CHAPTER 6

CREATION OF DESIGN CROSS SECTIONS

IGrds creates design cross sections at any baseline station by interacting pertinent design data with the terrain cross sections at that station. This section describes the process used in creating the design section. Two cases are discussed:

° Design Process - Without subsurface data

° Design Process - With subsurface data

The second case is a variation of the first. The differences are highlighted. The second case occurs when subsurface cross sections and subsurface material criteria are present. Subsurface cross sections are discussed in Chapter 4.

DESIGN PROCESS - WITHOUT SUBSURFACE DATA

The previous Chapter described the data needed to generate an individual design cross section. This data is summarized in Table 6-1. Actually, this data describes the entire project and can be compiled into a design cross section at any terrain cross section. Terrain cross sections are stored per baseline in the baseline cross section file, and corresponding design cross sections will be stored on the same file.

The designer makes requests for design cross section generation for a particular baseline by giving:

° Beginning and ending baseline stations

° Design Exception requests, discussed below

° Roadways to be included in design sections - any of the six design roadways associated with the particular baseline can be included

° Requests for horizontal position calculation, when needed

° Request to use maximum slope intercept data, if applicable

The processes for generating design cross sections also compute and store end areas for computing earthwork quantities, which will be covered later. The steps in the design process are discussed below.

Design Exceptions

Sometimes it is desirable to interrupt the design process and omit generation of design cross sections within bridge limits and other such areas. The Design Exception request gives station limits for the request and criteria for handling volumes at bridge ends.

Horizontal Position Calculation

The first step in the IGrds design process is the computation of the horizontal position (offset) between the particular baseline and each design roadway associated with that baseline. The computed offsets are stored in the cross section file for that baseline at each terrain station (see Figure 6-1). As mentioned earlier, within the IGrds/IG Option, this process is performed automatically.

ROW and Maximum Slope Intercept Update

The second step is the interpolation and storing of the right-of-way and maximum slope intercept distances in the cross section file for the selected baseline (see Figure 6-2).
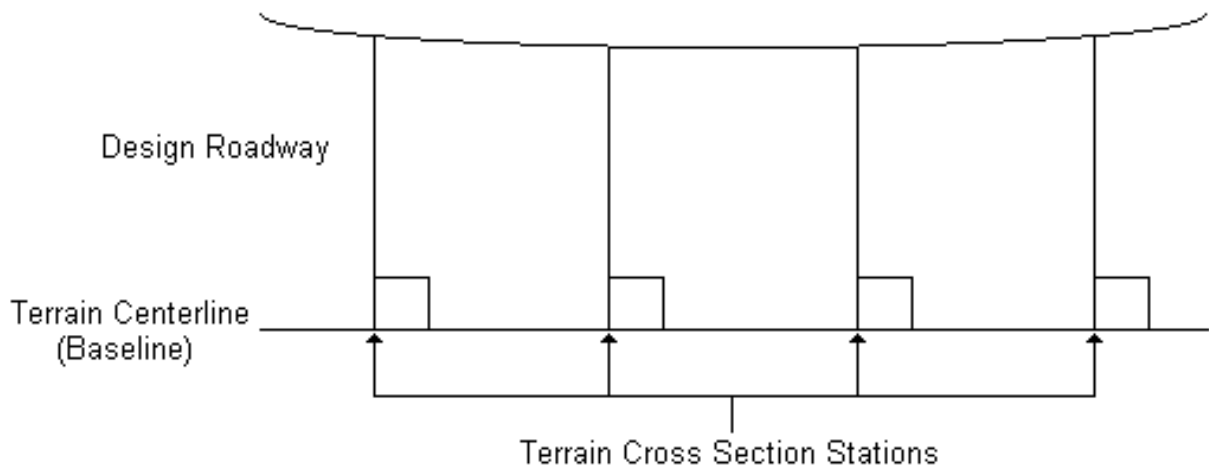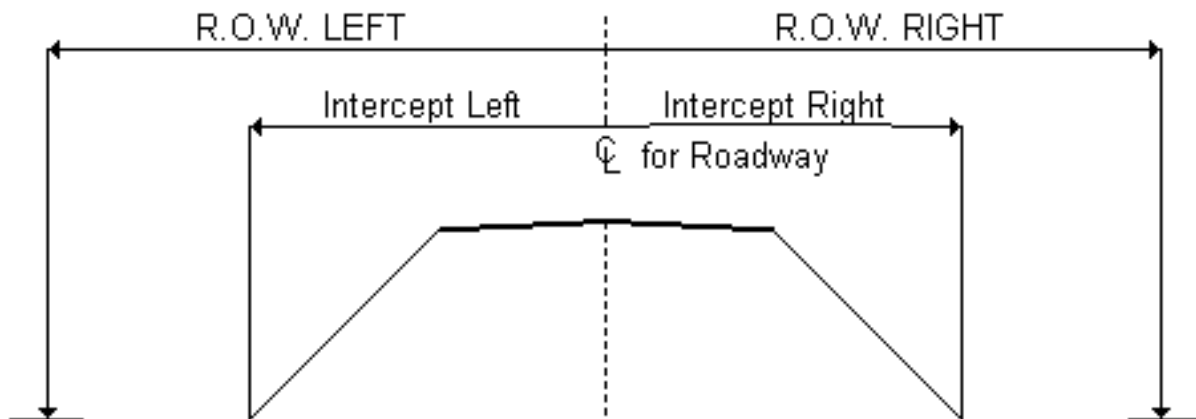
Figure 6-1 - Terrain Offsets

