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# 6D CUT-AND-FILL

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A Cross-Section Design and Drafting Solution for Highway Projects



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# 6D Cut-and-FILL

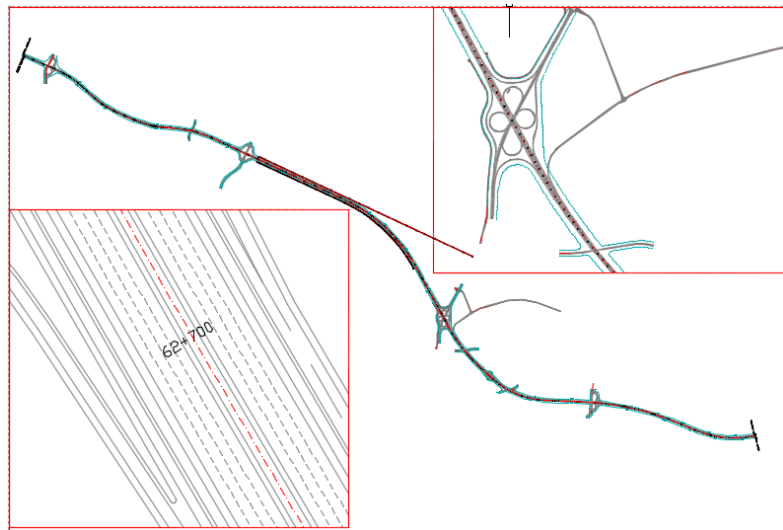
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## 1 The Need & Concept

### 1.1 WHY Cross-Sections:

1. Highways are built on country specific design standards that contain a final approved alignment before being taken up for construction. Construction of a highway project involves ground survey levels to be captured jointly by the owner representatives and executing agency and recorded as Original Ground Levels (OGLs). Finished Road Levels (FRLs) from the design profile are to be superimposed over the OGLs and shown in the drawings and mutually agreed before taking up any construction activity. The method of such super-imposing levels at agreed certain intervals is called generating cross-sections. Several complexities are involved in generating those cross-sections good for construction based on typical cross sections supplied in the designs.

2. Huge time is lost in recreating such cross-sections suiting the ground requirements, country specific designs and alignment designs. There are several software solutions that exist as legacy systems that mainly involve only designs up to certain level of complexities. Simple solutions are not available in the market that can handle OMAN specific standards.



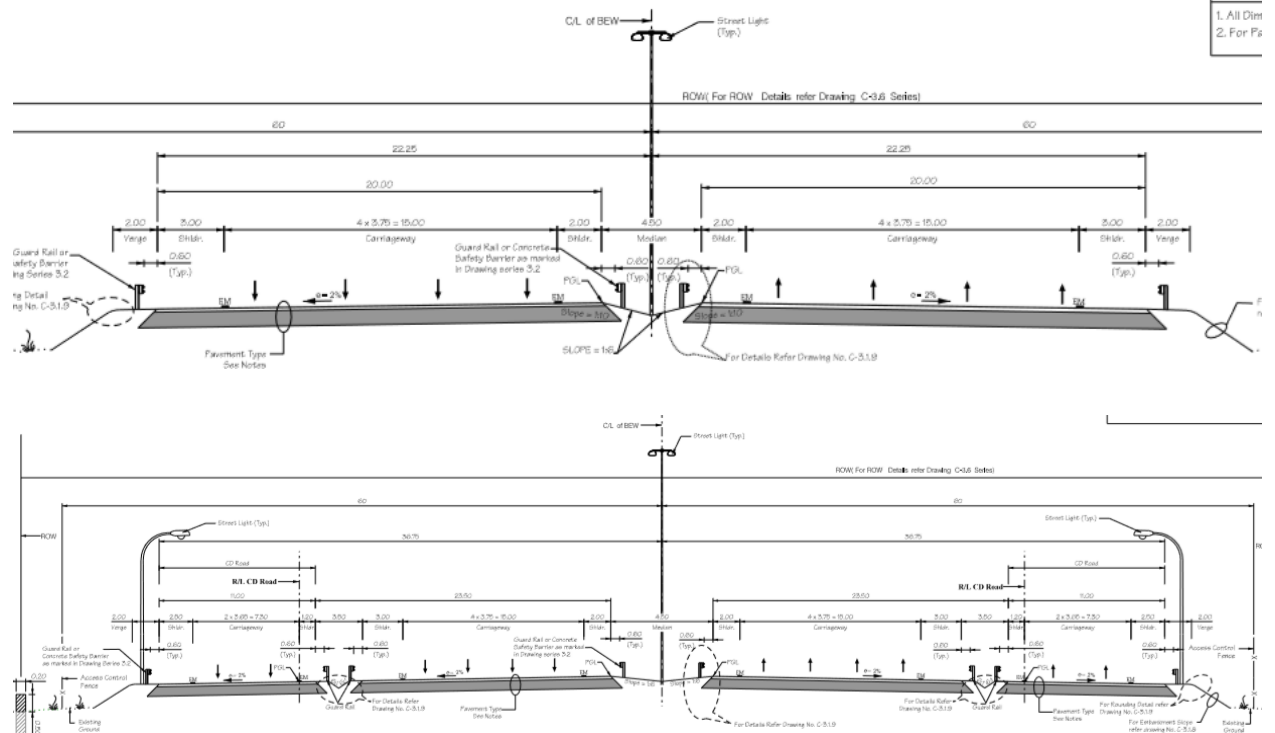
Therefore most companies are presently using manual systems in generating cross-sections. Speed of such generation depend of project requirements and drafter capabilities. In general a person with good caliber can generate about 25 cross section a day on AutoCAD. Errors are very common and can never be avoided making companies reproduce them when observed by the supervision consultants making them to redraft.

3. Therefore there is a great need gap to invent a system that can automate this manual recreations to improve drafting speed to 50 – 100 times faster with 100% accuracy in ONE-SHOT. Hence this 6D Cut-and-FILL. Present practices versus advantages of using this are explained in this documentation.

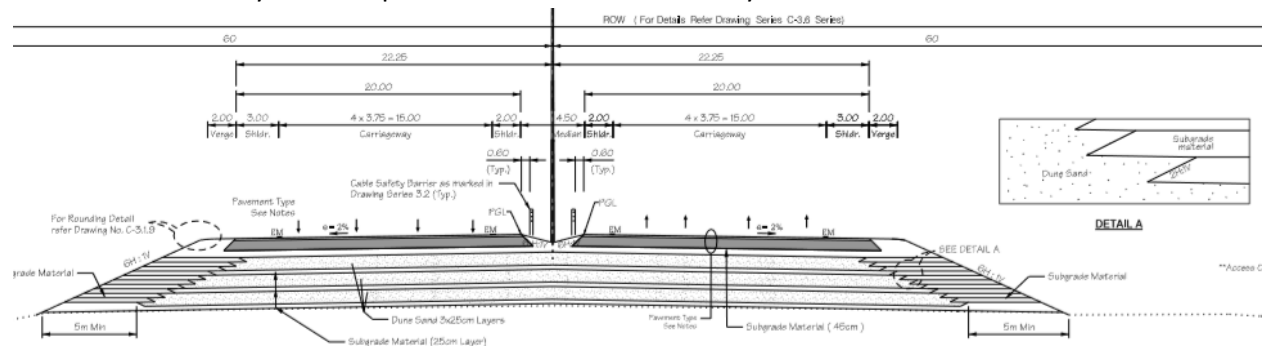
4. Let an alignment contain any number of lanes with several interchanges with loops, level crossings, widened features, service roads and so on. Project Authorities/Contracting companies responsible to build need a comprehensive solution to handle every complex feature to generate drawings, models and reports to deliver the project.

