



# **TSTOWER FOR POLES**

## **STRUCTURAL ANALYSIS SOFTWARE FOR COMMUNICATION POLES**

### **USER'S MANUAL**

BY

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## CHAPTER 1 INTRODUCTION

*TSTower* is a general computer program for the analysis and design of cantilevered tubular pole structures. Poles can have a round or multiple sided cross sections. The program will perform the analysis using the United States applicable code TIA/EIA 222-F, ANSI/TIA-222-G and ANSI/TIA-222-H or the Canadian equivalent CSA S37-94, CSA S37-01, CSA S37-13 and CSA S37-18. Load generation, capacity assessments follow the applicable codes, and the structural analysis is based on a three-dimensional beam model.

The program analyzes the pole for all loads and determines the capacity of the sections. The results are displayed graphically on the screen. This allows the designer to visually check the adequacy of the design and quickly make adjustments to achieve the optimum solution. The program allows for a full printout or a summary printout of the results. A graphical printout of the profile is also available.

### **HARDWARE REQUIREMENTS**

The following minimum system requirements to run TSTower:

- An IBM compatible PC equipped with a Pentium processor running under Windows 98, 2000, NT, XP, Windows 7 and Windows 8
- 30 MB free disk space
- 16 MB RAM
- 14 inch SVGA monitor with (800 x 600 min resolution)
- A pointing device, a mouse or graphical tablet configured to work under windows.
- An optional printer that is set from windows

### **INSTALLING TSTOWER**

The TSTower installation is initiated from windows. From start menu choose run, and choose file setup.exe

The setup program will create a TSTower directory on the hard drive at a location designated by the user. The user may change the name of the folder in which the program will copy all necessary files required to run TSTower.

Choose the folder name and click OK, the installation program will copy all necessary files into the different directories of your system. Follow the program instructions and place the subsequent disks into the disk drive.

At the end of the installation the program will notify you that the installation was completed successfully. Refer to the purchasers' agreement regarding the number of authorized users allowed to run the program.

## **DISCLAIMER**

Extensive care has been taken during the development and testing of TSTower program to ensure that both the source code and the underlying engineering principles comply with standard engineering practice. Should any discrepancies or possible program errors occur, please notify TowerSoft immediately.

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User's comments and suggestions are welcomed. Please forward all your comments to [support@towersft.com](mailto:support@towersft.com).

## Chapter 2 INPUT

*TSTower* is an analysis software program. The user inputs all the necessary information required to perform the analysis, the finite element program is run, and the results are shown in a graphical format on the screen.

For design purpose, the user decides a tentative section and analysis is performed. The user examines the results of the preliminary selection and modifies any of the design parameters before reanalyzing the structure. Using successive runs, the user can quickly arrive at an optimum solution. The designer makes the choices, interprets the output and has full control on the design process.

This Chapter illustrates how *TSTower* work by explaining the input of a typical example. The input values and results of the example are shown on the figures in the chapter. This example may not use all the features of the software, however it gives the user a quick introduction to the main features and the use of the program. Features available in the program that are not used for this example are explained in the context.

**EXAMPLE**

The example, presented in Chapter 4 - Output, is based on a 131.23ft pole, made of 6 sections, with (2) microwave dishes at an elevation of 65.6ft. The structure will be analyzed as per EIA-222-F.

**START THE PROGRAM**

When TSTower starts, the data will be initialized with default settings. The screen will be blank as shown.

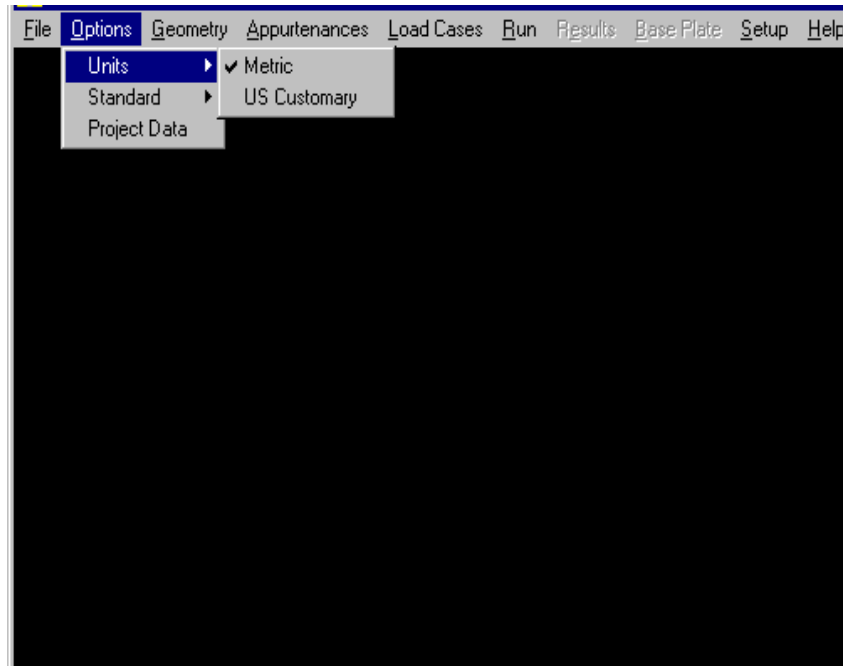


Note the status bar at the bottom of the windows showing the following data in order:

- 1- The current mode of units (metric or imperial)

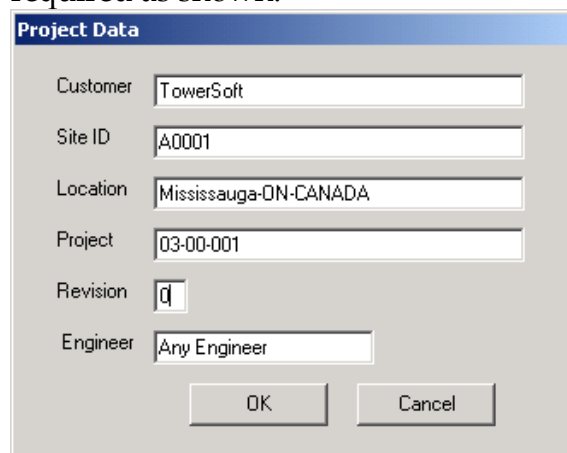
- 2- The applicable code of design (CSA S37-18, CSA S37-13, CSA S37-01, CSA S37-94, EIA 222-F, EIA 222-G, EIA 222-H)
- 3- The problem file name, and path

Select **Options** from the main menu and from the list choose the required code and the system of units.



## PROJECT DEFINITION

Select **Project Data** from the **Options** menu. Type in any identification data required as shown.



Customer	TowerSoft
Site ID	A0001
Location	Mississauga-ON-CANADA
Project	03-00-001
Revision	0
Engineer	Any Engineer

OK Cancel



To add data to any box, move the cursor into the box, click inside the box and type in the data using the keyboard. To change any existing data in an edit box, delete the entry using the <Del> key or the <Backspace> key.

Alternatively, highlight the existing characters by pressing and dragging the left mouse button, then type over the existing entry. This is a standard Windows feature.

## GEOMETRY DEFINITION

Select **Structure** then **Tubular SS** from the main menu, this will show the Tubular Tower Geometry Definition Window. Initially the window will show default geometry data and the user changes that to the required parameters.

The screenshot shows the 'Tubular Tower Geometry' window. It contains input fields for Total Height (130.00 ft), Bot Diam. (15.00 in), Top Diam. (9.00 in), and Section No. (5). There are also dropdown menus for Cross-Section (Circular) and Joint Type (Telescopic). Below these is a table titled 'Section Data' with 15 columns: Sec., Length (ft), Overlap (at top) (ft), Bot Diam. (in), Top Diam. (in), Plate Thick. (in), Cross Sect., Joint Type (Bottom), Locked, Yield Stress (ksi), Mass (lbs), Calc. Taper (in/ft), Radome Covered, Radome Diameter (in), and Radome Unit Weight (lbs/ft). The table contains 5 rows of data for sections 1 through 5. An 'OK' button is at the bottom right.

Sec.	Length (ft)	Overlap (at top) (ft)	Bot Diam. (in)	Top Diam. (in)	Plate Thick. (in)	Cross Sect.	Joint Type (Bottom)	Locked	Yield Stress (ksi)	Mass (lbs)	Calc. Taper (in/ft)	Radome Covered	Radome Diameter (in)	Radome Unit Weight (lbs/ft)
5	27.19	0.000	10.57	9.00	0.19	Circular	Telescopic	U	65	523.0	0.0577	<input type="checkbox"/>	0.00	0.00
4	27.19	1.274	11.69	10.12	0.19	Circular	Telescopic	U	65	584.0	0.0577	<input type="checkbox"/>	0.00	0.00
3	27.19	1.414	12.80	11.23	0.19	Circular	Telescopic	U	65	644.6	0.0577	<input type="checkbox"/>	0.00	0.00
2	27.19	1.553	13.90	12.34	0.19	Circular	Telescopic	U	65	704.8	0.0577	<input type="checkbox"/>	0.00	0.00
1	27.19	1.691	15.00	13.43	0.19	Circular	Flange	U	65	764.5	0.0577	<input type="checkbox"/>	0.00	0.00

In this window the user inputs the total height, top diameter of the pole, bottom diameter and number of sections along the height of the pole (for multi-sided poles, diameter is considered as the outside dimension between two opposite flat sides)

Note that the bottom diameter of the pole (or any section of it) cannot be specified to be less than the top diameter.

Also on the same window the user specifies the number of sides of the cross-section and the connection type (splice or telescopic).

The following values are the limits for these input fields:

- TotalHeight (1m - 213.36m) (3.28ft - 700ft)
- Top Diameter (75mm - 7600mm) (2.95in - 300in)
- Bottom Diameter (75mm - 7600mm) (2.95in - 300in)

- Number of Sections (1 – 15)  
*Also, a minimum of 1.0m (3ft) for section length is imposed*

Cross-section type and Joint Type can be set for entire structure in “Global Changes” box. If this feature is used it will overwrite all previous entries in “Section Data”. Note that the bottom section is always set as Flange. The only other option for bottom section is embedded.

In case the Embedded bottom section is selected the program will require the entry of Embed. Depth. The default (and minimum) value of embedment depth is  $3 * \text{Bottom Diameter}$  of the bottom section. The embedded joint type means that the pole is fixed in concrete and the program will not perform the base plate calculation.

On the same window a table for **Section Data** is displayed. In this table the following data is shown for each section of the pole:

- |                              |   |
|------------------------------|---|
| • Section number             | (from bottom to top)                    |
| • Section length             | (m or ft)                               |
| • Section overlap (at top)   | (m or ft)                               |
| • Section bottom diameter    | (mm or inches)                          |
| • Section top diameter       | (mm or inches)                          |
| • Section plate thickness    | (mm or inches)                          |
| • Cross-section type         | (Circular, 6,8,10,12,16,18,20,24-sides) |
| • Joint Type (Bottom)        | (Flange, Telescopic, Embedded)          |
| • Section length lock status | (Locked or Unlocked)                    |
| • Section yield stress       | (MPa or ksi)                            |
| • Section mass               | (kg or lbs.)                            |
| • Calc. Taper                | (mm/m or in/ft)                         |

Based on the total height of the pole and the number of sections, the program calculates equal section lengths with an overlap length equal to  $1.5 * \text{diameter}$  at that height. The user may change the section length to match the exact height of the section. Once the section length is changed the new overlap distance, section bottom diameter, top diameter and section mass is calculated and displayed accordingly and this section becomes locked (i.e. any future change to the total pole height is to be distributed equally to the remaining unlocked sections). At this point the overlap distance may be also changed to any value greater than  $1.5 * \text{diameter}$ .

In this table the user may also specify for each section the plate thickness, which may be chosen from the available thickness or typed in the field. The

type of cross section may vary from one section to another only if flange type of connection is chosen.

The user may change Joint Type of a given section within this table. The rule imposed on this feature, however, requires that in case of mixed Joint Type sections the Flange Joint sections must be located at the uppermost part of the pole – in other words the program will not permit Telescopic Joint section above Flange Joint section. The exception to this rule, of course, applies to the bottom section, which is always flanged or embedded.

## ANTENNAS DEFINITION

From the main menu choose **Appurtenances** then sub-menu **General Appurtenances** and then select **Antennas**, the following window is displayed.

No.	Elev. (ft)	Antenna Type	No. of Ant.	Ant. Az. (deg.)	Radius (ft)	Vert. Offset (ft)	Mount Type	Mount Az. (deg.)	TxLine Type	No. of TxL.	Mount Pipe	Mount Pipe Length (ft)	Mount Pipe Shielded Length (ft)	Mount Ref. #	Ka	User Defined Ka	Gh	Mount Ka
1	120.00	HP4	1	35.0	1.33	0.00		35.0			(None)	0.00	0.00	0	1.000	No	1.10	

In this window the pole elevation is shown along with the plan cross-section at the marked antenna. To add a new antenna select **New** and a blank line with an antenna type (none) is shown. The user inputs the following data as defined below:

- **Elevation:** Elevation of the center of the antenna marked from the bottom of the pole and shown in meters or ft.
- **Antenna Type:** Type of antenna and can be chosen from the antennas database available. To choose an antenna click on this field and an antenna type window will be displayed and the required type and size is specified.
- **No of Ant.:** Number of Antennas. For M/W antennas the number cannot be more than one.
- **Ant. Az. (deg.):** Antenna beam azimuth measured from the zero azimuth of the pole and may be referred to as pole's north (specified in degrees).
- **Radius:** Radius is measured from the pole center to the mounting point of the antenna (m or ft.). Also, note that the pole radius at that elevation is shown for guidance on the section drawing.

- **Vert. Offset:** Vertical distance from antenna mount point to attachment point on tower (m or ft.). This distance may be positive (meaning that the attachment point is above the antenna) or negative (meaning that the attachment point is below the antenna). It should be applied only for cases of stand-off mount supporting the antenna and having only one point of attachment to tower (cantilever mount).
- **Mount Type:** Type of antenna mount and can be chosen from the database available. To choose a mount click on this field to select from the database.
- **Mount Az. (deg.):** Angle between the tower's north and the antenna's mount point measured in the clockwise direction.
- **TxLine Type:** Type of transmission lines associated with that antenna and can be chosen from a database available.
- **No. of TxL:** Quantity of TX lines associated with that antenna.
- **Mount Pipe:** Size of mounting pipe selected from database.
- **Mount Pipe Length:** Full length of the mounting pipe (m or ft.)
- **Mount Pipe Shielded Length:** Length of the mounting pipe shielded by antenna (m or ft.)
- **Mount Ref. #:** Reference number (antenna number) of the mount for an antenna, where mount type was defined.
- **Ka:** Shielding factor Ka (default Ka=1) can be overwritten by User. (Does not apply to EIA-222-F standard)
- **User Defined Ka (No or Yes):** Indicates if Ka was defined by User (Yes) or left as default (No). If the indicator is "Yes" then by clicking on this cell the Ka will be changed back to default and the indicator will be back to "No". (Does not apply to EIA-222-F standard)
- **Gh:** Gust factor for the antenna. Default is equal to gust factor for the tower but can be overwritten by User. (Does not apply to EIA-222-F standard)
- **Mount Ka:** Shielding factor for mount, if applicable. Default Ka = 1. (Does not apply to EIA-222-F standard)

Following functions are available:

- Select: Marks an antenna for copying or deleting
- Copy: Allows to copy selected antenna
- Delete: Allows to delete selected antenna
- Sort: Sorts antennas by elevation
- Delete All: Allows to delete all antennas

**Antenna Type:**

Click on type in the antenna table and the following window is displayed and from which the antenna type and size is specified.

The image shows a software dialog box titled "Antenna Type". It has two tabs: "Microwave" and "Other". The "Microwave" tab is selected. Inside the "Microwave" tab, there are several input fields and radio buttons. "Dish Type" is a dropdown menu set to "Shielded". "Dish Size" is a dropdown menu set to "HP4". "Frequency (GHz)" is a dropdown menu set to "E". "Allowable Tilt/Twist (deg)" is a text box containing "2.21". There is a "Radome" section with two radio buttons: "Yes" (selected) and "No". There is an "Allowable signal loss" section with two radio buttons: "3 db" and "10 db" (selected). At the bottom of the dialog are "OK" and "Cancel" buttons.

For microwave dishes available in the database the following dish types and sizes are available:

Shielded	(2, 4, 6, 8, 10, 12, 15 ft.)
Focal plane	(4, 6, 8, 10, 12 ft. – with or without radome)
Standard	(2, 4, 6, 8, 10, 12 ft. – with or without radome)
Grid	(4, 6, 8, 10, 12, 15 ft.)
GRIDPAK	(4, 6, 8, 10, 12, 13 ft.)

