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Chapter 7: Horizontal and Vertical Design

Introduction

Since there are many different, and acceptable, methods of creating horizontal and vertical geometry using GEOPAK, this chapter will not dictate the exact methods to use. Instead we will describe the different methods that can be used and provide a workflow for a macro that will check the horizontal alignment design for kinks, once completed. This chapter will be in two sections: Horizontal Design and Vertical Design.

Horizontal Design

There are four methods of setting a horizontal alignment: Coordinate Geometry (COGO), Graphical COGO, Horizontal Alignment Generator, and Store Graphics. Any of these methods are acceptable to CFLHD. Each one of these methods has their advantages and disadvantages, since graphical COGO and the horizontal alignment generator are similar, we will address these tools together. This chapter will describe each of the above listed methods and indicate their advantages and disadvantages. **Regardless of the method used, the final alignment must be drawn into MicroStation using the GEOPAK D&C Manager, with the CFLHD .ddb file.** This will assure that the elements are drawn with the correct symbology, matching the CFLHD standards.

Coordinate Geometry

Coordinate Geometry can be accessed using Project Manager by selecting the Coordinate Geometry button.

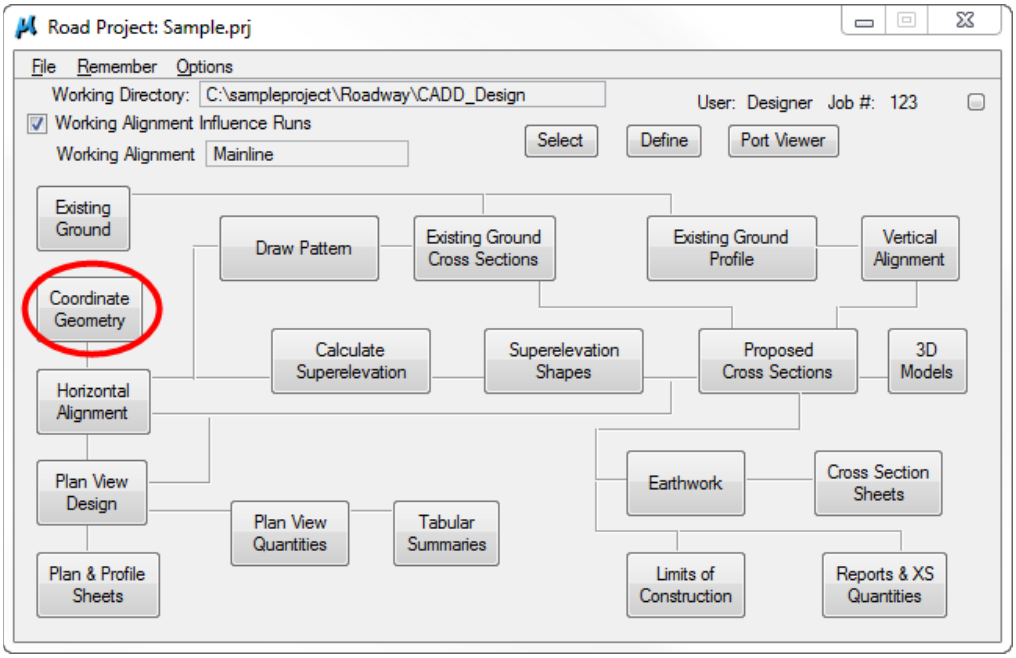

Figure 7-1: Accessing COGO through Project Manager

You can also select the Coordinate Geometry button on the GEOPAK main dialog box.

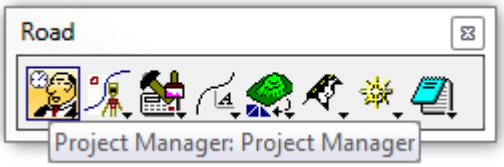

Figure 7-2: Accessing COGO through Road Tools Icon

If you are using Project Manager, Coordinate Geometry dialog box will be invoked. Otherwise, the Job Number and Operator code will have to be entered in the COGO Startup dialog box. Project Name and Subject are optional fields. Press the OK button to bring up the Coordinate Geometry window.

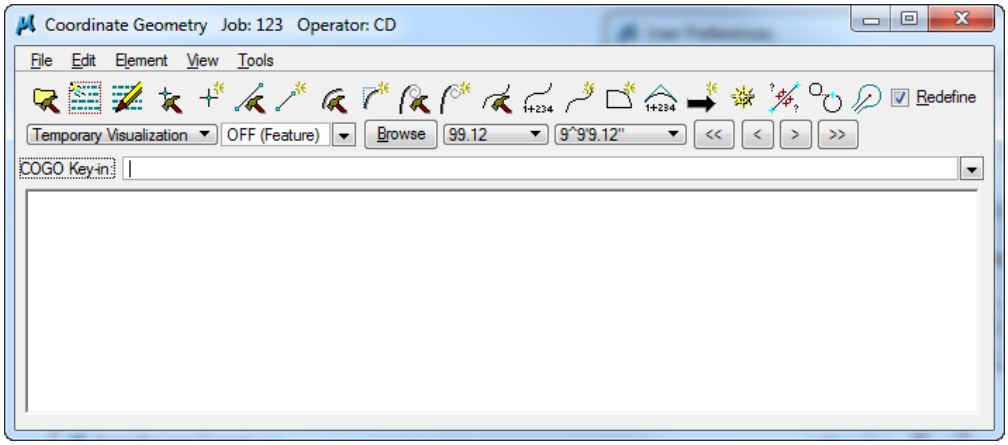

Figure 7-3: Coordinate Geometry

You can create the horizontal geometry by typing commands in at the COGO command line, by creating an input file with a sequence of COGO commands and loading it into COGO, or by using the dialog box driven Store Curve from Tangents, Locate Traverse, etc., tools that are accessed from the COGO pull down menus to generate the commands. If you use the input file method, remember that the COGO input file name can only be 8 characters long, must have the job number as the last three digits in the name, and the extension has to have an “i”+ the operator code. (i.e. XXXXX101.ijd), where the i stands for input file.

Advantages.

- This method allows the user to have more precise control over tangent bearings, control point coordinates, etc., than with Store Graphics, if done properly.
- The user can set visualization on to view progress of design.

Disadvantages.

- Commands for the command line and input file methods are difficult to memorize.

- Small adjustments are hard to make.
- Process is time consuming.

Uses.

- Reviewing both horizontal and vertical alignments.
- Creating output of alignments for printing.
- Tweaking alignments that were created using store graphics, or any of the other methods.
- Storing as-built centerline chain and profiles, especially those for which there are only hard copy paper plans.

Graphical COGO

Graphical COGO allow the user to create coordinate geometry elements using COGO tools with graphic and a user-friendly process. Graphical COGO can be accessed by selecting:

Applications>GEOPAK>ROAD>Geometry>Graphical Coordinate Geometry

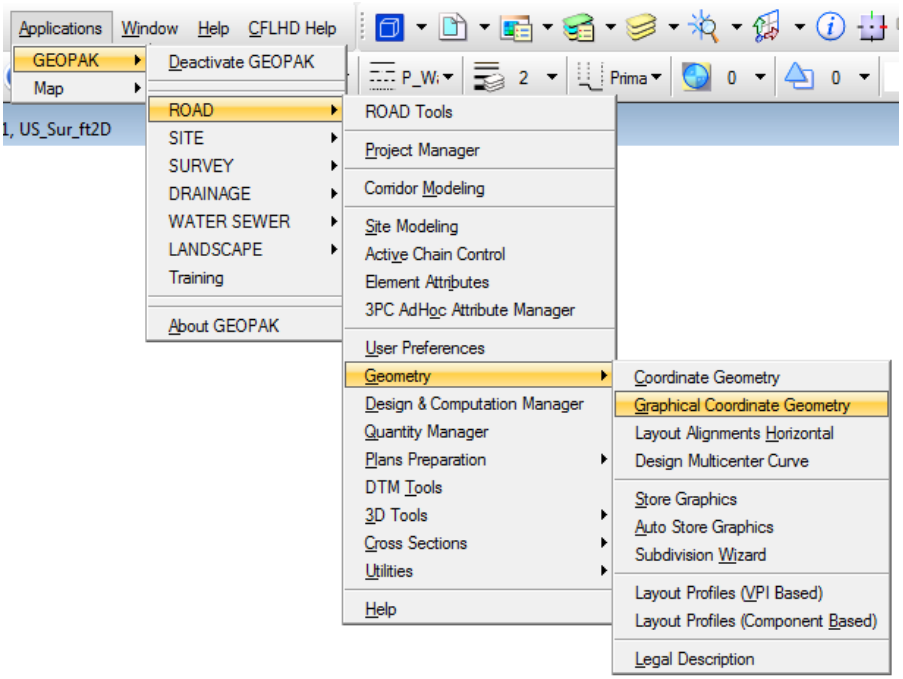

Figure 7-4: Accessing Graphical COGO

Or by selecting the icons from the main GEOPAK Road tool dialog box.

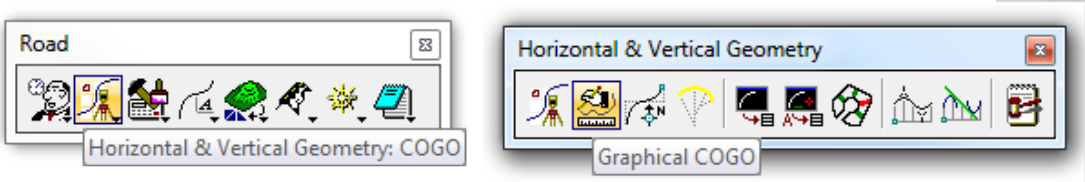

Figure 7-5: Graphical COGO Icons

The Graphical COGO tool frame shown below contains tools for creating COGO elements such as lines, points, curves, modifying COGO elements, manipulating elements, and grouping elements.

Figure 7-6: Graphical COGO Tool Frame

From the main Graphical COGO tool frame, shown above, additional tools may be accessed from each of the four main tool boxes.

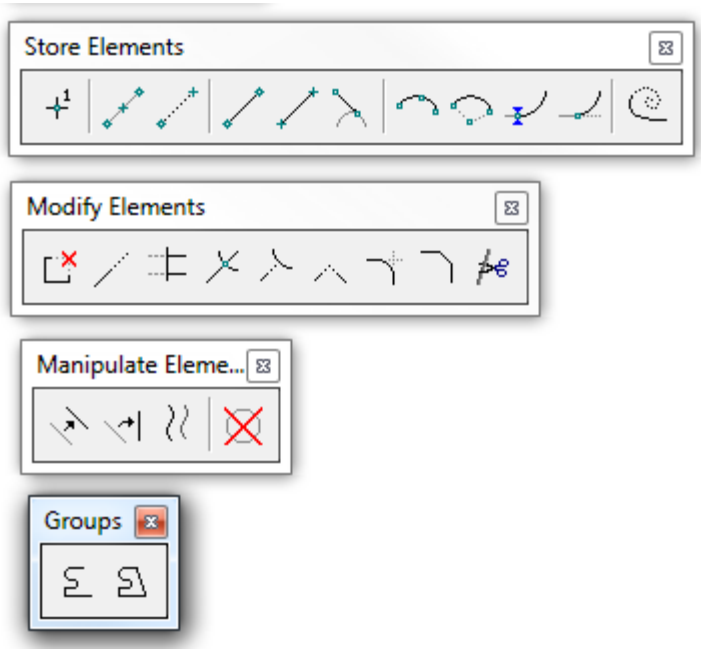

Figure 7-7: Graphical COGO Tools

The Graphical COGO tools shown above, and those in the Horizontal Alignment Generator, look and act the same as many MicroStation tools. However, these tools are not relying on the accuracy of MicroStation graphics, but rather the much more accurate GEOPAK coordinate geometry engine.

Horizontal Alignment Generator (Element Based)

Graphical COGO and the Horizontal Alignment Generator, allow the user to create coordinate geometry elements, much the same as the original COGO tools, but with a much more graphic and user-friendly process.

The Horizontal Alignment Generator can be accessed through the Project Manager by clicking on the Horizontal Alignment button on the flow chart and selecting Graphical Element Based geometry. Horizontal Alignment Generator can also be accessed by selecting:

Applications>GEOPAK>ROAD>Geometry>Layout Alignments Horizontal

Or by selecting third icon in the Horizontal & Vertical Geometry tool box. Selecting this icon will invoke the Horizontal Alignment Generator Menu.

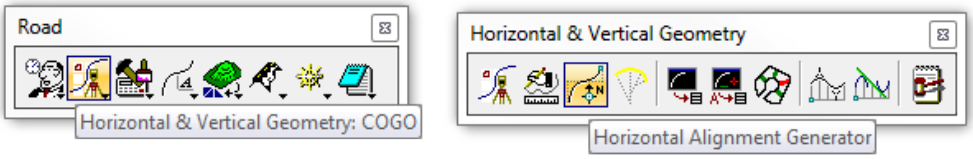

Figure 7-8: Horizontal Alignment Generator

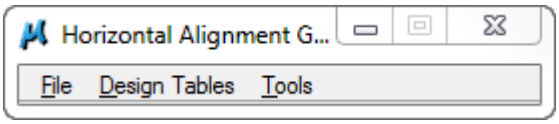

Figure 7-9: Horizontal Alignment Generator Menu

The File pull-down menu allows the user to set preferences for how newly created elements will be displayed, how to name elements, and which geometry tables to use as a default. CFLHD uses the Spiral Design Tables. To access the Spiral Design Tables, path should be set to *V8i_Resource\FLH_Common\GEOPAK\Resources\English or Metric\.*

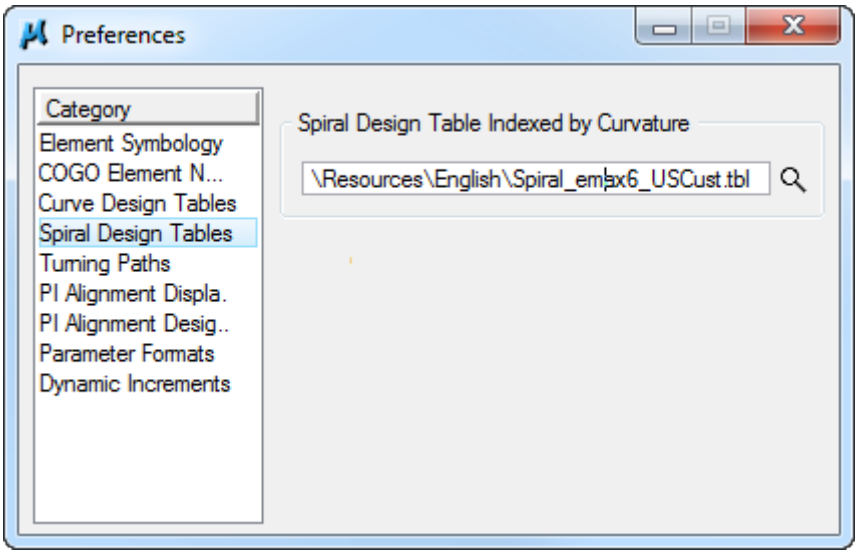

Figure 7-10: Horizontal Alignment Generator Preference

The Design Tables menu allows the user to view the settings for the current default design tables. In the Design Tables pulldown, the user sets the paths and file names for the tables to be accessed. Currently CFLHD uses only the Spiral Curve tables (Metric and English). Once the English or Metric Spiral Curve table is selected, select the design speed and number of lanes. These tables correspond with the AASHTO Green Book.

