Civil/Site Engineering Solutions Manual

Project 99.013

The CADD/GIS Technology Center

for Facilities, Infrastructure, and Environment

August 1999

Civil/Site Engineering Solutions Manual

Table of Contents

* Items shown but not included in the Draft Set are still under development.

Civil/Site Solutions Manual

Section 1 -- Shortcuts and Tricks

This section provides brief tricks and design shortcuts that are applicable to most types of Civil/Site layout, and are designed to make the process of design easier and more straight forward.

Section 1 -- Contents

Solution 1.1

Application
InRoads
InRoads SelectCAD

Displaying a Cut/Fill Interface Line in Plan View

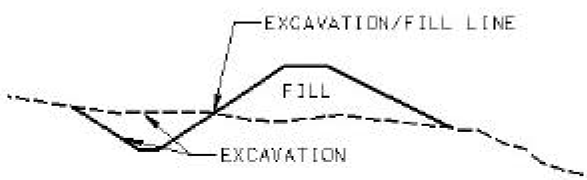
DESCRIPTION OF PROBLEM:

When a design for earthwork is completed, it usually includes areas of cut and fill that must be quantified, and displayed in plan drawings to guide the contractor. InRoads does not provide a single button routine to display the plan line that represents the interface between an area of cut and an area of fill.

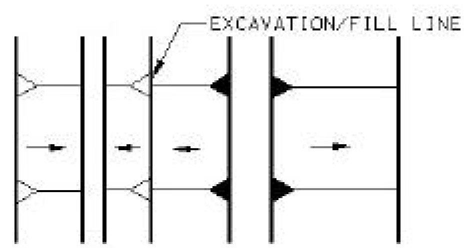
This solution provides the means to draw the excavation/fill line in plan view. The resulting line will be a three-dimensional linestring.

DISCUSSION:

The normal end product in the design process is an 'existing condition' DTM and a 'final surface' DTM. The excavation/fill line is the line that defines where the two surfaces intersect -- where excavation ends and fill begins. The figures below show this line in section and plan view. The final construction plan drawings delineate areas of excavation and fill differently (as in plan view below), and the excavation/fill line locates that transition in the plan view.



SECTION VIEW



PLAN VIEW

DESIGN SOLUTION:

The delineation of the excavation/fill line in the plan view makes use of the InRoads **View** > **Isopach** feature, which draws contours that represent the 'difference surface' between the existing condition DTM and the final surface DTM. When displayed, the zero contour of an isopach between surfaces is the intersection point of those surfaces. This solution creates an isopach between the existing and final design surfaces, and displays the z = 0 contour to define the excavation/fill interface line.

SOLUTION PROCEDURE:

1. Load the two surfaces representing the existing condition, and the final design condition.
2. Select **View** > **Isopach**
3. Within the **View Isopach** dialog box, set the following variable settings and then **Apply**:

   Original Surface: {select your existing condition surface}

Design Surface:	{select the final design surface}
Isopach Surface:	toggle on {select "Default" or empty surface of choice}
Display Mode:	{Grid Point}
Northing Interval:	set according to the accuracy required (the lower the number, the more intersection points you will receive)
Easting Interval:	set to the same number used for Northing Interval
Cut Height:	toggle off
Fill Height:	toggle off
Planarize	toggle off

4. Triangulate the Isopach surface you just created, using **Utilities** > **Triangulate Surface**.

5. Select **View** > **Contours**

6. Within the **View Contours** dialog box, set the following variable settings and then **Apply**:

Surface:	{select the Isopach surface created above}
Scale:	1
Interval:	10,000 (or some other really large number)
Minors per Major:	0
Planarize	toggle off

7. The line(s) that is displayed is a zero contour at the intersection of the two surfaces. If the line does not display, first check to make sure that your "Write" lock is on. If your "Write" lock was on and it still did not display, fit your view.

8. You can then drape the zero contour line(s) against the original or design surface used in step 2 to display a copy of the intersection line(s) at the correct elevations (use **View** > **Drape Surface**).

RELATED APPLICATIONS:

In addition to displaying the line for use as a drawing element in the Plan View, the lines may be used as an 'element fence' to restrict quantity calculations in InRoads to a specific excavation or fill area.

Solution 1.2

Reporting Horizontal Alignments

Application
InRoads
InRoads SelectCAD

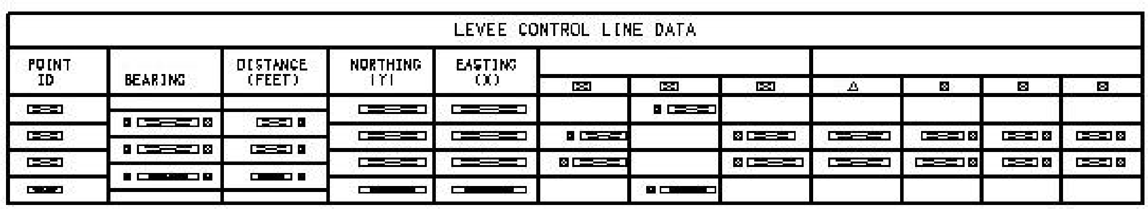
DESCRIPTION OF PROBLEM:

InRoads does not report the PI information such as coordinates, bearings, or distances for curves when creating reports for the horizontal alignments.

This solution provides the means to report the PI information for horizontal alignments.

DISCUSSION:

When inserting curves into a horizontal alignment, InRoads does not keep the PI information such as the coordinates, bearings or the distances. InRoads reports on the curve information only. The coordinate, bearing and distance information given with curves is for the PC and PT. As shown in the example below, the information on the PI and the curve data are desired.



CONTROL TABLE

DESIGN SOLUTION:

The PI information can be reported by creating two horizontal alignments – one with the curves and one without the curves. The desired horizontal alignment (with curves) is created, then the second alignment is created by making a copy of the desired alignment by using **Utilities** > **Copy Geometry** > **Horizontal Alignment**. On the second alignment, the curves are removed (edited the radius to 0) so that the alignment consists of just PI's (alignment without curves.) The alignment with the curves will report the curve data and the alignment without the curves will report the PI information.

SOLUTION PROCEDURE:

1. Create horizontal alignment. In this example, it will be called " align1." If alignment is to have a letter (A 0+00), define under station equation using **Palettes** > **Stationing & events** > **Stationing.**

2. Copy horizontal alignment " align1" to " align1_pi." Use **Utilities** > **Copy Geometry** > **Horizontal Alignment** with the following settings:
   Original alignment : align1 (even though it says align1, select align1 from the listing)
   Destination geometry: {Select geometry}
   Destination alignment: align1_pi
   Apply.

3. Modify all curves in " align1_pi" to 0. First use **Utilities** > **Active Geometry** to make " align1_pi" the active geometry. Then use **Palettes** > **Horizontal Edit** > **Modify Curve** to modify the curves to radius 0. Select the curve (on the screen) with the data button and accept. Then use the following settings:
   Additional data – Radius 1: 0.0
   OK
   Accept the change (with data button.)
   Repeat the above steps for each curve.

4. Save geometry. **File** > **Geometry** > **Save**.

5. Create report file for " align1." Use **Utilities** > **Report** > **Geometry** with the following settings:
   Report type: Horizontal alignment
   DBAccess library: corps.dba
   DBAccess template: CONT_STD_STA
   Output ascii (select): *//PROJECT/civ/align/align1.asc*
   Parameters include alignment: align1
   Apply

6. Create report file for " align1_pi." Use **Utilities** > **Report** > **Geometry** with the following settings:
   Report type: Horizontal alignment
   DBAccess library: corps.dba
   DBAccess template: CONT_STD_PI
   Output ascii (select): *//PROJECT/civ/align/align1_pi.asc*
   Parameters include alignment: align1_pi
   Apply

7. Edit *align1.asc* as follows. Bring up *align1.asc* in notepad. Delete black line, delete all lines with " PT xx+xx.xx". Make sure that one empty line remains between each line of data. Be careful not to delete any PI stationing. Edit the POB, PI, and POE lines by deleting " POB," "PI," and " POE." Make sure that that columns containing the POB, PI, and POE stations line up by adding or deleting spaces. **File** > **Save.**

8. Edit *align1_pi.asc* as follows. Bring up *align1_pi.asc* in notepad. Delete black line. **File** > **Save**.

9. Bring in control table cell. Attach cell library - *civsur.cel*. Active cell = CONTBL. (AS=1 for 1" =10' scale drawing.) Bring in cell at the appropriate scale.

10. Set text size and attributes. Drop cell. Match text attributes - select data. Match element attributes - select data.

11. Bring in text file with PI information. **File** > **Import** > **Text**. Select *align1_pi.asc* and tentative to the text node located in the blank space below the B in BEARING. (You may want to toggle text nodes on in your view attributes settings box.) The text in the Northing and Easting columns should highlight. Accept to place text.

12. Bring in text file with curve information. **File** > **Import** > **Text**. Select *align1.asc* and tentative to the text node located in the blank space below PC. . (You may want to toggle text nodes on in your view attributes settings box.) The text in the PI column should highlight. Accept to place text. Delete original cell text with the exception of the POINT ID column and the column headings.

13. Edit point ID. Edit the PI numbers in the POINT ID column, adding the letter designation if necessary.

RELATED APPLICATIONS:

Solution 1.3

3-D Model Viewing

Application
InRoads
InRoads SelectCAD

DESCRIPTION OF PROBLEM:

Usually a designer is limited to plan, profile, and sectional views when reviewing work. These views can be restrictive with regard to the design detail. With Inroads and Microstation, the designer can view work 3-dimenionally, which can give a better conceptional look of the design.

Model viewing provides the means to review work 3-dimenionally, therefore giving the designer a better concept of the overall solution.

DISCUSSION:

To obtain the desired end product the designer needs the original DTM of the existing conditions along with the structure DTM's generated during the design. Using the Microstation command of **Render** while in an **Iso** view, the designer will be able to view the work 3-dimenionally.

DESIGN SOLUTION:

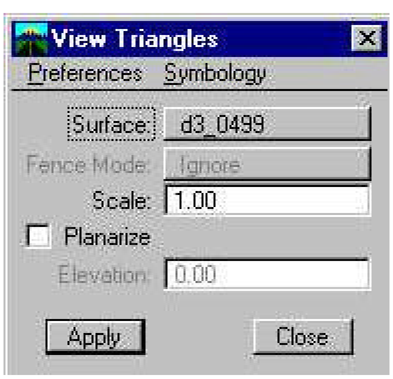
Details of design surfaces will not be discussed in this solution, and it will be assumed that the designer will have them generated. Inroads will be used to load and write the original and design surfaces to the design file. As mentioned above, Microstation commands will then be used to display the surfaces in 3-D model viewing.

SOLUTION PROCEDURE:

7. Select InRoads Main Menu, **File, Surface, Open** to load the original surface and design surfaces.

8. Select InRoads Main Menu **Settings, Locks, Write** for graphics to be written to design file.

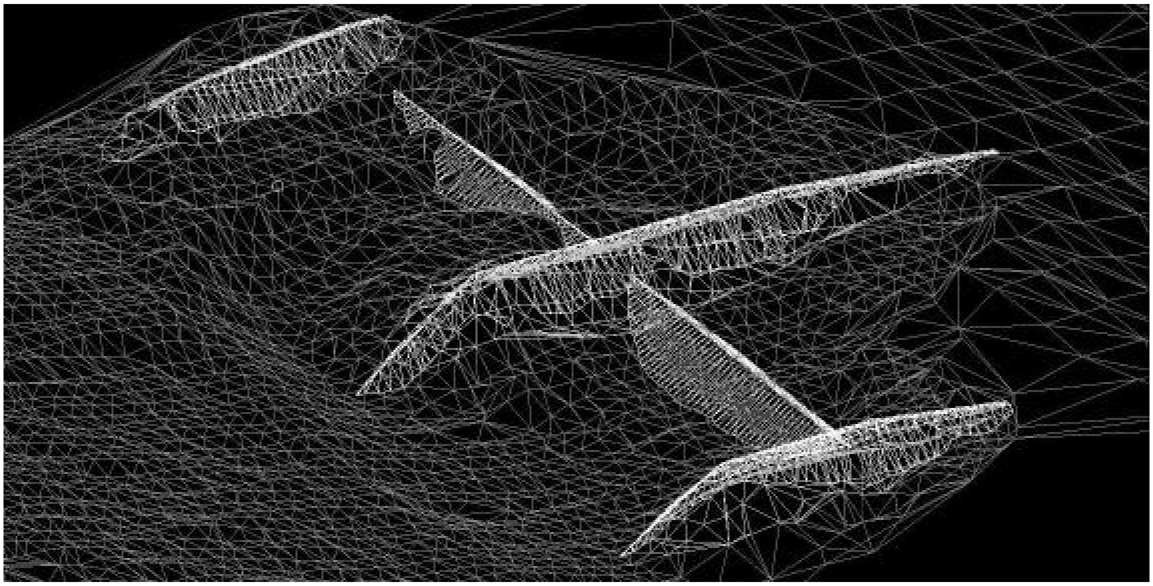
9. Select InRoads Main Menu, **View, Triangles** for the following dialog box:



Surface triangles should be placed on a level which has no other graphics. Use Symbology to change characteristics of triangles, if desired. Select appropriate surface then Apply. Display all surfaces in same manner.

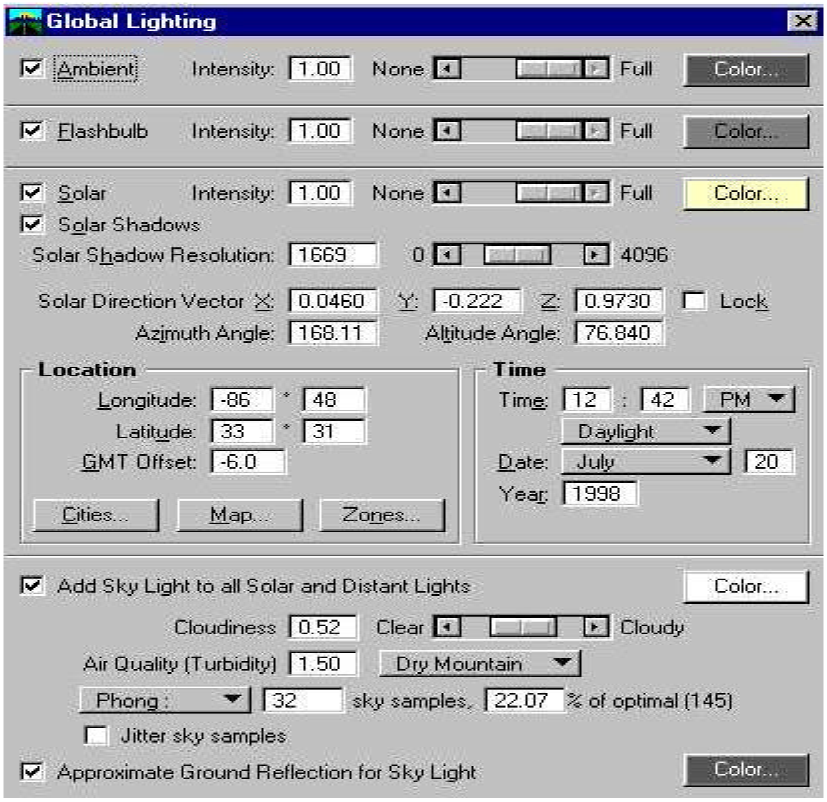
10. Turn all levels OFF, except for those on which the surface triangles are located.

