Cross section area, AT:	Cross section area of messenger
Outside diameter, D:	Equivalent diameter equal to the sum of the diameters of all the cables in the bundle (diameter of messenger plus 3 times diameter of conductors for situation in Fig. 9-10-e).
Unit weight, UW:	Total unit weight of messenger plus supported conductors
Ultimate tension, ULT:	Ultimate tension of messenger
Number of independent cables, N:	Number of spaced cables in bundle (4 for situation in Fig. 9-10-e). This number is used internally for the calculation of ice and wind-on-ice loads which take into account the fact that each cable in the bundle is subjected to a coating of uniform ice thickness
Stress-strain and other properties:	Properties of messenger

Number of conductors per phase: One

Special consideration for depth of bundle:

You should take into account the vertical dimension of the bundle (DEPTH in Fig. 9-10-e) when checking vertical clearances. This can be done by lowering the bundle attachment point by the length DEPTH (for example by using longer suspension insulators) or increasing the required vertical clearance by that amount.

9.2.2 GAP-type conductor

In ordinary bi-metallic conductors, the outer material is under tension at the time of installation (sagging condition). However, in GAP-type conductors, the outer material can slide around the core in such a way that it is possible, at time of installation when the conductor is clipped-in, to force a zero tension in the outer material. This basically forces the outer material to behave as a non-structural material (dead weight only) for temperatures higher than the installation temperature and it removes all uncertainties regarding creep and sags at high temperature. If you select *Conductor is a GAP-type conductor* in the **Cable Data** dialog box, **PLS-CADD** will assume that the installation was made such that the stress in the outer material is zero at installation and all sags and tension calculations will be made as if the initial stress-strain curve of the outer material was translated to the right by the distance O - A, as shown in Fig. 9-11.

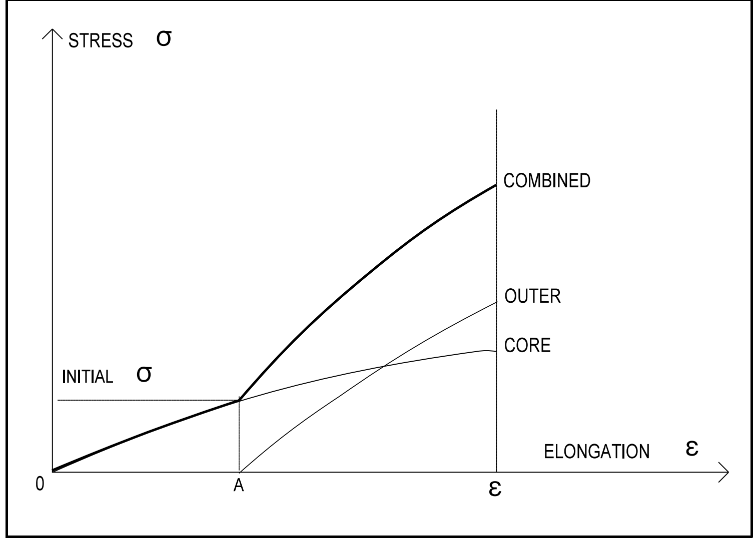

Fig. 9-11 Behavior of GAP conductor

9.3 High or extremely high temperature considerations

At high, but not extremely high, temperatures (generally considered to be less than 90 degrees C), ACSR conductors normally shed some of the tension load in their outer aluminum strands onto their steel core due the higher thermal expansion coefficients of the aluminum vs. steel. This behavior is automatically handled by **PLS-CADD**. The normal redistribution of tension between outer and core strands due to the creep of the outer strands at the assumed *Weather case for final after creep* (see Section 7.3.4) is also handled automatically by **PLS-CADD**. Therefore, sags at high temperature for any conductor should be well predicted unless additional accelerated creep at extremely high temperature takes place (in addition to the creep from everyday tension over 10 years). Additional accelerated creep should only be of concern if you run your conductors for limited periods of time at extremely high temperatures (generally considered to be above 90 degrees C). At these extremely high temperatures, you should also be concerned about the potential for loss of strength. The effects of using conductors at extremely high temperatures are discussed in the IEEE Guide for Determining the Effects of High Temperature Operation on Conductors, Connectors, and Accessories (IEEE 1283, 2002).