Also, for microwave antennas the allowable Tilt/Twist is calculated by the program as a function of frequency, dish diameter and allowable signal degradation (3 db or 10 db) based on the following formula:

a) For a parabolic reflector with an allowable 10dB signal degradation:

$$\theta = \frac{C_{10}}{D - \alpha}$$

b) For a parabolic reflector with an allowable 3dB signal degradation:

$$\theta = \frac{C_3}{D - \alpha}$$

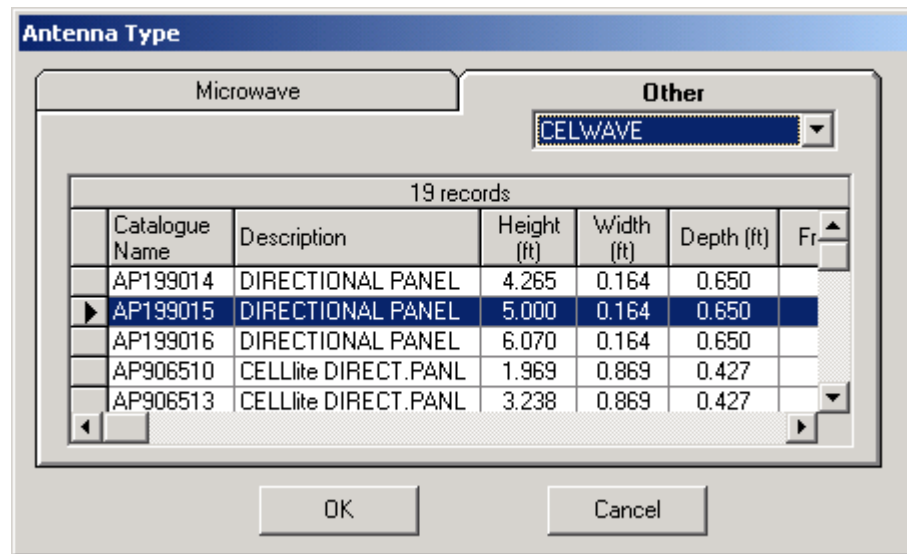
where:

$\theta$  = twist or sway limit, degrees

$C_{10} = 53.1 \text{ GHz.ft.deg}$  [16.2 GHz.m.deg]  
 $C_3 = 31.0 \text{ GHz.ft.deg}$  [9.45 GHz.m.deg]  
 $D = \text{Diameter of dish, ft [m]}$   
 $\alpha = \text{Dish Frequency, GHz.}$

For “Other” (Non-Dish Antennas) a variety of Antennas, organized by manufacturers is available from the database.

Following screen is displayed when the Tab “Other” is clicked.



The data shown includes all parameters of these antennas necessary for the program to calculate wind loads and weight effects.

The User may add any type of Non-Dish Antenna to the database –using the “Database Management” option from the main menu. Refer to Database Management Chapter for details.

After specifying an antenna, the user may wish to copy it by highlighting the specific line and click on **select** and then on **Copy**. A new line of antenna will be displayed and the user may edit that line. A similar procedure is used to delete an antenna.

Loads are calculated for microwave dishes as per Andrew's catalogue number 36. Also load calculations for wind loads under different directions are based on ANSI/TIA-222-G tables (ANNEX C: DESIGN WIND FORCE ON TYPICAL ANTENNAS (Normative).

Also, from this window the user can define the TX-lines type and number that are used for this antenna.



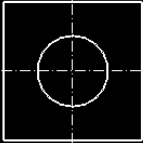
## POINT LOADS DEFINITION

From the main menu choose **Appurtenances** then sub-menu **General Appurtenances** and then select **Point Loads**, the following window is displayed.

**Point Loads**

Antennas | Point Loads | TxLines | Ladders

**Point Load View**  
 Point Load No. 1  
 Pole Radius = 1.00(ft)



**Notes:**  
 1) Drawing of the Point Load is not to scale. The actual dimensions (width and depth) are not defined. The dimensions in the drawing are based on assumption that the frontal and lateral surfaces are square and that the force coefficient  $C_a = 2.0$   
 2) The Azimuth and Orientation are relative to actual North, as defined in Leg Azimuth from North (Deg.).  
 3) The Areas (Frontal and Lateral) are defined as containing force coefficient.

**Point Load Data**

No.	Desc.	Elev. (ft)	Azin. (deg.)	Radius (ft)	Orient. (deg.)	Vertical Offset (ft)	Frontal Wind Area (bare) (ft <sup>2</sup> )	Frontal Wind Area (iced) (ft <sup>2</sup> )	Lateral Wind Area (bare) (ft <sup>2</sup> )	Lateral Wind Area (iced) (ft <sup>2</sup> )	Weight (bare) (Kips)	Weight (iced) (Kips)	TX Line Type	No. of TX Lines	Comments	Gh	Antenna?
1	Mount 1	120.00	0.0	0.00	0.0	0.00	30.00	36.00	30.00	36.00	1.50	1.85				1.10	<input type="checkbox"/>

Leg Azimuth from North (Deg.)

OK

In this window the pole elevation is shown along with the plan cross-section at the point load elevation. To add a new point load select **New** and input line with zero values is shown. The user inputs the following data as defined below:

- **Desc.:** Text description of the point load. This description will be displayed on the design profile.
- **Elev.:** Elevation from the bottom of the pole to the center of the applied load (m or ft.)
- **Azin.:** Angle between the pole's north and the point load radius measured in the clockwise direction (specified in degrees).
- **Radius:** Radius is measured from the pole center to the point load (m or ft.). Also, note that the pole radius at that elevation is shown for guidance on the section drawing.
- **Orient.:** Angle between the tower's north and the point load mount point measured in the clockwise direction.
- **Frontal Wind Area (Bare):** Bare wind area perpendicular to the point load azimuth of the point load multiplied by the

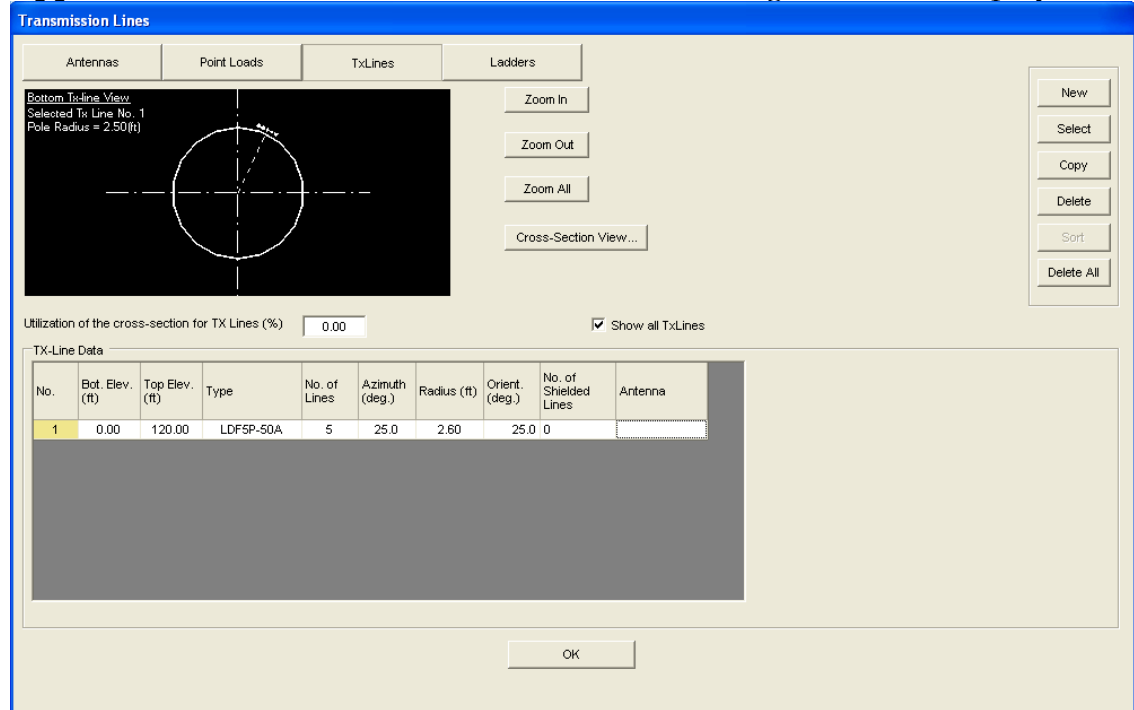
- appropriate force coefficient or drag factor depending on the shape of the appurtenance ( $\text{m}^2$  or  $\text{ft}^2$ ).
- **Vertical Offset:** Vertical distance from antenna mount point to attachment point on tower (m or ft.). This distance may be positive (meaning that the attachment point is above the antenna) or negative (meaning that the attachment point is below the antenna). It should be applied only for cases of stand-off mount supporting the antenna and having only one point of attachment to tower (cantilever mount).
  - **Frontal Wind Area (Iced):** Iced wind area perpendicular to the point load azimuth of the point load multiplied by the appropriate force coefficient or drag factor depending on the shape of the appurtenance and the ice accretion ( $\text{m}^2$  or  $\text{ft}^2$ ).
  - **Lateral Wind Area (Bare):** Bare wind area parallel to the point load azimuth of the point load multiplied by the appropriate force coefficient or drag factor depending on the shape of the appurtenance ( $\text{m}^2$  or  $\text{ft}^2$ ).
  - **Lateral Wind Area (Iced):** Iced wind area parallel to the point load azimuth of the point load multiplied by the appropriate force coefficient or drag factor depending on the shape of the appurtenance and the ice accretion ( $\text{m}^2$  or  $\text{ft}^2$ ).
  - **Weight (Bare):** Bare weight of the load (kN or kips)
  - **Weight (Iced):** Weight of the load including ice (kN or kips)
  - **TX Line Type:** Type of transmission lines associated with that point load and can be chosen from a database available.
  - **No. of TX Lines:** Quantity of TX lines associated with that point load.
  - **Comments:** A comments field that does not get displayed on the profile.
  - **Gh:** Gust factor for the point load. Default is equal to gust factor for the tower but can be overwritten by User.
  - **Antenna?:** Tick box to indicate if the point load is an antenna.

Following functions are available:

- Select: Marks point load for copying or deleting
- Copy: Allows to copy selected point load
- Delete: Allows to delete selected point load
- Sort: Sorts point loads by elevation
- Delete All: Allows to delete all point loads

## TRANSMISSION LINES DEFINITION

From the main menu choose **Appurtenances** then sub-menu **General Appurtenances** and then select **Tx-lines**, the following window is displayed.



In this window the pole elevation is shown along with the plan cross-section at the bottom of the Tx-line. To add a new line or group of lines select **New** and a blank line with a line type (none) is shown. The user inputs the following data as defined below:

- **Bot. Elev.:** Elevation of the bottom of the lines (m or ft.)
- **Top Elev.:** Elevation of the top of the lines (m or ft.)
- **Type:** Type of lines and can be chosen from the tx-lines database available. To choose line type click on this field and the required type and size can be specified as explained in the sequel.
- **No of lines.:** Number of lines having the same properties shown on that line
- **Azimuth:** Group of lines azimuth (specified in degrees).
- **Radius:** Radius is measured from the pole center to the center of the lines group (m or ft.).
- **Orient.:** Angle between the pole's north and the lines group radius measured in the clockwise direction.
- **No of Shielded Lines:** For shielded lines (e.g. inside the pole) only gravity loads are considered.

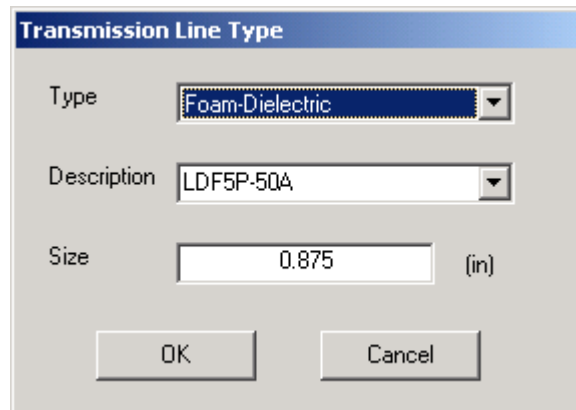
- **Antenna:** Antenna description for cases where the TX lines were defined for a specific antenna or point load.
- **Show all TX Lines:** Tick box allowing to show only selected line or all lines.
- **Utilization of the cross-section for TX Lines (%):** Percentage of utilization of the inner cross-sectional area of the pole by TX lines.

Following functions are available:

- Zoom In: Allows to zoom in the sketch of lines
- Zoom Out: Allows to zoom out the sketch of the lines
- Zoom All:
- Cross-Section View: Opens another form with enlarged cross-sectional view at selected elevation. This form is printable.
- Select: Marks a line for copying or deleting
- Copy: Allows to copy selected line
- Delete: Allows to delete selected line
- Sort: Sorts lines by elevation
- Delete All: Allows to delete all lines

### **Transmission Line Type:**

Click on type in the tx-lines table and the following window is displayed and from which the tx-lines type and size is specified.

A screenshot of a software dialog box titled "Transmission Line Type". It contains three input fields: "Type" with a dropdown menu showing "Foam-Dielectric", "Description" with a dropdown menu showing "LDF5P-50A", and "Size" with a text box containing "0.875" and a unit label "(in)". At the bottom are "OK" and "Cancel" buttons.

The following default Transmission Line types are available:

- Air-Dielectric
- Foam-Dielectric
- Elliptical Waveguide
- Circular Waveguide
- Rectangular Waveguide

Users can create more transmission line types and add lines as needed using Database Management functions of the program.

Different sizes can be chosen from the description field and the actual size for the chosen lines is displayed in the size field (mm or in.).

## LADDER DEFINITION

From the main menu choose **Appurtenances** then sub-menu **General Appurtenances** and then select **Ladders**, the following window is displayed.

No.	Bot. Elev. (ft)	Top Elev. (ft)	Width (in)	Dist. (in)	Azimuth (deg.)	Radius (ft)	Orient. (deg.)	Rung Type	Rail Type
1	0.00	120.00	17.7	11.8	180.0	2.83	180.0	SR 0 3/4	SR 0 3/4

In this window the pole elevation is shown along with the plan cross-section at the bottom of the ladder. To add a new ladder select **New** and a blank line with a rail type, and rung type (none) is shown. The user inputs the following data as defined below:

- **Bot. Elev.:** Elevation of the bottom of the ladder (m or ft.)
- **Top Elev.:** Elevation of the top of the ladder (m or ft.)
- **Width:** Width of ladder rungs (mm or in.)
- **Dist.:** Distance (spacing) between rungs (mm or in.)
- **Azimuth:** ladder azimuth (specified in degrees).
- **Radius:** Radius is measured from the pole center to the center of the ladder (m or ft.).
- **Orient.:** Angle between the pole's north and the ladder's radius measured in the clockwise direction.
- **Rung Type:** Rung size chosen from available steel sections database for angles and solid rounds.
- **Rail Type:** Rail size chosen from available steel sections database for angles and solid rounds.

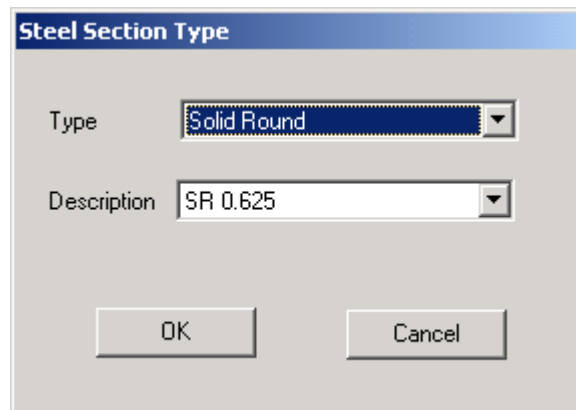
Following functions are available:

- Select: Marks ladder for copying or deleting
- Copy: Allows to copy selected ladder

- Delete: Allows to delete selected ladder
- Sort: Sorts ladders by elevation
- Delete All: Allows to delete all ladders

**Steel Section Type:**

Click on rail type or rung type in the ladder data table and the following window is displayed, from which the steel section type and size is specified.



The following steel sections for ladders are available:

Solid Round (SR13, SR16, SR19, SR25, SR50)  
(SR.5, SR.625, SR.75, SR1.0, SR2.0)

Angle (L51x51x6, L51x51x13)  
(2x2x1/4, 12x2x1/2)

## WIND TURBINE DEFINITION

The loading for wind turbine definitions are based on ANSI/TIA-222-G-DS1 "Design Supplement for Small Wind Turbine Support Structures". Small Wind Turbines (SWT's) defined as wind turbines with rotor swept areas less than 2,200 sq. ft. [200 sq. m].

From the main menu choose **Appurtenances** then sub-menu **General Appurtenances** and then select **Wind Turbine**, the following window is displayed.

**Wind Turbine Loading**

Wind Turbine? ☒

TURBINE MANUFACTURER DATA			
Rotor Diameter:	62.999	(ft)	Model Name: PGE 20/50
Weight of Rotor (Hub and Blades):	3.246	(Kips)	<b>Optional Equivalent Constant Range Fatigue Turbine Loads</b> Horizontal Force (Fxt): 0.000 (Kips) Overturning Moment (Mty): 0.000 (Kipsft) Shaft Torsion (Mtx): 0.000 (Kipsft)
Offset of Rotor from Tower Center:	1.873	(ft)	
Rotor Rotational Speed:	42	(rpm)	
Wind Speed:	29.09	(mph)	
Weight of Turbine:	5.508	(Kips)	Note: Wind Turbine weight without weight of rotor.
Effective Projected Area (EPA):	256.719	(ft <sup>2</sup> )	
Fatigue Importance Factor (If):	1.00		Note: Make sure it is consistent with structure class
Vertical Offset from Tower Top:	3.530	(ft)	
Twisting (Yaw) Moment:	6.343	{ Kipsft	
Overturning Moment:	0.000	{ Kipsft	Note: If Overturning Moment is left as zero the program will calculate it as Rotor Weight x Horizontal Offset
Fatigue Stress Limit Cat. A:	4.50	(ksi)	
Fatigue Stress Limit Cat. B:	2.61	(ksi)	Fatigue stress should contain fatigue resistance factor

OK

The user inputs the following data as defined below:

- **Wind Turbine?** Tick-box indicating if the Wind Turbine should be considered in analysis.
- **Rotor Diameter:** Rotor diameter (m or ft.)