Figure 6-2 - Maximum Slope Intercept

Table 6-1

Summary of Design Data Types

DATA RELATED TO DESIGN SECTION	
Data Type	Purpose
Horizontal Alignment	Defines Centerlines Locates template horizontally
Geometry	Helps define PI locations for horizontal alignments
Terrain Cross Sections	Combines with design data
Terrain Profile	Helps define vertical alignments
Vertical Geometry	Helps define the VPI locations for vertical alignments
Vertical Alignment	Defines profile grade Locates template shapes vertically
Template Shapes	Defines roadway surface shape
Template Stations	Defines where template shapes apply
Superelevation	Modifies template shape slopes
Widening	Modifies template shape widths
Geometric Template Modification	Modifies template shape elevations and/or widths
Median Shapes	Defines median shape criteria
Median Stations	Defines where median shapes apply
Special Ditch Grades	Defines special guidelines to modify median or sideslope shapes
Sideslope Shapes	Defines sideslope criteria
Sideslope Stations	Defines where sideslope shapes apply
ROW Distances	Draws location arrows on cross sections
Maximum Slope Intercepts	Defines maximum limits of sideslope catch points

Other Design Section Modifications
    Trench Sections (Chokers)
    Step Subgrade
    Slope Rounding
    Erosion Control Ditch Shapes
    Erosion Control Ditch Stations
	Further modifies design cross sections
	    Modifies subgrade shape
	    Modifies subgrade shape
	    Provides rounding at terrain intercepts
	    Defines ditch criteria
	    Defines where ditches apply

In the next step, the actual design of roadways is performed. A design request between specified baseline station limits is accomplished in a single pass through the cross section files. IGrds accesses the first applicable station on the file and creates the entire design cross section before proceeding to the next station. Using the horizontal position, profile alignments, and template data, it first establishes the location and shape of each roadway template. This is done in design roadway order and templates will reflect any superelevation, widening, or geometric template modification. The result of this step is shown in Figure 6-3.

The next step of the design process is to connect adjacent roadways with medians when median data has been entered. The result of this step is shown in Figure 6-4.

The roadway shoulder points, which have not been connected by medians, are then connected to original ground using sideslope selection data. This is done in design roadway order, without regard to any overlap that may occur (see Figure 6-5).