11. **Select Microstation, Key-in, View=ISO, then place data point within design file. Select Microstation Main Menu** Tools, 3D and B-Splines, 3D View Control **for rotation of the view as needed.**



In this example, the dark triangles represent the original ground surface. The lighter triangles represent three dikes to be constructed along with containment stone to be placed between the dikes.

12. Select Microstation Main Menu **Settings, Render, Global Lighting** for following dialog box:



Settings can be as shown above, or the designer may want to experiment.

13. Select Microstation Main Menu **Utilities, Render, Smooth** and place a data point in the design file.

Conforming to the colors of the triangles and the settings chosen in Step 6, the view will be shaded accordingly. The 3D Model Viewing allows the designer to view shaded surfaces from any angle, thus giving a clearer understanding of the design.

RELATED APPLICATIONS:

3D Model Viewing is possible for any surface(s) comprised of closed elements.

Solution 1.4

Creating 3D Fillets

Application
Microstation
InRoads
InRoads SelectCAD

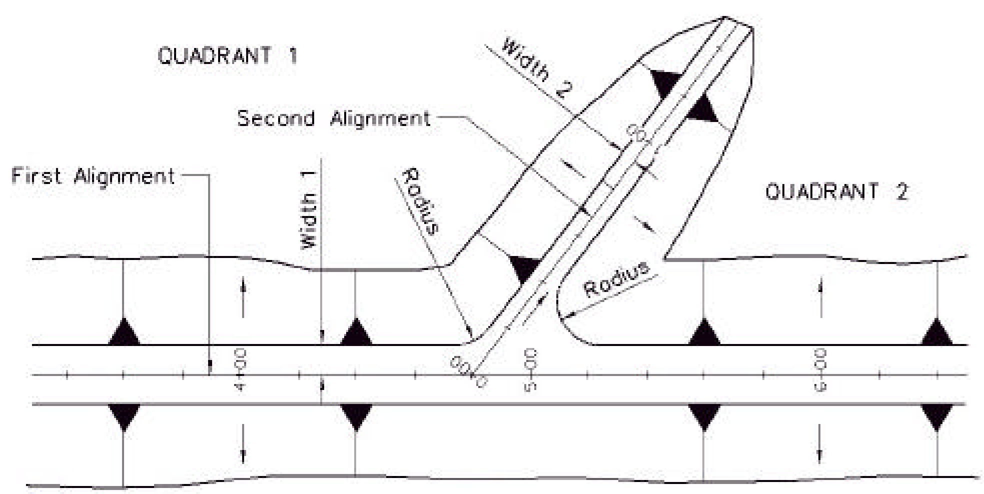
DESCRIPTION OF PROBLEM:

There is no direct way of creating a fillet between non-planar elements in either MicroStation or Inroads.

This solution provides the means to draw a 3D fillet for plan views. The resulting drawing element will be a complex chain.

DISCUSSION:

Most of the time drawings will need to be " cleaned up" after two intersecting surfaces have been created and written to a design file using Inroads' roadway modeler. 3D fillets may be required when a road/ramp intersects another road atop a levee. These elements can then be incorporated into the final design surface.



PLAN VIEW

DESIGN SOLUTION:

Inroads **One-Center Curve** feature can be utilized to create a planar fillet-type horizontal alignment between two intersecting horizontal alignments. The Inroads **View>3D Alignment** feature can then be used to create this alignment three dimensionally by utilizing vertical offsets.

SOLUTION PROCEDURE:

1. Open the geometry file containing the two intersecting horizontal alignments.

2. Make sure that both **Write** and **Auto Plot** are toggled on in the Inroads **Locks** dialog box.

3. Select **Palettes>Figure** from the Inroads pull-down menu.

4. From the figure pallet, select **One-Center Curve**.

5. Enter the desired radius, and offset widths in the **One-Center Curve** dialog box and hit **OK**.

6. Inroads will then prompt you to " Identify First Alignment." Place a data point to select the horizontal alignment associated with **Width 1** in the **One-Center Curve** dialog box. Inroads will then prompt you in a similar manner to " Identify Second Alignment." Place a data point to select the horizontal alignment associated with **Width 2**. You will next be prompted to "Identify Quadrant for Return." Place a data point in the quadrant in which you require a fillet and a second data point to accept the fillet or hit reset to reject the curve. This process can be repeated for each quadrant requiring a fillet. At this point, Inroads has created a planar, fillet-shaped horizontal alignment for each quadrant selected. The stationing for each fillet-shaped horizontal alignment runs from the point nearest the " First Alignment" to the point nearest the " Second Alignment."

7. MicroStation's **Partial Delete** can now be used to truncate roadway lines to the tangent points of the fillets.

8. Snap to the roadway lines at these tangent points, and record the elevations on a piece of scratch paper.

9. Select **View>3D Alignment** from the Inroads pull-down menu.

10. In the **View 3D Alignment** dialog box, select **Include Alignment**, and enter the name of one of the fillet-shaped alignments you have just created. Inroads automatically names these alignments with sequential numbers reflecting the order in which they were created. Make sure the **Station** toggles are off and **Horizontal Offsets** are set to " 0" . **Vertical Offsets** should be set with the elevations at the points tangent to the edge of the roadways. The **Start** elevation should be the point tangent to the edge parallel to the " First Alignment," and the **Stop** elevation should be the point tangent edge parallel to the " Second Alignment."

11. It is important to note that the 3D alignment created is actually a complex chain; therefore, the radius cannot be dimensioned using automatic dimensioning tools. The planar alignment created is an arc and can be automatically dimensioned. For this reason, you may wish to retain the planar alignment on a non-plotted level, or dimension this element prior to deleting it.

EXAMPLES/RESOURCES:

None.

RELATED APPLICATIONS:

Solution 1.5

Application
InRoads
InRoads SelectCAD

Converting Raw Sounding Data (water depth) into DTM (elevation) File

DESCRIPTION OF PROBLEM:

Raw sounding data can come in the format of Easting, Northing, and depth. It is desired to have the DTM file using elevations instead of water depths.

This solution provides the means to create a DTM file with elevation to represent the sounding data.

DISCUSSION:

The normal end product in the sounding process is an 'existing condition' DTM representing the elevation of the river or lake bottom. The survey may have done by measuring the water depths.

DESIGN SOLUTION:

The creation of the existing surface with elevations makes use of the InRoads **View** > **Isopach** feature, which draws contours that represent the 'difference surface' between water depth condition DTM and the elevation condition DTM.

SOLUTION PROCEDURE:

14. Select **File** > **Surface** > **New**. Type in a surface name *(depth)* and then hit **Apply**.

15. Select **File** > **Import** > **ASCII Surface**. Set the following settings and then hit **OK**:

    Surface: depth {select the surface name that you just created}
    Name: {select the filename of the data file}
    Directory: {select the directory where the data file exists}
    Filter: *.* {or select the extension of the data file}
    Point Type:Random
    File Type: Easting Northing Elevation {or Northing Easting Elevation if appropriate}

16. Triangulate the surface you just created, using **Utilities** > **Triangulate Surface**.

17. Select **View** > **Perimeter**

18. Select **File** > **Surface** > **New**. Type in a surface name *(lcp)* and then hit **Apply.**

19. Select **Utilities** > **Generate** > **Surface**. Set the following settings and then hit **Apply**:

    Surface: lcp {select the surface name that you just created}
    Generate As: Planar
    Number of Points: 1000
    Origin Northing: {select a point outside of the displayed perimeter and to the lower left}
    Origin Easting: {select a point outside of the displayed perimeter and to the lower left}

Origin Elevation: {elevation of water on day of sounding (usually LCP)}
Extents Delta Northing: {a distance in the y direction to a point outside of the displayed perimeter and to the upper right}
Extents Delta Easting: {a distance in the x direction to a point outside of the displayed perimeter and to the upper right}
Extents Delta Elevation: 0

20. Triangulate the surface you just created, using **Utilities** > **Triangulate Surface**.

21. Select **File** > **Surface** > **New**. Type in a surface name *(elevations)* and then hit **Apply.**

22. Select **View** > **Isopach**. Set the following settings and then hit **Apply**:

Original Surface: depth {select the surface name representing the water depths}
Design Surface: lcp {select the surface name representing the water elevation}
Isopach Surface: Toggle on – elevations {select the surface name that you just created}
Display Mode: all points
Cut Height: Toggle off
Fill Height: Toggle off
Planarize: Toggle off

23. Triangulate the isopach surface you just created, using **Utilities** > **Triangulate Surface**.

24. Select **Utilities** > **Review Surface**. Review the elevations of the isopach surface to verify that they seem reasonable. If not, review the other two surfaces to see if they seem reasonable.

25. Select **File** > **Surface** > **Save As**. Save the isopach surface. (Save the other surfaces if desired.)

RELATED APPLICATIONS:

Solution 1.9

Application
MicroStation SE/J
InRoads

MicroStation Macro for Plotting Station-Elevation Data on a Profile

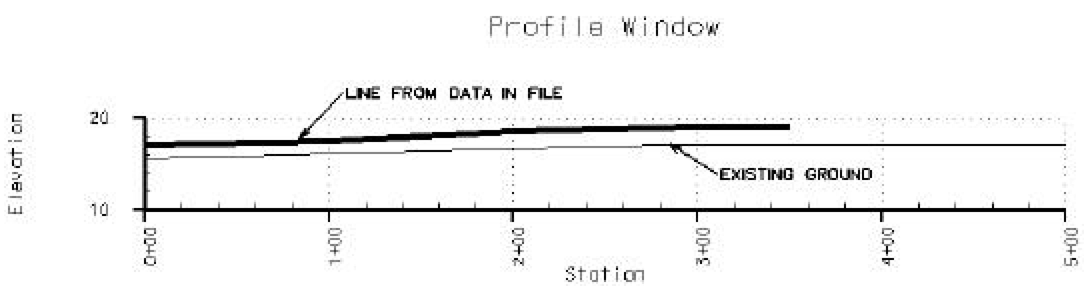
DESCRIPTION OF PROBLEM:

A designer often needs to plot data from ASCII files in graphs. The data could be station – elevation pairs from a hydraulic design program, or other data.

This solution provides a MicroStation Basic Macro that reads station – elevation data from an ASCII file and plots the data in a design file.

DISCUSSION:

A profile along an alignment, possibly representing a channel, can be generated very quickly using InRoads. Adding a line to a profile representing the computed water surface, for example, can be very tedious if each point is added manually. Many hydraulic analysis packages are able to output a data file that represents the position along the channel (station), and the computed water surface at the station.



DESIGN SOLUTION:

This MicroStation SE and J macro reads point data from a text file and places a line in the design file from point to point. Dialog boxes allow the user to set line attributes and the profile's exaggeration, beginning elevation, and beginning station.

SOLUTION PROCEDURE:

1. From the MicroStation pull down menu select **Utilities > Macros > graph3b > run**.
2. In the " Choose a File to Open" dialog select your file and data point on **OK**.
3. In the " Macro – Line" dialog, set the line preferences and the profile parameters. The line color and weight are selectable. Profile parameters such as horizontal and vertical exaggeration, as well as the beginning station and elevation of the profile are entered. Data point on **OK** when complete.
4. Tentative to the lower left corner of the profile window and accept this point. A line will be drawn in the profile window from point to point along the user defined data.

EXAMPLES/RESOURCES:

Files Included:

Graphb3.ba	compiled macro code (needed to use the program's dialog boxes)
Graphb3.bas	macro source code
Graph.txt	sample data file listed below

Data File:
The data file must be in the format shown below. The first number represents the station and the second represents elevation. The numbers in each line must be separated by a comma, and each line must end with a return

```
0,17
100,17.5
200,18.5
300,19
350,19.5
```

Installation:
Copy the graphb3.ba and graphb3.bas files to the MicroStation macros directory. This is usually c:\win32app\ustation\macros.

RELATED APPLICATIONS:

The profile command from InRoads can be used to generate the profile window.

Civil/Site Solutions Manual

Section 2 -- Levees and Channels

This section provides design solutions specifically applicable to Flood Control projects making use of Levee and Channel features to provide protection against flooding.

Section Contents

Solution 2.1

Application
InRoads
InRoads SelectCAD

Drainage Channel at Toe of Levee

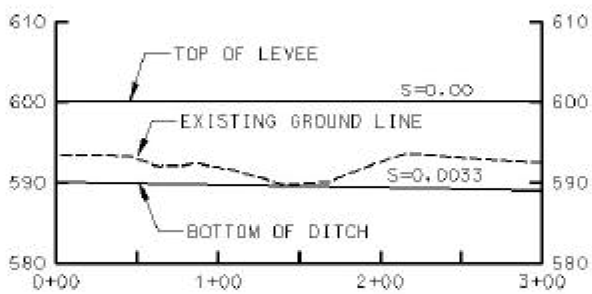
DESCRIPTION OF PROBLEM:

The design problem is having a levee with a ditch along the toe, and both features having different slopes along the centerlines. A single template will not work in this situation because the horizontal distance between the centerline of the levee and the centerline of the ditch is constantly changing.

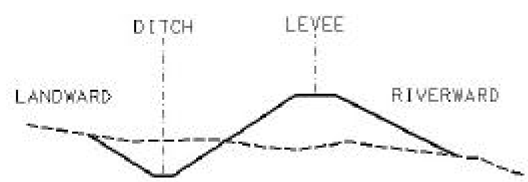
"This solution provides the means to draw the ditch along the toe of a levee in plan view.

DISCUSSION:

The interior drainage plan includes having a ditch run along the toe of the landward side of the levee. The figures below show this in profile and section view. This dilemma occurs when the slope along the centerline of the levee varies from the slope defining the drainage ditch. (i.e. The top of the levee is at elevation 600.0; but at sta 0+00, the ditch elevation is at 590.0 and at sta 3+00, the ditch elevation is at 589.0.)



PROFILE



SECTION

DESIGN SOLUTION:

The answer is to define the horizontal and vertical alignment of the levee and to define a vertical alignment for the ditch based on the horizontal alignment of the levee. Then by defining a template and using a decision table, the roadway modeler will be used.

SOLUTION PROCEDURE:

1. Load the surface representing the existing condition, the geometry representing the horizontal alignment and the vertical alignment [top1] of the levee, the project template library [english.tml], and the project roadway library.

2. Select **File > Geometry > New** and create a new vertical alignment [ditch1] under horizontal alignment levee1. Select **Palettes > Vertical Edit > Add Vertical PI** and define the new vertical alignment representing the ditch.