- **Weight of Rotor (Hub and Blades):** Combined weight of hub and blades (kN or kips)
- **Offset of Rotor from Tower Center:** Horizontal offset of turbine weight from vertical centerline of turbine base (m or ft.)
- **Rotor Rotational Speed:** Rotational rotor speed at AWEA electrical power rating of turbine (RPM)
- **Wind Speed:** Wind speed at hub height associated with the specified maximum turbine horizontal thrust (m/s or mph)
- **Weight of Turbine:** Weight of turbine (kN or kips)
- **Effective Projected Area (EPA):** The effective projected area ( $\text{m}^2$  or  $\text{ft}^2$ ) of a turbine shall be calculated in accordance with ANSI/TIA-222-G-DS1 unless the effective projected area is specified by the turbine manufacturer. The effective projected area of a turbine shall be considered to be constant for all wind directions with a wake interference factor,  $K_a$ , equal to 1.0.
- **Fatigue Importance Factor:** Importance factor for fatigue from Table 11-1 of ANSI/TIA-222-G-DS1
- **Vertical Offset from Tower Top:** Hub height above turbine base connection to supporting structure (m or ft.)
- **Twisting (Yaw) Moment:** A specified twisting (yaw) moment considered to act about the vertical centerline of the turbine base in a counterclockwise direction in the plan view (kNm or kipft)
- **Overturning Moment:** A specified overturning moment shall be considered to occur in the same direction as the wind. Rotor Weight times Horizontal Offset (kNm or kipft). If this value is left as zero the program will calculate it automatically.
- **Fatigue Stress Limit Cat. A:** Equivalent fatigue damage stress ranges for Category A components and shall not exceed the design stress ranges specified in Sections 11.4.1 of ANSI/TIA-222-G-DS1 (MPa or ksi)
- **Fatigue Stress Limit Cat. B:** Equivalent fatigue damage stress ranges for Category B components and shall not exceed the design stress ranges specified in Sections 11.4.2 of ANSI/TIA-222-G-DS1 (MPa or ksi)
- **Model Name:** Name of the Wind Turbine Model
- **Horizontal Force (Fxt):** Equivalent constant range turbine horizontal force, (kN or kips). This entry is optional and if left as zero the program will calculate it.
- **Overturning Moment (Mty):** Equivalent constant range turbine overturning moment, (kNm or kipft). This entry is optional and if left as zero the program will calculate it.

- *Shaft Torsion (Mtx)*: Equivalent constant range turbine rotor shaft torsion (kNm or kipft). This entry is optional and if left as zero the program will calculate it.

## Chapter 3 ANALYSIS

This Chapter explains the input of the code-related data and material data. Also, the assumptions and the underlying theory of the analysis are explained in the sequel.

### CODE DATA

#### Wind Loads

From the main menu choose **Load Cases**, and then the following window will appear depending on the design standard specified:

##### a) ANSI/TIA/EIA-222-F-1996

Having the EIA 222-F as the design code, the wind Loads window will be as shown:

**EIA-222-F Code Data**

Wind Speed	80.00	(mph)
Service Wind Speed	50.00	(mph)
Ice Thickness	0.50	(inch)
Start wind direction	0.00	(degrees)
End wind direction	330.00	(degrees)
Increment wind direction	30.00	(degrees)
Elev. above ground	0.00	(ft)
Wind pressure reduction for iced conditions	0.75	
<input checked="" type="checkbox"/> Increase allowable stresses		
<input checked="" type="checkbox"/> Strength - Wind only	<input checked="" type="checkbox"/> Service - Wind only	
<input checked="" type="checkbox"/> Strength - Wind and Ice	<input type="checkbox"/> Service - Wind and Ice	

US Counties

OK

The input data is explained as follows:

- Wind Speed: Design wind speed for the structure (m/sec or mph).
- Service Wind Speed: for the calculation of deflections (tilt/twist) under service load conditions (m/sec or mph).
- Ice Thickness: specified ice thickness for the design of the structure depending on the location (mm or inches).
- Start Wind Direction: Starting wind directions from which the wind loads are considered.
- End wind directions: Last wind direction for which the wind loads are considered
- Increment Wind direction: Wind increment in degrees at which wind loads are calculated. For example, in the above shown example wind will be considered at the following directions (0, 30, 60, 330)
- Elevation above ground: The elevation of the structure base above ground this is used for wind loads calculations. The height factor is increased accordingly.
- Allowable stress factor: For the structural assessment of the pole, the allowable stress is increased to 1.33 as per EIA 222-F when applicable. However, the user has the option to limit the allowable stress to 1.0
- Wind pressure reduction for the case of iced conditions (default is 0.75 as per code).
- Options to mark the analysis loading cases for wind only or for combined case of wind and ice under strength conditions and service conditions.
- US Counties: If this button is clicked a form appears, allowing to select State, County and to automatically apply wind speed and ice thickness matching the selection.

**b) ANSI/ TIA-222-G-2005**

Selecting the ANSI/TIA-222-G as the design code, the wind Loads window will be displayed as shown:

**ANSI/TIA-222-G Code Data**

Wind Speed ( $V$ )	<input type="text" value="90.00"/>	<input type="button" value="↑"/> <input type="button" value="↓"/>	(mph)	Ice Density	<input type="text" value="56.19"/>	(pcf)
Wind Speed with Ice ( $V_i$ )	<input type="text" value="40.00"/>	<input type="button" value="↑"/> <input type="button" value="↓"/>	(mph)	Dead Weight Load Factor	<input type="text" value="1.20"/>	
Serviceability Wind Speed	<input type="text" value="60.00"/>	<input type="button" value="↑"/> <input type="button" value="↓"/>	(mph)	Min. Dead Weight Load Factor	<input type="text" value="0.90"/>	
Ice Thickness ( $t_i$ )	<input type="text" value="0.50"/>	<input type="button" value="↑"/> <input type="button" value="↓"/>	(inch)	Wind Load Factor	<input type="text" value="1.60"/>	
Start wind direction	<input type="text" value="0.00"/>	<input type="button" value="↑"/> <input type="button" value="↓"/>	(degrees)	Directionality Factor $K_d$	<input type="text" value="0.95"/>	
End wind direction	<input type="text" value="315.00"/>	<input type="button" value="↑"/> <input type="button" value="↓"/>	(degrees)	Serviceability Directionality Factor $K_d$	<input type="text" value="0.85"/>	
Increment wind direction	<input type="text" value="45.00"/>	<input type="button" value="↑"/> <input type="button" value="↓"/>	(degrees)	Importance Factor	<input type="text" value="1.00"/>	
Elev. above ground	<input type="text" value="0.00"/>	<input type="button" value="↑"/> <input type="button" value="↓"/>	(ft)	<input type="checkbox"/> Ultimate Wind Speed ASCE 7-10		
Structure Class	<input type="text" value="2"/>	<input type="button" value="↑"/> <input type="button" value="↓"/>		<div style="border: 1px solid black; padding: 5px;">           Note: If wind speed is ultimate (from ASCE 7-10), with load factor and importance factor included then make sure to set importance factor to 1.00.         </div>		
Exposure Category	<input type="text" value="A"/>	<input type="button" value="↑"/> <input type="button" value="↓"/>				
Topographic Category	<input type="text" value="1"/>	<input type="button" value="↑"/> <input type="button" value="↓"/>				
Survival Wind (as per Annex A - A.2.3.2)				<input type="checkbox"/>		
<input checked="" type="checkbox"/> Strength - Wind only		<input checked="" type="checkbox"/> Service - Wind only				
<input checked="" type="checkbox"/> Strength - Wind and Ice		<input type="checkbox"/> Earthquake Loading		<input checked="" type="checkbox"/> Apply Addendum 2		
<input type="button" value="OK"/>		<input type="checkbox"/> User Defined Wind				<input text"="" type="button" value="1.10"/>
						<input type="button" value="US Counties"/>

The input data is explained as follows:

- Wind Speed ( $V$ ): 3-second gust speed for the structure (m/sec or mph).
- Wind Speed with Ice ( $V_i$ ): 3-second gust speed concurrent with the design ice at 33 ft above the ground (m/sec or mph).
- Serviceability Wind Speed: for the calculation of deflections (tilt/twist) under service load conditions (m/sec or mph).
- Ice Thickness ( $t_i$ ): specified ice thickness for the design of the structure depending on the location (mm or inches).
- Start Wind Direction: Starting wind directions from which the wind loads are considered.

- End wind directions: Last wind direction for which the wind loads are considered
- Increment Wind direction: Wind increment in degrees at which wind loads are calculated.
- Elevation above ground: The elevation of the structure base above ground this is used for wind loads calculations. The height factor is increased accordingly.
- Structure Class as defined in Table 2-1 of TIA-222-G. Values are 1 through 3 with class 2 as default.
- Exposure Category as defined in clause 2.6.5.1 of TIA-222-G. Options are Exposure B, C or D with Exposure C as default.
- Topographic Category as defined in clause 2.6.6.2 of TIA 222-G ranging from Category 1 through 5 with Category 1 as default.
- Ice Density: Density of ice (mm or inches)
- Dead Weight Factor: Default 1.20, can be overwritten by user
- Min. Dead Weight Factor: Default 0.90, can be overwritten by user
- Wind Load Factor: Default 1.60, can be overwritten by user
- Directionality Factor ( $k_d$ ): Default 0.85, can be overwritten
- Serviceability Directionality Factor ( $k_d$ ): Default 0.85, can be overwritten
- Importance Factor: Default 1.00, can be overwritten
- Ultimate Wind Speed: Tick box, if selected then the wind speed is understood as Ultimate Wind Speed defined by ASCE 7-10
- Gust Effect Factor ( $G_h$ ): Default 1.10, can be overwritten
- Option to use survival wind speed as defined in Annex A of the standards. This option assumes that the wind speed used is a survival wind speed with Load factors, gust factors and height factors of 1.0 as per clause A2.3.2.
- Options to mark the analysis loading cases for wind only or for combined case of wind and ice under strength conditions and service conditions.
- Earthquake Loading: Tick box, if selected then following data entries will be showing and relevant data should be entered by User

**Seismic Analysis Design parameters**

Max. Earthquake spectral acceleration at short periods (Ss)

Max. Earthquake spectral acceleration at 1 second (S1)

Site Class based on the soil properties (as in Table 2-11)

Seismic Analysis Procedure Method

OK

- Apply Addendum 2: Tick box, by default it is selected and in such case the Addendum 2 of the ANSI/TIA-222-G will be applied
- User Defined Wind: If this option is selected following form will be displayed

**User Defined Wind**

#	Bottom Elevation (m)	Top Elevation (m)	Bottom Factor	Top Factor
1	0.00	5.00	1.000	1.000
2	5.00	10.00	1.000	1.000
3	10.00	15.00	1.000	1.000
4	15.00	20.00	1.000	1.000
5	20.00	25.00	1.000	1.000
6	25.00	30.00	1.000	1.000
7	30.00	35.00	1.000	1.000
8	35.00	40.00	1.000	1.000
9	40.00	45.00	1.000	1.000

Default Elevation Increment:  (m)

OK Add Line Remove Last Line Cancel

User should declare elevation increments and the using "Add Line" button create lines to cover entire structure height. Then the bottom height factor and top height factor should be entered. If

this option is applied the program will apply height factors at each tower elevation as entered by User.

- US Counties: If this button is clicked following form appears, allowing to select State, County and to automatically apply wind speed, ice thickness and Ss matching the selection.

**US Counties Defaults for EIA-222-G**

Select State: Texas

List of counties for: Texas

County	Min V (mph)	Max V (mph)	Min Vi (mph)	Max Vi (mph)	Min Ice (in)	Max Ice (in)
CARSON	90	90	40	40	0.75	0.75
CASS	90	90	30	30	0.75	0.75
CASTRO	90	90	40	40	0.5	0.75
CHAMBERS	110	130	30	30	0.5	0.5
CHEROKEE	90	90	30	30	0.75	0.75
CHILDRESS	90	90	40	40	0.75	0.75
CLAY	90	90	30	30	0.75	0.75
COCHRAN	90	90	30	40	0.25	0.5
COKE	90	90	30	30	0.75	0.75
COLEMAN	90	90	30	30	0.75	0.75
COLLIN	90	90	30	30	0.75	0.75
COLLINGSWORTH	90	90	40	40	0.75	0.75
COLORADO	95	105	30	30	0.5	0.5
COMAL	90	90	30	30	0.5	0.5
COMANCHE	90	90	30	30	0.75	0.75
CONCHO	90	90	30	30	0.5	0.75

☒ Maximum Wind?    ☒ Maximum Ice?    ☒ Maximum Ss?

OK

### c) ANSI/ TIA-222-H-2018

Selecting the ANSI/TIA-222-H as the design code, the wind Loads window will be displayed as shown:



ANSI/TIA-222-H Code Data

Wind Speed (V)	90.00	(mph)	Ice Density	56.19	(pcf)
Wind Speed with Ice (V <sub>i</sub> )	40.00	(mph)	Dead Weight Load Factor	1.20	
Serviceability Wind Speed	60.00	(mph)	Min. Dead Weight Load Factor	0.90	
Ice Thickness (t <sub>i</sub> )	0.50	(inch)	Wind Load Factor	1.00	
Start wind direction	0.00	(degrees)	Directionality Factor K <sub>d</sub>	0.95	
End wind direction	315.00	(degrees)	Serviceability Directionality Factor K <sub>d</sub>	0.85	
Increment wind direction	45.00	(degrees)	<a href="#">View Importance Factor</a>		
Elev. above ground	0.00	(ft)	Gust Effect Factor (G <sub>h</sub> )	1.10	
Risk Category	2				
Exposure Category	A				
Topographic Category	1				

☒ Strength - Wind only    ☒ Service - Wind only  
☒ Strength - Wind and Ice    ☐ Earthquake Loading  
☐ Existing Structure (as per Table S-1)    ☐ User Defined Wind

[Get Wind Speed](#)


Rooftop Wind Speed-up Factor (K <sub>s</sub> )	1.00
H <sub>s</sub> / Tower Height (for rooftop)	0.00
Mean Elevation of Base of Structure above Sea Level	0.00 (ft)

OK

The input data is explained as follows:

- Wind Speed (V): 3-second gust speed for the structure (m/sec or mph).
- Wind Speed with Ice (V<sub>i</sub>): 3-second gust speed concurrent with the design ice at 33 ft above the ground (m/sec or mph).
- Serviceability Wind Speed: for the calculation of deflections (tilt/twist) under service load conditions (m/sec or mph).
- Ice Thickness (t<sub>i</sub>): specified ice thickness for the design of the structure depending on the location (mm or inches).
- Start Wind Direction: Starting wind directions from which the wind loads are considered.

- End wind directions: Last wind direction for which the wind loads are considered
- Increment Wind direction: Wind increment in degrees at which wind loads are calculated.
- Elevation above ground: The elevation of the structure base above ground this is used for wind loads calculations. The height factor is increased accordingly.
- Risk Category (value 1 to 4), default is 2
- Exposure Category as defined in clause 2.6.5.1 of TIA-222-G. Options are Exposure A, B, C, D or E with Exposure A as default.
- Topographic Category as defined in clause 2.6.6.2 of TIA 222-G ranging from Category 1 through 5 with Category 1 as default.
- Ice Density: Density of ice (pcf)
- Dead Weight Load Factor: Default 1.20, can be overwritten by user
- Min. Dead Weight Load Factor: Default 0.90, can be overwritten by user
- Wind Load Factor: Default 1.00, can be overwritten by user
- Directionality Factor ( $k_d$ ): Default 0.95, can be overwritten
- Serviceability Directionality Factor ( $k_d$ ): Default 0.85, can be overwritten
- Importance Factor:
  - Wind Load without ice: default set to 1.00
  - Wind Load with ice: default set to 1.00
  - Ice Thickness: default set to 1.00
  - Earthquake: default set to 1.00
- Options to mark the analysis loading cases for wind only or for combined case of wind and ice under strength conditions and service conditions.
- Earthquake Loading: Tick box, if selected then following data entries will be showing and relevant data should be entered by User

Seismic Analysis Design Parameters									
Max. Earthquake spectral acceleration at short periods (Ss)	0.000								
Max. Earthquake spectral acceleration at 1 second (S1)	0.000								
Site Class based on the soil properties (as in Table 2-10)	D 								
Long-period transition period (TL)	0.000								
<input type="checkbox"/> Default site class (as per Table 2-11)									
<div>Seismic Analysis Procedure Method</div> <div> <input checked="" type="radio"/> Equivalent Lateral Force Procedure  <input type="radio"/> Modal Analysis Procedure         </div>									
<div>Calculated Values</div> <table> <tbody> <tr> <td>Fa</td> <td>1.600</td> <td>Fv</td> <td>2.400</td> </tr> <tr> <td>Sds</td> <td>0.000</td> <td>Sd1</td> <td>0.000</td> </tr> </tbody> </table>		Fa	1.600	Fv	2.400	Sds	0.000	Sd1	0.000
Fa	1.600	Fv	2.400						
Sds	0.000	Sd1	0.000						
OK									

- User Defined Wind: If this option is selected following form will be displayed
- Existing structure: if ticked, values will be used as per Table S-1 of the ANSI/TIA 222 H
- Rooftop Wind Speed-up Factor(Ks): default of 1.00
- Hs/Tower Height (for roof top): default of 0.00
- Mean Elevation of Base of structure above Sea level: default of 0.00

User Defined Wind

	#	Bottom Elevation (ft)	Top Elevation (ft)	Bottom Factor (Kz)	Top Factor (Kz)
▶	1	0.00	5.00	1.000	1.000
	2	5.00	10.00	1.000	1.000
	3	10.00	15.00	1.000	1.000
	4	15.00	20.00	1.000	1.000
	5	20.00	25.00	1.000	1.000
	6	25.00	30.00	1.000	1.000

Default Elevation Increment  (ft)

User should declare elevation increments and the using “Add Line” button create lines to cover entire structure height. Then the bottom height factor and top height factor should be entered. If this option is applied the program will apply height factors at each tower elevation as entered by User.