The next step in the design process is to resolve overlap conditions and compute end areas for each roadway. In overlap cases, it is assumed that the slope of the later roadway always intersects the slope of an earlier roadway. The sketch below shows how end areas are divided in median areas and when slope overlaps occur. Removal of surface material, if requested, is then accomplished, followed by template subcut, if requested. (See Figure 6-6.) Also see Appendix N for a detailed discussion of surface material removal and template subcut.
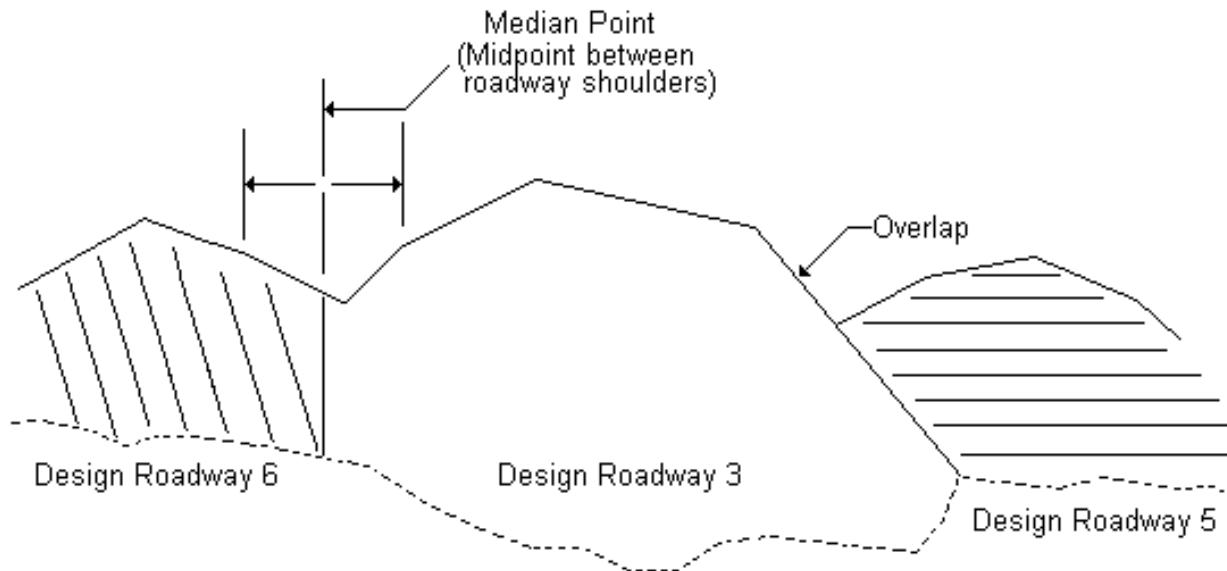
The final step of the design process is to store the design cross section and end area data in the cross section file of the appropriate baseline. Figure 6-6 shows the completed design section with all overlaps removed as it is stored in the file.
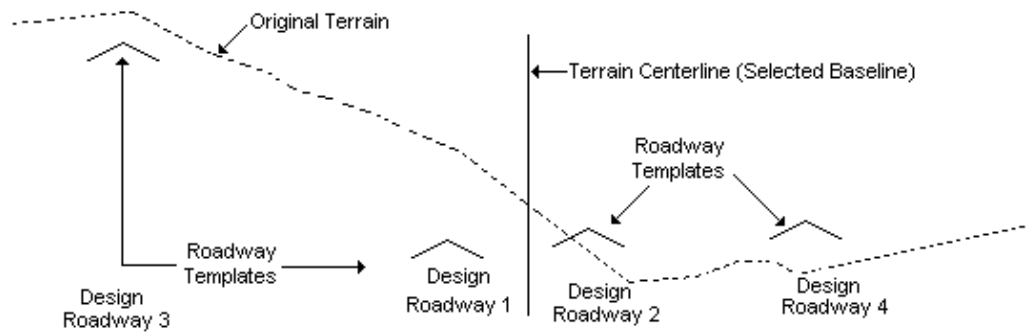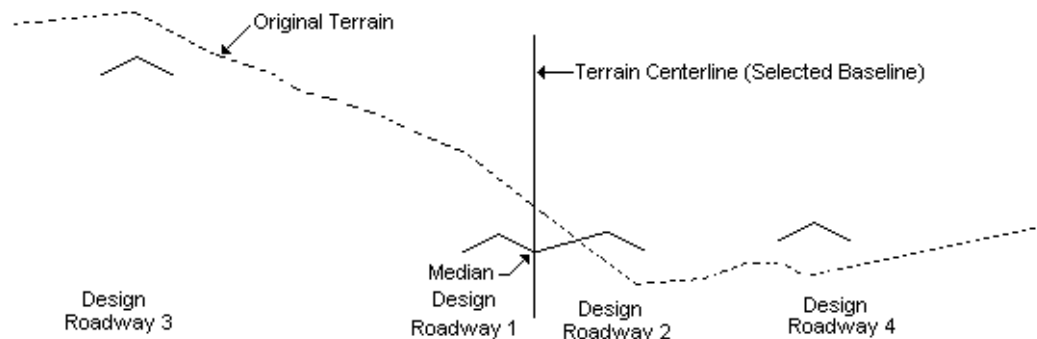
Figure 6-3 - Roadway Template Established
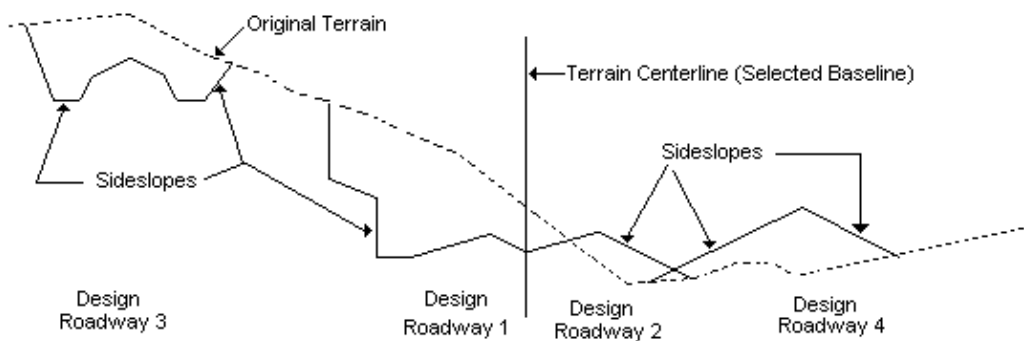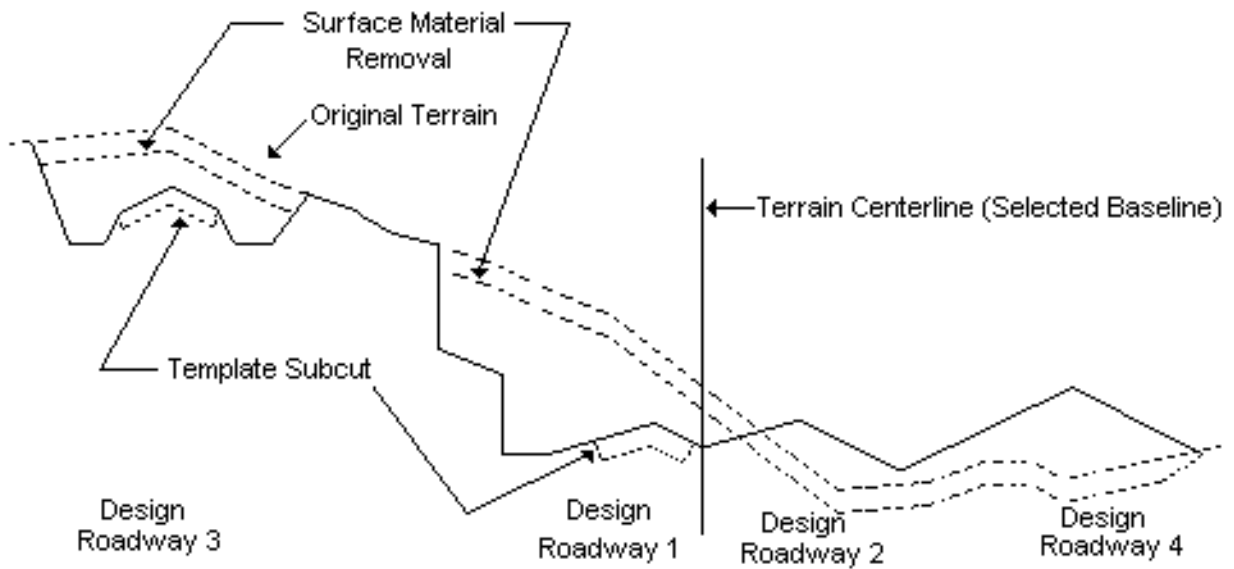
Figure 6-4 - Median Connections Established