3. Select **Palettes > Design Roadway > Define Template**. Select **Add**. Within the Add Template dialog box, type in the name of the template and a description and toggle the type to template. Then select **OK**.

4. Within the Define Template dialog box, hilight the template that was just created and select **Edit**. Define the levee top width as the backbone and the side slopes as the cut and fill. Select **Close**. Select **File > Save**.

5. Select **Palettes > Design Roadway > Define Template**. Select **Add**. Within the Add Template dialog box, type in the name of the decision table [ditch] and a description and toggle the type to decision table. Then select **OK**.

6. Within the Define Template dialog box, hilight the decision table that was just created and select **Edit**. Within the Edit Decision Table dialog box, select **+after**. Edit the Add Decision Table Record such that the final decision table has entries as shown below. Select **Close**. Select **File > Save**.

Decision Table

Hinge	Cut	-25.000%	500.00	*	*		*	*	Alg. Z	levee1, ditch1	0.00
Cut	Bench	0.000%	10.00			*	*	*	Alg. Z	levee1, ditch1	0.00
Bench	Fill	33.333%	500.00		*		*	*	DTM	orig	0.00

7. Select **Palettes > Design Roadway > Define Roadway**. Select **Add**. Within the Add Roadway dialog box, type in the name of the roadway and a description. Then select **OK**.

8. Within the Define Roadway dialog box, hilight the roadway that was just created and select **Edit**. Within the Edit Roadway Table dialog box, select **Add**. Within the Add Roadway Entry dialog box, type in the beginning station and the interval distance. Toggle the alignment side to left and right. Select the template for each the left and the right. Toggle decision table for the left and template for the right. For the left, enter in the decision table name. Select **Apply**. Select **Cancel**. Within the Define Roadway dialog box, select **Close**. Select **File > Save**.

9. Select **Palettes > Design Roadway > Roadway Modeler**. Within the Roadway Modeler dialog box, hilight the roadway and the original surface and select **Apply**.

EXAMPLES/RESOURCES:

Template library = english.tml

RELATED APPLICATIONS:

Solution 2.2

Application
InRoads
InRoads SelectCAD

Design of Dike for Bank Stabilization and Navigation

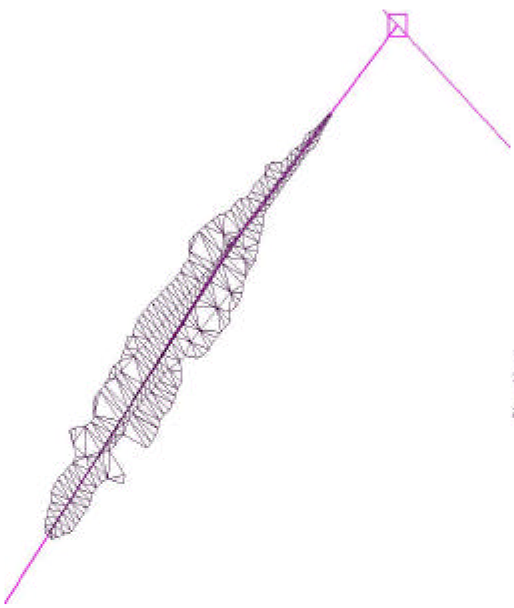
DESCRIPTION OF PROBLEM:

Dikes are a proven means to help bank stabilization and navigation within virtually all types of waterways. A dike design will vary as to the engineering need and funding available. With InRoads the designer can vary their design in effort to obtain a quality and economical solution.

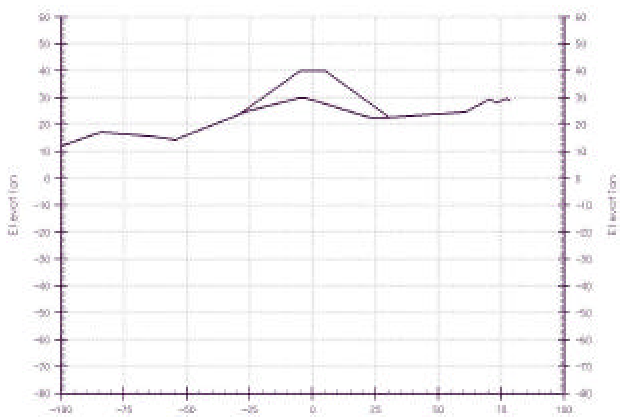
This solution provides the means to design a dike and vary the height, crown width, and length as needed to obtain the desired solution.

DISCUSSION:

The normal end product in the design process is an 'existing condition' DTM and a 'dike surface' DTM. To obtain a desirable end product, the designer may have to go through several iterations where the height, width, and length of the dike will vary.



PLAN VIEW



SECTION VIEW

DESIGN SOLUTION:

Dike design uses many InRoads features that will be reviewed below. The end product will be a dike surface, which will display accurately on the original surface. From these surfaces, cross sections can be generated and stone quantities can be obtained.

SOLUTION PROCEDURE:

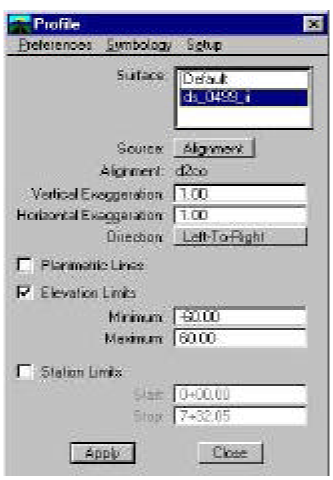
26. Select InRoads Main Menu, **File** to load the original surface, representing the existing condition, and create a project geometry, template library, and roadway.

27. In Microstation, place a line along the azimuth and in the location chosen for the dike.

28. Select InRoads Main Menu, **File, Import, Geometry from Graphics** , and the following tutorial will appear:

Select Horizontal Alignment, give an alignment name, select Use Tag Data, and Apply. Identify the line placed in Step 2 with a data point. The dike horizontal alignment has been created.

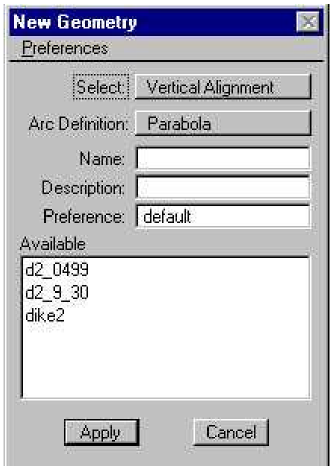
29. Select InRoads Main Menu **Palettes, Profile, Profile** for the following tutorial:



Identify Surface, Source is alignment, set exaggeration and elevation limits then Apply. Place a data point in the design file to identify the desired location for the profile.

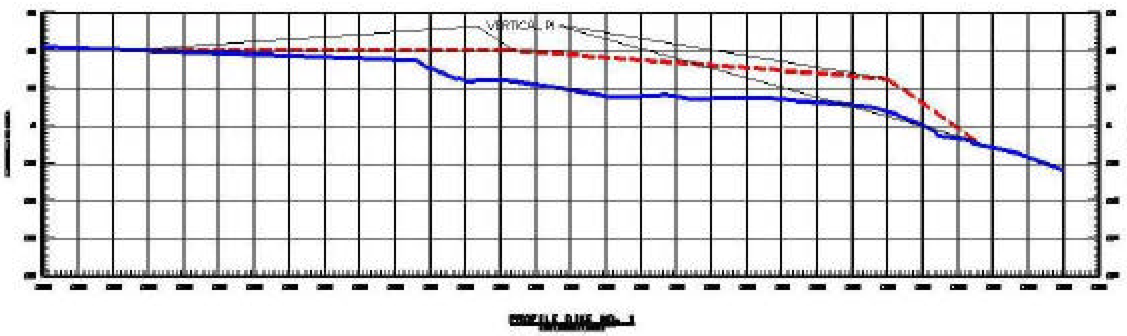
30. The total horizontal alignment should be shown on the profile. Use Microstation Place Line command to draw the outline of the dike on the horizontal profile.

31. Select InRoads Main Menu **File, Geometry, New**, for the following tutorial:



Select Vertical Alignment, Arc Definition is Parabola, name the alignment, give description, then Apply.

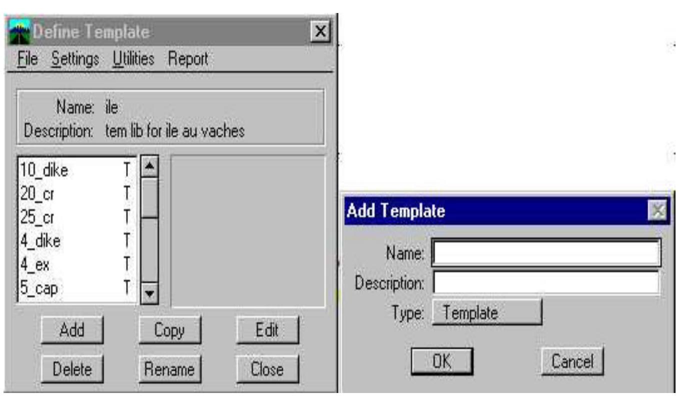
32. Select InRoads Main Menu **Palettes, Vertical Edit, Add Vertical PI**.



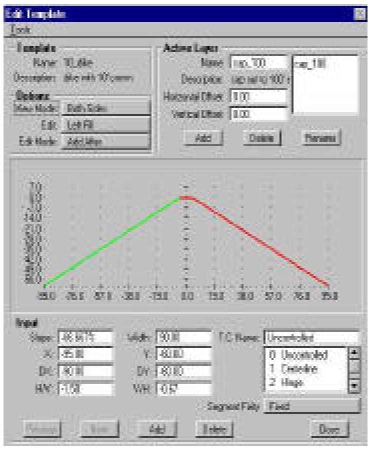
Add a vertical PI at the start, at each breakpoint, and at the end of the dike outline placed in Step 5.

33. Select InRoads Main Menu **Utilities, Review Alignment, All Vertical**. Identify the vertical alignment with a data point and a dialog box will show the vertical PI stationing.

34. Select InRoads Main Menu **Palettes, Design Roadway, Define Template**, to design dike template.

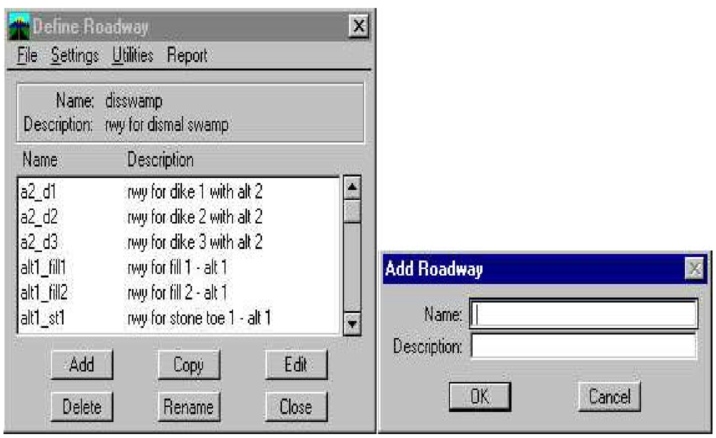


Select Add, assign name and description, then OK. Select the template just created then Edit.

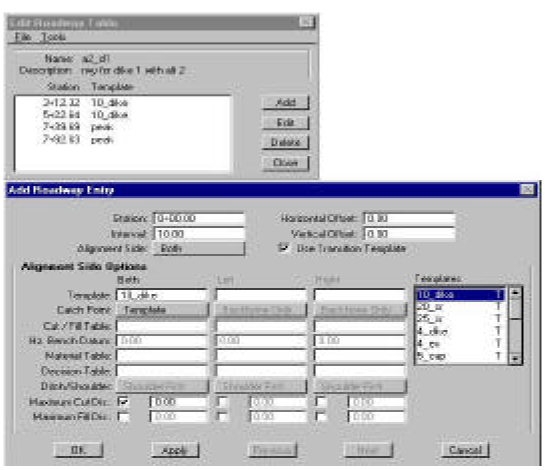


Assign dike crown to left and right backbone and extend left and right fill to ensure intersect with original ground surface when roadway modeler is executed. Note: There are other methods available to obtain the desired dike template.

35. Select InRoads Main Menu **Palettes, Design Roadway, Define Roadway**, to set the stationing of the template.

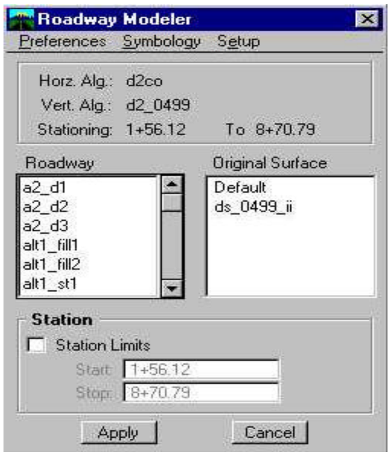


Select Add, assign name and description, then OK. Select the roadway just created then Edit.



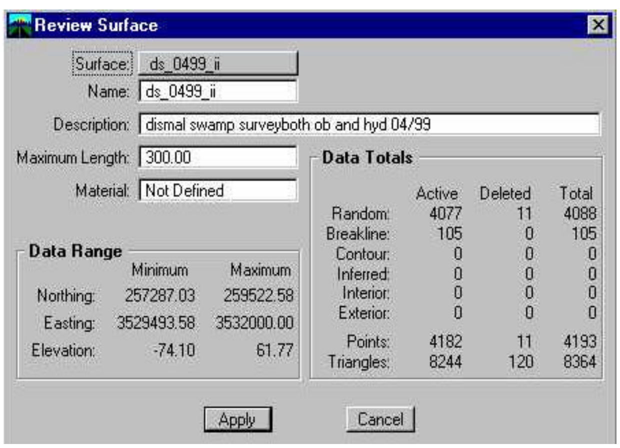
Select Add, for Add Roadway Entry. Enter Station, Interval, and Offset. Select Template from list. Enter Catch Point as template and Maximum Cut Dis. as zero, then OK. Do the same entries for each station needed.

36. Select InRoads Main Menu **Palettes, Design Roadway, Roadway Modeler.**



Select Roadway from Step 10 and Original Ground surface then Apply. A dike surface has been created along the horizontal alignment and to the limits of the vertical alignment. The surface has been assigned the name given to the Active Layer, Edit Template dialog box shown in Step 9.

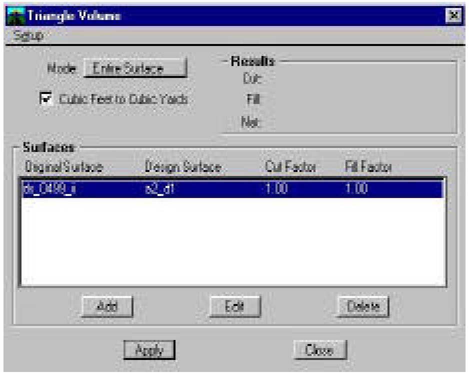
37. Select InRoads Main Menu **Utilities, Review Surface**. The following dialog box will allow the surface name to be changed, if needed.