- - Get Wind Speed button: will take you to the website (<https://hazards.atcouncil.org/>) to get the Wind, Snow, Tornado or Seismic hazards corresponding to a given address

**d) CSA S37-94**

Having the CSA S37-94 as the design code, the wind Loads window will be displayed as shown for CSA S37-01.

**e) CSA S37-01**

Having the CSA S37-01 as the design code, the wind Loads window will be displayed as shown:

**CSA-S37 Code Data**

Wind Pressure	450.00 (Pa)	Ice Density	900.00 (kg/m <sup>3</sup> )
Ice Thickness	25.00 (mm)	Dead Weight Factor	1.25
Importance Factor	1.00	Min. Dead Weight Load Factor	0.85
Serviceability Factor	1.00	Wind Load Factor	1.50
Start wind direction	0.00 (degrees)	Ice Weight Load Factor	1.50
End wind direction	315.00 (degrees)	Min. Ice Weight Load Factor	0.85
Increment wind direction	45.00 (degrees)	Roof Wind Speed-up Factor (Ca)	1.00
Elev. above ground	0.00 (m)	Ha / Total Tower Height (for roof top)	0.00
		Gust Effect Factor for Tubular Structures <input checked="" type="radio"/> Cg = 2.5 <input type="radio"/> Cg = 2.0	
<input checked="" type="checkbox"/> Strength - Wind only <input checked="" type="checkbox"/> Serviceability - Wind only <input checked="" type="checkbox"/> Strength - Wind and Ice <input checked="" type="checkbox"/> Serviceability - Wind and Ice		Hydro-Quebec Coefficients? <input type="checkbox"/> Hydro-Quebec Ce and Cg values	
Site Specific Wind <input type="checkbox"/>		<input type="checkbox"/> User Defined Wind	
OK			

The data for which is explained as follows:

- Wind Pressure: Reference wind pressure (q) as per CSA S37-01
- Ice thickness: Radial ice thickness for the design
- Importance factor: Importance factor as per S37-01
- Serviceability factor: Serviceability factor for service load conditions as per S37-01
- Start Wind Direction: Starting wind directions from which the wind loads are considered.
- End wind directions: Last wind direction for which the wind loads are considered
- Increment Wind direction: Wind increment in degrees at which wind loads are calculated.

- Elevation above ground: The elevation of the structure base above ground. This is used for wind loads calculations.
- Ice Density: Density of ice (mm or inches)
- Dead Weight Factor: Default 1.25, can be overwritten by user
- Min. Dead Weight Factor: Default 0.85, can be overwritten by user
- Wind Load Factor: Default 1.50, can be overwritten by user
- Ice Weight Load Factor: Default 1.50, can be overwritten by user
- Min. Ice Weight Load Factor: Default 0.85, can be overwritten by user
- Roof Wind Speed-up Factor ( $C_a$ ): Applicable for roof top structure
- $H_a$  / Total Tower Height (for roof top): Fraction of tower height, for which the  $C_a$  as entered will be applied and above which the  $C_a = 1.0$  will be applied
- Hydro-Quebec  $C_e$  and  $C_g$  values: if this option is selected the height factor and gust factor will follow the specifications of Hydro-Quebec
- User Defined Wind: If this option is selected following form will be displayed

**User Defined Wind**

#	Bottom Elevation (m)	Top Elevation (m)	Bottom Factor	Top Factor
1	0.00	5.00	1.000	1.000
2	5.00	10.00	1.000	1.000
3	10.00	15.00	1.000	1.000
4	15.00	20.00	1.000	1.000
5	20.00	25.00	1.000	1.000
6	25.00	30.00	1.000	1.000
7	30.00	35.00	1.000	1.000
8	35.00	40.00	1.000	1.000
9	40.00	45.00	1.000	1.000

Default Elevation Increment:  (m)

User should declare elevation increments and the using "Add Line" button create lines to cover entire structure height. Then the bottom height factor and top height factor should be entered. If this option is applied the program will apply height factors at each tower elevation as entered by User.

- Site Specific Wind: If Site Specific Wind option is selected following data entries will be displayed:

	0 - z	> z
Coefficient a1:	0.0000	0.0000
Coefficient a2:	0.00000	0.00000
Coefficient a3:	0.000	0.000
Coefficient Zh:	0.000	0.000
Coefficient Z01:	0.000	0.000
Coefficient V01:	0.000	0.000
Height (z) for 2nd curve: (m)		0.00

User should enter the site specific wind coefficients as per data supplied by Environment Canada.

- Gust Effect Factor for Tubular Structures:

This form allows the user to choose the value of  $C_g$  as per CSA S37-01. If  $C_g = 2.0$  is selected, then the program will check if the condition 4.6.2 (a) of S37-01 is satisfied. If that is the case, then no other checkups are performed and the program applies  $C_g = 2.0$ . If, however, the condition in clause 4.6.2 (a) is not satisfied then the program uses the clause 4.6.2 (b) and adds one more loading case (Vortex Shedding) to the analysis. The calculation of the applied loads in this case is based on the Supplement to the National Building Code of Canada 1990, Commentary B, Wind Loads. An important parameter for these calculations is the critical damping ratio  $\beta$ . The Engineer should enter or verify the value of the critical damping ratio (accessed through the "Calculation Parameters" sub-menu of the Setup Menu. The default value is  $\beta = 0.004$ .

Notes: Selections of User Defined Wind, Hydro-Quebec Wind and Site Specific Wind are mutually exclusive. Only one selection will be applied for analysis

**f) CSA S37-13**

Having the CSA S37-13 as the design code, the wind Loads window will be displayed as shown:

**CSA-S37 Code Data**

Wind Pressure	500.00	(Pa)	Ice Density	900.00	(kg/m <sup>3</sup> )
Service Wind Pressure	440.47	(Pa)			
Ice Thickness	10.00	(mm)	Dead Weight Factor	1.25	
			Min. Dead Weight Load Factor	0.85	
Importance Factor	1.00		Wind Load Factor	1.40	
Serviceability Factor	1.00		Ice Weight Load Factor	1.45	
Start wind direction	0.00	(degrees)	Min. Ice Weight Load Factor	0.82	
End wind direction	330.00	(degrees)	Roof Wind Speed-up Factor (Ca)	1.00	
Increment wind direction	30.00	(degrees)	Ha / Total Tower Height (for roof top)	0.00	
Elev. above ground	0.00	(m)			
			Gust Effect Factor for Tubular Structures		
			<input checked="" type="radio"/> Cg = 2.5	<input type="radio"/> Cg = 2.0	
<input checked="" type="checkbox"/> Strength - Wind only	<input checked="" type="checkbox"/> Serviceability - Wind only				
<input checked="" type="checkbox"/> Strength - Wind and Ice	<input checked="" type="checkbox"/> Serviceability - Wind and Ice				
Site Specific Wind	<input type="checkbox"/>				
			Roughness of the Surrounding Terrain		
			Open Terrain		
			Select Wind / Ice / Seismic Data from Table		
			Seismic Analysis		
			<input type="checkbox"/> Earthquake Loading		
			Importance Category:		
					OK

The data for which is explained as follows:

- Wind Pressure: Reference velocity pressure ( $q$ ) as per CSA S37-13 (50-year return period mean hourly wind pressure at 10 m above ground level), (Pa or psf)
- Service Wind Pressure: Service velocity pressure as per CSA S37-13 (10-year return period mean hourly wind pressure at 10 m above ground level), (Pa or psf)
- Ice thickness: Reference radial ice thickness ( $t_i$ ), (mm or inches)
- Importance factor: Importance factor as per S37-13
- Serviceability factor: Serviceability factor for service load conditions as per S37-13
- Start Wind Direction: Starting wind directions from which the wind loads are considered.
- End wind directions: Last wind direction for which the wind loads are considered



- Increment Wind direction: Wind increment in degrees at which wind loads are calculated. For example, in the above shown window, wind will be considered only from 0 degrees.
- Elevation above ground: The elevation of the structure base above ground. This is used for wind loads calculations (m or ft).
- Ice Density: Density of ice (mm or inches)
- Dead Weight Factor: Default 1.25, can be overwritten by user
- Min. Dead Weight Factor: Default 0.85, can be overwritten by user
- Wind Load Factor: Default 1.40, can be overwritten by user
- Ice Weight Load Factor: Default 1.45, can be overwritten by user
- Min. Ice Weight Load Factor: Default 0.82, can be overwritten by user
- Roof Wind Speed-up Factor ( $C_a$ ): Applicable for roof top structure
- $H_a$  / Total Tower Height (for roof top): Fraction of tower height, for which the  $C_a$  as entered will be applied and above which the  $C_a = 1.0$  will be applied
- Options to mark the analysis loading cases for wind only or for combined case of wind and ice under strength conditions and service conditions.
- Roughness of the surrounding terrain, following options are available:
  - Open terrain (default)
  - Rough terrain
  - Intermediate terrain (if this option is selected the user should enter the upstream extent of the rough terrain,  $x_r$  (km))
- Hydro-Quebec  $C_e$  and  $C_g$  values: if this option is selected the height factor and gust factor will follow the specifications of Hydro-Quebec
- User Defined Wind: If this option is selected following form will be displayed

**User Defined Wind**

#	Bottom Elevation (m)	Top Elevation (m)	Bottom Factor	Top Factor
1	0.00	5.00	1.000	1.000
2	5.00	10.00	1.000	1.000
3	10.00	15.00	1.000	1.000
4	15.00	20.00	1.000	1.000
5	20.00	25.00	1.000	1.000
6	25.00	30.00	1.000	1.000
7	30.00	35.00	1.000	1.000
8	35.00	40.00	1.000	1.000
9	40.00	45.00	1.000	1.000

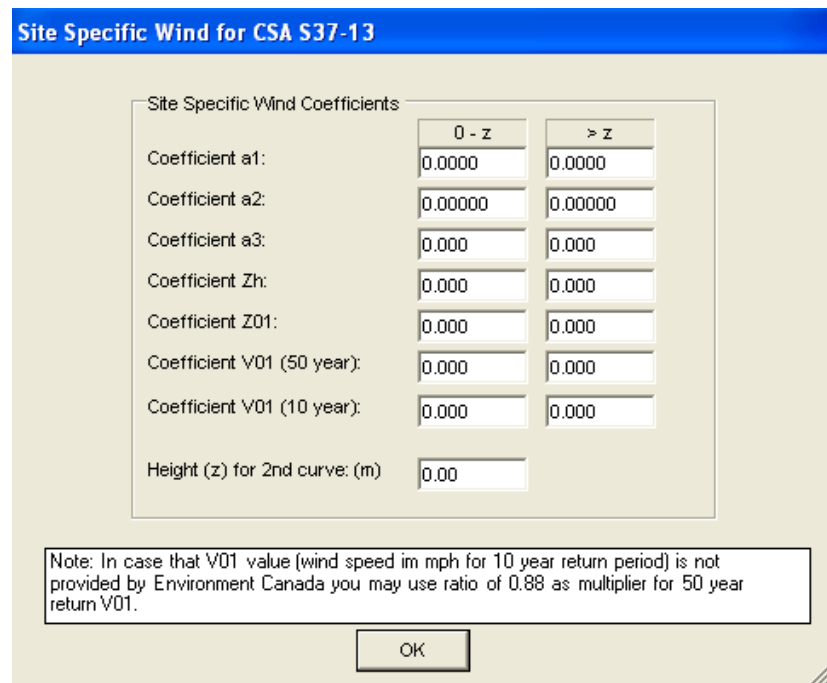
Default Elevation Increment:  (m)

User should declare elevation increments and the using “Add Line” button create lines to cover entire structure height. Then the bottom height factor and top height factor should be entered. If this option is applied the program will apply height factors at each tower elevation as entered by User.

- **Gust Effect Factor for Tubular Structures:**

This form allows the user to choose the value of  $C_g$  as per CSA S37-13. If  $C_g = 2.0$  is selected, then the program will check if the condition 5.6.2 of S37-13 is satisfied. If that is the case, then no other checkups are performed and the program applies  $C_g = 2.0$ . If, however, the condition in clause 5.6.2 is not satisfied then the program adds one more loading case (Vortex Shedding) to the analysis. The calculation of the applied loads in this case is based on the Supplement to the National Building Code of Canada 1990, Commentary B, Wind Loads. An important parameter for these calculations is the critical damping ratio  $\beta$ . The Engineer should enter or verify the value of the critical damping ratio (accessed through the “Calculation Parameters” sub-menu of the Setup Menu. The default value is  $\beta = 0.004$ .

- Site Specific Wind: If Site Specific Wind option is selected following form will be displayed:



The dialog box is titled "Site Specific Wind for CSA S37-13". It contains a section titled "Site Specific Wind Coefficients" with two columns of input fields: "0 - z" and "> z". The coefficients listed are a1, a2, a3, Zh, Z01, V01 (50 year), and V01 (10 year). Below these is a field for "Height (z) for 2nd curve: (m)". A note at the bottom states: "Note: In case that V01 value (wind speed in mph for 10 year return period) is not provided by Environment Canada you may use ratio of 0.88 as multiplier for 50 year return V01." An "OK" button is at the bottom right.

	0 - z	> z
Coefficient a1:	0.0000	0.0000
Coefficient a2:	0.00000	0.00000
Coefficient a3:	0.000	0.000
Coefficient Zh:	0.000	0.000
Coefficient Z01:	0.000	0.000
Coefficient V01 (50 year):	0.000	0.000
Coefficient V01 (10 year):	0.000	0.000
Height (z) for 2nd curve: (m)	0.00	

Note: In case that V01 value (wind speed in mph for 10 year return period) is not provided by Environment Canada you may use ratio of 0.88 as multiplier for 50 year return V01.

OK

User should enter the site specific wind coefficients as per data supplied by Environment Canada.

Select Wind/Ice/Seismic Data from Table: This option will open following form

Canadian Locations Defaults for CSA S37-13

Select Province: **ON** Search by Coordinates ☐

List of Locations for: Ontario

Location	Altitude	Latitude	Longitude	Ice Thickness (mm)	Wind Pressure (Pa)	Service Wind Pressure	Sa(0.2)	Sa(0.5)	Sa(1.0)
Centralia	260	43.28	81.47	21	490	380	0.13	0.08	0.052
CFB Borden	225	44.27	79.88	22	360	280	0.14	0.1	0.063
Chapleau	425	47.83	83.4	21	300	230	0.095	0.057	0.037
Chatham	180	42.4	82.18	28	430	330	0.16	0.092	0.05
Chesley	275	44.28	81.08	21	480	370	0.12	0.082	0.053
Clinton	280	43.62	81.53	21	490	380	0.12	0.078	0.05
Coboconk	270	44.65	78.8	23	350	270	0.18	0.13	0.074
Cobourg	90	43.97	78.17	20	490	380	0.22	0.14	0.079
Cochrane	245	49.07	81.02	17	350	270	0.18	0.098	0.054
Colborne	105	44	77.88	20	490	380	0.23	0.14	0.081
Collingwood	190	44.48	80.22	20	390	300	0.13	0.097	0.06
Cornwall	35	45.03	74.73	30	410	320	0.62	0.31	0.14
Corunna	185	42.88	82.43	22	470	360	0.12	0.074	0.047
Deep River	145	46.1	77.5	22	350	270	0.63	0.3	0.13
Deseronto	85	44.2	77.05	25	430	330	0.27	0.17	0.092

☒ Select Reference Wind? 
 ☒ Select Service Wind Pressure? 
 ☒ Select Ice?

Exit and Save Selection      Cancel and Exit

Seismic Data

☒ Select Sa(0.2)?      ☒ Select Sa(0.5)?  
☒ Select Sa(1.0)?      ☒ Select Sa(2.0)?

### Seismic Analysis

If "Earthquake Loading" is selected following form will be displayed:

**Seismic Analysis Design parameters**

Spectral response acceleration Sa(0.2)

Spectral response acceleration Sa(0.5)

Spectral response acceleration Sa(1.0)

Spectral response acceleration Sa(2.0)

Site Class (as in Table 4.1.8.4.A. of NBCC)

User should enter Spectral response acceleration factors Sa(0.2) through Sa(2.0) and Site Class.

The Importance Category shall be defined. Options are: Low, Normal, High and Post-Disaster.