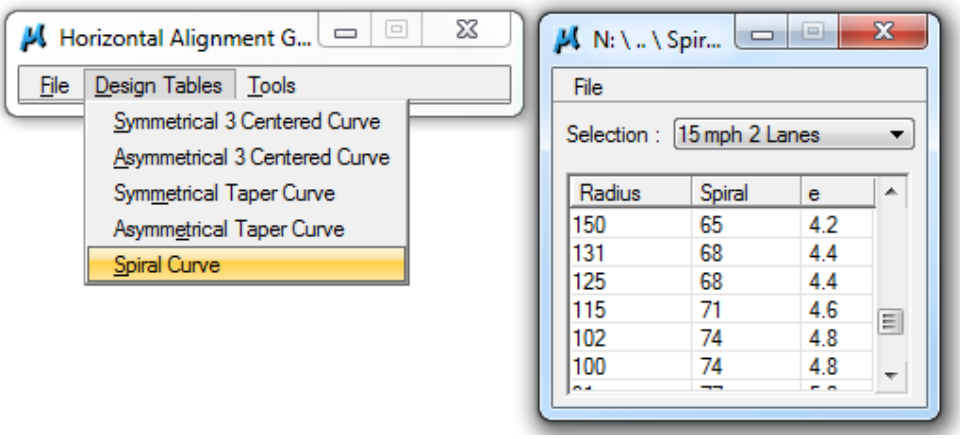

Figure 7-11: Design Tables – Spiral Curve

The tools menu activates the COGO tools that will be used to create geometry elements. Selecting **Tools>Main** accesses the following tool frame.

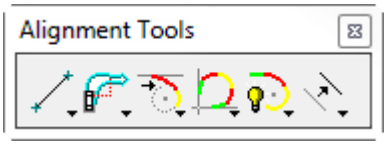

Figure 7-12: Horizontal Alignment Generator Tool Frame

From the main tool frame, shown above, additional tools may be accessed from each of the six main toolbox icons.

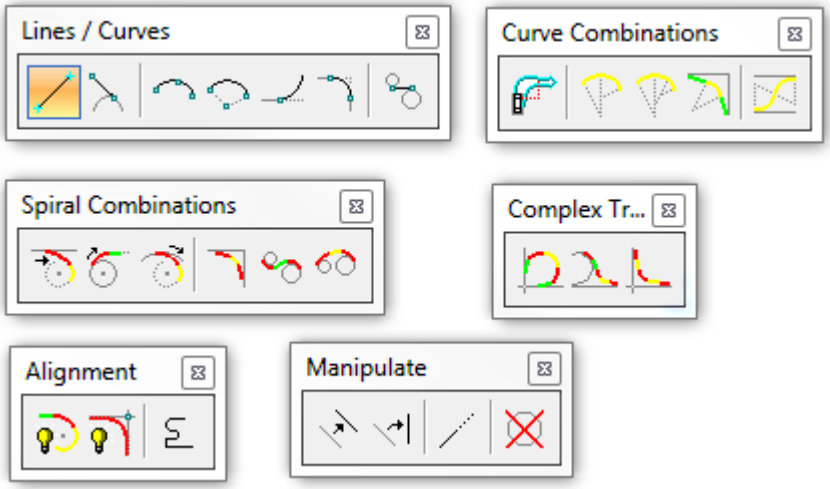

Figure 7-13: Horizontal Alignment Generator Tools

Each of the tool boxes shown, as well as the tools from Graphical COGO, may be used together to create any combination of geometry, from the simplest to the most complex.

Advantages

- Using these tools to set a horizontal alignment, if done properly, is just as accurate as traditional command line COGO.
- The user does not have to remember syntax of COGO commands.

Disadvantages

- The Graphical COGO and Horizontal Alignment Generator tools can be complicated.
- The process is slower than using store graphics, as detailed below.

Uses

- When the geometry is known, as the input of As-Built alignments.
- When the user wants to give exact bearings and distances.

Store Graphics

The store Graphics procedure is the simplest and quickest method to create a horizontal alignment. The user can use standard MicroStation draw utilities to layout the alignment then use the Store Graphics tool to store the alignment into COGO. Even though MicroStation measurements are to single precision, GEOPAK stored elements are computed to double precision accuracy. Store Graphics will make slight adjustments to the graphical element locations as required forcing each element in the chain to be exactly connected to the immediately preceding element and the immediately following element. These adjustments are always minor (e.g. the coordinates of a curve's PC and/or PT may be adjusted a few inches to force the curve to match the tangents exactly) but they do occur and the user has no control over them. However, if the graphical elements were drawn correctly then the chain that gets stored into the gpk file is exactly as "accurate" as a chain stored using any of the other methods.

TIP: Use the filet tool to construct the final curves in the alignment. Placing an arc by tangential snap does not always give accurate results.

This command cannot be accessed using Project Manager, but can be accessed the following two ways. From the GEOPAK pull down menus select, **Applications>GEOPAK>ROAD>Geometry>Store Graphics**

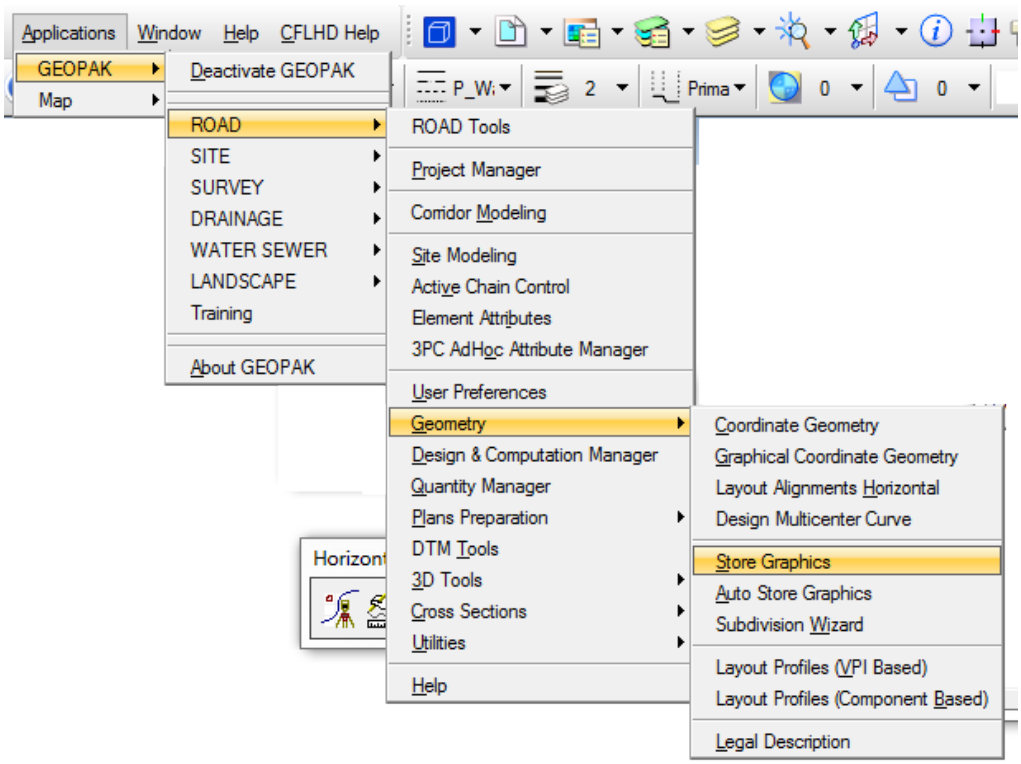

Figure 7-14: Accessing Store Graphics

Or by selecting the icons from the Geopak Road tool box as shown below:

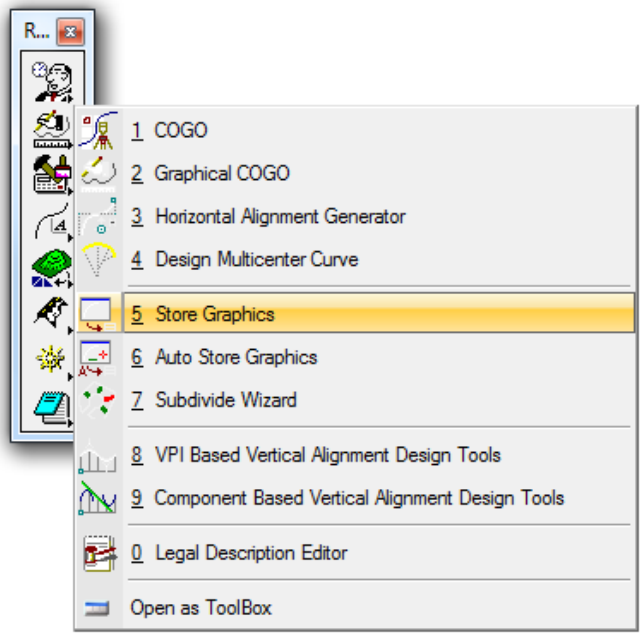

Figure 7-15: Store Graphics Icon

Selecting the Store Graphics Icon will invoke the Store Graphics Dialog box. Points, curves, chains and parcels can be stored with this dialog box. To store a horizontal alignment, toggle to **Chain** as shown below. Set the Mode to **Complex Chain**. Enter the **Job** number (use the magnifying glass to browse to the GPK file), the **Operator Code** (users first and last initial), the

name of the chain that will be stored and the **Beginning Station** of the horizontal alignment.

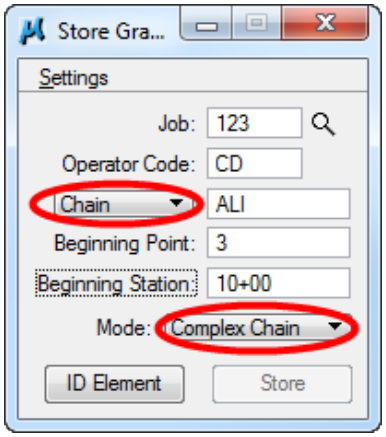

Figure 7-16: Store Graphics

The **Beginning Point** of the chain must be a unique point that has not been used previously. To check what points have already been used in the project, go to Coordinate Geometry (**COGO**) Dialog box as shown below. Select **Element** from the top of the COGO Dialog box. Go to **Point** and then **Utility**. This opens the Point Utility Dialog box which lists all of the points that have been used already. Points can contain numbers and letters. After determining an unused point, close the COGO Dialog box (Choose **No** when the 'COGO session not saved' Alert appears).

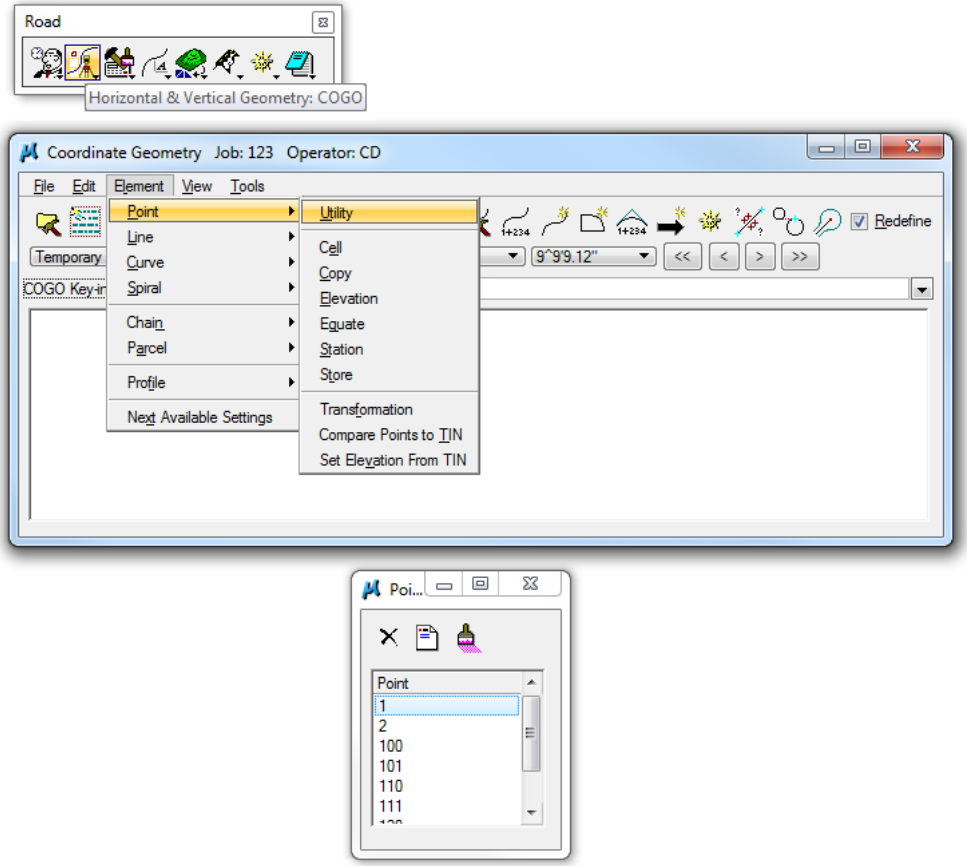

Figure 7-17: Unique Beginning Point

Enter a unique **Beginning Point** in the Store Graphics Dialog box. Fit the entire horizontal alignment in a View (if a portion of the alignment is not in the view, it will not be stored). Click on the **ID Element** button.

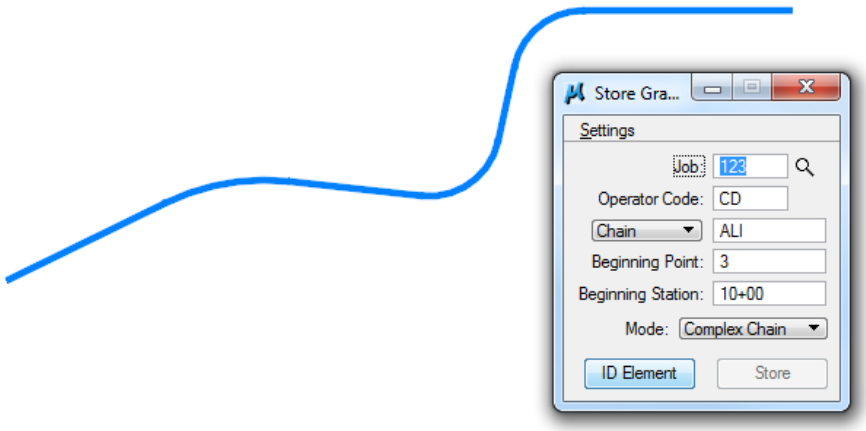

Figure 7-18: ID Element

In the view with the entire alignment, data point the first element in the horizontal alignment, the element will then appear highlighted. Click again, and the rest of the elements will be highlighted. Click again to accept the chain, and the **Store** button will become un-ghosted. Click the **Store** button. Click **OK** on the Store Graphics Notification.