## 1.2 Typical Cross Sections:

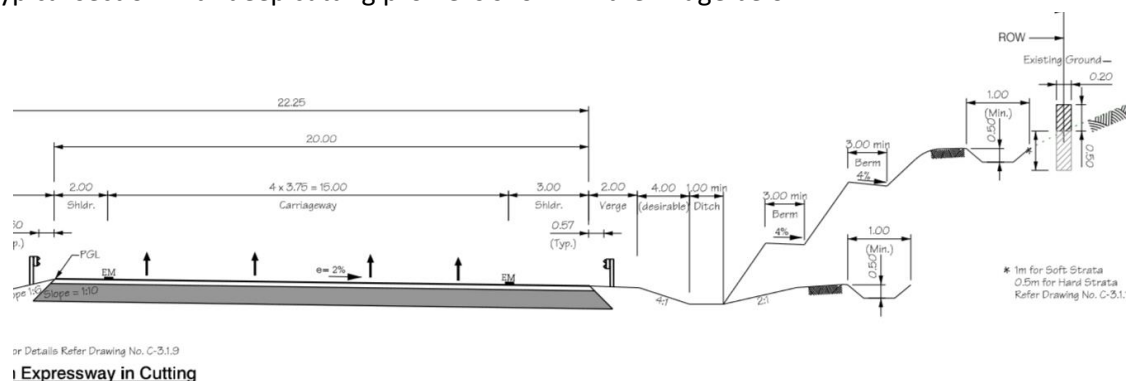
5. Few sample typical sections are shown below. Every feature stated on the typical section may be required by the client shown on each cross section taking in to consideration of actual data matching to plans.



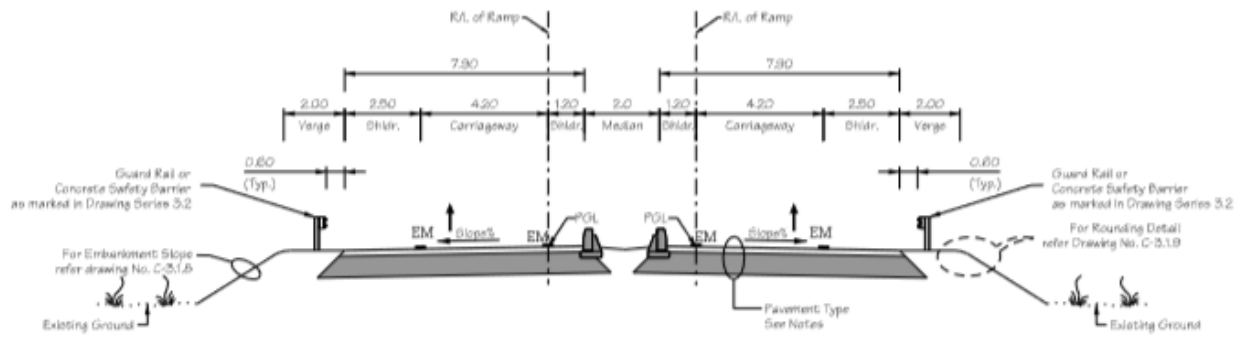
6. The sections may contain special features with in the body of embankment.



7. A typical section with deep cutting profile is shown in the image below.

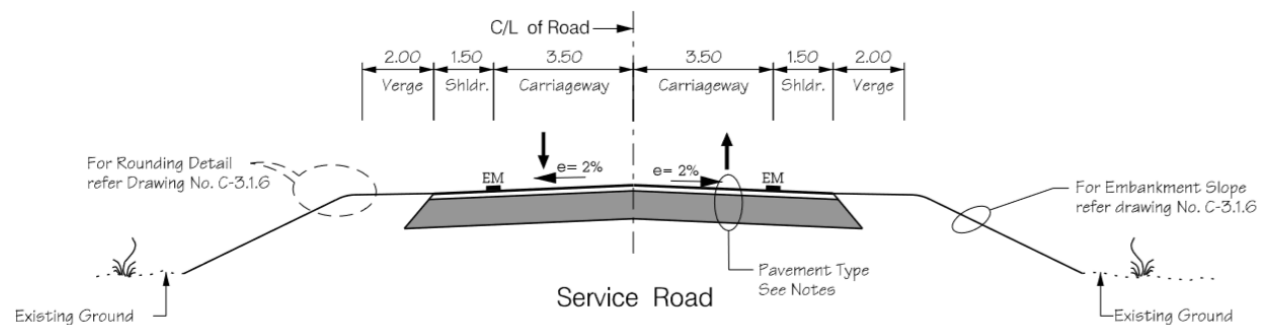


8. Typical ramps that the project contains are shown below.

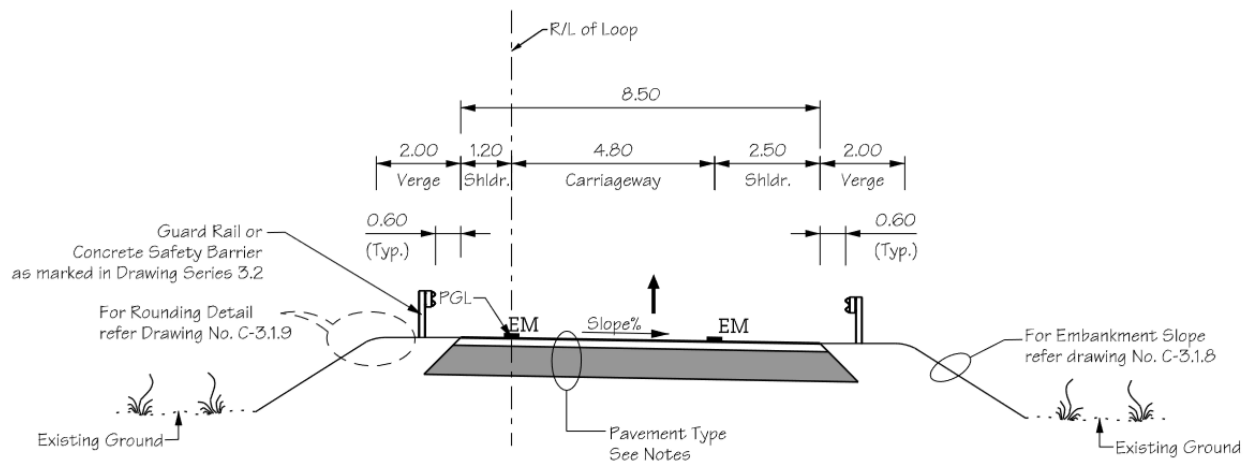


Typical Section of Ramp Applicable Location IC 07  
(Dual Carriageway)