Notes: Selections of User Defined Wind, Hydro-Quebec Wind, Site Specific Wind and Wind Data from Table are mutually exclusive. Only one selection will be applied for analysis

### g) CSA S37-18

Having the CSA S37-18 as the design code, the wind Loads window will be displayed as shown:

**CSA S37-18 Code Data**

Wind Pressure	12.52	(psf)	Ice Density	56.19	(pcf)
Service Wind Pressure	9.20	(psf)	Dead Weight Factor	1.25	
Ice Thickness	0.50	(inch)	Min. Dead Weight Load Factor	0.85	
Importance Factor	1.00		Wind Load Factor	1.40	
Serviceability Factor	1.00		Ice Weight Load Factor	1.45	
Start wind direction	0.00	(degrees)	Min. Ice Weight Load Factor	0.82	
End wind direction	315.00	(degrees)	Roof Wind Speed-up Factor (Ca)	1.00	
Increment wind direction	45.00	(degrees)	Ha / Total Tower Height (for rooftop)	0.00	
Elev. above ground	0.00	(ft)			

☒ Strength - Wind only    ☒ Serviceability - Wind only  
☒ Strength - Wind and Ice    ☐ Serviceability - Wind and Ice  
☐ Site Specific Wind

☐ User Defined  
 Strength: 0.5  
 Serviceability: 0.5

☐ Hydro-Quebec Coefficients?  
☐ Hydro-Quebec Ce and Cg values

☐ User Defined Wind

☒ Apply Minimum qh = 290 Pa

Roughness of the Surrounding Terrain  
 Open Terrain

Select Wind / Ice / Seismic Data from Table

Fatigue Load (as per N.2.2)  
 Wind Gusts (Qwg)  
 (psf)  
 Calculated value: 5.26 psf

Seismic Analysis  
☐ Earthquake Loading  
 Importance Category:

Critical Damping Ratio: 0.003

OK

The data for which is explained as follows:

- Wind Pressure: Reference velocity pressure (q) as per CSA S37-18 (50-year return period mean hourly wind pressure at 10 m above ground level), (Pa or psf)
- Service Wind Pressure: Service velocity pressure as per CSA S37-18 (10-year return period mean hourly wind pressure at 10 m above ground level), (Pa or psf)

- Ice thickness: Reference radial ice thickness ( $t_i$ ), (mm or inches)
- Importance factor: Importance factor as per S37-18
- Serviceability factor: Serviceability factor for service load conditions as per S37-18
- Start Wind Direction: Starting wind directions from which the wind loads are considered.
- End wind directions: Last wind direction for which the wind loads are considered
- Increment Wind direction: Wind increment in degrees at which wind loads are calculated. For example, in the above shown window, wind will be considered only from 0 degrees.
- Elevation above ground: The elevation of the structure base above ground. This is used for wind loads calculations (m or ft).
- Ice Density: Density of ice (mm or inches)
- Dead Weight Factor: Default 1.25, can be overwritten by user
- Min. Dead Weight Factor: Default 0.85, can be overwritten by user
- Wind Load Factor: Default 1.40, can be overwritten by user
- Ice Weight Load Factor: Default 1.45, can be overwritten by user
- Min. Ice Weight Load Factor: Default 0.82, can be overwritten by user
- Roof Wind Speed-up Factor ( $C_a$ ): Applicable for roof top structure
- $H_a$  / Total Tower Height (for roof top): Fraction of tower height, for which the  $C_a$  as entered will be applied and above which the  $C_a = 1.0$  will be applied
- Options to mark the analysis loading cases for wind only or for combined case of wind and ice under strength conditions and service conditions.
- Load Combination factors for Wind and Ice, defaults for strength is 0.5 and for serviceability is 0.5
- Roughness of the surrounding terrain, following options are available:
  - Open terrain (default)
  - Rough terrain
  - Intermediate terrain (if this option is selected the user should enter the upstream extent of the rough terrain,  $x_r$  (km))
- Hydro-Quebec  $C_e$  and  $C_g$  values: if this option is selected the height factor and gust factor will follow the specifications of Hydro-Quebec
- User Defined Wind: If this option is selected following form will be displayed

User Defined Wind					
	#	Bottom Elevation (ft)	Top Elevation (ft)	Bottom Factor (Ce)	Top Factor (Ce)
▶	1	0.00	15.00	1.000	1.000
	2	15.00	30.00	1.000	1.000
	3	30.00	45.00	1.000	1.000
	4	45.00	60.00	1.000	1.000
	5	60.00	75.00	1.000	1.000
	6	75.00	90.00	1.000	1.000

Default Elevation Increment  (ft)

User should declare elevation increments and the using “Add Line” button create lines to cover entire structure height. Then the bottom height factor and top height factor should be entered. If this option is applied the program will apply height factors at each tower elevation as entered by User.

- Gust Effect Factor for Tubular Structures:

This form allows the user to choose the value of  $C_g$  as per CSA S37-13. If  $C_g = 2.0$  is selected, then the program will check if the condition 5.6.2 of S37-13 is satisfied. If that is the case, then no other checkups are performed and the program applies  $C_g = 2.0$ . If, however, the condition in clause 5.6.2 is not satisfied then the program adds one more loading case (Vortex Shedding) to the analysis. The calculation of the applied loads in this case is based on the Supplement to the National Building Code of Canada 1990, Commentary B, Wind Loads. An important parameter for these calculations is the critical damping ratio  $\beta$ . The Engineer should enter or verify the value of the critical damping ratio (accessed

through the "Calculation Parameters" sub-menu of the Setup Menu. The default value is  $\beta = 0.004$ .

Site Specific Wind: If Site Specific Wind option is selected following form will be displayed:

Site Specific Wind for CSA S37-13

Site Specific Wind Coefficients		
	0 - z	> z
Coefficient a1:	0.0000	0.0000
Coefficient a2:	0.00000	0.00000
Coefficient a3:	0.000	0.000
Coefficient Zh:	0.000	0.000
Coefficient Z01:	0.000	0.000
Coefficient V01 (50 year):	0.000	0.000
Coefficient V01 (10 year):	0.000	0.000
Exponent of z/10:	0.200	0.200
Height (z) for 2nd curve: (ft)	0.00	

Note: In case that V01 value (wind speed in mph for 10 year return period) is not provided by Environment Canada you may use ratio of 0.88 as multiplier for 50 year return V01.

OK

User should enter the site specific wind coefficients as per data supplied by Environment Canada.

- Select Wind/Ice/Seismic Data from Table: This option will open following form



Canadian Locations Defaults for CSA S37-13

Select Province: **ON** Search by Coordinates ☐

List of Locations for: Ontario

Location	Altitude	Latitude	Longitude	Ice Thickness (mm)	Wind Pressure (Pa)	Service Wind Pressure	Sa(0.2)	Sa(0.5)	Sa(1.0)
Centralia	260	43.28	81.47	21	490	380	0.13	0.08	0.052
CFB Borden	225	44.27	79.88	22	360	280	0.14	0.1	0.063
Chapleau	425	47.83	83.4	21	300	230	0.095	0.057	0.037
Chatham	180	42.4	82.18	28	430	330	0.16	0.092	0.05
Chesley	275	44.28	81.08	21	480	370	0.12	0.082	0.053
Clinton	280	43.62	81.53	21	490	380	0.12	0.078	0.05
Coboconk	270	44.65	78.8	23	350	270	0.18	0.13	0.074
Cobourg	90	43.97	78.17	20	490	380	0.22	0.14	0.079
Cochrane	245	49.07	81.02	17	350	270	0.18	0.098	0.054
Colborne	105	44	77.88	20	490	380	0.23	0.14	0.081
Collingwood	190	44.48	80.22	20	390	300	0.13	0.097	0.06
Cornwall	35	45.03	74.73	30	410	320	0.62	0.31	0.14
Corunna	185	42.88	82.43	22	470	360	0.12	0.074	0.047
Deep River	145	46.1	77.5	22	350	270	0.63	0.3	0.13
Deseronto	85	44.2	77.05	25	430	330	0.27	0.17	0.092

☒ Select Reference Wind? 
 ☒ Select Service Wind Pressure? 
 ☒ Select Ice?

Exit and Save Selection      Cancel and Exit

**Seismic Data**  
☒ Select Sa(0.2)?      ☒ Select Sa(0.5)?  
☒ Select Sa(1.0)?      ☒ Select Sa(2.0)?

- Fatigue Load , wind Gusts
- Critical Damping Ratio: a default of 0.003 value, can be overwritten
- Seismic Analysis

If "Earthquake Loading" is selected following form will be displayed:


**Seismic Analysis Design parameters**

Spectral response acceleration Sa(0.2)

Spectral response acceleration Sa(0.5)

Spectral response acceleration Sa(1.0)

Spectral response acceleration Sa(2.0)

Site Class (as in Table 4.1.8.4.A. of NBCC)  

OK

User should enter Spectral response acceleration factors  $S_a(0.2)$  through  $S_a(2.0)$  and Site Class.

The Importance Category shall be defined. Options are: Low, Normal, High and Post-Disaster.

Notes: Selections of User Defined Wind, Hydro-Quebec Wind, Site Specific Wind and Wind Data from Table are mutually exclusive. Only one selection will be applied for analysis

## **ANALYSIS THEORY**

The analysis is based on three-dimensional beam model with geometrical non-linear capabilities. Increased moment due to P-delta effects are accounted for in the analysis. Wind load calculations and analysis are based on the following assumptions:

### **Wind Loads Calculations**

1. Wind is assumed horizontal and is blowing from a certain direction throughout the whole pole height.
2. Force coefficients (drag factors) are calculated as per applicable code.
3. Load calculations for multi-sided poles not explicitly spelled out in the codes (poles with number of sides greater than 16) are based on linear interpolation between 16-sided poles and circular poles.
4. No shielding is considered on the pole from antennas, Tx-lines, or ladders.
5. Tx-lines and ladders located inside the pole are considered shielded by the pole.
6. Ice built up is considered uniform on the structure, external tx-lines and ladders.
7. Wind loads considered on iced structures are reduced as per applicable code.
8. For wind load calculations, each pole section is discretized into 5 sub-sections.

9. Loads that are offset from the tower center are applied at the tower center with the corresponding moments (torsional and bending).
10. Loads that extend beyond the height of the structure are applied at the top of the structure with the corresponding additional moments (torsional and bending).

### **Analysis and Capacities**

1. Each pole section is modeled as five elements but the maximum length of an element does not exceed 6.00 m (20 ft).
2. Each element is modeled as two-noded three-dimensional beam elements with six degrees of freedom at each node.
3. Element properties are calculated based on mid-height dimensions.
4. Pole is considered fixed in all directions at the base.
5. Uniform loads applied to the element are distributed to the top and bottom element nodes.
6. Capacities are calculated based on applicable codes and the structure is assessed at each element.
7. Capacities for 6 and 10 sided poles are based on 8 sided equations. Poles with number of sides greater than 16 sides are based on 16 sided equations.

### **Analysis Options**

Following types of analysis can be performed:

1. Full analysis for ultimate limit states and serviceability limit states (as selected by User) for selected wind directions.
2. Modal analysis.
3. Fatigue strength analysis, provided that User selects Wind Turbine loading.

Notes:

- With selection of EIA-222-F the analysis is performed for working loads (not factored).
- In case of applying Wind Turbine loading both full analysis and fatigue analysis should be performed.

## Chapter 4 OUTPUT

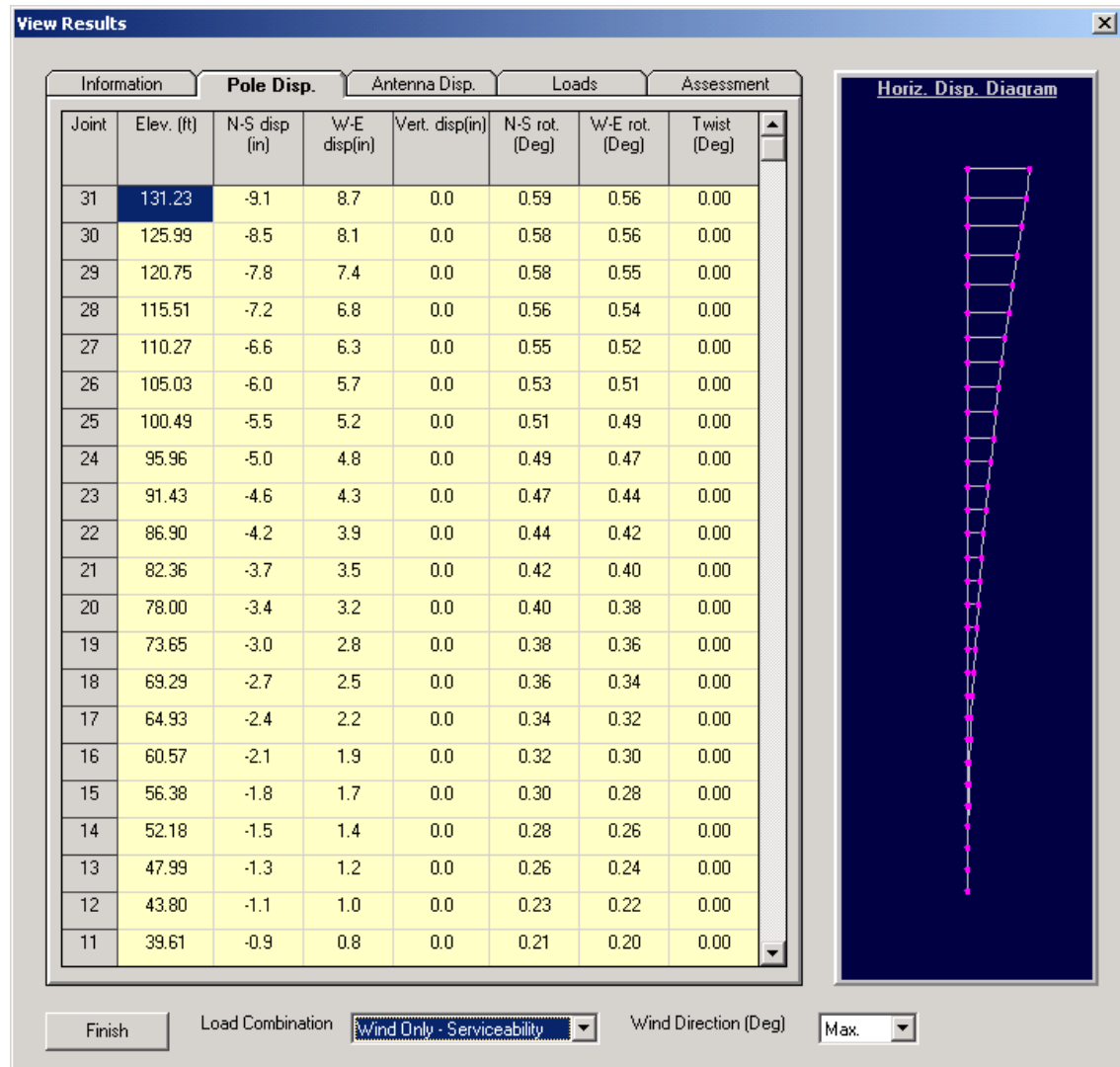
In this Chapter the printed and viewable output options for the program are explained. After the input data phase is completed, the user chooses **Run** from the main menu. The program performs the wind load calculations and executes the structural analysis. From the main menu the user may choose **Results** and the following screen is displayed which shows the number of joints (nodes), number of members (elements), number of wind directions considered for each load combination, and number of load combinations.

Information	Pole Disp.	Antenna Disp.	Loads	Assessment
No. of joints	31			
No. of members	30			
Wind directions	12			
Load combinations	3			
Fundamental natural frequency (Hz)	1.79			

Finish Load Combination Wind Only Wind Direction (Deg) Max.

## Pole Displacement

The user may view the pole displacement on screen by choosing the **Pole Disp.** tab from the **Results** menu.



On this screen, the user can see the joint number (for this example, the tower has 3 sections and 5 elements per section, 16 joints), and the elevation at each joint number, displacements in the orthogonal three directions, rotations and twist.

Also, on the bottom of the screen, the user may select the load combination for which results are to be displayed. Load combinations selected from the analysis menu are shown in the load combination list. Specific wind direction may be chosen or simply the envelope of the maximum values.

## Antenna Displacement

The user may view the antenna displacement at the location of microwave antennas chosen by clicking on the **Antenna Disp.** tab from the **Results** menu.

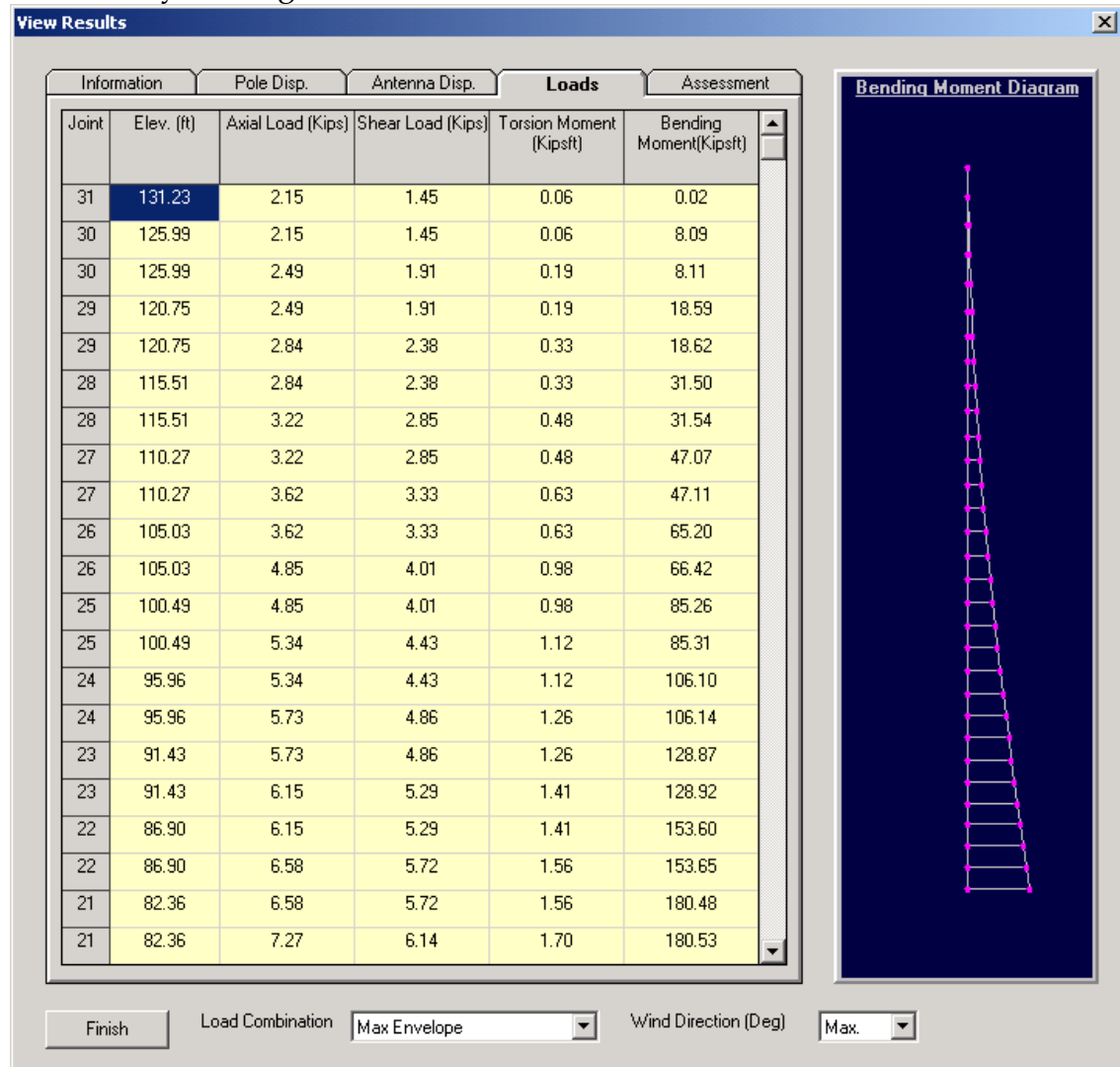
[illegible]

On this screen, the user can see the antenna number (for this example, the tower has 2 antenna at 20m elevation), and the elevation at each antenna, displacements in the orthogonal three directions, rotations and twist.