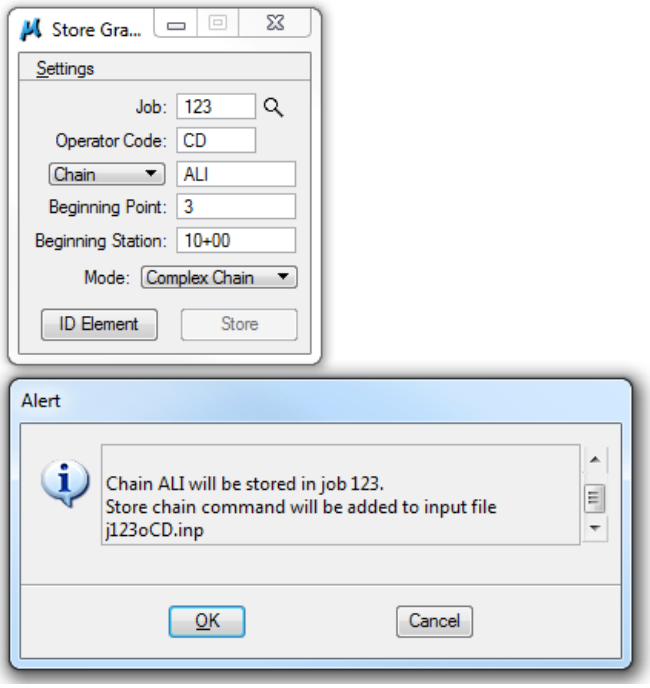

Figure 7-19: Store Chain

Advantages

- Use simple MicroStation commands to layout alignment, adjustments to alignment are quick, and the only point numbers used are on the alignment (usually just the first and last).

Disadvantages

- Not as accurate as COGO. Store Graphics makes minor adjustments to the as-drawn elements in order to get them to tie together mathematically.
- Cannot draw spirals using MicroStation commands. If spirals are needed, you must use Horizontal Alignment Generator to create that element, and then you may continue using MicroStation commands.

Uses

- For general and normal chain creations.
- For long alignments with many elements.

Coordinate Geometry (COGO) Tools

The main COGO dialog box includes utilities for each type of COGO element such as points, lines, curves, chains, etc. The utility dialog box will allow the user to functions such as visualize, print, transpose, etc., for each element type. This allows the user to more efficiently work with each type of element independently. The COGO dialog box, along with some of the utility dialog boxes is shown below.

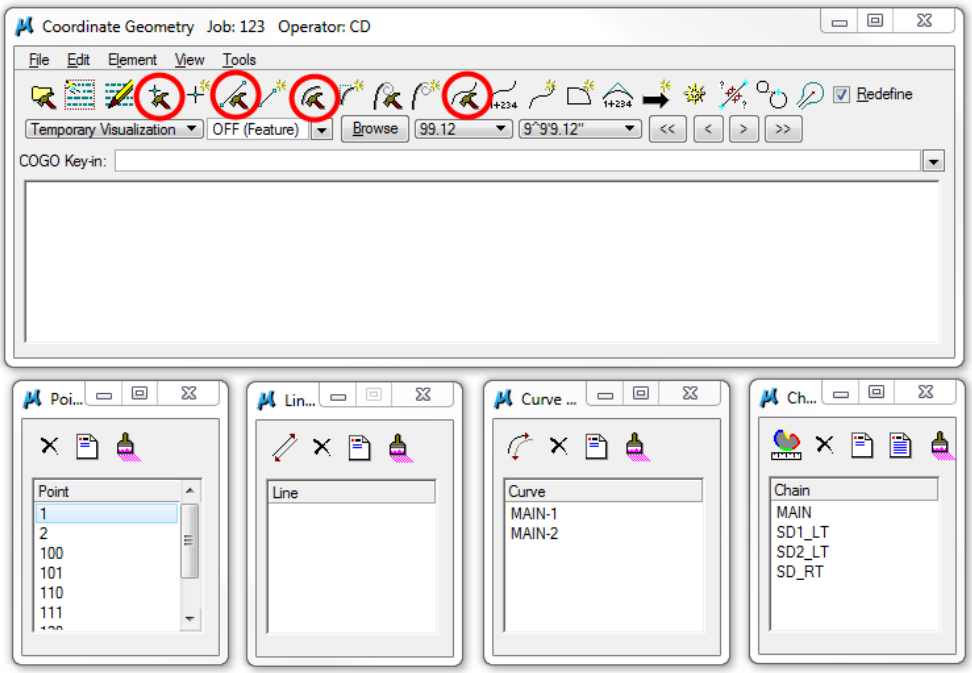

Figure 7-20: COGO Tools

Vertical Design

There are two methods available for creating and storing an Existing Ground profile; Traditional method and the new Draw Profile Tool method.

Traditional Existing Ground Profile Tool

Once a run is created for the working alignment, the existing ground profile should be created and then drawn using the D & C Manager. CFLHD's traditional method for cutting existing ground profile is shown below. Existing Ground Profile can be accessed through the Project Manager by selecting the Existing Ground Profile button.

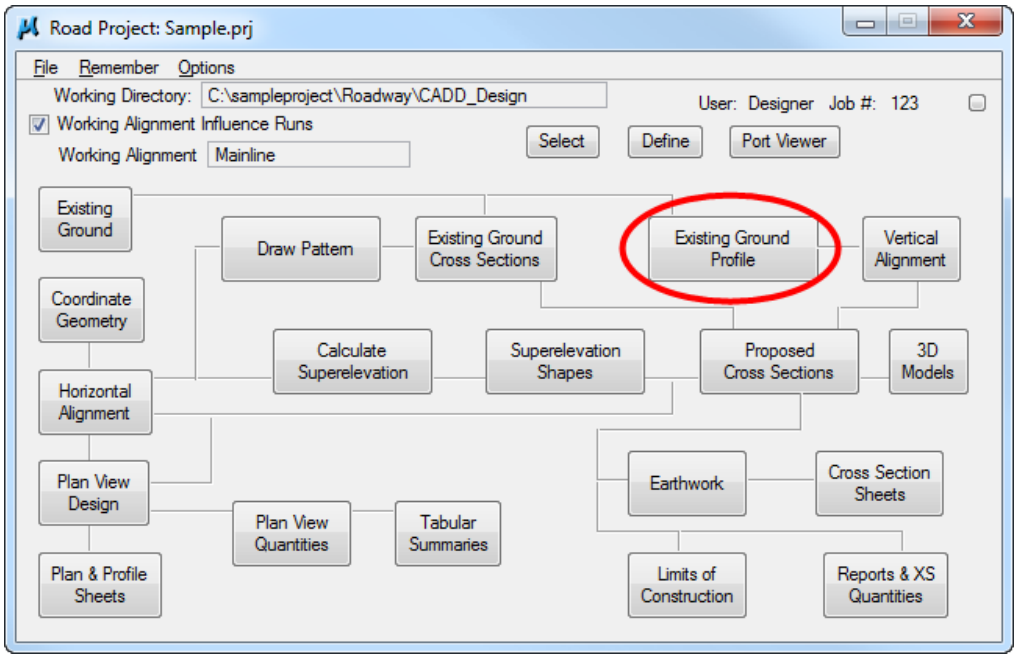

Figure 7-21: Accessing Existing Ground Profile through Project Manager

The Existing Ground Profile dialog can also be accessed by typing in **mdl load ex_prof** command in the MicroStation Key-in box.

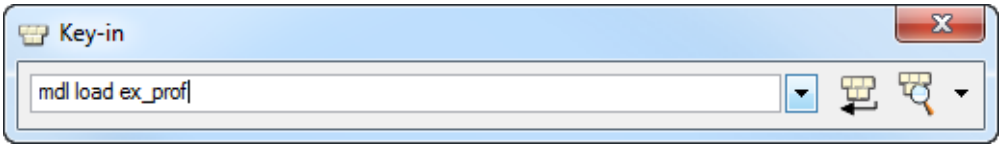

Figure 7-22: MicroStation Key-in

The following Existing Ground Profile dialog box will appear.