9. Typical service loops that the project contains are shown below.



10. Typical ramps that the project can contain are shown below.

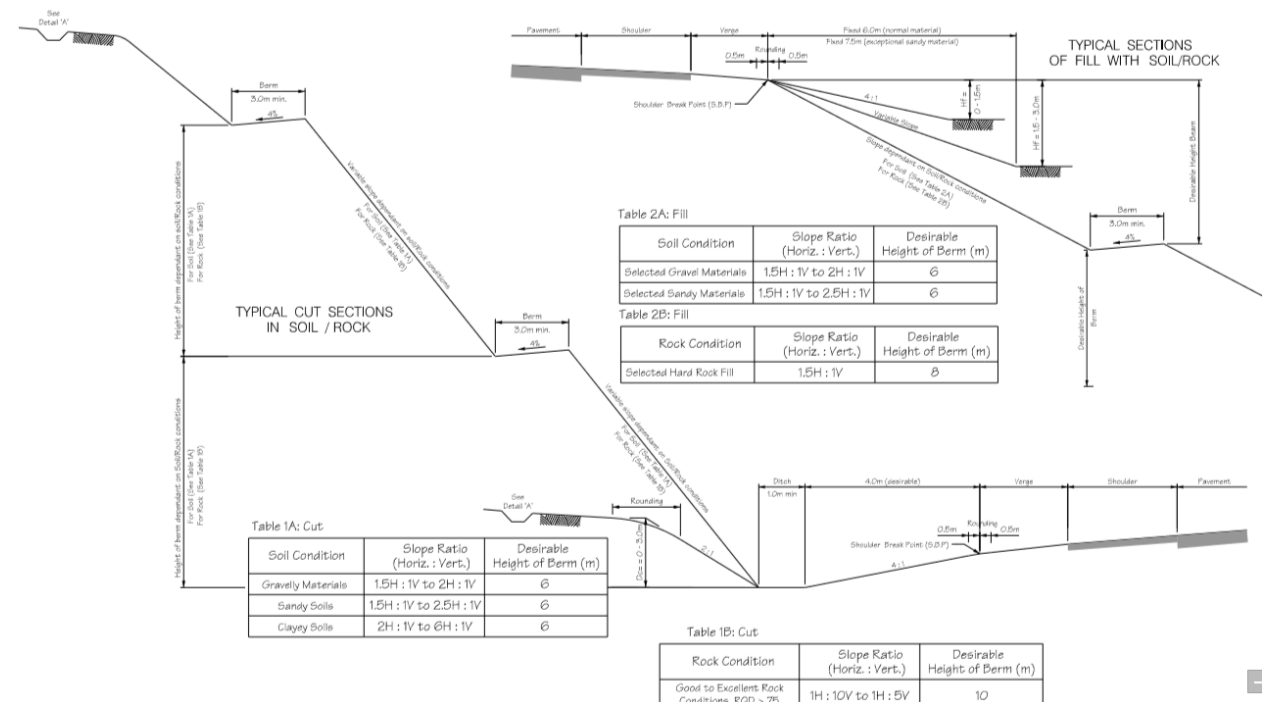


Typical Section of Loop (IC - 05)

### 1.3 Complex Slopes

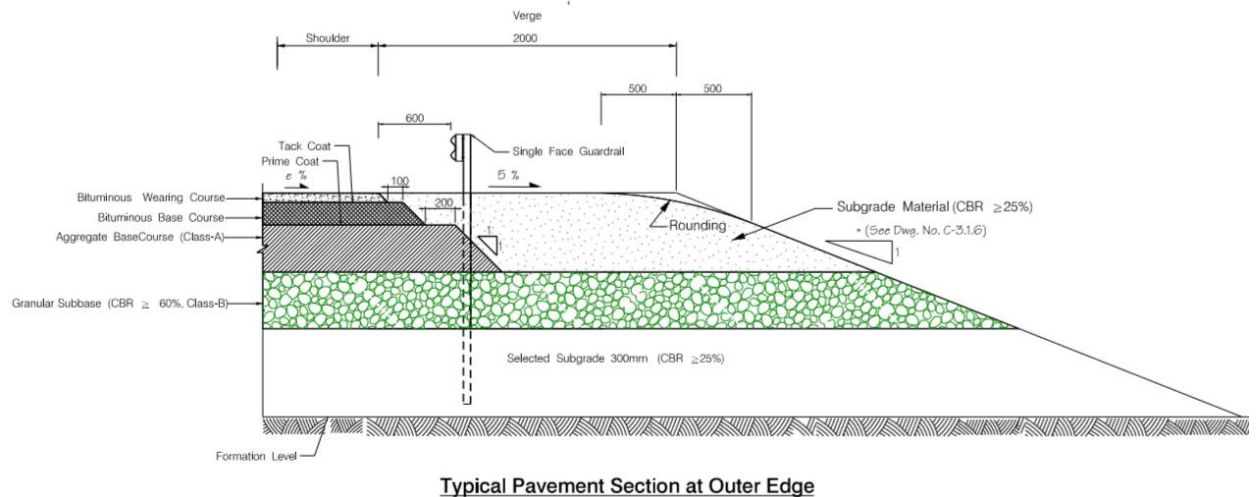
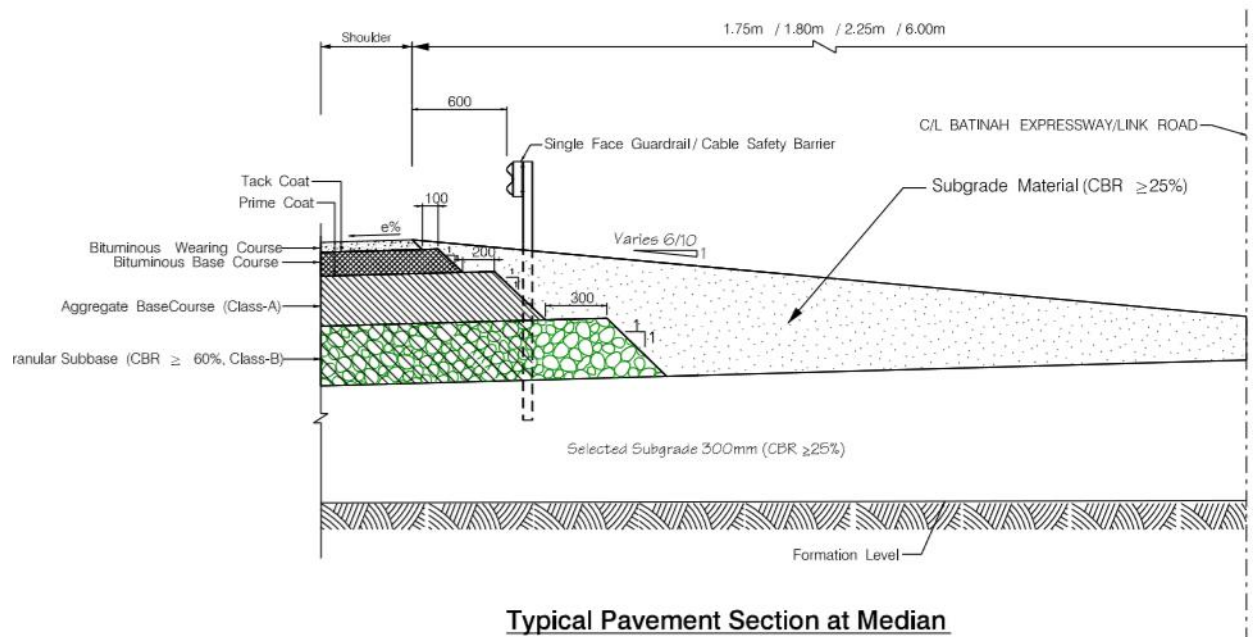
11. Slope definitions that the project defines are shown in the image below. These slopes are the most complicated taking in to consideration of both SLOPE FIXED and OFFSET FIXED scenarios. The program solves these definitions though complex algorithms built in the solution.

