector Load Cases* or *Loads/Wire Load Cases.*

For some codes, separate drag coefficients may be calculated for insulators, but for those where it is not you should input a factored insulator area (real area * drag coefficient) in the insulator library. However, the insulator will see the same adjusted wind pressure as the rest of the structure (which includes poles, angle members, arms, guys, equipment etc.).

You can graphically review the drag coefficients, gust response factors and wind escalation that the program uses by clicking the *Create Graphs* button in the *Loading Method Parameters* dialog reached from *Loads/Vector Loads* by clicking on the *Edit Loading Method Parameters* button.

You should verify your understanding of the application of all the factors involved in calculating loads by performing at least one hand calculation and comparing it with the results from the program. Modern codes are regrettably complicated, so this may be a long and tedious process, but it is the only way to assure yourself that your interpretation of the code matches the programs.