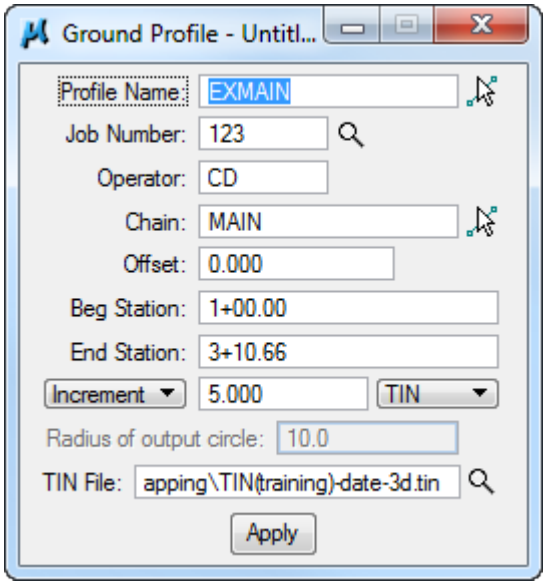

Figure 7-23: Traditional Existing Ground Profile

Enter in the required information and select Apply. Apply will cut your existing ground profile for the chain and store it into the GPK file. Existing ground profile can be accessed and drawn into MicroStation using the Geopak D & C Manager, with the CFLHD **.ddb** file. This will assure that the existing ground profile is placed with the correct symbology.

Draw Profile Tool

The Draw Profiles tool is not available through project manager workflow dialog box, but can be accessed by selecting **Applications>GEOPAK>ROAD>Plans Preparation>Draw Profiles**

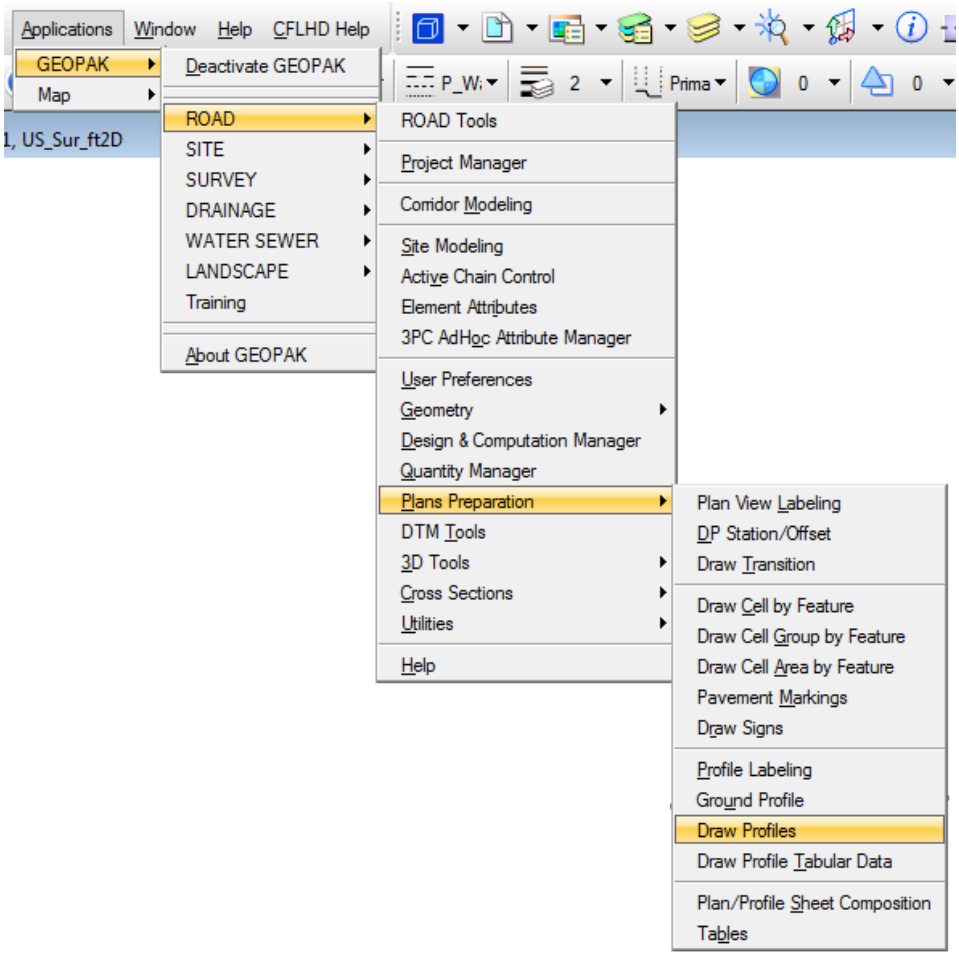

Figure 7-24: Select Draw Profiles

The Draw Profiles tool may also be accessed from the Plans Preparation tool palette as shown below.

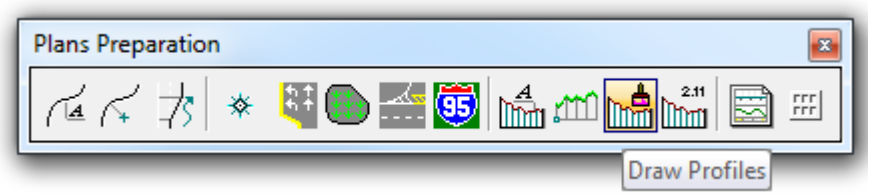

Figure 7-25: Draw Profile Icon

All that is needed for this tool is a horizontal alignment and a **.tin** file. This tool allows for the creation of an existing ground profile in much the same way as the Traditional method, but does so behind the scenes, with increased efficiency and a much cleaner workflow. This tool also allows the user to draw profiles into MicroStation using the D&C Manager **.ddb** settings ensuring adherence to the CADD standards. Also, with the Draw Profiles tool, there is no need to delete before re-drawing updated profiles.

Workflow 1: Creating an existing ground profile using Draw Profiles Tool

To access this workflow, follow this link:

http://flh.fhwa.dot.gov/resources/cadd/cfl/documents/Workflow_7.1_v8i.pdf

One advantage of using the draw profile tool is the Update application. With this, it is possible to update all profiles and the Label Scale with one click. The user does not need to delete and redraw elements.