9.3.1 Additional creep from using conductors at extremely high temperatures

As discussed above, the after *Creep* sags normally calculated by **PLS-CADD** are based on the assumption that conductors are subjected to an everyday weather case over a long period of time, conductors at extremely high temperatures (in excess of 90 degrees C) for limited periods of time. The effect of this additional elevated temperature creep can be accounted for by artificially increasing the conductor temperature above its actual temperature, say by T, when making sag calculations (Harvey, 1979). T is a function of the accumulated times the conductors spend at each increment of elevated temperatures, for example at 100, 125, 150, .. degrees C. The IEEE Guide (IEEE 1283, 2002) has an example showing how to make the calculation.

9.3.2 Aluminum in compression

As the temperature of an ACSR conductor increases, a proportionately greater portion of the conductor tension load gets carried by the steel core because the aluminum thermal expansion coefficient is larger than that of steel. In fact, beyond a certain high transition temperature the aluminum may lose all its tension or may even go into compression. Whether one should assume that 1) the aluminum cannot physically go into compression because it would "bird cage", 2) the aluminum does go into some compression, or 3) manufacturing built-in stresses in the aluminum still keep it under tension at high temperature, has been debated over the past 20 years (Barrett, 1983; Rawlins, 1999). Using one or the other assumption may result in significant sag differences at high temperature. If you assume that the aluminum does not go into compression, you are assuming that the final stress-strain relationship is bilinear with a knee point (somewhat similar to the line P-B-A in Fig. 9-2). If you assume that the aluminum can go into compression or is prestressed, you are assuming that the final stress-strain relationship is linear (as if line B-A in Fig. 9-2 was extended all the way to its intersection with the elongation axis).

PLS-CADD (Section 7.3.5) lets you make your own assumption regarding the behavior of aluminum at high temperature. You can assume that the aluminum is incapable of carrying compression or that it can carry some compression, limited by an upper limit of the virtual stress in Eq. 9-5. You describe your assumptions in the **ACSR Model** dialog box that you reach with **Criteria/ ACSR Cable Model.** For bi-metallic conductors, the sag-tension reports shows what fraction of the total tension is carried by the outer strands and what fraction is carried by the core.

9.3.3 Steady state and transient thermal ratings

Conductor properties and other data needed to perform steady state and transient thermal ratings of a line are discussed in Section 11.2.6.

10. CREATING OR EDITING LINE MODEL

Starting a new project with **PLS-CADD** is different from loading, viewing and checking an existing one as was described in Section 5. In this section we will describe the steps necessary to create a new line model named *Project.* The amount of work required to build a model depends on whether you can reuse items in existing libraries or need to create them from scratch.

Items normally stored in library files for use across projects include:

Feature codes: Assume that a feature code file *Features.fea* has already been prepared as described in Section 6.1

Design criteria: Assume that a design criteria file *Criteria.cri* has already been prepared as described in Section 7.3.

Structures: Assume that some dead-end (*StructDead.**), some angle (*StructAng.**) and some tangent (*StructTang.**) structure files have already been prepared as described in Section 8.6.

Cables: Assume that some conductor and ground wire files (*Cables.**) have already been prepared as described in Section 9.2.

Plan & Profile sheets drafting parameters: You do not need these drafting parameters (see Section 13.2.5) at this point.

Building a line model involve three basic steps: 1) loading a terrain model and defining the alignment, 2) spotting the structures, and 3) stringing and sagging the cables

10.1 Loading terrain data and defining the alignment

The steps to follow in preparing the terrain and defining the alignment depend on what terrain data you have available.

10.1.1 When a *Project.xyz* file is available

You should:

* Load the *Project.xyz* terrain file (format defined in Appendix D) with **File/ New**. You will get a warning that feature codes are undefined. Ignore the warning.

Features.fea into *Project.fea* or use **Terrain/ Feature Code Data/ Edit** to create *Project.fea* from scratch or edit it.