Also, on the bottom of the screen, the user may select the load combination for which results are to be displayed. Load combinations selected from the analysis menu are shown in the load combination list. Specific wind direction may be chosen or simply the envelope of the maximum values.

## Loads Output

The user may view the output loads (forces and moments) at each of the elements by clicking on the **Loads** tab from the **Results** menu.



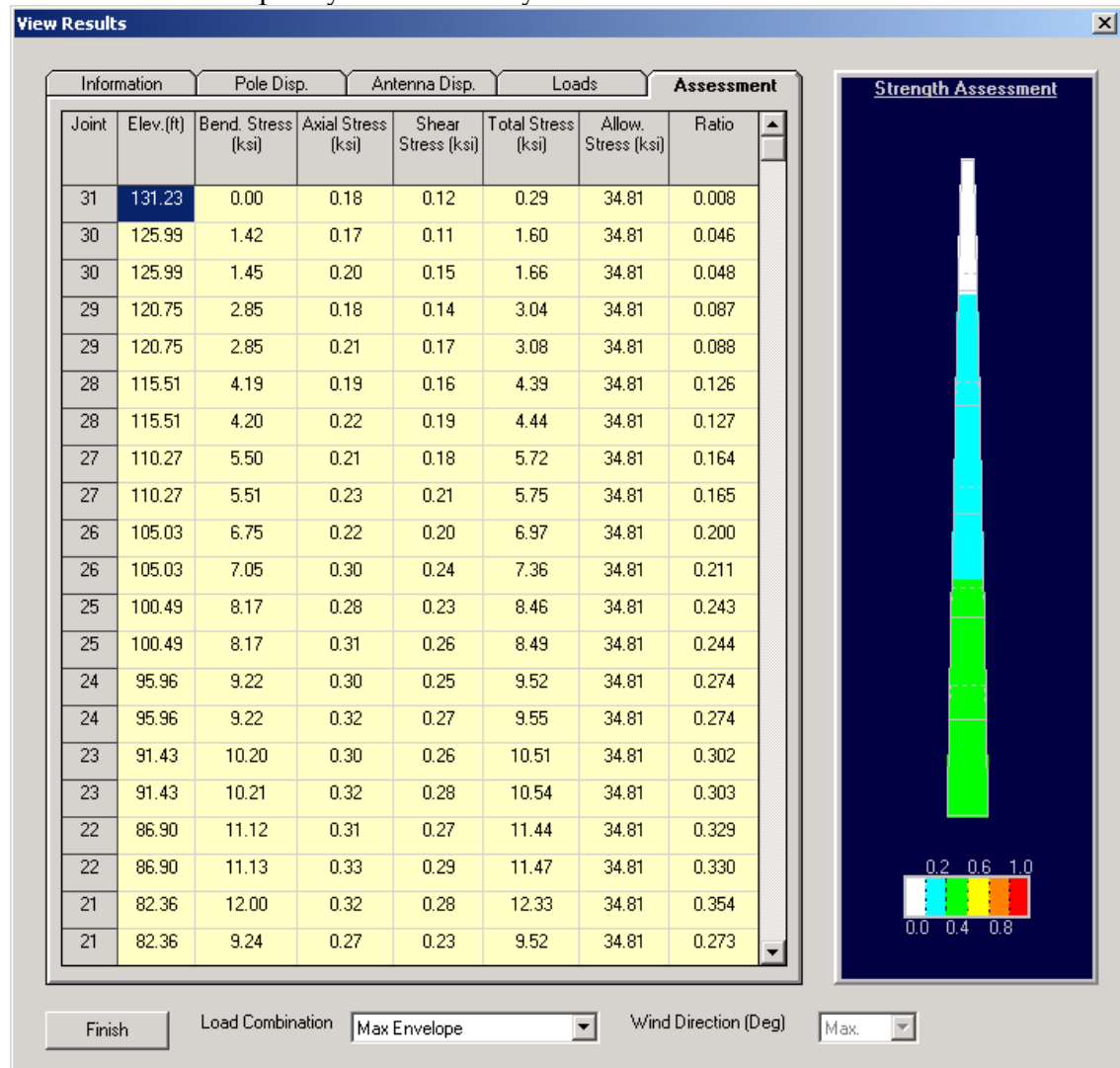
On this screen, the user can see the element number, elevation, shear forces in both directions, bending moment in the two orthogonal directions and the twisting moment.

Also, on the bottom of the screen, the user may select the load combination for which results are to be displayed. Load combinations selected from the analysis menu are shown in the load combination list. Specific wind direction may be chosen or simply the envelope of the maximum values.



### Structural Assessment

The program performs a structural assessment based on the applicable code. The results are displayed in the format of contour lines based on the usage factor. In general, a usage factor greater than 1.0 (shown in red) is considered not to meet the capacity as defined by the code.



On this screen, the user can see the element number, elevation, bending stresses, shear stresses, total stresses, allowable stress, and the usage ratio defined as the ratio between the actual maximum stress and the allowable stress at this elevation.

Also, on the bottom of the screen, the user may select the load combination for which results are to be displayed. Load combinations selected from the analysis menu are shown in the load combination list. This screen is calculated only for

the maximum loads of the specific load combination regardless of the wind direction.

## Printout

From the main menu, click on **View and Print Results**, and the following screen will be displayed. From this screen the user may choose the required printout sections by clicking on the corresponding check box.

<u>Input Data</u>	<u>Output Data</u>	<u>Diagrams</u>
<input type="checkbox"/> Project Data	<input type="checkbox"/> Wind Load Data	<input type="checkbox"/> Profile
<input type="checkbox"/> Structure Data	<input type="checkbox"/> Structure Displ. Data	<input type="checkbox"/> Displacements
<input type="checkbox"/> Antenna Data	<input type="checkbox"/> Antenna Displ. Data	<input type="checkbox"/> Bending Moment
<input type="checkbox"/> Tx Line Data	<input type="checkbox"/> Structure Load Data	
<input type="checkbox"/> Ladder Data	<input type="checkbox"/> Assessment Data	
<input type="checkbox"/> Point Load Data	<input type="checkbox"/> Section Capacities	

Note that for analysis including several load combinations and different wind directions as well the user has the option to select the required sections for printing and also the desired wind directions. . This may result in a relatively large number of pages in the printout.

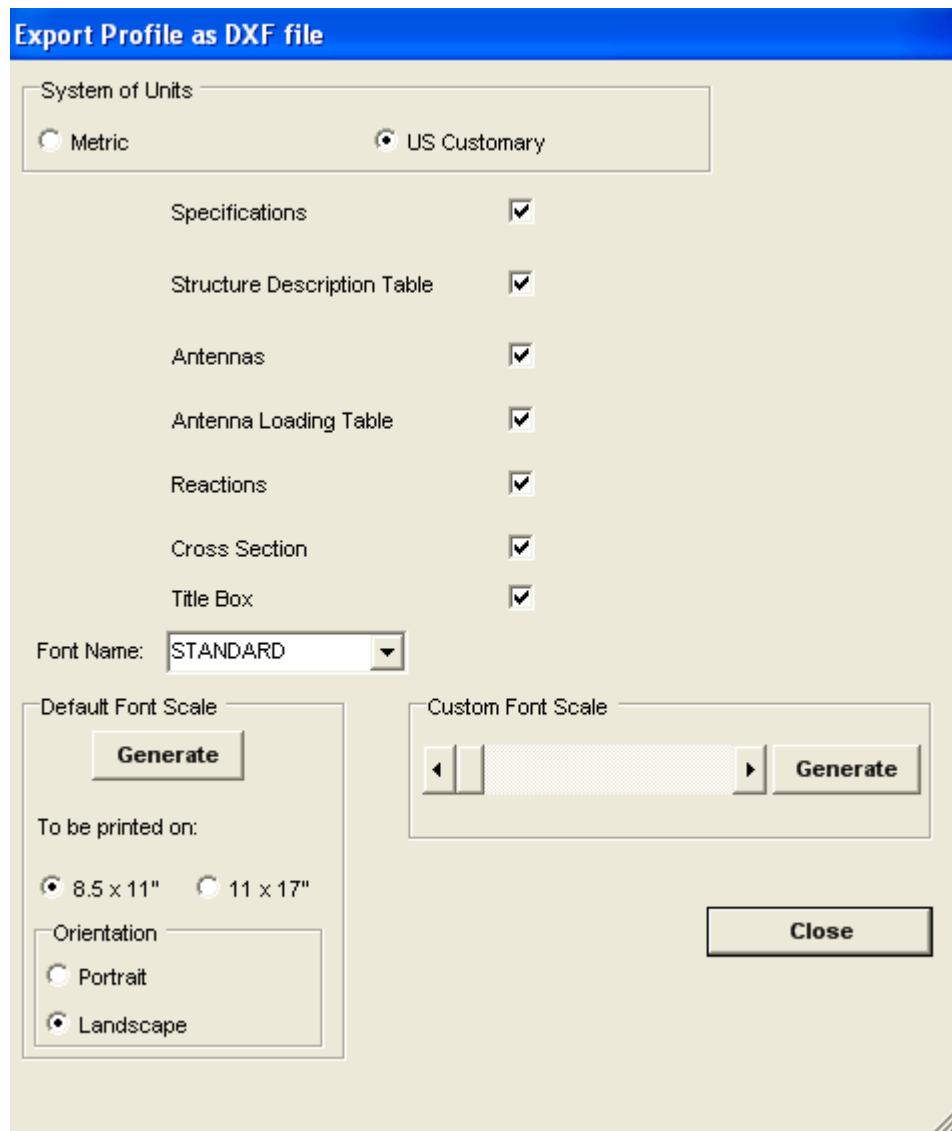
The diagram option allows the user to print a simple profile on which the project data, design specification, base reactions and pole geometry are printed in a graphical format. The profile for the example tower is shown in the next figure.

The resulting print out is a Rich Text File (.rtf) that can be viewed and printed by either MS Word or Word Pad. The header of the output file will show the Program information, file information as well as the licensee's information.

<b>TSTower - v 3.16 Monopole Analysis Program</b> Licensed to: Radian Communication Services Corp., Oakville, ON, Canada (c) 1997-2003 TowerSoft, Mississauga, Ontario. Customer: Project: Site : Contract: Engineer: Any Engineer File: C:\Development\TSTower\Example.tap						<b>DESIGN SPECIFICATION</b> Design Standard: EIA-222-F Wind speed = 80.0 (mph) Ice thickness = 0.50 (in)																																											
<table border="1"> <thead> <tr> <th>Sec.</th> <th>Length (ft)</th> <th>Overlap (ft)</th> <th>Top Dia. (in)</th> <th>Bot Dia. (in)</th> <th>Thick. (in)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>26.21</td> <td>6.78</td> <td>51.56</td> <td>60.80</td> <td>0.2500</td> </tr> <tr> <td>2</td> <td>26.21</td> <td>6.03</td> <td>45.79</td> <td>54.23</td> <td>0.2500</td> </tr> <tr> <td>3</td> <td>26.21</td> <td>5.24</td> <td>39.77</td> <td>48.21</td> <td>0.2500</td> </tr> <tr> <td>4</td> <td>26.21</td> <td>4.41</td> <td>33.50</td> <td>41.84</td> <td>0.2500</td> </tr> <tr> <td>5</td> <td>26.21</td> <td>3.54</td> <td>26.85</td> <td>35.28</td> <td>0.1875</td> </tr> <tr> <td>6</td> <td>26.21</td> <td>0.08</td> <td>20.80</td> <td>28.35</td> <td>0.1875</td> </tr> </tbody> </table>						Sec.	Length (ft)	Overlap (ft)	Top Dia. (in)	Bot Dia. (in)	Thick. (in)	1	26.21	6.78	51.56	60.80	0.2500	2	26.21	6.03	45.79	54.23	0.2500	3	26.21	5.24	39.77	48.21	0.2500	4	26.21	4.41	33.50	41.84	0.2500	5	26.21	3.54	26.85	35.28	0.1875	6	26.21	0.08	20.80	28.35	0.1875		
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			Drawn by																																														
Project:			Date	SCALE N.T.S.	DRAWING NO. Rev. 1																																												

### Export Profile

Select sub-menu "Export Profile (\*.dxf)" from main menu "Results".  
 Following screen will be displayed.



The dialog box is titled "Export Profile as DXF file" in a blue header bar. It contains several sections for configuring the export:

- System of Units:** Two radio buttons, "Metric" and "US Customary", with "US Customary" selected.
- Checkboxes:** A list of items with checkboxes, all of which are checked:
  - Specifications
  - Structure Description Table
  - Antennas
  - Antenna Loading Table
  - Reactions
  - Cross Section
  - Title Box
- Font Name:** A dropdown menu currently showing "STANDARD".
- Default Font Scale:** A section containing a "Generate" button and the text "To be printed on:".
- Custom Font Scale:** A section containing a horizontal slider, a "Generate" button, and a "Close" button.
- Orientation:** Two radio buttons, "Portrait" and "Landscape", with "Landscape" selected.

Click on **"Generate"** button.

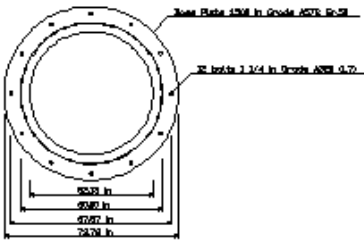
If you have selected DXF viewer you will see the profile appear, as shown below.

DESIGN SPECIFICATION EIA-22B-F  
BASIC WIND SPEED 80 mph  
RADIAL ICD 0.57 inch

SECTION NO.	1	2	3	4	5	6	7
ANTENNA DIAMETER	60.00 in	54.625 in	48.00 in	41.00 in	34.50 in	28.50 in	22.50 in
WALL THICKNESS	0.007 in	0.007 in	0.007 in	0.007 in	0.007 in	0.007 in	0.007 in
LENGTH	75.00 ft	65.00 ft	55.00 ft	45.00 ft	35.00 ft	25.00 ft	15.00 ft
WELD STRENGTH	44 ksi	44 ksi	44 ksi	44 ksi	44 ksi	44 ksi	44 ksi
SECTION WEIGHT	9996 lbs	7496 lbs	5996 lbs	4496 lbs	2996 lbs	1496 lbs	996 lbs

ANTENNA LOCATIONS CHART							
POS.	DESCRIPTION	QTY	ELEVATION	TX LINE	QTY	AZIMUTH	STATUS
1	HP4	1	65.60 ft			05	
2	HP4	1	65.60 ft			195	
STATUS: E=EXISTING, F=FUTURE, P=PROPOSED							

11



MAXIMUM BASE REACTIONS  
REACTION (kip) NAME  
TOWER (kip) L14  
MOMENT (kip-ft) L25.4

Attached is printout of the dxf profile from the example.

## Chapter 5 BASE PLATE

After the analysis is complete, the user may check the design of the base plate including the anchor bolts.

**Base Plate Analysis**

Ultimate Loads

**Base Loads**

Axial Load(Kips) 3.14 Torque(Kipsft) 0.00

Shear Load(Kips) 0.72 Bend. Mom.(Kipsft) 27.60

**Anchor Rod Data**

Detail Type Plate Bottom above Concrete

Bolt Detail Type Not Pretentioned

No. of Rods 6

Radius (in) 11.50

Lar \* (in) 0.000

Size 1 1/2 in

Grade 300W

Shear Load (Kips) 0.12

Shear Cap. (Kips) 38.75

Axial Load (Kips) 10.12

Axial Cap. (Kips) 69.20

Assessment Ratio 0.15

**Plate Data**

Connect. Type Full Penetration Weld

Plate Shape Round

Inner Dia. (Dop)(in) 7.00

Outer Dia.(in) 29.00

Thickness(in) 1.000

Grade 300W

Stress(ksi) 16.76

Allow. Stress(ksi) 39.16

Assessment Ratio 0.43

**Base Plate Section View**

Rods spacing dia. = 23.000

7.000

15.000

29.000

\*Lar = Length from top of concrete to bottom of anchor rod leveling nut

OK Print Print All

From the main menu, choose **Connections** and then **Base Plate** and the above window is displayed. The reactions from the analysis are displayed at the top portion of the screen and the screen is divided into two frames one for bolts and the other for plate data.

The bolt data is calculated based on the following:

- Tension and compression resulting from base moments is resisted by bolts and calculated based on the bolt diameter circle
- Shear is distributed equally to the number of bolts

- The user may change bolt radius, size of bolts and number of bolts.
- The shear load, shear capacity, axial load and axial capacity are calculated and shown on the bolt data frame.
- Bolt assessment is shown based on the combined axial and shear stresses in the bolts and printed on the bolt data frame
- Connection Type : options are : Full penetration Weld, Double Fillet Weld or Fillet Weld with Stiffeners. For the later, No. of Stiffeners and Stiffener Height and Thickness need to be provided

### **Base Plate**

On the base plate window, the user may change the inner base plate diameter (which is only shown for the output diagram purpose), the outer diameter, plate thickness, and steel grade.