12. Slopes may vary in every adjacent cross section owing to FIXED OFFSET. Program dynamically reads the depth of FILL/CUT and decides the slope and makes a cross section.
13. Special feature like rounding at Shoulder Break Point (SBP) with quantity adjustment that should be calculated for every varying slope for every cross section that consumes enormous amount of manual efforts if managed without using automated programs.
14. Varying slopes have effect on the pavement layers that extend up to the slopes making it involving complex calculations repeatedly.



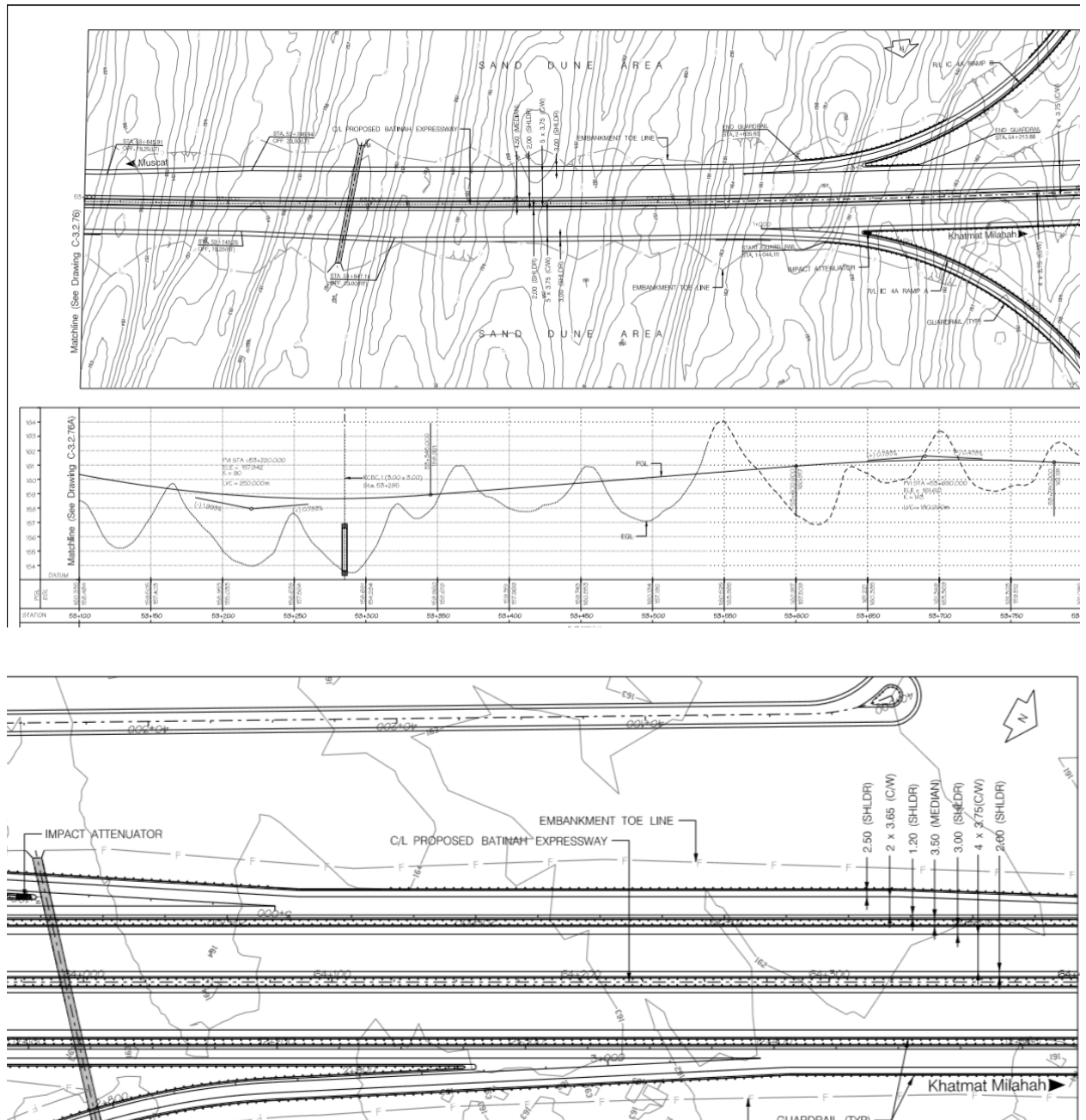
## 1.4 Pavement Rotation at Super-Elevations

15. Pavement composition layers may contain several features, slopes, offsets that should rotate with the super-elevation for both carriageways. Unless these rotations are calculated accurately it may be very difficult to implement the project on ground. Managing such cumbersome calculations involve loss of huge manpower coupled with errors.
16. Thicknesses for each layer may undergo changes when such rotations are effected. Program takes care of such changes with option to make these thicknesses measured vertically or normal to the road surface.