Surface name is same as the Active Layer, Edit Template dialog box shown in Step 9. Name and Description is changed as needed.

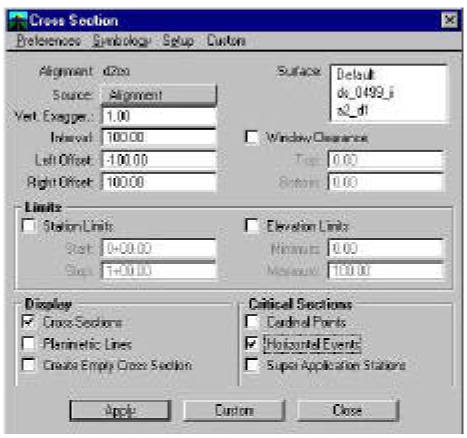
38. Select InRoads Main Menu **File, Surface, Save As** to save file to appropriate directory.

39. Select InRoads Main Menu **Palettes, Volumes, Triangle Volume** for surface comparison.



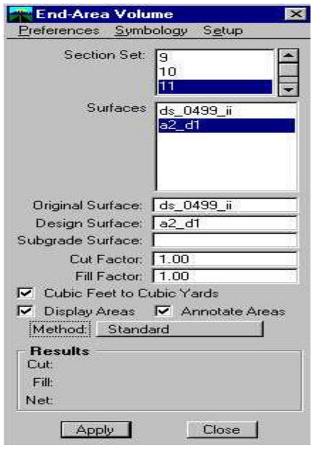
Select Add, choose Original Surface and Design Surface just created in Step 11. These surfaces will be shown in the dialog box. Highlight with data point as shown above, then Apply. The surfaces will be compared and the volume of stone required will be shown.

40. To compare surfaces using cross sections InRoads Main Menu **Palettes, Cross Section, Cross Section**.



Alignment should be the current horizontal alignment and Source is alignment. Use Preferences to choose desired grid scale. Insert desired Vert. Exaggeration and Interval. Insert the Left and Right Offset for the desired cross section length. Surface should be both the original surface and the dike surface created in Step 11. Display is set to Cross Sections, Critical Sections to Horizontal Events, then Apply. Place a data point within the design file and the cross section group will be displayed.

41. For cross section volume, Select InRoads Main Menu **Palettes, Volumes, End-Area Volume**.



Select Section Set, and Original Surface and Design Surface from Surface list. If desired, check Cubic Feet to Cubic Yards, Display Areas, and Annotate Areas. Select Setup, Report, and ASCII Report to enter report name and directory, then Apply. The surfaces on the cross sections will be compared and the needed volume of stone will be recorded under Fill. The report can then be imported in to Excel or a similar spreadsheet for editing.

42. Dike configurations can be change by modifying the current template or copying the template to another name and modifying the copied template. This can be done by choosing the Add and/or Edit Command shown in Step 9.

43. All or portions of the dike can be moved horizontally and/or vertically by use of the horizontal and vertical offset shown in Step 10, Edit Roadway Entry. To move the dike template to the left of the alignment, use a negative number for the horizontal offset, and a positive number for a right horizontal offset. Likewise, use a negative number in the vertical offset to move the dike template below the alignment elevation, and a positive number in the vertical offset to move the template above the alignment elevation. To move the alignment permanently, the PI's for the horizontal alignment can be moved by **Palettes, Horizontal Edit, Move Horizontal PI**, and the PI's for the vertical alignment can be moved by **Palettes, Vertical Edit, Move Vertical PI**.

RELATED APPLICATIONS:

In addition to designing and estimating quantities for dikes, this procedure can be used for road and levee design.

Solution 2.3

Application
InRoads
InRoads SelectCAD

Layout of Channel Excavation with Multiple Intersections of Existing Ground Line

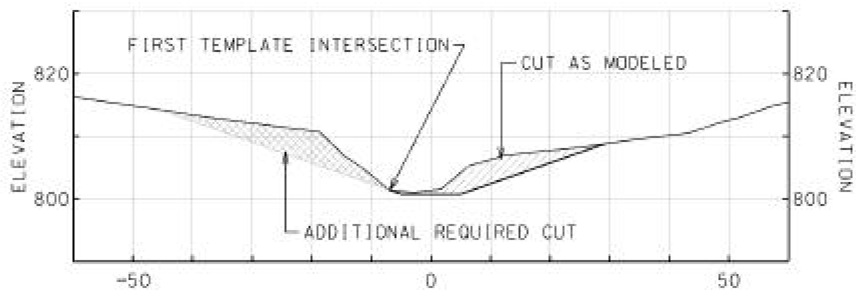
DESCRIPTION OF PROBLEM:

When an InRoads template is used for creating a channel cut, there are situations where the outslope of the channel may intersect the existing ground line several times. In these situations the template will terminate the slope at the first intersection with the ground surface. If the design requires that the channel slope be carried beyond the first intersection with the ground, the problem exists in getting InRoads to ignore the first intersection, in order to search for a second (or third) intersection with the existing slope.

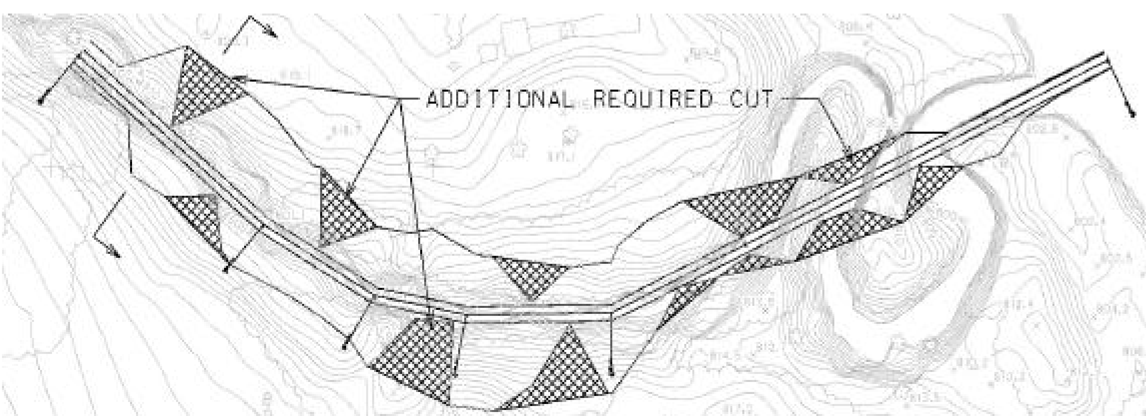
This solution provides the method for directing InRoads to continue the slope of a channel template beyond the first intersection with the ground.

DISCUSSION:

Often, in channel modification for a flood control project, an existing stream channel is reshaped to provide larger capacity, cleaner flow lines, and stable channel slopes. The standard tools for designing the channel cut in InRoads are templates, however there are conditions where a template does not deliver the desired result. One such condition is when the existing channel has very steep, benched, or undercut banks. When this condition is present, a simple InRoads template often produces an incorrect top of slope line because it stops at the first intersection that it finds with the existing ground. An example of this condition is shown in the plan and section below.



Typical Section



Plan View

DESIGN SOLUTION:

Method 1 -- Graphical.
If the sections which prematurely intersect the ground surface are relatively few, and the reach being designed is short, a graphical solution can be used. This solution makes use of the InRoads **Cross Section to Surface** command to modify each errant section found. The desired channel template is used to generate an initial design surface using **Roadway Modeler**, sections of the existing and design ground surfaces are displayed, and each section is inspected, and corrected to intersect the existing ground at the proper location. Finally, the modified sections are used to recreate the design surface correctly, using **Cross Section to Surface**.

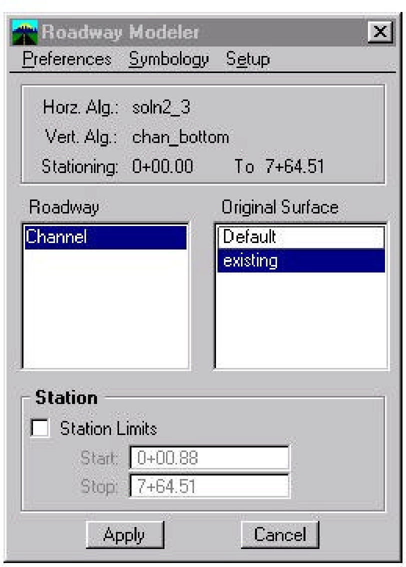
Method 2 -- Decision Table.
When a long reach is being designed, and there are numerous sections which incorrectly intersect with the existing groun, a decision table may be used to define the highest intersection of the channel cut slope with the existing ground line. The decision table is set up to test each section for an intersection of the slope with the ground surface, beginning with a slope purposely long. The decision table seeks the ground surface with incrementally shorter outslopes, until it finds one which intersects the existing ground. The first intersection it locates will be the last, or "highest" intersection of the slope with the ground.

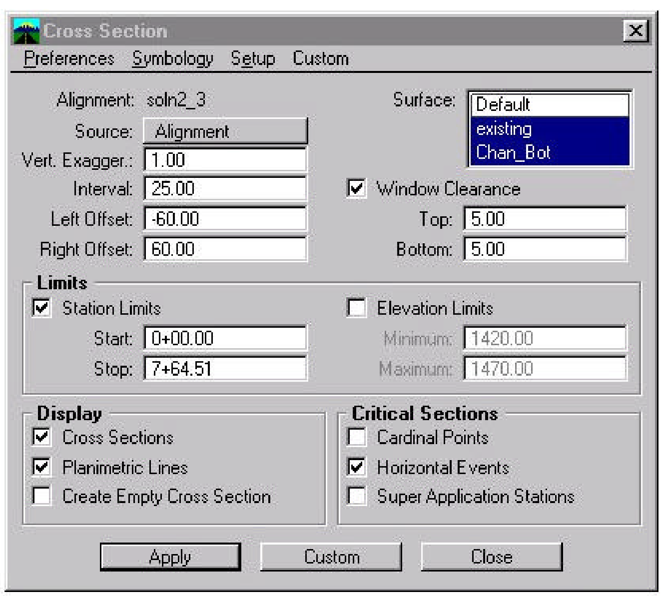
SOLUTION PROCEDURE:

Method 1 -- Graphical. *(Filenames included in the procedure are for the example provided).*

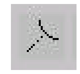
10. Load the existing ground surface DTM, the geometry representing the horizontal and vertical alignments for the channel, the template library, and the project roadway library. For the example they are:
    Existing Ground Surface DTM = 2_3exist.dtm
    Geometry File = sol2_3.alg
    Template Library = sol2_3.tml
    Roadway Library = sol2_3.tml

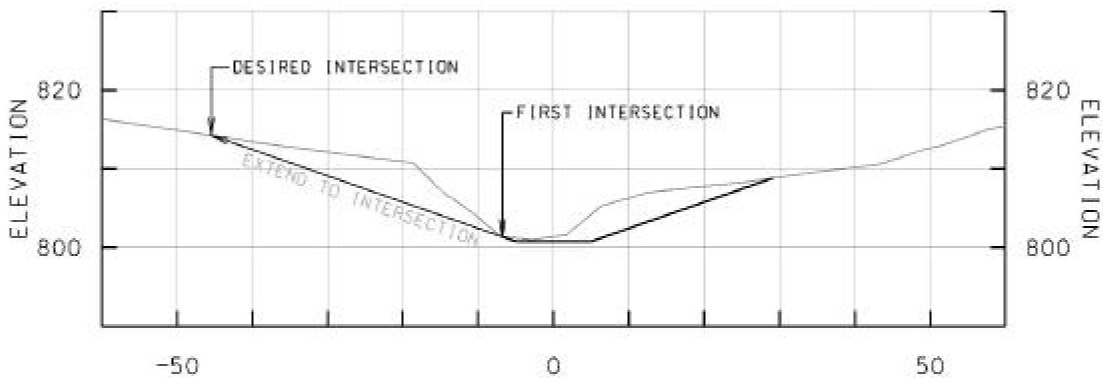
11. Select **Palettes > Design Roadway > Roadway Modeler**, run the roadway modeler to create the design surface, and display the channel cut lines. Select "Channel" and "existing" for Roadway and Original Surface respectively, as shown in the palette view below, and **Apply**.



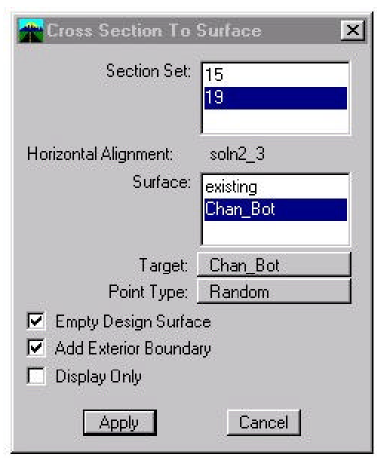


12. Select **Palettes > Cross Section > Cross Section**, and set up the fields as shown in the pallate view above. Make sure that the "Interval" shown matches the interval used to place the templates within the roadway modeler run. Select **Appy**, and select a data point in the design file to display the cross sections.

13. Viewing each cross section individually, use the MicroStation command  **Extend Element to Intersection** to extend each design channel section to meet the existing ground line at the point desired. An example section is shown below.



14. Once all of the cross sections have been adjusted to intersect the ground line at the correct location, select **Palettes > Cross Section > Cross Section to Surface**. Select the section set that represents the corrected cross sections *(note: sets are numbered in order of creation, with the highest number representing the last section set produced).* Select the surface name of the channel design surface that is being modified (in this example, "Chan_bot"). **Target** is the surface that the corrected DTM will be created in, and can either be the same as the original surface, or can be any of the other surfaces loaded. Use random point type. The **Empty Design Surface** toggle will delete all previous DTM data from that surface name, and should be used any time the data is being directed to a surface that has previously loaded data on it Enable **Add Exterior Boundary**. **Display Only** acts as a "reverse write lock", and may be used if you would like to review the results of your changes, without actually re-writing the previous data. **Apply** the dialog box.



15. Select **Palettes > Cross Section > Cross Section** and set up the dialog box to redisplay the cross sections, as in step #3 above. Review the cross sections in comparison to the original displayed set, in order to verify their accuracy.

Method 2 -- Decision Tables.

EXAMPLES/RESOURCES:

Method 1 -- Graphical.