Based on the number of bolts the program calculates the influence area for each bolt and the moment is calculated at the intersection between the base plate and the pole. The bending moment is calculated based on the cantilever distance from the center of the bolt to the pole edge. Stresses are calculated based on the plate thickness and the tributary perimeter of the plate. The plate is assessed as per applicable code and result is shown in the assessment ratio.

Note: An option of using "Structural Standard for Antenna Supporting Structures and Antennas – Addendum 3" TIA-222-G-3 is available for the design and analysis of tubular pole base plates. This option can be selected using "Setup" / "Calculation Parameters" (see Chapter 6, Setup).



## Connection Analysis

Connection Analysis

Section 1 Top (Telescopic) Ultimate Loads ☐ NotApplicable Elevation (ft) 25.99

**Connection Loads**

Axial Load(Kips)	1.92	Torque(Kipsft)	0.00
Shear Load(Kips)	0.50	Bend. Mom.(Kipsft)	11.89

Axial Cap. (Kips) 402.85

Moment Cap. (Kipsft) 132.35

Assessment Ratio 0.095

OK Print All

Values for each section can be entered.

specify the section from the drop down box. For each section (top and bottom), specify the following:

- Load type: ultimate loads, Fatigue Loads- Wind Gusts or Fatigue loads – Vortex Shedding
- Connection loads values: Axial Load, Shear Load, Torque and Bend Moment
- Axial Capacity
- Moment Capacity
- Assessment Ratio

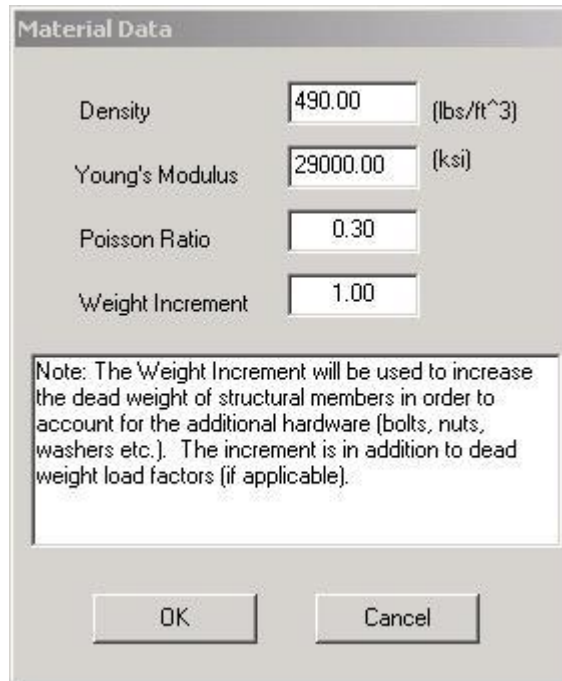
## Chapter 6 SETUP

The program uses defaults based on the selections by user selected options below:

### Material Data

Clicking on **Setup** from the main menu the material data can be defined. The user inputs the material density (lbs/ft<sup>3</sup> or kg/m<sup>3</sup>), Young's modulus (ksi or MPa) and Poisson's ratio.

Also, a weight increment (factor) which can be used to increase dead weight of structural members to account for connecting hardware (bolts, nuts, etc.), galvanizing, etc.



The image shows a 'Material Data' dialog box with a title bar. It contains four input fields with labels to their left: 'Density' (value 490.00, unit lbs/ft^3), 'Young's Modulus' (value 29000.00, unit ksi), 'Poisson Ratio' (value 0.30), and 'Weight Increment' (value 1.00). Below these fields is a text box containing a note: 'Note: The Weight Increment will be used to increase the dead weight of structural members in order to account for the additional hardware (bolts, nuts, washers etc.). The increment is in addition to dead weight load factors (if applicable).' At the bottom are 'OK' and 'Cancel' buttons.

Property	Value	Unit
Density	490.00	(lbs/ft <sup>3</sup> )
Young's Modulus	29000.00	(ksi)
Poisson Ratio	0.30	
Weight Increment	1.00	

Note: The Weight Increment will be used to increase the dead weight of structural members in order to account for the additional hardware (bolts, nuts, washers etc.). The increment is in addition to dead weight load factors (if applicable).

### Default Standards, Units & Analysis Engine

In this menu, the user may choose to select the default standards used for the analysis and select also the default units for the analysis, the analysis engine used for the different types of structures as well as the file path to these programs.

### Calculation Parameters

In this menu, the user may change the equivalent wind area calculations for non-dish antennas and setup the critical damping ratio " $\beta$ " for vortex shedding analysis as required by Canadian Standards CSA S37-01 and CSA S37-13 for cases, where gust factor is selected as  $C_g = 2.0$ .

**Calculation Parameters**

Equivalent Wind Area for Non-Dish Antennas

- ☐ Eq. Area = Frontal Area x Cos( Angle of Attack) + Lateral Area x Sin( Angle of Attack)
- ☒ Eq. Area = Frontal Area x Cos^2( Angle of Attack) + Lateral Area x Sin^2( Angle of Attack)
- ☐ Eq. Area = Maximum Area( Frontal or Lateral )

Minimum Embedment Depth for Tubular Structures

- ☒ Min. Embedment Depth = 3 x Bottom Diameter
- ☐ Min. Embedment Depth as per 1997 UBC Sect. 1612.3.3 for "EIA" Normal Soil

Critical Damping Ratio:

Apply Addendum 3 of ANSI/TIA-222-G ☐

OK Cancel

For non-dish antennas, the user can select the calculation method for the equivalent wind area of non-symmetric antennas.

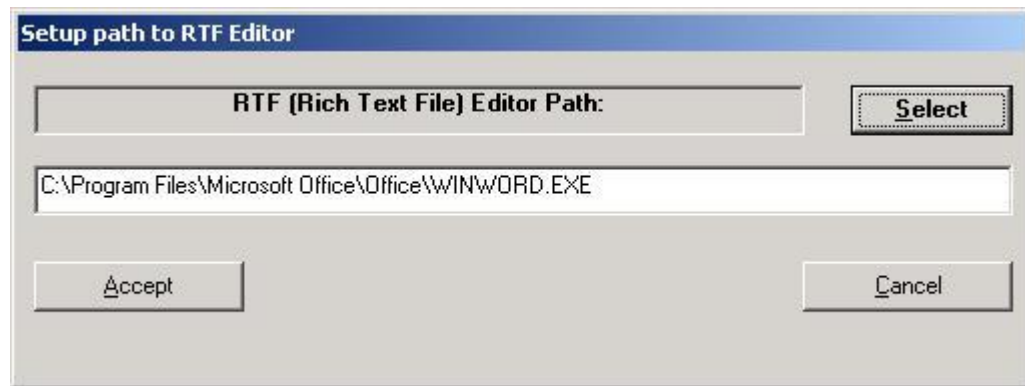
Users may select "Apply Addendum 3 of ANSI/TIA-222-G" to perform the design or analysis of the base plate as per requirements of TIA-222-G-3.

Also, on this menu, the user (Engineer) can select the appropriate critical damping ratio  $\beta$ , the entered value impacts the calculations of the Vortex Shedding effects.

Note: it is possible that the program cannot perform the calculation of the dynamic effects of vortex shedding (an expression in formula, using square root of the difference between  $\beta$  and  $C_2 * \rho * D^2 / M$  might be negative (Refer the National Building Code for explanation of the symbols used in the expression). If that happens then the program will display a warning message indicating that the reduced value of  $C_g = 2.0$  can be used.

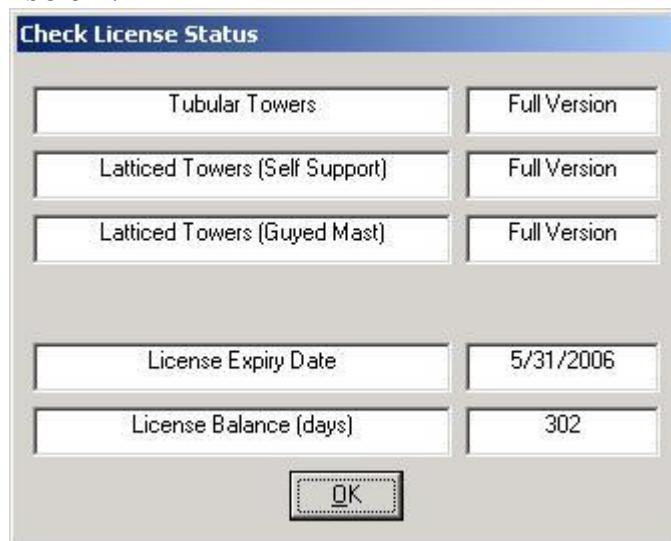
### Selection of Viewers

In these sub-menus, the user may select the programs and paths to the different viewer used by the program. For the .DXF files, .PDF and .RTF files. The user must select the path to the other 3<sup>rd</sup>-party programs that can used to open, view and print such files. An example of these sub-menus is shown below:



### Check License Status

In these sub-menus, the user may view the status of the license and the validity period as shown below:



## Chapter 7 DATABASE MANAGEMENT

The program uses "USER" Antenna database for selection of the antennas, mounts and TX Lines.

Apart from the "USER" database there is "MASTER" database (not to be modified) and "REMOTE" database or databases, which can be placed in commonly accessed server and thus shared by different users typically within the same organization.

The "USER" and "REMOTE" databases can be modified by the users.

### Antennas Database

From the main menu, click on **Database Management** and **Antennas** submenu. Following screen will be displayed.

The screenshot shows the 'Antenna Database Management' window. It has four tabs: 'Dish Antennas', 'Non-Dish Antenna Manufacturers', 'Non-Dish Antennas', and 'TX Lines'. The 'Dish Antennas' tab is selected, showing a table with 39 records. The table has columns: ID, Manufacturer, Microwave Code, Shielded Type, Catalogue Name, Description, Radome, and Diameter (ft). The records are numbered 1 through 12, all with 'Andrews' as the manufacturer. Records 1-7 are 'Shielded' type, and records 8-12 are 'Focal Plane' type. All have 'M/w' in the description. The 'Radome' column has checkboxes, all of which are checked except for record 12. The 'Diameter (ft)' column shows values ranging from 2.001 to 14.993. Below the table is a 'Print' button and a note: 'Note: This table is non-editable (read only.)'. At the bottom, there is an 'Exit' button, a 'Database: USER' label, and a 'Change Database' button.

ID	Manufacturer	Microwave Code	Shielded Type	Catalogue Name	Description	Radome	Diameter (ft)
1	Andrews	<input checked="" type="checkbox"/>	Shielded	HP2	M/w Shielded	<input checked="" type="checkbox"/>	2.001
2	Andrews	<input checked="" type="checkbox"/>	Shielded	HP4	M/w Shielded	<input checked="" type="checkbox"/>	4.003
3	Andrews	<input checked="" type="checkbox"/>	Shielded	HP6	M/w Shielded	<input checked="" type="checkbox"/>	6.004
4	Andrews	<input checked="" type="checkbox"/>	Shielded	HP8	M/w Shielded	<input checked="" type="checkbox"/>	8.005
5	Andrews	<input checked="" type="checkbox"/>	Shielded	HP10	M/w Shielded	<input checked="" type="checkbox"/>	10.007
6	Andrews	<input checked="" type="checkbox"/>	Shielded	HP12	M/w Shielded	<input checked="" type="checkbox"/>	12.008
7	Andrews	<input checked="" type="checkbox"/>	Shielded	HP15	M/w Shielded	<input checked="" type="checkbox"/>	14.993
8	Andrews	<input checked="" type="checkbox"/>	Focal Plane	FP4	M/w Focal Plane	<input checked="" type="checkbox"/>	4.003
9	Andrews	<input checked="" type="checkbox"/>	Focal Plane	FP6	M/w Focal Plane	<input checked="" type="checkbox"/>	6.004
10	Andrews	<input checked="" type="checkbox"/>	Focal Plane	FP8	M/w Focal Plane	<input checked="" type="checkbox"/>	8.005
11	Andrews	<input checked="" type="checkbox"/>	Focal Plane	FP10	M/w Focal Plane	<input checked="" type="checkbox"/>	10.007
12	Andrews	<input checked="" type="checkbox"/>	Focal Plane	FP4	M/w Focal Plane	<input type="checkbox"/>	4.003

The first group "Dish Antennas" is non-editable (read only), as it covers practically all types and sizes of Microwave Dish Antennas.

### Non-Dish Antenna Manufacturers

**Antenna Database Management**

Dish Antennas    **Non-Dish Antenna Manufacturers**    Non-Dish Antennas    TX Lines

14 records.

Manufacturer (Table) Name
▶ ALLGON
ANDREW
ANTEL
CAL
CELWAVE
COMSAT-RSI
DECIBEL
EMS Wireless
KATHREIN
LINDSAY
SCALA
SINCLAIR
SWEDCOM
TIL-TEK

Add new Manufacturer (Table)

Delete Manufacturer (Table)

Exit    Database: USER    Change Database

User can add new manufacturers. Such action will create an empty table and the user will then add records to such table. Deletion of manufacturer will cause removal of the manufacturer name from the list as well as deletion of a table of non-dish antennas associated with the manufacturer.

Default database is "USER" but any other "REMOTE" database can be selected (if present) and then the modifications are performed in the selected database. Once such "Remote" database is created and located remotely (on a server) other users can synchronize their local "USER" database with the "REMOTE".

## Non-Dish Antennas

**Antenna Database Management**

Dish Antennas    Non-Dish Antenna Manufacturers    **Non-Dish Antennas**    TX Lines

Table: ALLGON - 10 records.

	Catalogue Name	Description	Height (ft)	Width (ft)	Depth (ft)	Frontal Area (ft <sup>2</sup> )	Frontal Area Iced 10mm
▶	7145.21	CITY PANEL 105 deg	0.984	0.984	0.427	1.001	1.130
	7145.22	CITY PANEL 105 deg	1.969	0.984	0.427	1.981	2.174
	7145.23	CITY PANEL 105 deg	2.953	0.984	0.427	2.960	3.229
	7145.24	CITY PANEL 105 deg	3.937	0.984	0.427	3.950	4.284
	7145.26	CITY PANEL 105 deg	5.906	0.984	0.427	6.146	6.383
	7145.48	CITY PANEL 105 deg	7.546	0.984	0.427	7.901	8.148
	7183.15	PCS	3.281	0.459	0.164	3.057	3.563
	7184.14	PCS	4.265	0.459	0.164	3.057	3.541
	7184.15	PCS	4.265	0.459	0.164	3.057	3.541
	7185.15	PCS	3.281	0.853	0.164	4.155	4.575

Select Table: ALLGON    Edit Record    Add Record    Delete Record    Print

Exit    Database: USER    Change Database

To edit or add record for selected table click on “Edit Record” or Add Record” buttons. Following screen will be displayed.

**Edit Non-Dish Antenna, table: ALLGON**

Catalogue Name: 7145.21

Description: CITY PANEL 105 deg

Height: 0.984 (ft)    Weight: 4.41 (lbs)

Width: 0.984 (ft)    Weight Iced 10 mm (1/2"): 11.01 (lbs)

Depth: 0.427 (ft)    Weight Iced 50 mm (2"): 37.44 (lbs)

Frontal Area (EPA)N: 1.001 (ft<sup>2</sup>)    Round ☐

Frontal Area Iced 10 mm (1/2"): 1.130 (ft<sup>2</sup>)

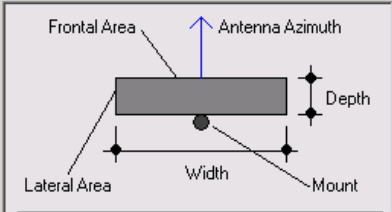
Frontal Area Iced 50 mm (2"): 1.776 (ft<sup>2</sup>)

Lateral Area (EPA)L: 0.441 (ft<sup>2</sup>)

Lateral Area Iced 10 mm (1/2"): 0.538 (ft<sup>2</sup>)

Lateral Area Iced 50 mm (2"): 1.023 (ft<sup>2</sup>)

Accept    Cancel



Effective Projected Area (EPA) Normal (Frontal) or Lateral includes all applicable drag factors or force coefficients but does not include height factors.

Changes of entries will become effective after “Accept” button is clicked.

## TX Lines

**Antenna Database Management**

Dish Antennas    Non-Dish Antenna Manufacturers    Non-Dish Antennas    **TX Lines**

27 records.

Type	Description	Size (in)	Width (in)	Depth (in)	Unit Mass (lbs/ft)	Shape
Air-Dielectric	HJ12P-50A	2.25	2.378	2.378	1.16	Round
Air-Dielectric	HJ5P-50A	0.875	1.102	1.102	0.54	Round
Air-Dielectric	HJ7P-50A	1.625	1.980	1.980	1.04	Round
Circular Waveguide	WC109	1.09	1.087	1.087	1.21	Round
Circular Waveguide	WC166	1.66	1.654	1.654	2.82	Round
Circular Waveguide	WC281	2.81	2.795	2.795	3.63	Round
Elliptical Waveguide	EW127	1.11	0.673	1.110	0.29	Elliptical
Elliptical Waveguide	EW132	0.96	0.610	0.961	0.22	Elliptical
Elliptical Waveguide	EW17	5.65	2.988	5.650	2.73	Elliptical
Elliptical Waveguide	EW180	0.79	0.488	0.791	0.15	Elliptical
Elliptical Waveguide	EW20	5.02	2.831	5.020	1.85	Elliptical
Elliptical Waveguide	EW220	0.7	0.441	0.701	0.12	Elliptical

Print    Add new Record    Delete Record    Edit Record

Exit    Database: USER    Change Database

To add or edit a record click on “Add new Record” or “Edit Record” buttons respectively. Following screen will be displayed.