Figure 6-5 - Sideslopes Established

(Completed design cross section is shown as a solid line.)

Surface Material Removal and Template Subcut Established

Figure 6-6 - Completed Design Cross Section

DESIGN PROCESS - WITH SUBSURFACE DATA

When subsurface cross section data has been stored for a selected baseline terrain cross section, the design process is basically the same, except for the sideslope process which modifies slopes according to the material criteria table which must also be available. Subsurface cross sections represent the tops of material layers and must reference the material corresponding to the Material Table. Storage of subsurface data is discussed in Chapter 4, and the material table format is discussed below.

A comparison of the design sequence with and without subsurface data is shown in Table 6-2. The methodology used to modify sideslopes according to material is discussed below under sideslope process.

Material Criteria Table

The material layer criteria file contains tabular criteria pertaining to each material. This is a user agency customized installation file created and modified by off-line edit processes. It includes the following:

- ° Material code
- ° Material name
- ° Criteria for design section
- ° Slope modification criteria for sideslope and median (maximum/minimum)
- ° Line symbology for plotting
- ° Layer pattern symbology

Sideslope Process - with Subsurface Data

This process constructs the design section between shoulder point and catch point. It is independent of the template, profile, median, superelevation, and widening processes. It is related to the right-of-way and maximum slope intercept, and special ditch processes.

When subsurface data is present, the sideslope process modifies each segment. It:

- ° determines the layer of the starting point, and

- ° modifies the segment slope in accordance with the material layer criteria file throughout the starting layer and any other applicable layers.

The slope selection process is outlined below. A complete discussion of the IGrds slope selection process is found in Appendix J. The following discussion is a brief description of the cut slope selection process when multiple subsurface layers are encountered.

Table 6-2

Design Sequence for Individual Design Section

GENERAL CASE Without Subsurface Data	GENERAL CASE With Subsurface Data
1. Build templates in specified design roadway order	1. Same
2. Resolve template overlaps	2. Same
3. Build specified medians connecting templates	3. Same 3A. Modify slope segments in subsurface layers according to material layer criteria
4. Resolve median overlaps	4. Same 4A. Define the design section for unsuitable material removal (consider this result in the processes below)
5. Compute the end areas that are complete	5. Compute cut end areas for each subsurface material.
6. Build sideslopes connecting templates with the terrain section	6. Same 6A. Modify slope segments in subsurface layers according to material layer criteria
7. Resolve sideslope overlaps	7. Same
8. Perform surface material removal and template subcut	8. Same 8a. Determine visibility of segments for template subcut.
9. Compute remaining end areas	9. Compute remaining cut end areas for each subsurface material

° All cut fixed slopes (i.e., ditches) are built in the normal IGrds fashion to determine the cut hinge point.

° The variable slope process is then begun. The software determines which slope would be used if there were no multiple materials. The variable slope process includes normal IGrds bench pattern calculations. Also, the maximum/minimum slope intercept conditions are honored.

° The multiple subsurface extension software then determines which layer the hinge point is within. The correlation between layers at a cross section station and the material criteria table described above is accomplished through the material code.

° The material criteria table is accessed for the necessary parameters for the material encountered.

° The slope determined from the variable slope process above (trial slope) is compared with the material cut slope tolerance depth. If the depth of material is less than the tolerance depth, then the trial slope is built to the top of the material layer without regard to the maximum and minimum of slopes. This step avoids abrupt changes of slope for thin layers of material.

° If the depth of material is greater than the tolerance depth, then the trial slope is compared to the maximum and minimum cut slopes for the material. If the trial slope is within the minimum/maximum slope band, then the trial slope is built to the top of the material layer.

° If the trial slope is not within the band, then either the minimum slope (if trial slope is flatter than the minimum) or maximum slope (if trial slope is steeper than the maximum) will be built to the top of the material layer

° A check is then performed to determine whether the top of this layer is coincident with the terrain; if so, the process is finished; if not, the process continues with the next higher material layer.

° If a top bench set back is specified for the layer just processed, then the bench set back is performed. Likewise, if a bottom bench set back is specified for the next material layer, then the bench set back is performed. If a bench set back is specified for both materials, then the largest set back is performed.

° If the terrain has not been encountered, then the process repeats as described above until the terrain is encountered. The entire process is sensitive to minimum and maximum slope intercept conditions.

Material "tail out" or "tail in" transitions are handled in the standard IGrds fashion. For example, if a material exists at the just previous station and does not exist at the current station, then the end area for that material at the current station is set to zero.

DESIGN PROCESS REPORTS

The IGrds design process does all of the computations needed to compile the various data into design cross sections as specified. Reports produced in relation to the design process include:

- ° Horizontal Position Calculation

- ° Design Exception Data

- ° Design Cross Section List (for any design surface)

Other related reports are shown under Earthwork Computations.

MODIFYING DESIGN CROSS SECTIONS

Design cross section modification may be used to modify and/or add a point on a design cross section or a range of design cross sections. This could be used to modify a design cross section because of a pipe culvert, transition sideslope ratio over several cross sections, or add a turning lane. The design specifications are not changed when design cross section modification is used.

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