The example that is used in the solution procedure consists of five InRoads files, that are included in the solution directory .\soln2_3\ :

soln2_3.dgn	MicroStation File containing topographic mapping
2_3exist.dtm	Existing Ground Digital Terrain Model for topographic map
soln2_3.alg	Alignment File
soln2_3.rwl	Roadway Library File
soln2_3.tml	Template Library File

RELATED APPLICATIONS:

Solution 2.4

Application
InRoads
InRoads SelectCAD

Placement of Keyed-in or Benched Riprap

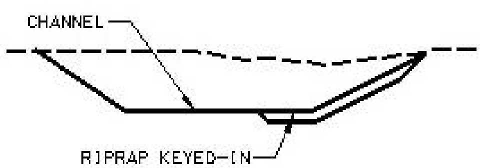
DESCRIPTION OF PROBLEM:

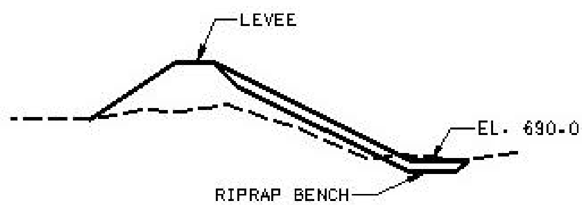
When channel or levee work is protected by riprap placed along the slope, the toe of the riprap is typically benched and keyed into the existing ground surface in order to provide a stable section. The problem laying out the section is generating a bottom of riprap surface, which properly intersects the existing and design surfaces at both ends of the section.

"This solution provides the means to generate a surface representing the bottom of the riprap layer.

DISCUSSION:

In order to accurately represent the riprap in section, and provide for quantity calculation, a surface must be generated which represents the bottom of the keyed-in riprap. A key-in may exist for a either channel excavation or levee placement. Examples are shown below. It is desireable to have the riprap surface intersect, and end exactly at, the design surface and existing ground surface respectively.





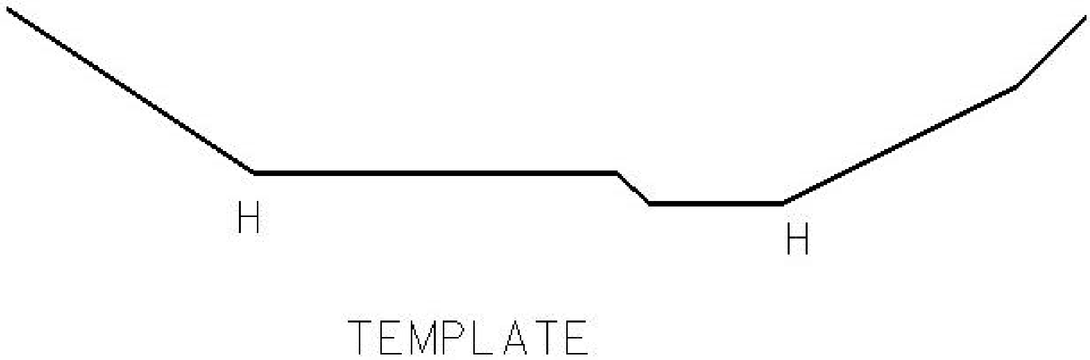
DESIGN SOLUTION:

The solution for both design situations is in the use of a decision table. The excavation and fill conditions are handled slightly different because of the starting point. For channel excavation, the starting point is near the bottom of the slope. For a levee, the starting point is near the top of the slope. The roadway modeler is used in both conditions to develop the DTM from the template and decision table.

SOLUTION PROCEDURE:

16. Load the surface representing the existing condition, the design situation, the geometry representing the horizontal alignment and the vertical alignment of the levee, the project template library [english.tml], and the project roadway library.

17. For channel excavation, start at the bottom. First Select **Palettes** > **Design Roadway** > **Define Template**. Select Add. Within the Add Template dialog box, type in the name of the template and a description and toggle the type to template. Then select **OK**. Within the Define Template dialog box, hilight the template that was just created and select **Edit**. Edit the template such that the hinge is at the bottom of the channel slope as shown below. Select **Close**. Select **File > Save**.

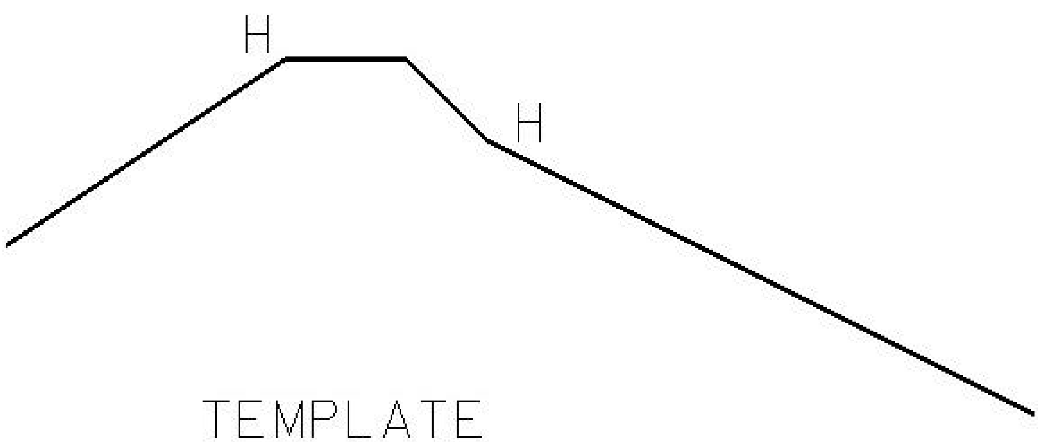


18. Select **Palettes** > **Design Roadway** > **Define Template**. Select Add. Within the Add Template dialog box, type in the name of the decision table and a description and toggle the type to decision table. Then select **OK**. Within the Define Template dialog box, hilight the decision table that was just created and select **Edit**. Within the Edit Decision Table dialog box, select **+after**. Edit the Add Decision Table Record such that the final decision table has entries as shown below. Select **Close**. Select **File > Save**.

Decision Table

Hinge	Cut	-33.333%	500.00	*	*	*	*	DTM	orig	-5.80
Cut	Shoulder	50.000%	500.00		*	*	*	DTM	MAIN	0.00

19. For a levee, start at the top. First Select **Palettes** > **Design Roadway** > **Define Template**. Select Add. Within the Add Template dialog box, type in the name of the template and a description and toggle the type to template. Then select **OK**. Within the Define Template dialog box, hilght the template that was just created and select **Edit**. Edit the template such that the hinge is near the top of the levee slope as shown below. Select **Close**. Select **File > Save**.



20. Select **Palettes** > **Design Roadway** > **Define Template**. Select Add. Within the Add Template dialog box, type in the name of the decision table and a description and toggle the type to decision table. Then select **OK**. Within the Define Template dialog box, hilight the decision table that was just created and select **Edit**. Within the Edit Decision Table dialog box, select **+after**. Edit the Add Decision Table Record such that the final decision table has entries as shown below. Select **Close**. Select **File > Save**.

Decision Table

Hinge	Cut	-33.333%	500.00	*	*				*	Fixed El.	690.00	0.00
Cut	Bench	-33.333%	6.70				*	*	*	Fixed El.	690.00	0.00
Bench	Fill	0.000%	12.70				*	*	*	Fixed El.	690.00	0.00
Fill	Shoulder	50.000%	500.00			*		*	*	DTM	MAIN	0.00

21. Select **Palettes > Design Roadway > Define Roadway**. Select **Add**. Within the Add Roadway dialog box, type in the name of the roadway and a description. Then select **OK**.

22. Within the Define Roadway dialog box, hilight the roadway that was just created and select **Edit**. Within the Edit Roadway Table dialog box, select **Add**. Within the Add Roadway Entry dialog box, type in the beginning station, the interval distance and the vertical offset. Toggle the alignment side to both or left and right which ever is applicable. Select the template for both sides. Toggle decision table for both sides and enter in the decision table name. Select **Apply**. Select **Cancel**. Within the Define Roadway dialog box, select **Close**. Select **File > Save**.

23. Select **Palettes > Design Roadway > Roadway Modeler**. Within the Roadway Modeler dialog box, hilight the roadway and the original surface and select **Apply**.

EXAMPLES/RESOURCES:

Template library - english.tml

RELATED APPLICATIONS:

Solution 2.5

Application
InRoads
InRoads SelectCAD

Generating Topsoil Surface

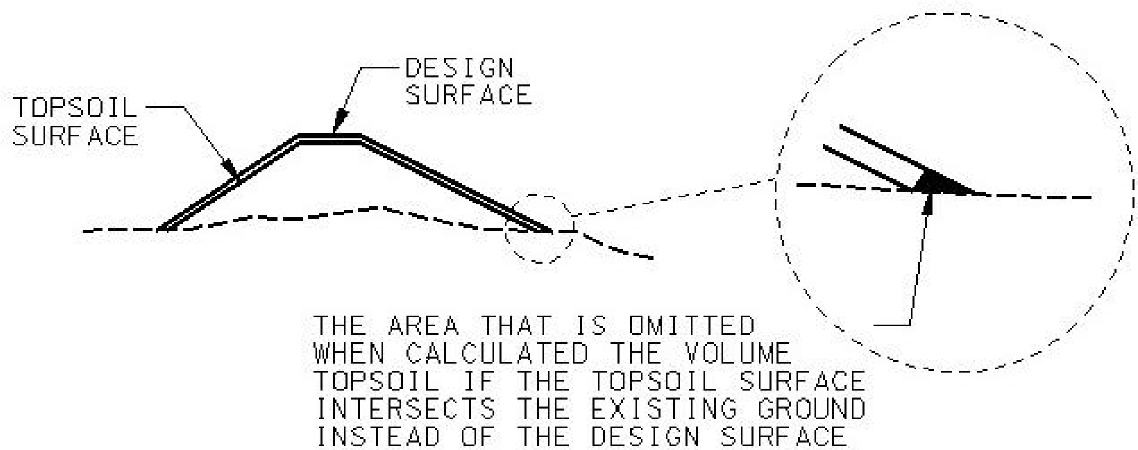
DESCRIPTION OF PROBLEM:

The problem is generating a topsoil surface that intersects with the design surface.

"This solution provides the means to generate a surface representing the bottom of the topsoil layer which will calculate a true volume of topsoil when calculated against the design surface.

DISCUSSION:

The problem is generating a topsoil surface that intersects with the design surface. It's easy to generate a topsoil layer that intersects with the existing ground surface and in section view, it looks correct. But when the volume is calculated between the design surface and the topsoil surface, it misses a small corner of topsoil. See example below. The topsoil surface needs to intersect with the design surface to get a true calculation of the volume.



DESIGN SOLUTION:

The answer is to have the topsoil surface intersect the design surface by using a decision table. Then the roadway modeler will be used.

SOLUTION PROCEDURE:

24. Load the surface representing the existing condition, the geometry representing the horizontal alignment and the vertical alignment of the levee, the project template library [english.tml], and the project roadway library.

25. Create a template for the topsoil layer. Select **Palettes > Design Roadway > Define Template**. Select **Add**. Within the Add Template dialog box, type in the name of the template and a description and toggle the type to template. Then select **OK**. Within the Define Template dialog box, hilight the template that was just created and select **Edit**. Define

the topsoil top width (which is less than the levee top width) as the backbone and the side slopes as the cut and fill. Select **Close**. Select **File > Save**.

26. Select **Palettes** > **Design Roadway** > **Define Template**. Select Add. Within the Add Template dialog box, type in the name of the decision table and a description and toggle the type to decision table. Then select **OK**. Within the Define Template dialog box, hilight the decision table that was just created and select **Edit**. Within the Edit Decision Table dialog box, select **+after**. Edit the Add Decision Table Record such that the final decision table has entries as shown below. Select **Close**. Select **File > Save**.

Decision Table

Hinge	Cut	-33.333%	500.00	*	*	*	*	DTM	orig	0.00
Cut	Bench	0.000%	500.00		*	*	*	DTM	MAIN	0.00
Hinge	Cut	-33.333%	500.00	*	*	*	*	DTM	orig	0.00
Cut	Bench	5.000%	500.00		*	*	*	DTM	MAIN	0.00

27. Select **Palettes > Design Roadway > Define Roadway**. Select **Add**. Within the Add Roadway dialog box, type in the name of the roadway and a description. Then select **OK**.

28. Within the Define Roadway dialog box, hilight the roadway that was just created and select **Edit**. Within the Edit Roadway Table dialog box, select **Add**. Within the Add Roadway Entry dialog box, type in the beginning station, the interval distance and the vertical offset. Toggle the alignment side to both. Select the template for both sides. Toggle decision table for both sides and enter in the decision table name. Select **Apply**. Select **Cancel**. Within the Define Roadway dialog box, select **Close**. Select **File > Save**.

29. Select **Palettes > Design Roadway > Roadway Modeler**. Within the Roadway Modeler dialog box, hilight the roadway and the original surface and select **Apply**.

EXAMPLES/RESOURCES:

Template library = english.tml

RELATED APPLICATIONS:

Solution 2.6.A.

Application
InRoads
InRoads SelectCAD

Ramps along a Slope (Channel or Levee)
Method A -- Simplified

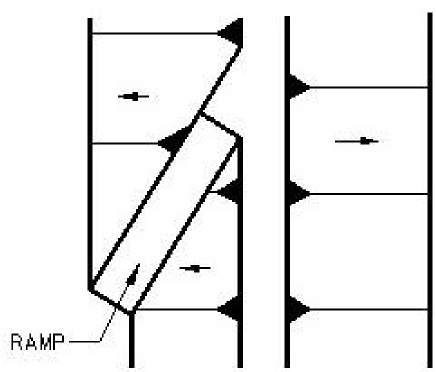
DESCRIPTION OF PROBLEM:

The design problem is having a ramp running off of or onto a levee or coming in or out of a channel. This ramp, for example, could be a maintenance road or a recreational trail. A single template will not work in this situation because the elevation of the ramp changes as it moves along the slope.

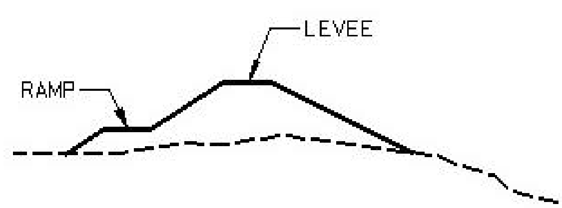
"This solution provides the means to draw a ramp along a slope in plan view.

DISCUSSION:

The design includes a recreational trail along the top of levee and the trail has entrance/exit points along the levee. The design could be used in many instances. The figures below show this in plan and section view. One single template can not be used to define this situation since the distance from the ramp to the levee changes as the elevation of the ramp changes.



PLAN



SECTION

DESIGN SOLUTION:

A simplified answer is to define the horizontal and vertical alignment of the top of levee. Then define two additional templates to be used at the beginning and end of the ramp. The roadway modeler will be used.

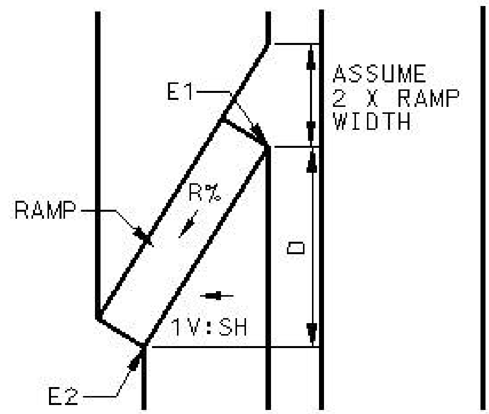
SOLUTION PROCEDURE:

30. Load the surface representing the existing condition, the geometry representing the horizontal alignment and the vertical alignment of the levee, the project template library, and the project roadway library.