* Select the terrain widths and side profile criteria with **Terrain/ Widths** and **Terrain/ Side Profiles**.
* Define the alignment with **Add, Insert, Delete or Move P.I.** as described in Section 6.3.1.
* Select the station of the first P.I. point with **Terrain/ Edit/ Edit Origin** if not zero
* Edit the terrain, if desired, with **Terrain/ Edit/ Edit XYZ** or by clicking on the **Edit XYZ** button of the **Terrain Info** dialog box which open after clicking on a terrain point
* Save your work using **File/ Save** or **File/ Save as**. **File/ Save** will not only save the updated *Project.*xyz file, but also the alignment information in file *Project.num* and the feature code file *Project.fea* in the same directory from which *Project.xyz* was imported. **File/ Save as** will let you not only change the name of the project but also file your work in a different directory.

10.1.2 When a *Project.pfl* file is available

You should:

* Load the *Project.*pfl terrain file (format defined in Appendix E) with **File/ New**. You will get a warning that feature codes are undefined. Ignore the warning.
* Use **Terrain/ Feature Code Data/ Load FEA** to import the existing feature code file *Features.fea* into *Project.fea* or use **Terrain/ Feature Code Data/ Edit** to create *Project.fea* from scratch or edit it.
* Select the terrain widths and side profile criteria with **Terrain/ Widths** and **Terrain/ Side Profiles**.
* Unlike with the XYZ terrain, there is no need to define the alignment since the information is part of the terrain file.
* Edit the terrain, if desired, with **Terrain/ Edit/ Edit PFL** or by clicking on the **Edit PFL** button of the **Terrain Info** dialog box which open after clicking on a terrain point
* Define the x and y coordinates of the first P.I. point and the initial bearing with **Terrain/ Edit/ Edit Origin** if you want to change the default values
* Save your work as described in the last step of Section 10.1.1.

10.1.3 When no *Project.xyz* or *Project.pfl* terrain file is available

If you want to create a terrain file from scratch you should :

* Select **File/ New** and enter the proposed terrain file name *Project.*xyz or *Project.pfl*
* Proceed as shown in 10.1.1 or 10.1.2 for the feature code file and terrain widths.
* Use **Terrain/ Edit/ Edit XYZ** or **Terrain/ Edit/ Edit PFL** to create terrain points
* Proceed as shown in 10.1.1 or 10.1.2

You can import, filter and/or merge XYZ points from different XYZ files by using **Terrain/ Edit/ Merge XYZ Points from XYZ File** as described in Section D.4.

formats required by **PLS-CADD** by using **Terrain/ Edit/ Merge XYZ Points from User Defined XYZ File** as described in Section D.3.

10.2 Interactive structure spotting

Once you have defined an alignment for a new project, you should use **Windows/ New Window/ Profile View** to open a **Profile** view where you will do the structure spotting. With **PLS-CADD**, there are two ways of spotting structures, interactive or automatic based on minimum cost (the optimization option). Spotting optimization is an advanced option which is discussed in Section 14. You should not attempt spotting optimization before you are completely familiar with interactive spotting. Except for a short introduction to optimization in sub-section 10.2.6, this section only covers interactive spotting.

Interactive spotting is the most commonly used method for locating structures on an alignment. It is used almost exclusively for modeling existing lines. For new lines to be built in highly developed environments, where there are many constraints from the existing infrastructure, interactive spotting is still the method of choice. In open country with few constraints, automatic spotting is generally more cost effective.

Whether you select a new structure or modify an existing one, you will be taken to the **Structure Selection** box shown in Fig. 10.2-1. For **Method 4** structures (or other structure files generated by our **PLS-POLE** or **TOWER** programs) an outline of the structure geometry appears in the lower right corner of the box.