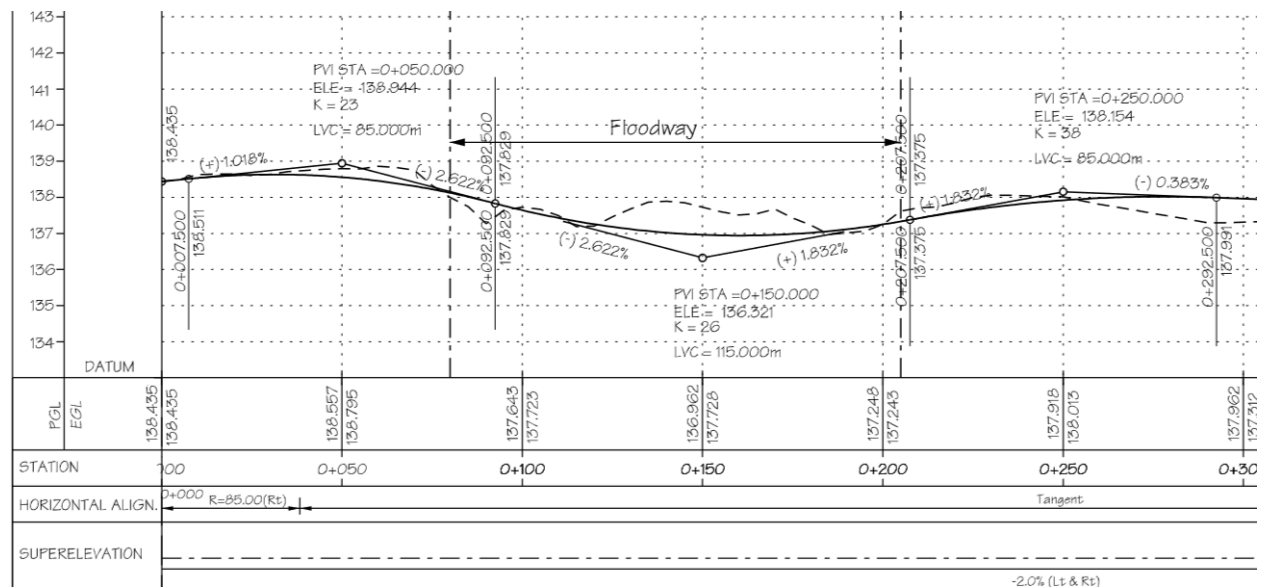
## 1.5 Complicated Transitions

17. The program comes with several features to handle most complicated plan with lane transitions to read directly from drawing to make thousands of templates on the fly.



## 1.6 Super-elevations & Curves

18. Program can write and read super-elevations from Longitudinal Sections to Comma Separated Values text files. These values are pushed to generation of Cut-and-Fill sections to drawings.

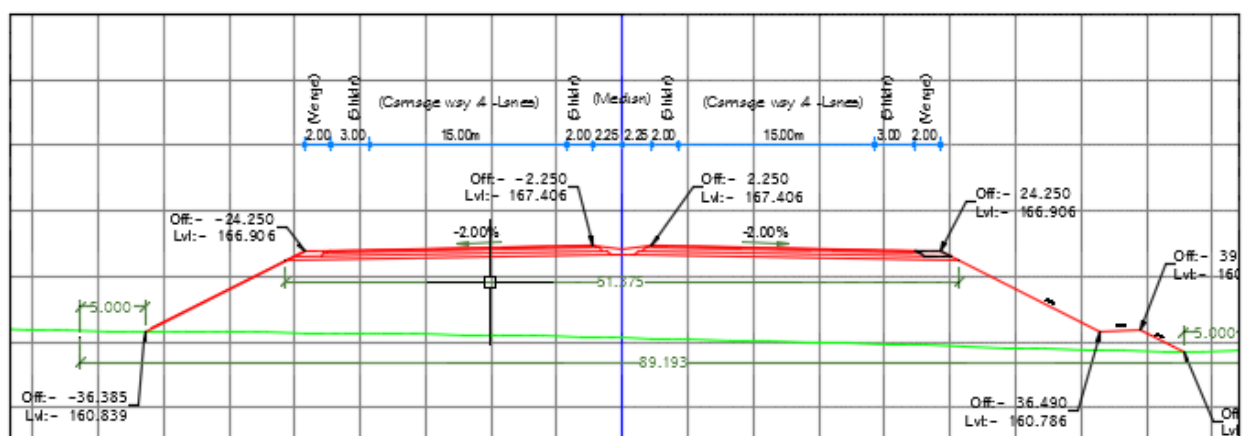


## 1.7 Earthwork Volumes

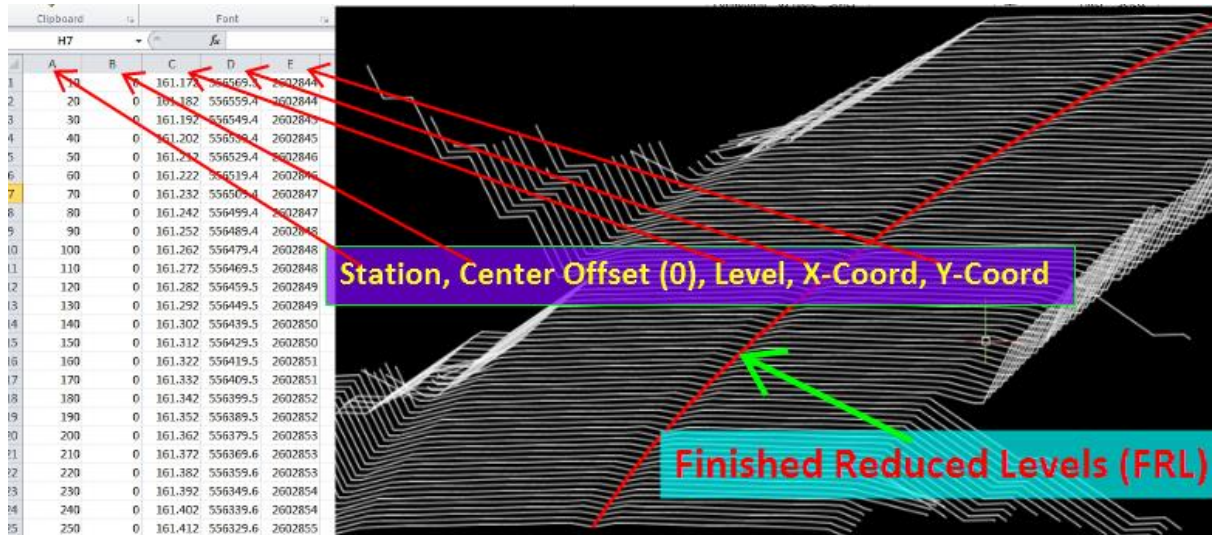
19. We can compute areas between the OGL and FRL and decide whether a CUT or FILL is involved for each cross section. At every cross-section station, we know the CUT & FILL areas involved. We can easily compute the quantity of CUT and FILL by taking average of two adjacent cross sections areas separately for cut and fill and multiplying them with the distance between the two cross-sections. Such repetition for each cross-section shall be the total volume of earth work involved in a project.

## 1.8 Drafting & Presentation

20. Generated Cross sections need to be presented for acceptance with required data to project authorities. Most programs in the market do not come with custom presentation methods. 6D Cut-and-FILL comes with special tools that are directly sitting on AutoCAD to automate drafting work by pulling data from XDATA feature of AutoCAD on to your project cross sections.