31. Choose in plan view where the ramp is to begin (the top.)
    Slope of the ramp = R
    Side slope of the levee = S

Elevation of the top of levee where the ramp begins = E1
Elevation of the existing topography where the ramp is to end = E2
Distance along the levee between the beginning and the end of the ramp = D

$$D = (E1 - E2)\sqrt{(R/100)^2 - S^2}$$

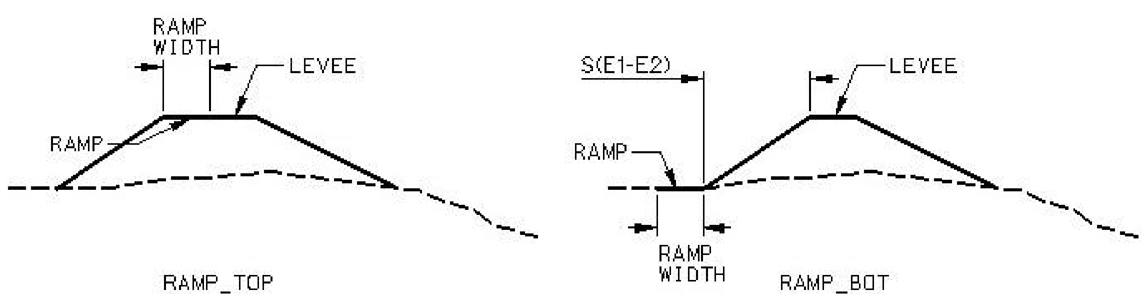


32. Select **Palettes > Design Roadway > Define Template**. Select **Add**. Within the Add Template dialog box, type in the name of the template [10_3] and a description and toggle the type to template. Then select **OK**.

33. Within the Define Template dialog box, hilight the template that was just created and select **Edit**. Define the levee top width as the backbone and the side slopes as the cut and fill. Select **Close**. Select **File > Save**.

34. Select **Palettes > Design Roadway > Define Template**. Select **Add**. Within the Add Template dialog box, type in the name of the template [ramp_top] and a description and toggle the type to template. Then select **OK**.

35. Within the Define Template dialog box, hilight the template that was just created and select **Edit**. Define the levee top width on one side as the backbone. Define the levee top width and ramp width (at the top of the slope) on the other side as the backbone. Define the side slopes as the cut and fill. Below shows an example. Select **Close**. Select **File > Save**.



36. Select **Palettes > Design Roadway > Define Template**. Select **Add**. Within the Add Template dialog box, type in the name of the template [ramp_bot] and a description and toggle the type to template. Then select **OK**.

37. Within the Define Template dialog box, hilight the template that was just created and select **Edit**. Define the levee top width on one side as the backbone. Define the levee top width and ramp width (at the bottom of the slope) on the other side as the backbone. Define the side slopes as the cut and fill. See example above. Select **Close**. Select **File > Save**.

38. Select **Palettes > Design Roadway > Define Roadway**. Select **Add**. Within the Add Roadway dialog box, type in the name of the roadway and a description. Then select **OK**.

39. Within the Define Roadway dialog box, hilight the roadway that was just created and select **Edit**. Within the Edit Roadway Table dialog box, select **Add**. Within the Add Roadway Entry dialog box, type in the beginning station and the interval distance. Toggle the alignment side to both. Select the template (10_3). Select **Apply**. Repeat for a station that is twice the ramp width before the start of the ramp. Select **Apply**. Type in the beginning station of the ramp and the interval distance. Toggle the alignment side to left and right side. Select the template (10_3) for the right side and the template (ramp_top) for the left side. (Reverse sides if necessary.) Make sure that the toggle Use Transition Template is on. Select **Apply**. Type in the end station of the ramp and the interval distance. Toggle the alignment side to left and right side. Select the template (10_3) for the right side and the template (ramp_bot) for the left side. (Reverse sides if necessary.) Make sure that the toggle Use Transition Template is on. Select **Apply**. Type in the end station of the ramp plus 10' and the interval distance. Toggle the alignment side to both. Select the template (10_3). Select **Apply**. Select **Cancel**. Within the Define Roadway dialog box, select **Close**. Select **File > Save**.

40. Select **Palettes > Design Roadway > Roadway Modeler**. Within the Roadway Modeler dialogs box hilight the roadway and the original surface and select **Apply**.

EXAMPLES/RESOURCES:

RELATED APPLICATIONS:

Solution 2.6.B.

Application
InRoads
InRoads SelectCAD

Ramps along a Slope (Channel or Levee)
Method B -- Detailed

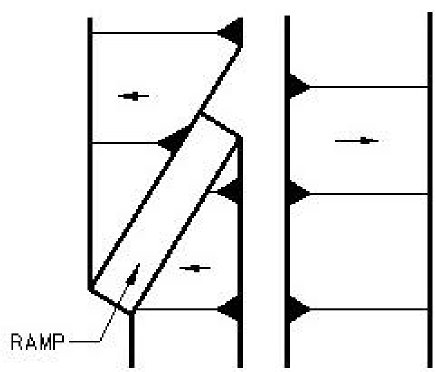
DESCRIPTION OF PROBLEM:

The design problem is having a ramp running off of or onto a levee or coming in or out of a channel. This ramp, for example, could be a maintenance road or a recreational trail. A single template will not work in this situation because the elevation of the ramp changes as it moves along the slope.

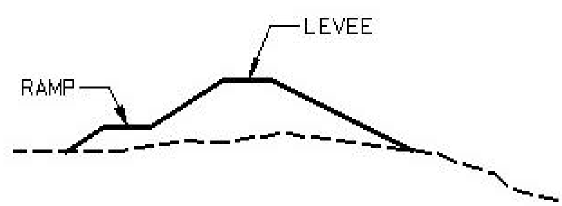
"This solution provides the means to draw a ramp along a slope in plan view.

DISCUSSION:

The design includes a recreational trail along the top of levee and the trail has entrance/exit points along the levee. The design could be used in many instances. The figures below show this in plan and section view. One single template can not be used to define this situation since the distance from the ramp to the levee changes as the elevation of the ramp changes.



PLAN



SECTION

DESIGN SOLUTION:

The answer is to first define a horizontal and vertical alignment for the top of levee. Then define a horizontal alignment for the ramp such that it lies along the slope of the levee. After defining the vertical alignment for the ramp and creating a ramp template, then the roadway modeler will be used.

SOLUTION PROCEDURE:

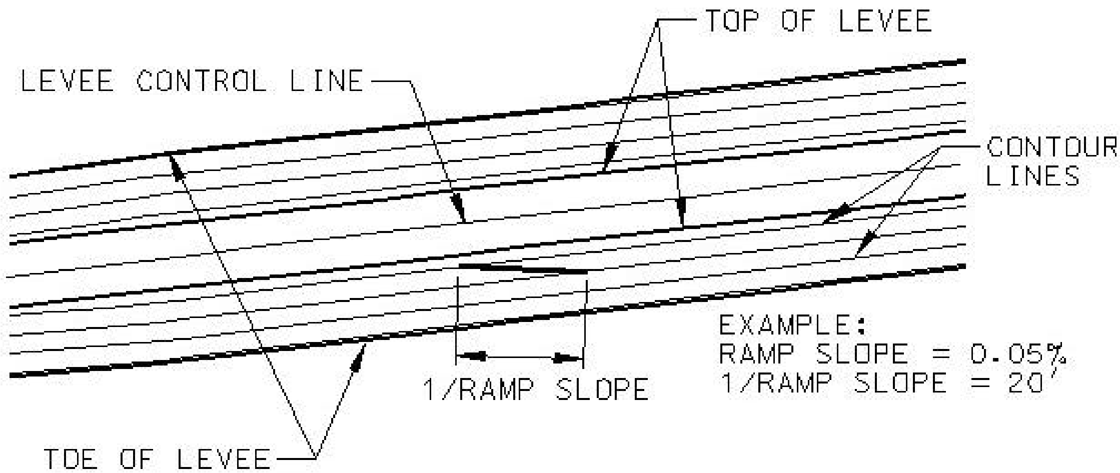
41. Load the surface representing the existing condition, the geometry representing the horizontal alignment and the vertical alignment of the levee, the project template library, and the project roadway library.

42. Load the design surface, if one exists, without the ramp in place, create a design surface

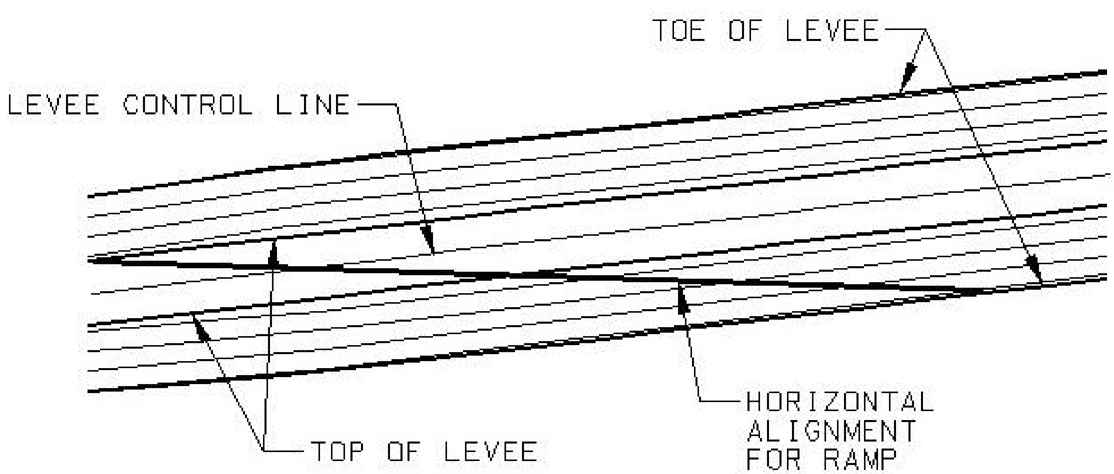
without the ramp in place, or do the following step to layout a basic levee. Select **Palettes > Design Roadway > Define Template**. Select **Add**. Within the Add Template dialog box, type in the name of the template and a description and toggle the type to template. Then select **OK**. Within the Define Template dialog box, hilight the template that was just created and select **Edit**. Define the levee top width as the backbone and the side slopes as the cut and fill. Select **Close**. Select **File > Save**. Select **Palettes > Design Roadway > Roadway Modeler Express**. Within the Roadway Modeler Express dialogs box hilight the horizontal alignment, vertical alignment, template, and the original surface. Type in the interval and select **Apply**.

43. Select **View > Contours**. Within the View Contours dialogs box, select the design surface. Select **Apply**.

44. Next, a horizontal alignment will be created for the ramp. In the vicinity of where the ramp is to be located, draw a line that is equal in length to the inverse of the ramp slope. The line should go from one contour line to the next contour line. See example below.

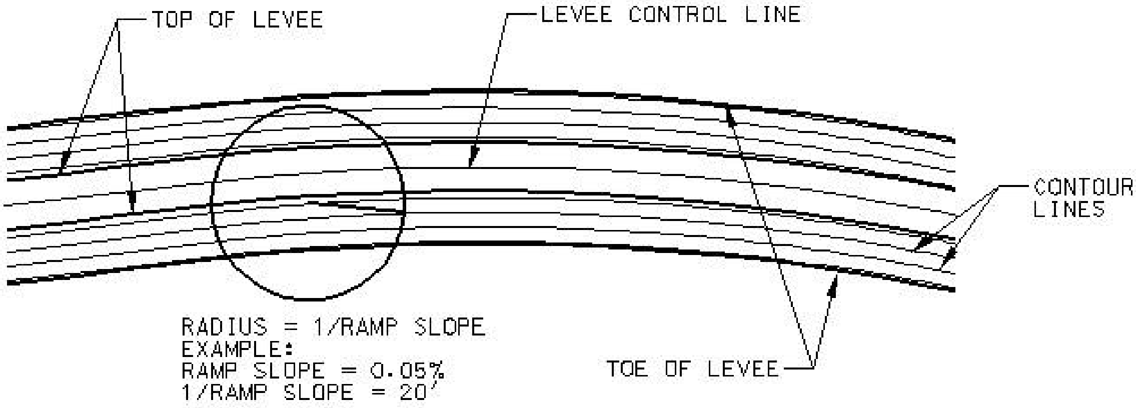


45. Extend the line to the control line of the levee and the toe of the levee. This line will be the horizontal alignment for the ramp along a straight line. See example below. Delete the contours.

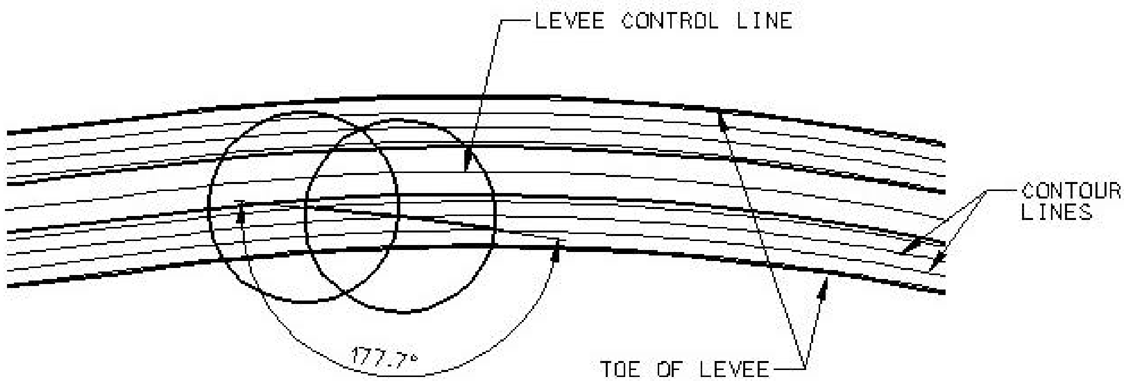


46. If the ramp falls along a curve of the levee, then there are a few different steps. Instead of

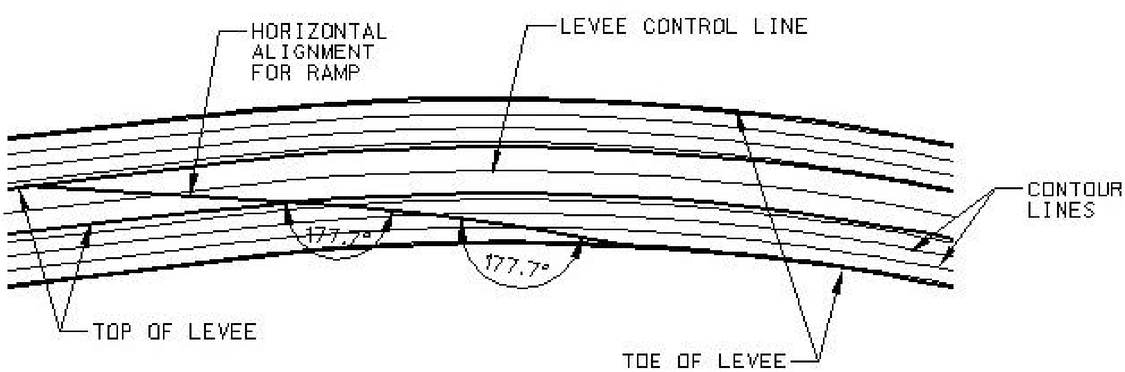
drawing a line, place a circle with a radius equal to the inverse of the ramp slope. Draw a line from the center of the circle to the edge of the circle where the circle crosses the next contour line. See example below.