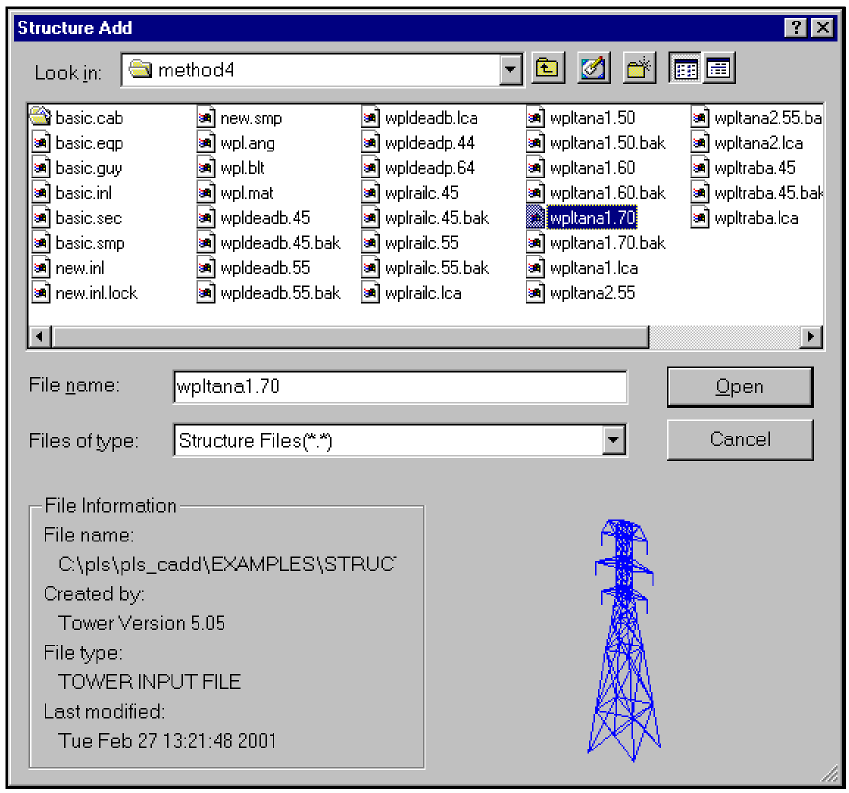

Fig. 10.2-1 Structure file selection box

However, before adding or modifying structures, you should make sure that design criteria are available, by either using **Criteria/ Load CRI** to import a library file *Citeria.cri* into *Project.cri* or going through all the **Criteria** menus to create new criteria.

feature code that will dictate the height of the ground clearance line. Then you should use **Terrain/ Clearance Line** and **Terrain/ Side Profiles** to display the proper clearance lines.

You should first spot structures at the ends of your line and at all line angles. There are various ways of doing this, three of which are described below.

10.2.1 Spotting structures at line angles

10.2.1.1 Terrain points at line angles have unique feature codes

When you are resurveying an existing line or scanning its existing drawings, it is recommended that you assign one or more distinctive feature code to all P.I. (line angles). At P.I. locations, you might also use as terrain point comment the name of the structure file for the P.I. structure. If this is the case, you can use **Structures/ Automatic Spotting/ Spot at Feature Code** to automatically locate specified structures at the appropriate line angles. For example, with the settings in Fig. 10.2-2, **PLS-CADD** will locate the structure *wpldeadb.45* at every line angle point having the feature code *333*. The structure type to be selected can be defined as a plan or profile comment.