## 2 WHY Cut-and-FILL

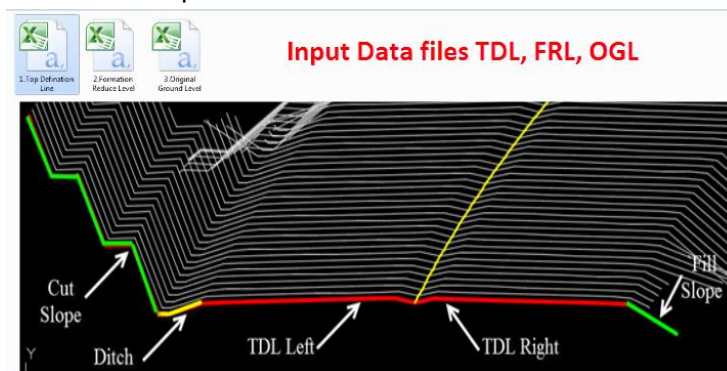
### 2.1 Design

23. 6D Cut-Fill is fully automated Highway cross-sections design with drafting tools on AutoCAD that can generate about 1000 cross sections per day per system. Under legacy systems it is possible to do this only 25 cross sections per day on AutoCAD.

24. Other programs in the market DO NOT address DRAFTING automation – HENCE this is UNIQUE SOLUTION in for highway construction.

25. Simplicity in creation of input files and operating platform

- Working interface is existing AUTOCAD platform -
- Input files are simple Excel / CSV files for the following. Therefore no special typing is required since machine data can be downloaded directly in to excel.



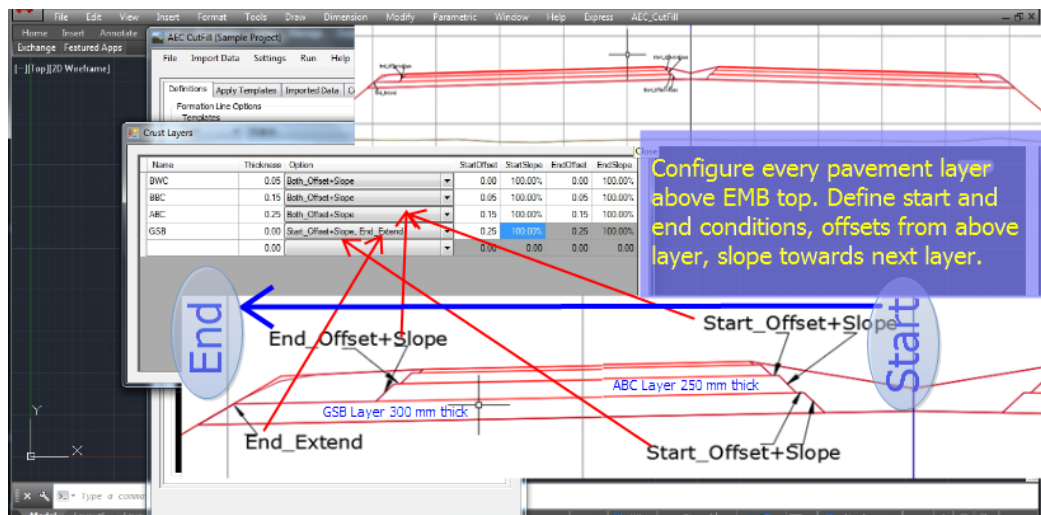
coordinate – in EXCEL format

- OGL** data must contain three fields – such as station, offset and level – in EXCEL format

26. It is simple to introduce berms at high embankments and deep cuttings.

27. Top Definitions and Drain Templates application for each cross section is most simplified with Ctrl+D option.

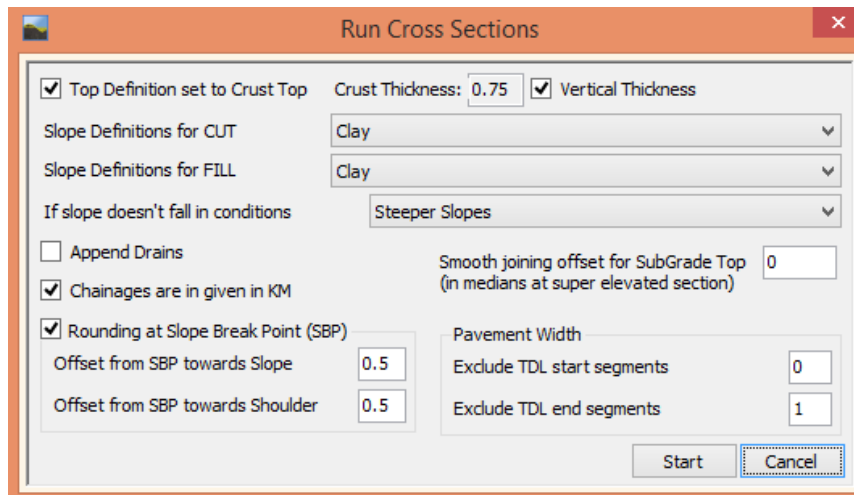
28. Easy Configurations of any type of Pavement composition above earth top. We can define start and end conditions, offsets from above layer, slope towards next layer. For single carriage way define start offset = 0 and start slope to infinity or near true vertical.



29. Some projects do not allow slope triangle portions of pavement ends as payable quantity. This can be excluded in computations automatically.
30. OMAN National Highway Design Standards are complicated taking in to consideration of both SLOPE FIXED and OFFSET FIXED scenarios. The program solves these definitions though complex algorithms.



31. Top Definition can be set to crust top or embankment top to make it possible for earthen fills to include or exclude crust Layers.
32. Crust thickness can be optionally set to perpendicular to Crust Layers or parallel to Y-Axis making easier to follow supervision consultant's instructions.
33. Several soil types can be configured in to the system making all variables fed to the system without referring to highway manuals every time.
34. Option to work Station values Kilo-meters or Meters making it simpler to interpret the way supervision consultant's desire.
35. Shoulder Break Point ROUNDING OFFSETS are parameterized for first offset towards SLOPE and the Second offset towards SHOULDER with option to vary dimensions.
36. We can automate to set Toe Drains included in the Design.