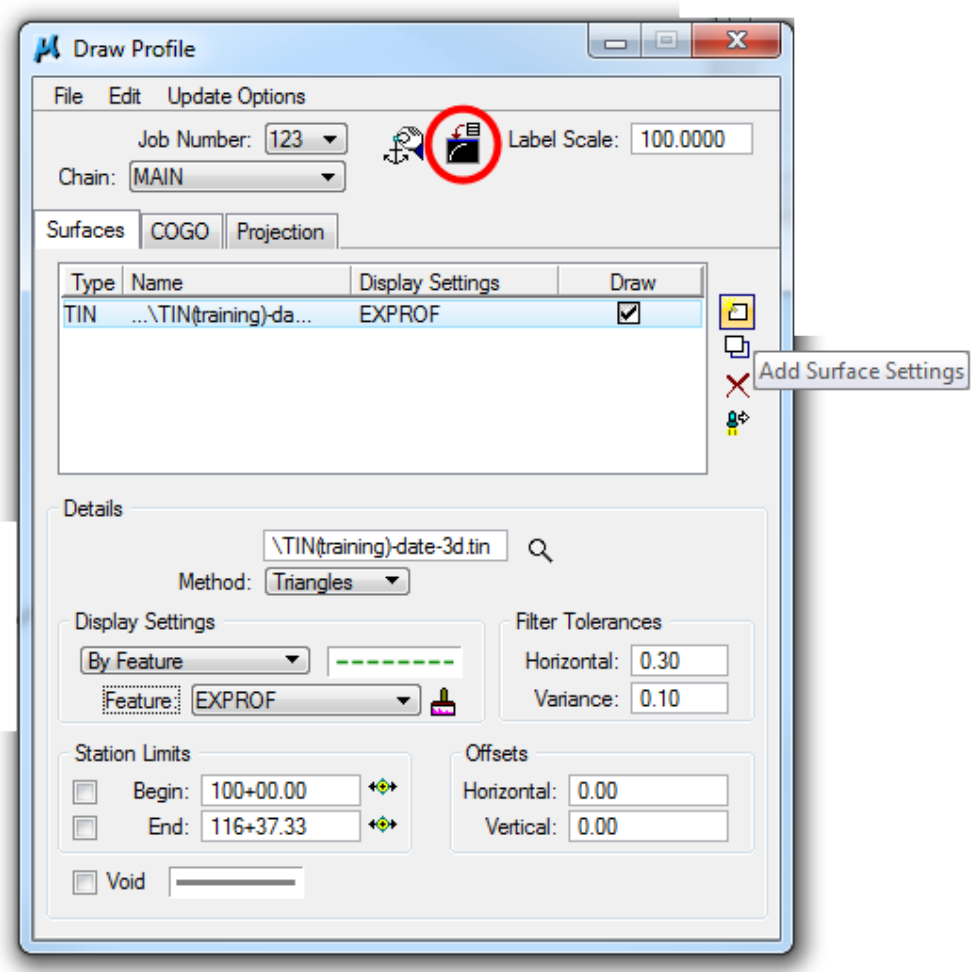

Figure 7-39: Profile Drawn into MicroStation

The projection tab can be used when the chain and profile that needs to be drawn is different than the chain and profile used to create the profile cell.

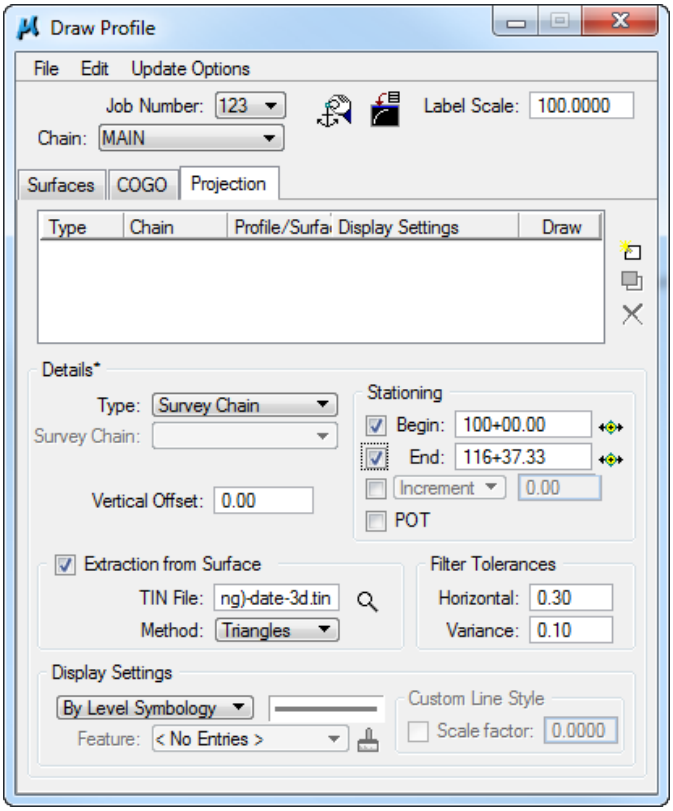

Figure 7-40: Profile Projection Tab

Proposed Vertical Alignment

There are two tools used to set proposed vertical alignments, and both are acceptable to CFLHD. Engineers and designers have used the VPI based Vertical Alignment Generator since the early days of GEOPAK. This tool, although having been around for years is still a user-friendly, accurate method for creating and storing vertical alignments. The second method is the Component Based Vertical Alignment Generator. This tool has been updated and improved over the VPI based tool, and has yet to be fully utilized by most GEOPAK users. Both these methods are just as accurate and depending on your preference, as easy to use.

VPI based Vertical Alignment Generator

The VPI based Vertical Alignment Generator is the traditional method used by CFL designers in creating vertical alignments. Vertical alignment generator can be accessed through Project Manager by selecting the Vertical Alignment button.

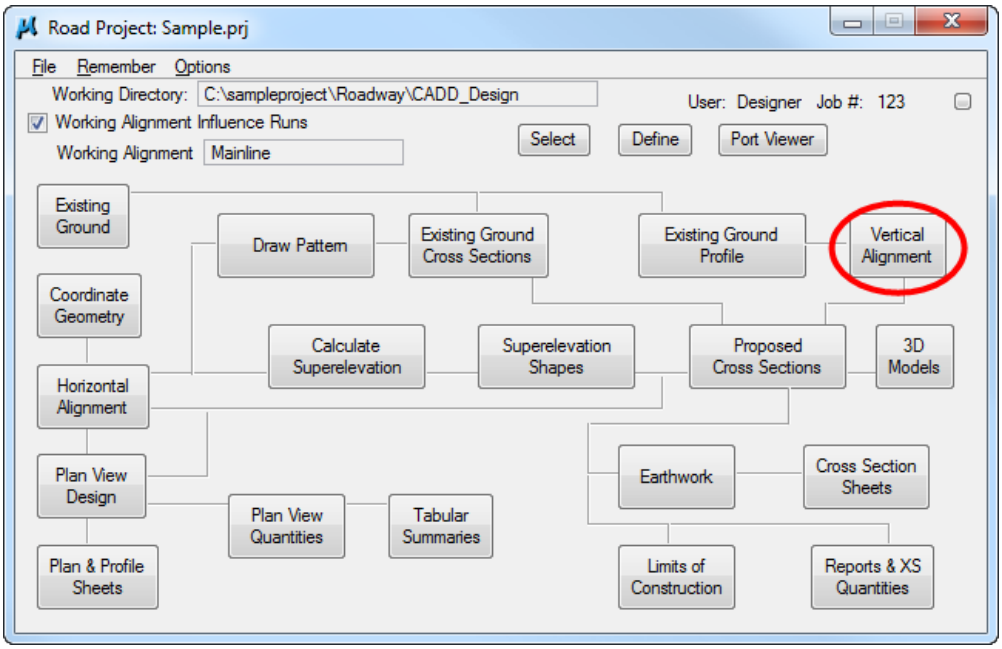

Figure 7-41: Accessing Vertical Alignment through Project Manager

The VPI Based Vertical Alignment Design Tool may also be accessed from the Horizontal & Vertical Geometry tool palette as shown below.

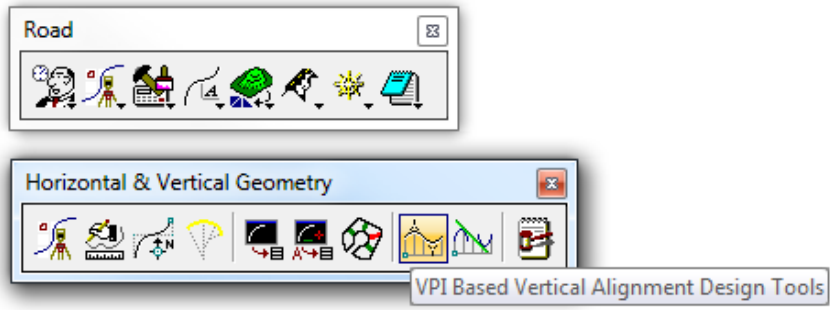

Figure 7-42: VPI Based Vertical Alignment Icon

Selecting the VPI Based Vertical Alignment Design Tool will invoke the following dialog box.