47. Repeat the above step with another circle placing it at the end of the new line. Draw another line from the end of the first line to the point at which the circle crosses the next contour line. Measure the angle between the two new lines. See example below.



48. Draw the remaining lines using the angle measured. Draw the lines so that there is a continuous line from the levee control line to the toe of the levee. This line will be the horizontal alignment for the ramp along a curve. See example below. A combination of the two may also be used. Delete the contours.

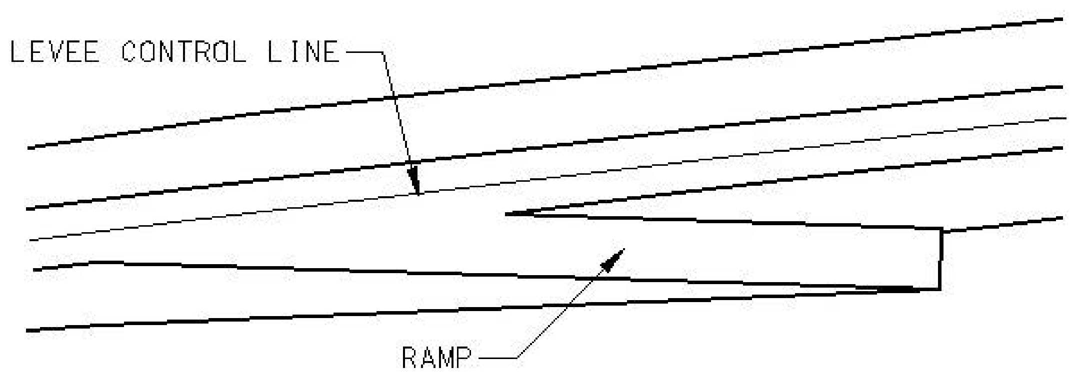


49. Select **File > Geometry > New**. Toggle Select to Horizontal Alignment and type in the fields for name and description as desired. Select **Apply**. Create a new horizontal alignment along the line drawn above (Select **Palettes > Horizontal Edit > Add PI**.) Select **File > Geometry > Save**.

50. Select **Palettes > Design Roadway > Define Template**. Select **Add**. Within the Add Template dialog box, type in the name of the template and a description and toggle the type to template. Then select **OK**. Within the Define Template dialog box, hilight the template that was just created and select **Edit**. Define the ramp width as the right backbone and the side slopes as the cut and fill. Select **Close**. Select **File > Save**.

51. Select **Palettes > Design Roadway > Roadway Modeler**. Select **Setup** > **Roadway**. Toggle side to Right and Select **OK**. Select **Cancel** in the Roadway Modeler dialog box. Select **Palettes > Design Roadway > Roadway Modeler Express**. Within the Roadway Modeler Express dialogs box hilight the horizontal alignment, vertical alignment, template, and the original surface. Type in the interval and select **Apply**.

52. The drawing needs to be cleaned up. Partial delete the toe of the levee that falls within the ramp area. See the finished ramp in the example below.



EXAMPLES/RESOURCES:

RELATED APPLICATIONS:

Civil/Site Solutions Manual

Section 3 -- Embankment Dams

This section provides solution for problems commonly encountered in the design and layout of embankment dams and other large earthen structures.

Section 3 -- Contents

Civil/Site Solutions Manual

Section 4 -- Tunnel Excavation Layout

This section provides solutions for layout problems that are encountered in the development of underground excavation designs.

Section 4 -- Contents

Civil/Site Solutions Manual

Section 5 -- Roadways and Super Elevation

This section provides design solutions that streamline the Civil/Site design process for laying out simple roadways, and for more complex designs that utilize super elevation of road surfaces at curves.

Section 5 -- Contents

Solution 5.2

Simple Superelevated Curve

Application
InRoads
InRoads SelectCAD

DESCRIPTION OF PROBLEM:

This solution provides the steps to layout a simple superelevated curve in plan view and provides a three-dimensional surface representing the design.

DISCUSSION:

DESIGN SOLUTION:

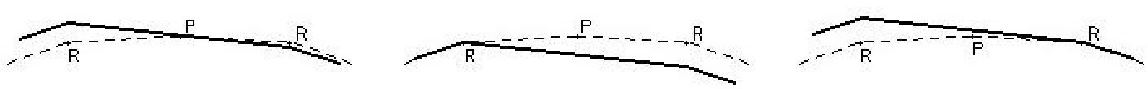
The layout of a simple superelevated curve is defined using **Palette** > **Superelevation** > **Superelevation Rate Calculator** and **Palette** > **Superelevation** > **Build Application Stations**.

SOLUTION PROCEDURE:

44. Load the horizontal geometry which also has a vertical geometry defined.

45. Select **File** > **Geometry** > **New**. Within the **New Geometry** dialog box, **Select** superelevation and type in a **Name** (*super1)*. Select **Apply**.

46. Select **Palettes** > **Design Roadway** > **Define Template**. **Add** a template and **Edit** that template to represent your typical road cross-section. Select **Tools** > **Set Super 1 Range Point**. Define the two points on the template in which the superelevation will occur. Do this by accepting the points on the screen. Select **Tools** > **Set Super 1 Pivot Point**. Define the point that keeps the same elevation if superelevation didn't occur. Below show some examples.



THE ORIGINAL (NON-SUPERELEVATED) ROAD IS SHOWN WITH A DASHED LINE.

47. Select **Palette** > **Superelevation** > **Superelevation Rate Calculator**. Select **Settings** > **Rate Parameters**. Set Parameters. Use **AASHTO Method 1,** select parameters, ignore curvature limits, and select **Close**. Select **OK** and **OK**.

48. Select **Palette** > **Superelevation** > **Build Application Stations**. Verify alignments and stations and select **Apply**, **OK**, and **Close**.

49. Select **Palette** > **Design Roadway** > **Roadway Modeler**. Set Roadway, surface, station limits (if applicable), and select **Apply**.

50. Select **File** > **Surface** > **Save As**.

RELATED APPLICATIONS:

Civil/Site Solutions Manual

Section 6 -- Utility Layout

This section provides brief tricks and design shortcuts that are applicable to most types of Civil/Site layout, and are designed to make the process of design easier and more straight forward.

Section 6 -- Contents

Solution 6.1

Application
InRoads
InRoads SelectCAD

Displaying Utilities on Profiles and Cross Sections

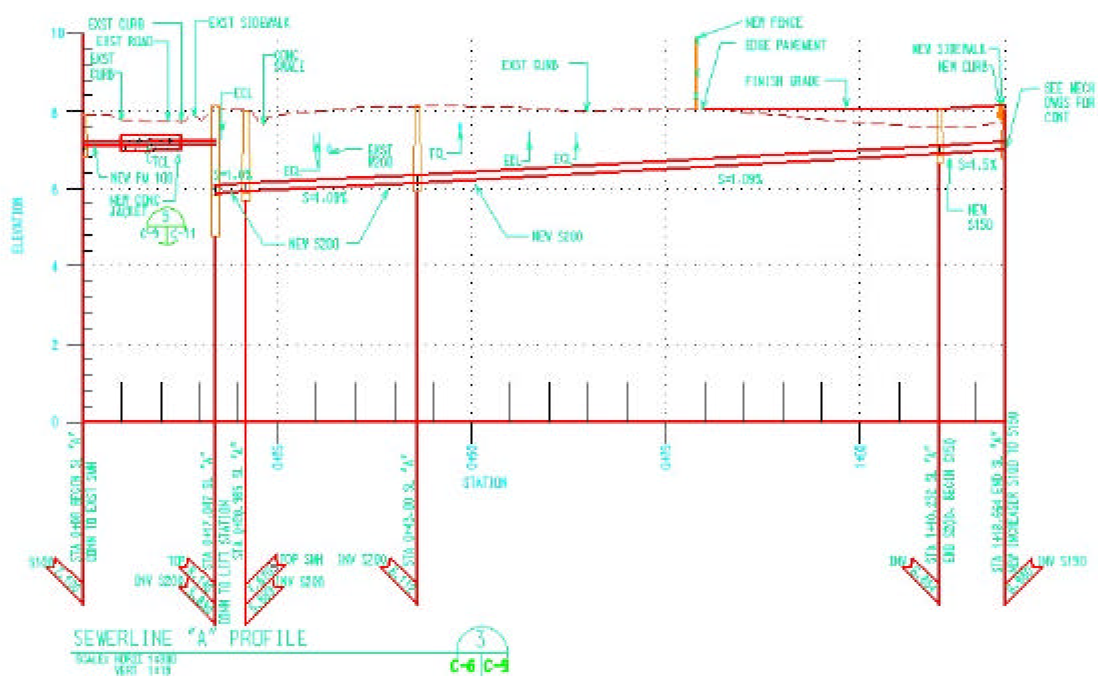
DESCRIPTION OF PROBLEM:

Civil site work designs frequently include road and utility profiles and grading cross sections. Profiles and cross sections normally indicate existing and new utility crossings. InRoads, however, does not provide a standard workflow to delineate these crossings on the profile window.

This solution provides the procedure to display the locations of the utility crossings on the profile window.

DISCUSSION:

A complete new site work design normally includes site, utility, and grading plans. In addition to these plans, profiles are frequently included in the construction plans to indicate vertical alignment requirements (as in profile view below). Profiles also serve to indicate utility crossings along the alignment. This information is need by the contractor to visualize how these crossings may affect his work. Engineers and/or technicians often expend significant effort to manually transcribe utility crossings from the plan view to the profile. InRoads provides specific tools and work flows to create and display profiles that include new existing ground lines and vertical alignment but do not provide simple solutions to indicate the utility crossings.



DESIGN SOLUTION:

The InRoads SelectCAD's user makes use of the **Evaluation>Profile>Add Feature to Profile** and **Surface>Design Surface>Drape Surface** tools to transfer the utility crossings from a surface (dtm) to a profile window. The final result will display the utility crossing locations in the profile window at the correct horizontal alignment station and elevation.

SOLUTION PROCEDURE:

1. The following files are required to be created, open and active in your InRoads environment.

a. MicroStation 3D dgn file.

b. Surface DTM that will be used to locate the utility line horizontal alignment and utility crossings.
c. Geometry Project (*.alg type file) that contains the horizontal alignment.
d. Horizontal alignment of the specific utility line that you intend to indicate utility line crossings.
e. referenced existing topographic survey *.dgn file
f. referenced site and or utility plan

2. Create a Profile Window **Evaluation>Profile>Create** using the active surface and the utility line horizontal alignment from the active geometry project. (Recommend that you should already have your desired preferences created and loaded to create an end product profile.)

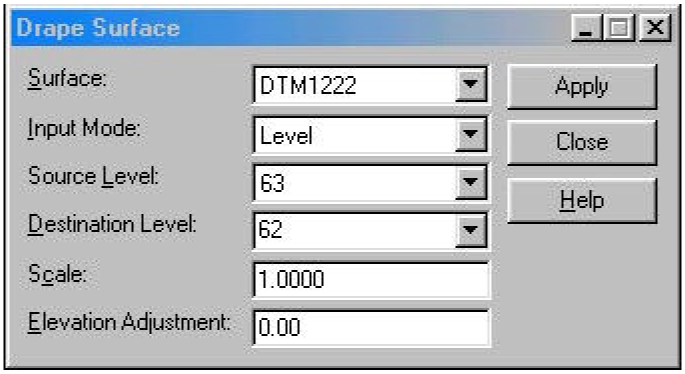
3. Using your referenced topographic survey and utility plan files annotate **all** locations of existing and new utility lines that cross the horizontal alignment of the utility line by using the **Place Smart Line Tool**. Use **Change Element Attributes** tool to select a vacant level to create the line elements.

Notes:
- To insure all utility line crossings are picked up by the **Add Feature to Profile Tool**, the line element must completely cross over the horizontal alignment.
- The active Z depth will not affect final results as the next step moves the crossing to the top of the ground surface.

4. Select **Surface>Design Surface>Drape Surface.**

5. Within the **Drape Surface** dialog box, set the following variable settings and then **Apply**:

Surface: Select surface that contains the horizontal alignment of the utility line
Input Mode: Level
Source Level: Select the level that contains the line elements used to delineate the utility crossings.
Destination Level Select a vacant level
Scale: 1
Elevation Adjustment: 0.00 (This selection will place the line elements on the active surface. For procedure to move crossing locations to the desired elevation below ground line see paragraph 11.



InRoads MDL and SelectCAD

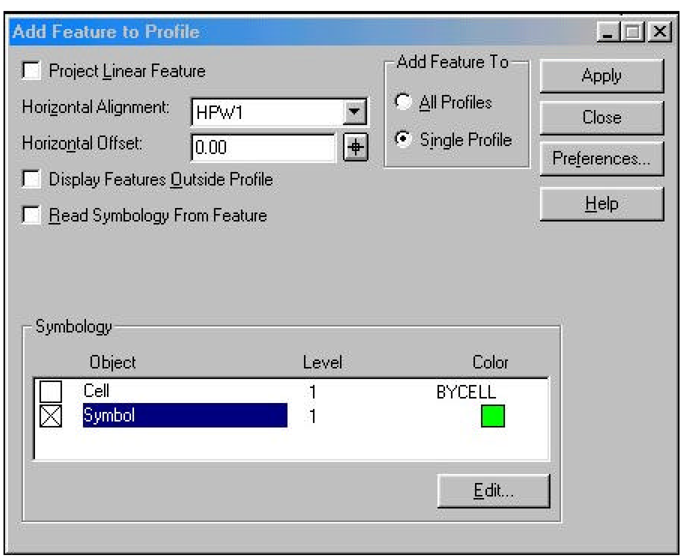
6. Select the **Analyze Element** tool to verify that the element was successfully draped to the surface.