**Edit TX Line**

Type: Elliptical Waveguide

Description: EW127

Size (in): 1.110

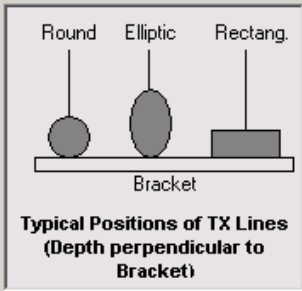
Width : 0.673 (in)

Depth : 1.110 (in)

Unit Mass : 0.29 (lbs/ft)

Shape  
☐ Round    ☒ Elliptical    ☐ Rectangular

Accept    Cancel



Round    Elliptic    Rectang.

Bracket

**Typical Positions of TX Lines  
(Depth perpendicular to Bracket)**

Changes of entries will become effective after “Accept” button is clicked.



## Mounts

From the main menu, click on **Database Management** and **Mounts** submenu. Following screen will be displayed.

**Antenna Mounts Management**

Table of Mounts Manufacturers

1 records.

Manufacturer (Table) Name
none

Add new Manufacturer (Table)

Delete Manufacturer (Table)

Exit Database: USER Change Database

User may add new manufacturers (as is the case with Non-Dish Antennas) or delete them.

## Antenna Mounts

**Antenna Mounts Management**

Table of Mounts Manufacturers

**Antenna Mounts**

Table: none - 1 records.

Catalogue Name	Description	Height (ft)	Width (ft)	Depth (ft)	Frontal Area (ft <sup>2</sup> )	Frontal Area Iced
none	n/a	0.000	0.000	0.000	0.000	0.000

Select Table none Edit Record Add Record Delete Record Print

Exit Database: USER Change Database

To add or edit a record click on “Add new Record” or “Edit Record” buttons respectively. Following screen will be displayed.

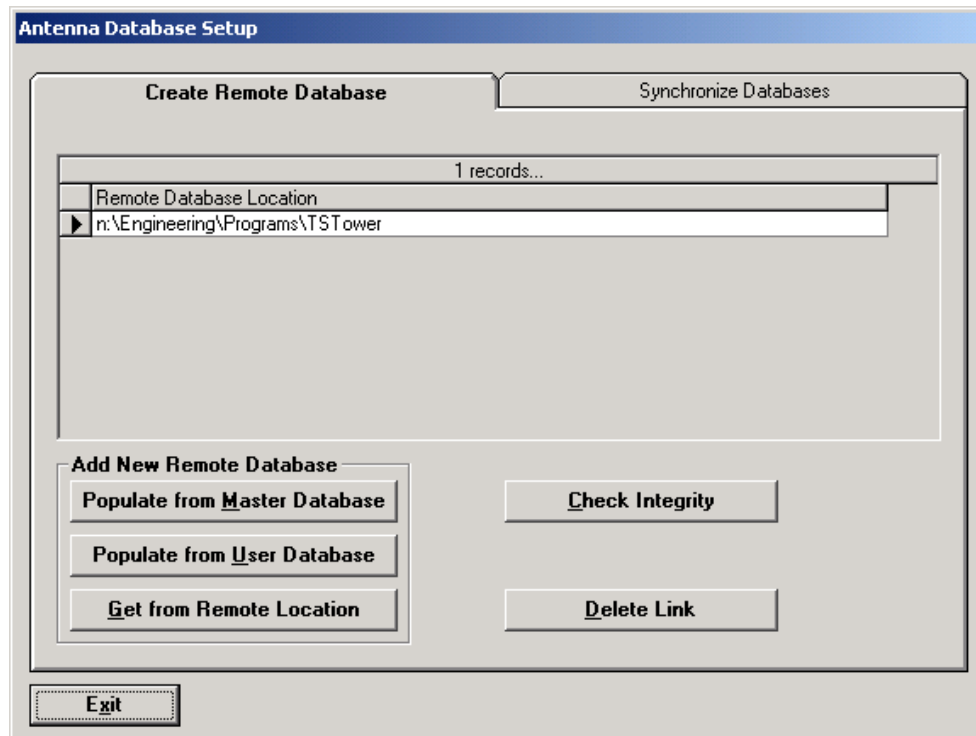
Edit: Antenna Mount, table: none					
Catalogue Name:	none				
Description:	n/a				
Height :	0.000	(ft)	Weight :	0.00	(lbs)
Width :	0.000	(ft)	Weight Iced 10 mm:	0.00	(lbs)
Depth :	0.000	(ft)	Weight Iced 50 mm :	0.00	(lbs)
Frontal Area :	0.000	(ft^2)	Round	<input checked="" type="checkbox"/>	
Frontal Area Iced 10 mm:	0.000	(ft^2)			
Frontal Area Iced 50 mm:	0.000	(ft^2)			
Lateral Area :	0.000	(ft^2)			
Lateral Area Iced 10 mm:	0.000	(ft^2)			
Lateral Area Iced 50 mm:	0.000	(ft^2)			
<div>Accept Cancel</div>					

Perform the editing and press “Accept” button to update or “Cancel” otherwise.

### Database Setup

From the main menu, click on **Database Management** and **Database Setup** submenu.

Following screen will be displayed.

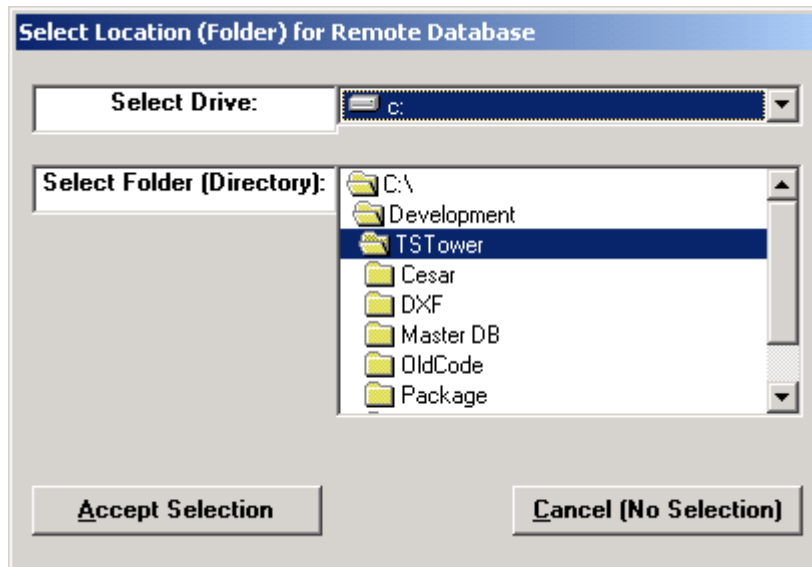


New remote database(s) can be created in three different ways:

“Populate from Master Database” – new “remote” database will be replicated from “Master Database” and then user will indicate the location of the new database – screen showing selection of “drives” and “folders” will be displayed.

“Populate from User database” – new “remote” database will be replicated from “User Database” and then user will indicate the location of the new database – screen showing selection of “drives” and “folders” will be displayed.

“Get from Remote Location” this action will prompt you to select existing “remote” database not linked to you computer so far.

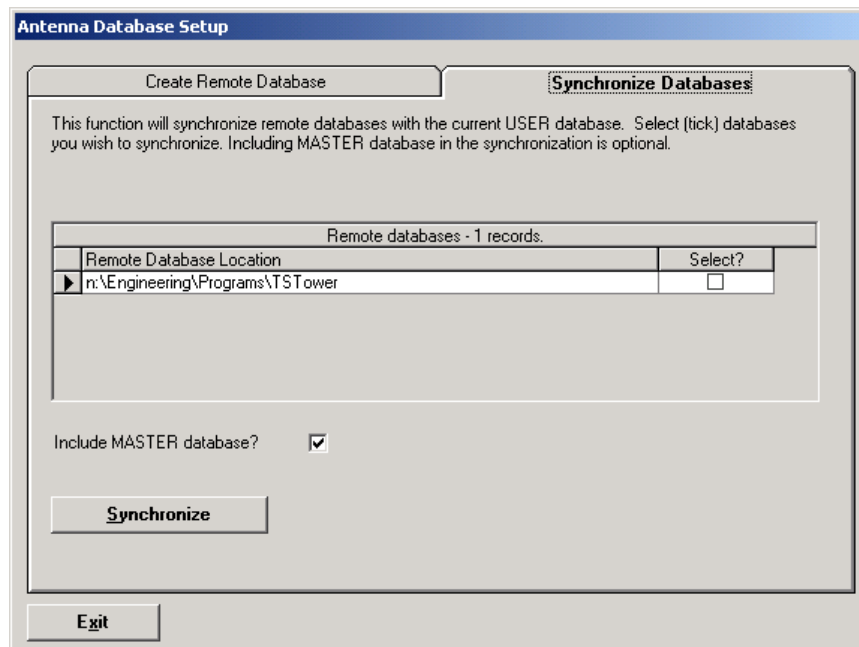


Once you selected the “remote” database it will be displayed in the “Remote Database Location” grid and you will have access to it via Database Management for Antennas or Mounts.

“Check Integrity” will perform the comparison of the records between selected remote database and “Master Database” and display differences.

“Delete Link” will remove a link between selected “remote” database and the program (such database will not be accessible to you).

Synchronize Databases – instructions as shown on attached screenshot.



## Steel Database

From the main menu, click on **Database Management** and **Steel DB** submenu. Following screen will be displayed.

The screenshot shows the 'Steel Database Manager' window. It has a tabbed interface with tabs for 'Bolt Sizes', 'Bolt Grades', 'Steel Sections', 'Steel Grades', and 'Anchor Rods'. The 'Anchor Rods' tab is active, displaying a table with 11 records. The table has columns for 'Rod Name', 'Size (in)', and 'Threads Per Inch'. Below the table are buttons for 'Select Table', 'Edit Record', 'Add Record', 'Delete Record', and 'Print'. At the bottom, there is an 'Exit' button and a 'Database: USER' label.

Rod Name	Size (in)	Threads Per Inch
5/8 in	0.625	11
3/4 in	0.75	10
7/8 in	0.875	9
1 in	1	8
1 1/8 in	1.125	7
1 1/4 in	1.25	7
1 3/8 in	1.375	6
1 1/2 in	1.5	6
1 3/4 in	1.75	5
2 in	2	4.5
2 1/4 in	2.25	4.5

For tubular structure (Poles), the user can edit anchor rod sizes as well as anchor rod grades.

## Anchor Rods

In this table the user may view, add, edit or delete a record in the database for the anchor rod sizes. If a record is selected for editing, the following menu will show allowing the user to edit these values.

The screenshot shows the 'Edit Anchor Rods' dialog box. It contains three input fields: 'Rod Name' with the value '7/8 in', 'Size' with the value '0.875 (in)', and 'Thread Per Inch' with the value '9'. At the bottom are 'Accept' and 'Cancel' buttons.

### Anchor Rods Grades

By selecting to view the anchor grades from the Anchor rods tab, the following window will be displayed.

The screenshot shows the 'Steel Database Manager' window with the 'Anchor Rods' tab selected. The window displays a table titled 'Anchor Rods Grades: 10 records.' with the following data:

Rod Grade	Fy (ksi)	Fu (ksi)
A36	36	58
A572 Gr. 42	42	60
A572 Gr. 50	50	65
A588	47	70
A615 Gr. 75	75	99.99
A320 (L7)	105	125
F1554 Gr. 105	105	125
300W	43.51	65.27
400W	58.02	75.42
480W	69.62	85.57

Below the table, there are buttons for 'Select Table', 'Anchor Rods Grades' (dropdown), 'Edit Record', 'Add Record', 'Delete Record', and 'Print'. At the bottom, there is an 'Exit' button and a 'Database: USER' field.

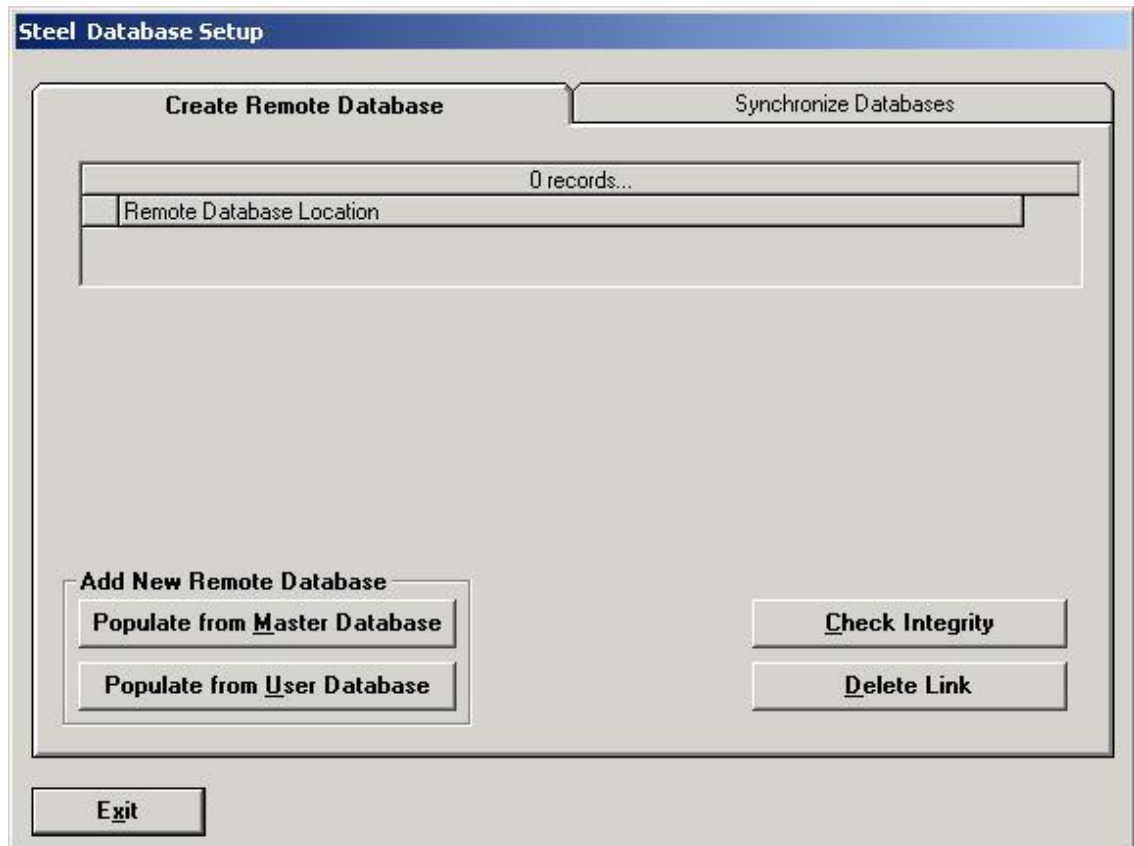
In this window the user may view, add, edit or delete a record in the database for the anchor rod sizes. If a record is selected for editing, the following menu will show allowing the user to edit these values.

The screenshot shows the 'Edit Anchor Rod Grades' dialog box. It contains the following fields and buttons:

- Rod Grade:** A572 Gr. 50
- Fy:** 50 (ksi)
- Fu:** 65 (ksi)
- Buttons:** Accept, Cancel

## Database Setup

From the main menu, click on **Database Management** and then select **Steel DB** submenu and then **Database Setup** the following screen will be displayed.

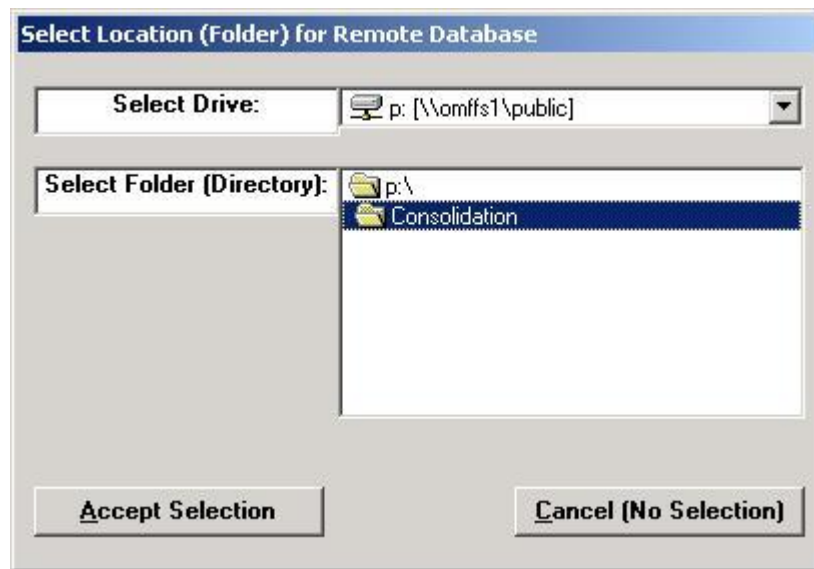


New remote database(s) can be created in three different ways:

"Populate from Master Database" – new "remote" database will be replicated from "Master Database" and then user will indicate the location of the new database – screen showing selection of "drives" and "folders" will be displayed.

"Populate from User database" – new "remote" database will be replicated from "User Database" and then user will indicate the location of the new database – screen showing selection of "drives" and "folders" will be displayed.

"Get from Remote Location" this action will prompt you to select existing "remote" database not linked to you computer so far.



Once you selected the “remote” database it will be displayed in the “Remote Database Location” grid and you will have access to it via Database Management for Steel.

“Check Integrity” will perform the comparison of the records between selected remote database and “Master Database” and display differences.

“Delete Link” will remove the link between selected “remote” database and the program (such database will not be accessible to you).

Synchronize Databases – instructions as shown on attached screenshot.