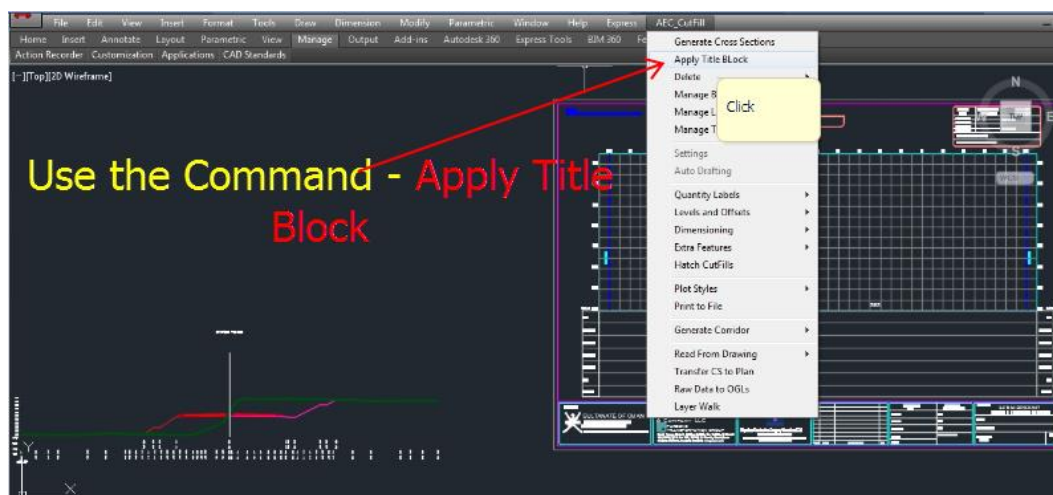


37. Cross-sections are drawn Station-wise on Layers making it easier and simpler to view them using LAYWALK command of AutoCAD. This can make viewing the road variances to catch eyes.

## 2.2 Drafting

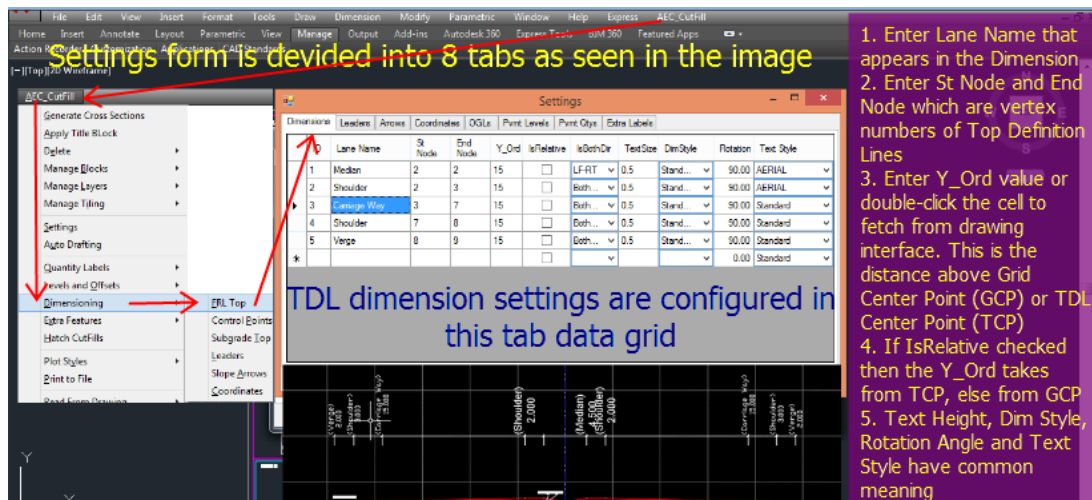
### 2.2.1 Automating Title Block

38. Applying Approved Title Block to every cross-section in seconds – An EXCELLENT FEATURE. Simply Paste a Title-Block anywhere in the project drawing on a blank area and use the Command - **Apply Title Block**. Just Inform the program of the layer on which graph grid is drawn and Pick grid center point when prompted by entering Graph X-Axis Length and Enter Graph Spacing. Enter Number of Grid Lines along X-Axis and Choose Text Style for Datum to automate creation of DATUM.

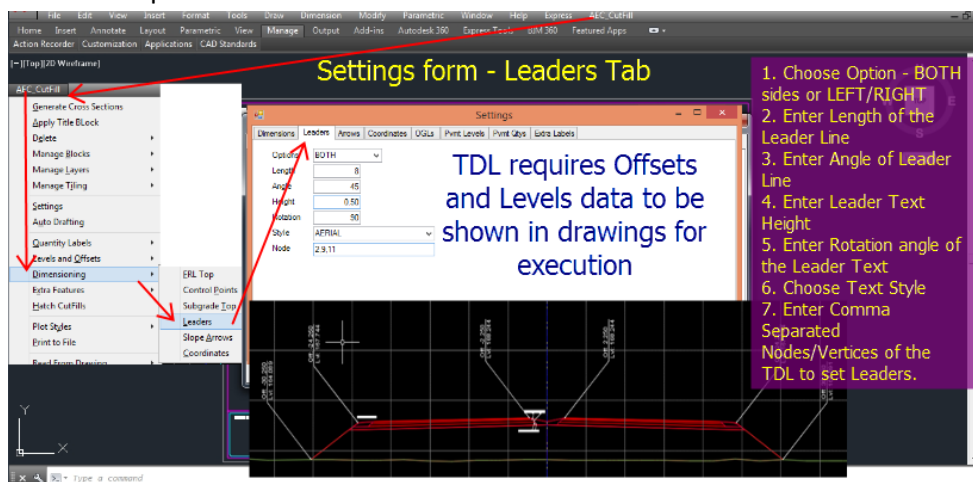


### 2.2.2 Centralized Configuration of SETTINGS

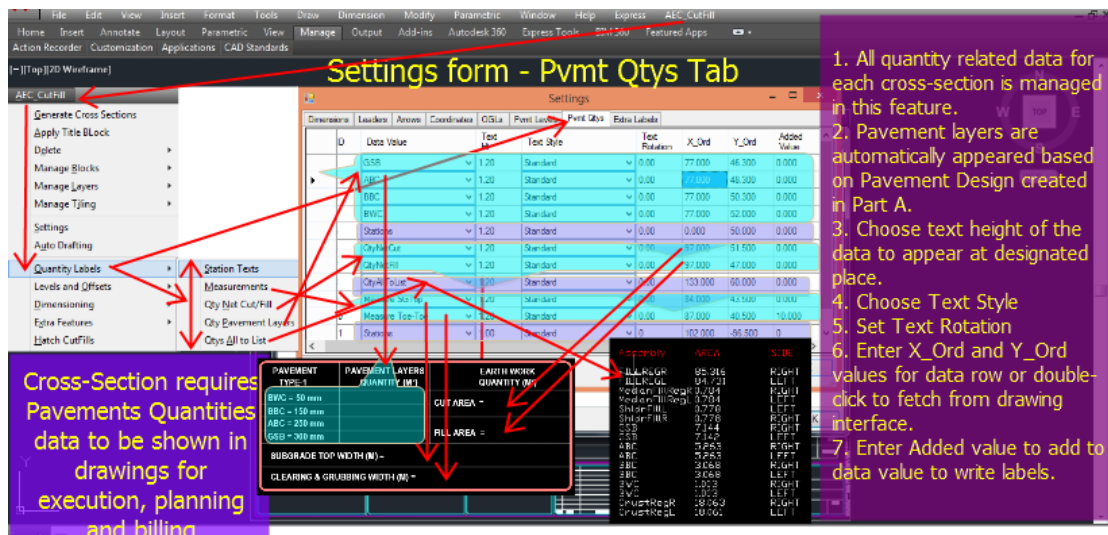
39. to Automate faster drafting centralized Settings are created that can perform drafting to place Cross-Section data at desired coordinates on the applied Title-Block
40. TDL dimension settings are configured to set Lane Names, start and end nodes or vertex numbers of TDL to automate **Dimensioning**. Text Height, Dim Style, Rotation Angle and Text Style and can be automated easily.