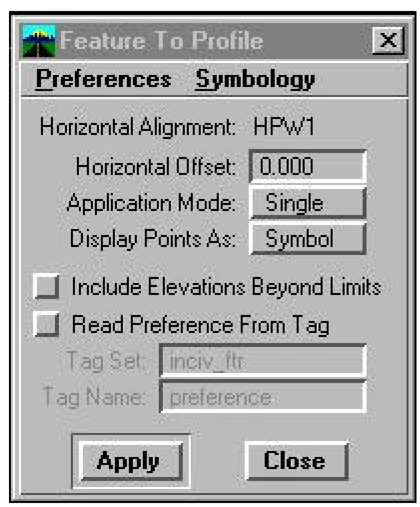
7. Select **Evaluation>Profile>Add Feature to Profile**

8. Within the **Add Feature to Profile** dialog box, set the following variable settings and then **Apply**:

Project Linear Feature: toggle off
Horizontal Alignment: Active Alignment (e.g. HPW1)
Horizontal Offset: 0.00
Display Features Outside Profile: toggle off
Read Symbology From Feature: toggle off
Add Feature To: Select Single Profile
Symbology:
Cell: toggle off
Symbol: toggle on and edit the symbology as desired. The "+" was selected because its center is readily snapped to.

9. Identify the elements by using the **Element Section** tool to select all line elements.





InRoads SelectCAD **InRoads MDL**

10. The location of the utility crossings are processed and displayed as "+"s on the existing ground surface in the profile window.

11. To move each "+" utility crossing to the desired elevation use **Move Element** Command and select either the **AccuDraw** tool or use the precision key in (dx=,,-x) to move the utility crossing to the desired elevation.

EXAMPLES/RESOURCES: (N/A)

RELATED APPLICATIONS:

In addition to displaying the utility crossings on utility line profiles, this solution procedure may be applied to road profiles and site grading cross sections. Other features such as pavement edges, curbs, sidewalks, concrete slabs may also be located on profiles and cross sections using this solution.

Civil/Site Solutions Manual

Section 7 -- Building Site Development

This section provides design solutions that are applicable to site development associated with the construction of buildings and other structures for occupancy.

Section 7 -- Contents

Civil/Site Solutions Manual

Section 8 -- Large Site Layout

This section provides site design solutions for laying out the very large sites that are found in some specific types of projects. Specific solutions include those for:

A. Fill Disposal Areas
B. Environmental Management Projects
C. Other Large Sites

Section 8 -- Contents

Civil/Site Solutions Manual

Section 9 -- Hydraulic Design

This section provides design solutions applicable to commonl hydraulic s design problems.

Section 9 -- Contents

Solution 9.1

Application
QuattroPro
Excel (*In Progress*)

Spreadsheet for Runoff Computations by Rational Method

DESCRIPTION OF PROBLEM:

The Rational Method is often used by designers in the computation of runoff for small drainage basins less than 1 square mile in size. Computing runoff for basins with many tributary drainage areas can be tedious to compute, and is ideal for solution by spreadsheet.

DISCUSSION:

A QuattroPro spreadsheet was developed for the computation of runoff for the pre-project, construction, and post-project conditions. The Rational Method (Q=CIA) is used to quantify runoff in cubic feet per second for tributary drainage areas within the project area. This solution concerns itself with overland flow only, not flow in channels or gutters.

The designer must know the rainfall intensity in inches/hour, measure tributary drainage areas, flow distances, ground or roof slope and decide what type of surface condition exists for a tributary area, e.g. is it roof, paved, poor soil, turf, etc. The spreadsheet will compute the runoff for each tributary area and sum the tributary runoff.

For drainage areas greater than 1 square mile in size, runoff should be computed by unit hydrograph or flood routing procedures.

DESIGN SOLUTION:

The solution makes use of values

SOLUTION PROCEDURE:

1. From a map of the project, delineate the drainage areas and compute their areas in acres.
2. Obtain the rainfall intensity in inches per hour for the design storm. Consult NOAA maps, use National Weather Service data, or your District's Hydrology Section/Branch. Enter this in the shaded cell with the address M5 in the appropriate page of the spreadsheet.
3. Enter the drainage area acreage in the appropriate shaded cells of Columns B, C, D, E and/or F. Some drainage areas may have values in multiple columns of the same row (tributary area), depending on the ground conditions.
4. The spreadsheet computes the weighted value of the roughness factor "n" and the total area of the tributary region.
5. The spreadsheet will also compute the percentage of the tributary area that is paved or roofed, for further computation purposes and checking.
6. Measure the path the runoff will take from the farthest point of accumulation to the point of discharge for each tributary area. Enter this value in Column J.
7. Determine the average slope along the path measured in the previous step.
8. Using the FAA equations, the spreadsheet will then compute the time of concentration (tc), comparing it with a computed minimum value. Infiltration and terrain factors are also computed using the FAA methodology.
9. Runoff for the tributary area will be computed in Column "S."

EXAMPLES/RESOURCES:

The QuattroPro file RAIN.WB1 *(is being converted to Excel)* is provided on the "Solution Manual Resource CD-ROM", and is necessary for the execution of the solution procedure described.

Rainfall data may be obtained from:

NOAA Technical Memorandum NWS HYDRO-35, Five to 60-Minute precipitation Frequency for the Eastern and Central United States, June 1977.

US Weather Bureau Technical Paper No. 40, May 1961, Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 hours and Return Periods From 1 to 100 Years.

Refer to TM 5-820-1 and TM 5-820-3 when designing storm drainage facilities for airfields.

RELATED APPLICATIONS:
None.

Solution 9.2

Extract Hec-2 Deck From DTM

Application
InRoads
InRoads SelectCAD

DESCRIPTION OF PROBLEM:

For the hydraulic design of structures it is necessary to input cross-section data from a site survey into various hydraulic models.

This solution provides the steps involved in using the HEC palette and an existing DTM to extract the cross-section data, which may be imported directly into the HEC-2 or Hec-Ras models.

DISCUSSION:

The site survey is usually delivered as a design file with the associated surface model or DTM. The hydraulic engineer must determine where cross-sections are required for each case. Add as many cross-sections as needed to accurately model the system. Do not extend cross-section lines beyond the limits of the DTM. In addition a line representing the approximate center of the channel is required, beginning at the downstream end of the channel. Channel distances between cross-sections will be determined from this center line alignment. The final product is an ASCII file in the proper format.

DESIGN SOLUTION:

It is necessary to define a new horizontal alignment and cross-section lines as inputs for the HEC2 procedure. The cross-section data will be extracted along these lines and written to a file in the proper HEC-2 format.

SOLUTION PROCEDURE:

1. Load the surface representing the elevation data.

2. Select **File>Geometry>New** and create a new project and a new horizontal alignment. Select **Palettes>Horizontal Edit>Add Horizontal PI** and define the new horizontal alignment representing the center of the channel.

3. Place cut lines at the locations where you want to extract the elevation data (cross-sections). Select **Tools>Main>Element Selection** and hold the Control Key to select all cut lines.

4. Select **Palettes>HEC2>Scan HEC-2** and click the apply button in the dialog box that appears. Make sure the Write Lock is off and enter a data point in the design file and close the dialog box. Select **Palettes>HEC2>Create HEC-2 Deck** enter a file name and click the **OK** button. Select **OK** again in the alert dialog box.

Civil/Site Solutions Manual

Section 10 -- Miscellaneous/Other Design Solutions

This section provides miscellaneous other design solutions that are specific to design problems not delineated in the other manual sections, or that are specific to many design situations.

Section 10 -- Contents

Solution 10.1

Application
Microsoft Word

Quality Control Checklists For Civil Site Development and Civil Design for Flood Control Project Plans and Specifications

DESCRIPTION OF PROBLEM:

Documentation of quality control for projects is being emphasized throughout the Corps. Criteria falls short of providing detailed checklists for verification of civil design drawings prepared for civil works projects.

DISCUSSION:

ER-1110-1-2, Quality Management, provides the general policy and principles for improving the quality of engineering and design services provided by the Corps. Together with other criteria, specific procedures can be found to gauge the quality and completeness of design products.

Checklists can be an important tool in the quality process. Albuquerque District has developed discipline-specific checklists as elements of the District's Quality Management Plan.

Contract A-E's more familiar with the state highway, city planning, and private-sector design processes often missed critical elements of design. The provision of these checklists has reduced the QA comments issued by the District.

DESIGN SOLUTION:

Checklists that can be used as part of the quality control process for the civil design of military site development and flood control projects such as levees are presented. Naturally, they can be edited to suit the reviewer's needs.

The checklists are not meant to be all-inclusive, nor are they a substitute for engineering judgement, and they are not the only element of design quality control. Reviewers should be experienced and qualified to spot problems in designs as they are reviewed.

SOLUTION PROCEDURE:

The checklists are self-explanatory. Design elements may be checked off or initialed off.
The user may wish to append items from their District's Lessons Learned files.

EXAMPLES/RESOURCES:

The file CIV_CHK1.DOC contains the flood control checklist, and the file SIT_CHK1.DOC contains the site development checklist on the "Solution Manual Resource CD-ROM", and are necessary for the execution of the solution procedure described.

RELATED APPLICATIONS:

These checklists are focused on civil design, not the details of any appurtenant mechanical, electrical, architectural, structural, etc. design. The user may wish to expand on the items to be coordinated with these disciplines, or to suit their District's mission, e.g. navigation projects.

Solution 10.2

Application
Microsoft Word

Boilerplate Scope of Work for Civil Works Contract Design

DESCRIPTION OF PROBLEM:

Corps criteria in the civil works design process are second nature to experienced Corps engineers and technical staff. Requirements for the contracting-out of civil works design requires that detailed scopes of work are issued to Architect-Engineer (A-E) firms that convey the desired level of design, the criteria involved, and the products to be delivered.

DISCUSSION:

Civil works projects have traditionally been designed in-house by most Corps Districts, utilizing staff expertise. Mandated contracting-out goals for civil works have led to the requirement that Districts hire A-E firms to engage in the design of such projects.

Albuquerque District has many A-Es who were familiar with the MILCON design process and criteria. These requirements had been solidified in a boilerplate scope for military design.

A boilerplate scope was developed for civil works design by A-E, with flood control projects in mind. When using the scope, please keep in mind that navigation and shore protection (for instance) are not elements of Albuquerque District's mission in the desert Southwest. Therefore, the scope does not list criteria pertinent to those types of projects.

DESIGN SOLUTION:

This solution provides an editable scope of work that can be used to specify civil works design done by A-E.

AutoCAD files are also required by many local sponsors as part of the final deliverables for incorporation in their planning and GIS departments, and is included in the scope.

SOLUTION PROCEDURE:

The accompanying Microsoft Word document should be edited to suit the needs of the project. This scope is primarily used with Indefinite Delivery-Type contracts with A-E firms to produce plans and specifications for flood control projects. If the scope is used as part of a design Request for Proposal, the appropriate contract clauses shall be added, or the scope may be edited and included as an exhibit in the RFP.

The Technical Manager/Leader must be familiar with the civil works design process to edit the scope appropriately.

Information that must be filled in by the user is highlighted in all-capital letters, in red text between brackets. Sections that do not pertain to the project shall be deleted.

While a design analysis narrative and computations are typically set out in design memorandums, the plans and specifications done in-house by a District would probably not include a narrative or compiled design computations from the engineering disciplines involved. However, the user may wish to retain the requirements for the A-E to produce a design analysis with computations for review and record-keeping.

EXAMPLES/RESOURCES:

Refer to the boilerplate scope named CIV_SCP1.DOC furnished on the CD-ROM.

The following criteria are particularly useful in conveying the detailed requirements of civil works design to the A-E, and may be found at the Corps TECHINFO web site located at http://www.hnd.usace.army.mil.

ER 1110-2-1150	Engineering and Design for Civil Works Projects
ER 1110-2-1200	Plans and Specifications for Civil Works Projects

RELATED APPLICATIONS:

The civil engineering portions of the scope may be edited out to produce requirements for studies or designs by other disciplines.

Solution 10.3

Application
Microsoft Word

Boilerplate Scope of Work for Digital Photogrammetric Surveys

DESCRIPTION OF PROBLEM:

Surveying contractors may not be familiar with Corps of Engineers requirements for digital photogrammetric mapping. Corps designers may not know the limitations of mapping flown at a certain altitude for a particular target map scale. Without a concise scope that details the requirements of the work, the mapping produced may be unusable by the designer, or used at a higher resolution than intended. This solution provides an editable scope of work that can be used to specify surveys done by contract mapping firms.

DISCUSSION:

Albuquerque District found that the level of accuracy civil designers were expecting in digital mapping products did not meet our expectations when we began to use InRoads for civil design. We found that contractor-prepared digital terrain models would not match the contours displayed in the contractor-prepared MicroStation files.

Elevations specified in designs based on contractor-produced mapping often did not match the true elevations in the field, resulting in construction modifications.

Consultation with mapping contractors revealed that our expectations and their scope requirements were often not in alignment. With the advent of metric design, there was confusion on the part of designers and contractors as to how to interpret Corps Engineer manual criteria that only addressed English units. It was decided to construct a boilerplate scope of work that incorporated modern, definitive requirements for map accuracy, digital data, and verification.

DESIGN SOLUTION:

This solution provides an editable scope of work that can be used to specify surveys done by contract mapping firms.

The scope may be used for civil works for military design projects. Since Albuquerque District has many Air Force customers, the scope makes reference to features that might only be found on an Air Force Base. These can easily be edited out.

AutoCAD files are also required by many local sponsors and by the Air Force, and is included in the scope.

SOLUTION PROCEDURE:

1. The accompanying Microsoft Word document should be edited to suit the needs of the project. This scope is primarily used with Indefinite Delivery-Type survey and mapping contracts. If the scope is used as part of an Issue For Bid project, the appropriate contract clauses shall be added.

2. Application of the scope requires the proper specification of mapping accuracy. This should be discussed by the design team, with reference made to the criteria mentioned in the scope.

Miscellaneous/Other

3. Field work mentioned in the scope is beyond the control surveys required for establishing photogrammetric control. With the exception of bare or natural sites, it is recommended that the field survey include hard-man-made features that are crucial to the design. For example, we found that field-surveyed points on tie-ins to hard surfaces such as roads and aircraft aprons were critical. Points derived from aerial photogrammetry may not be accurate enough for precise tie-in of critical features.

3.1 We also found that surveying the corners of concrete slabs and aprons led to wiser placement of new features, eliminating the partial demolition of large slabs, and the reduction of small, reinforced, odd-shaped slabs.

4. It is important the aerial survey contractor closely coordinate flights in restricted or military operating areas, or in areas frequented by birds. The designer and contractor need to be aware that military training requirements may limit or hamper aerial photography, and a ground survey might be more cost-effective in some cases.

EXAMPLES/RESOURCES:

Refer to the boilerplate scope named SRV_SCP1.DOC furnished on the CD-ROM.

Corps criteria referenced in the scope includes the following documents, which may be found at the Corps TECHINFO web site located at http://www.hnd.usace.army.mil.

ER 1110-1-8156, Policies, Guidance and Requirements for Geospatial Data and Systems, dated 1 August 1996.

EM 1110-1-1000, Photogrammetric Mapping, dated 31 March 1993.

EM 1110-1-1002, Survey Markers and Monumentation, dated 14 September 1990.

TL 1110-1-183, Using Differential GPS Positioning for Elevation Determination, dated 1 April 1998.

RELATED APPLICATIONS:

The photogrammetric requirements of the scope may be edited out to produce requirements for topographic surveying by total station or similar radial survey methods.