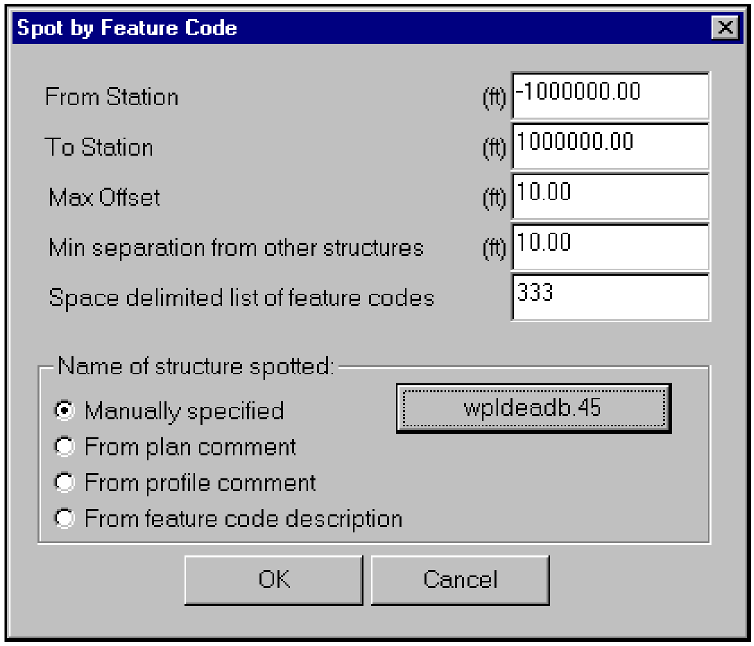

Fig. 10.2-2 Spotting at feature codes

10.2.1.2 Locating one structure type at all line angles

One way to make sure that there is a structure at each line angle and at your first and last alignment points is to spot one arbitrary structure at all these locations and later use the **Structures/ Modify** command to change it to the appropriate type and height. The arbitrary structure is spotted at all line angles with the **Structures/ Automatic Spotting/ Angle Structures** command.

10.2.1.3 Snapping structure to line angle location

With this method, you spot the desired structure near the angle using the same procedure as described below for tangent structures. Then you can use **Structures/ Move On (Snap)** to snap the structure dialog box which opens when you select the structure with the **Structures/ Modify** command.

Once you have located structures at all line angles, you should spot your tangent structures.

10.2.2 Spotting tangent structures

To spot a structure on the profile, select **Structures/ Add** and then click where you want to place the structure. A black stick tracking the mouse cursor shows the spotting location with the corresponding station displayed in the lower status bar. Do not try to select an exact station with the mouse as there is a much easier and precise way to do it in the **Structure Modify** dialog box. Once you have selected a structure in the **Structure File Selection** box of Fig. 10.2-1, you are taken to the **Structure Modify** dialog box (Fig. 10.2-3). You can also get to the **Structure Modify** dialog box at any time using **Structures/ Modify**.

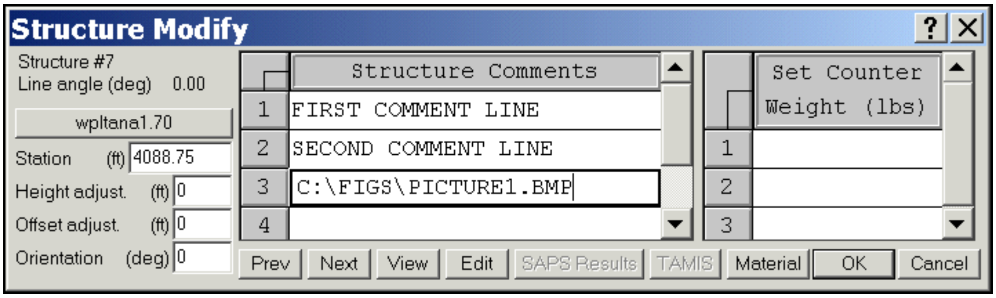

Fig. 10.2-3 Structure Modify dialog box

Once in the **Structure Modify** dialog box you can:

1) Change your structure type by clicking on the **Button** showing the name of the current structure near the top left of the box.

2) Adjust the structure station by typing it in the *Station* field.

3) Raise or lower the structure by the amount typed in the *Height adjustment* field.

4) Adjust its offset (distance from center line) by typing a value in the *Offset adjustment* field.

> **Note**: Unlike older versions of **PLS-CADD** (prior to Version 4.65), more recent versions take the offset into account when calculating the structure loads and the insulator swings for each individual cable. This offset includes not only the *Offset adjustment*, but also the natural offset that may exist between the centerline of the structure and each individual attachment point. For calculation purposes, each cable is treated as if it had its own alignment. However, the same ruling span is used for all cables in one set. The ruling span of one set is based on span lengths between centers of gravity of set attachment points at each structure. The motivation for the change was the need for improved accuracy as well as the ability to determine clearances between crossing spans with the procedure described in Section 11.2.3.2.