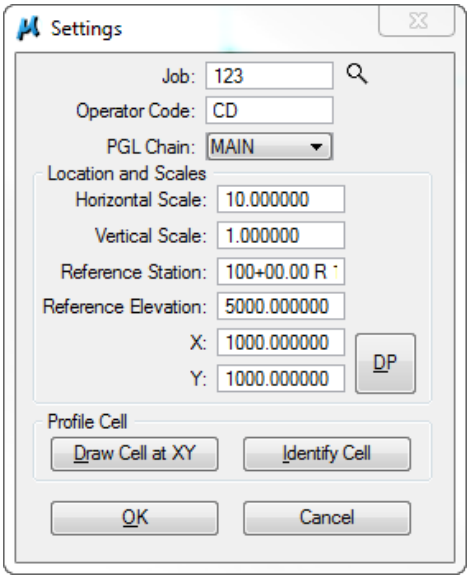

Figure 7-43: VPI Based Vertical Alignment Settings

Once the settings are defined, selecting OK will invoke the GEOPAK Profile Generator.

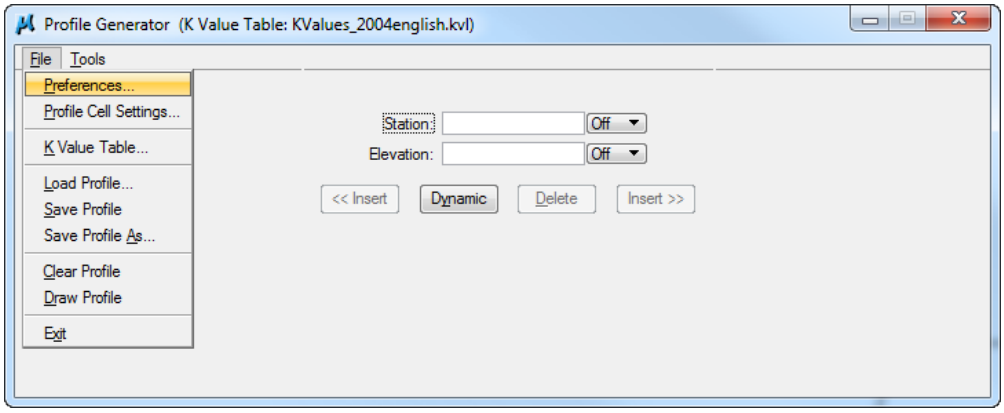

Figure 7-44: Profile Generator

For US Customary projects, the User Preferences are as shown below:

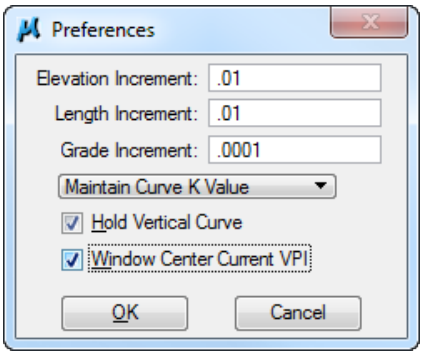

Figure 7-45: User Preferences

If the project requires the use of Maintaining K value instead of Maintain VC Length, commonly used, attach the correct K-Value table. K Value Table can be accessed by selecting **User>K-Values**. The following dialog will appear:

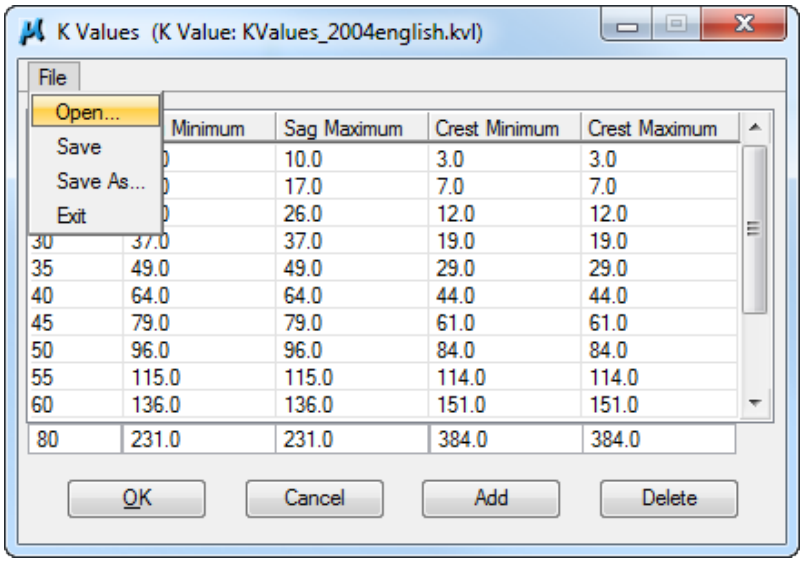

Figure 7-46: K-Value Table

Use **File>Open** to attach the correct unit K-Value table (**.kvl**). K-Value table can be attached from *V8i_RESOURCE\FLH_Common\GEOPAK\Resources\ english or metric.*

After the proposed vertical alignment is created and saved, use the Draw Profile Tool or the D&C Manager to drawn profile in MicroStation, ensuring adherence to the CADD standards. For CFLHD projects, the toggles shown below must be selected prior to drawing the profile.

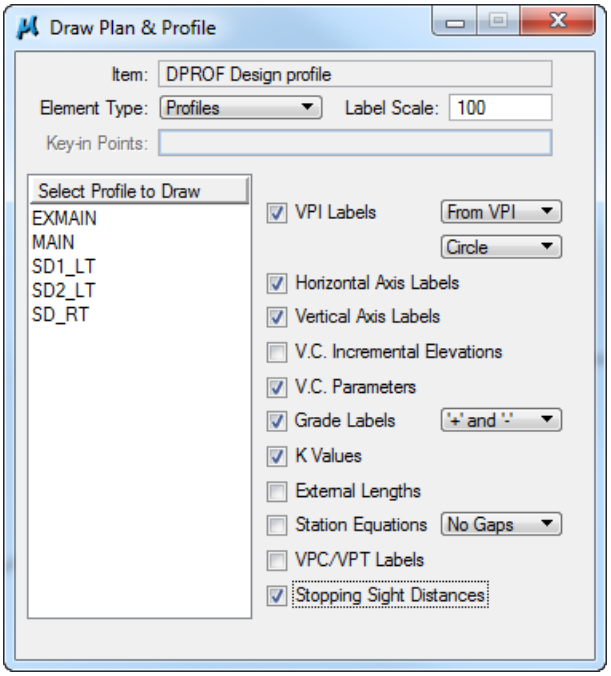

Figure 7-47: D & C Manager to Draw Profile Draw

Component Based Vertical Alignment Design Tool

This method allows for vertical alignment to be created graphically and stored using Store Graphics command, similar to the horizontal alignment Store Graphics command. The Component Based Vertical Alignment Design Tool requires COGO to be active as well as an Active Chain and Active Profile Cell. Component Based Vertical Alignment Design Tool requires the use of Active Chain Control, a method introduced with Geopak 2000. Active Chain Control can be used in place of the 3 port viewer.

Workflow 2: Creating Proposed Vertical alignment using Component Based Vertical Alignment Design Tool

To access this workflow, follow this link:

http://flh.fhwa.dot.gov/resources/cadd/cfl/documents/Workflow_7.2_v8i.pdf

The various methods for creating horizontal and vertical geometry using GEOPAK are describe in this chapter. Regardless of the method used, the final alignment and profile must be drawn into MicroStation using the GEOPAK D&C Manager, with the CFLHD .ddb file. Workflow 3 outlines a macro used at CFLHD to check the horizontal alignment design for kinks.

Workflow 3: Macro - Checking for Kinks in Horizontal Alignment

To access this workflow, follow this link:

http://flh.fhwa.dot.gov/resources/cadd/cfl/documents/Workflow_7.3_v8i.pdf