41. TDL requires Offsets and Levels data to be shown in drawings for execution. We can optionally choose - BOTH sides or LEFT or RIGHT. Leader Line Length, Angle, Text Height, Rotation angle and style of the Leader Text can be centrally controlled to draft. Simply enter Comma Separated Nodes or Vertices of the TDL to set Leaders.
42. TDL requires Slope Arrows data to be shown in drawings for execution. We can choose Option - BOTH sides or LEFT or RIGHT and set them where ever desired. We can also choose format either in Slope % or horizontal to vertical ratio."



43. TDL requires plan coordinates to be shown in drawings. This can be set at any node or optionally we may enter X Offset from each node point to calculate and set coordinate labels at such location.
44. Cross-Section requires OGL data and LEVELS to be shown in drawings. We can enter Y Ordinate value for placement of OFFSET text or click Pick button to fetch from drawing interface.
45. Cross-Section requires every pavements Layer Levels to be shown in drawings. We can enter 0 or a value. If the entry = 0 then LEVELS are written at every Node, else the entry has a value then levels are written at value intervals. We can choose Text Style and Height.
46. Every cross-section requires pavement layers quantities to be shown in drawings for planning and invoicing. All quantity related data for each cross-section are managed in this feature. Pavement layers are automatically appeared based on pavement design created in Part 1. If required, enter Added value to add to the data value to write in labels.



47. Cross-Section requires general entries like date of submission, drawn by, checked by, scale and the list can go on. We can enter in Text string that every cross-section should bear such labels.

### 2.2.3 Auto-Drafting

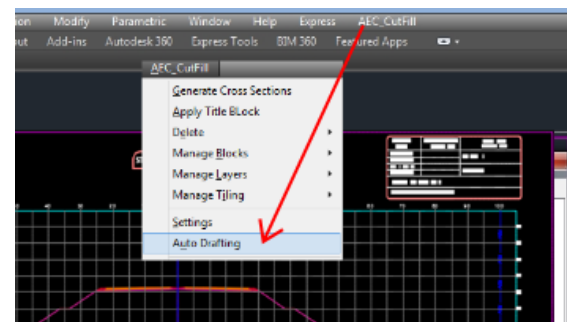
48. 6D Cut-and-FILL comes with Auto Drafting feature that can stunningly automate your work based on Predefined Settings.

49.

50. Auto-Drafting command writes data to Title-Block place holders and decorate your cross-sections with several dimensional and data features. Placements coordinates, styles, heights are read from predefined Settings.

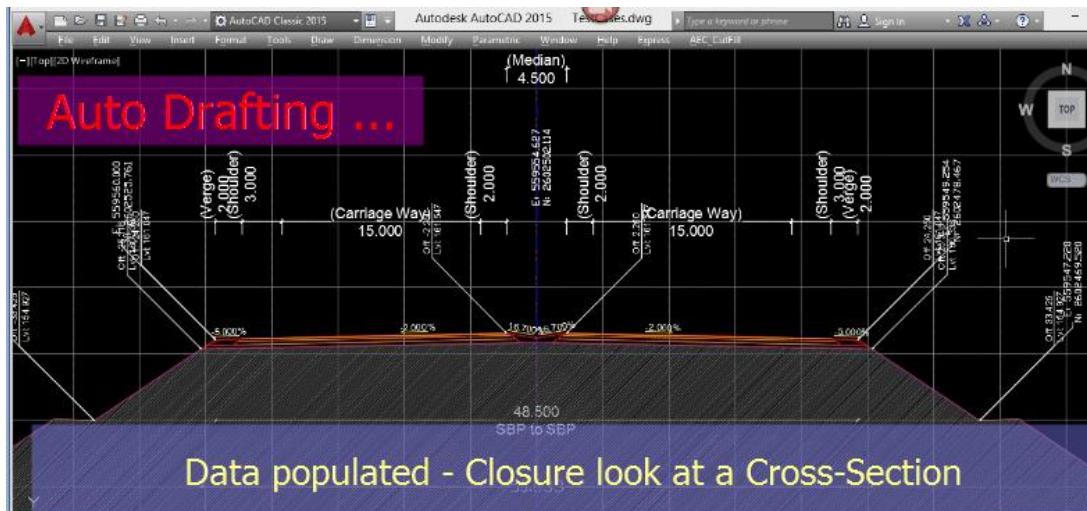
51. A kilometer long project with 100 cross-sections that contain approximately 20,000 items of data are written in ten minutes.

After this command these 100 cross-sections can be ready for printing and submittals.



52. Settings may have to be changed for each Title-Block changes to work the way you desire. Such changing is faster since the system is scientifically designed.

53. Few hundred data features are added to each cross-section by the Auto Drafting command.

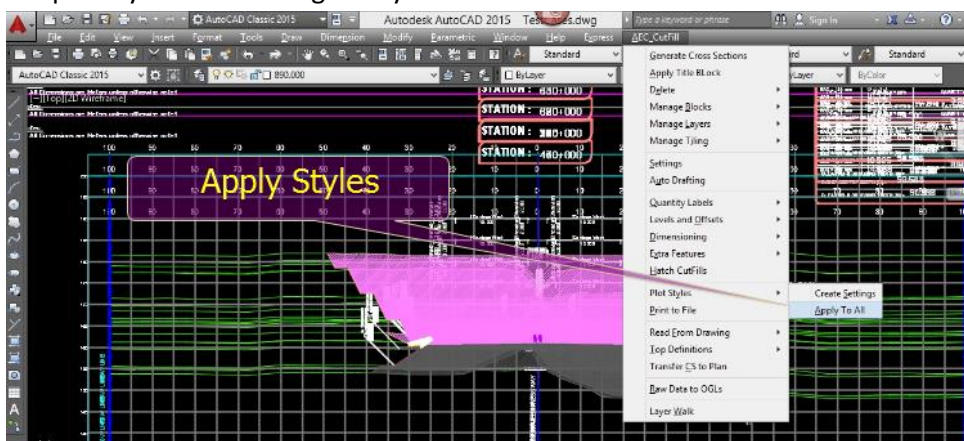


## 2.2.4 Feature-wise Drafting

54. If you need to Add More features after Auto-Drafting feature-wise commands that can operate on all cross-sections at a time.
55. Feature wise drafting writes data labels to Title-Block place holders and decorate your cross-sections based on Predefined Settings. All Cross-sections are drafted at a time.
56. Inserting blocks on TDL is made simplest and can be done by simply Copy-Paste such blocks from an existing drawing and Set them at desired nodes or at a specified distance from a Node.
57. System interacts with user to seek data block and options to insert in all layered cross-sections at a time.

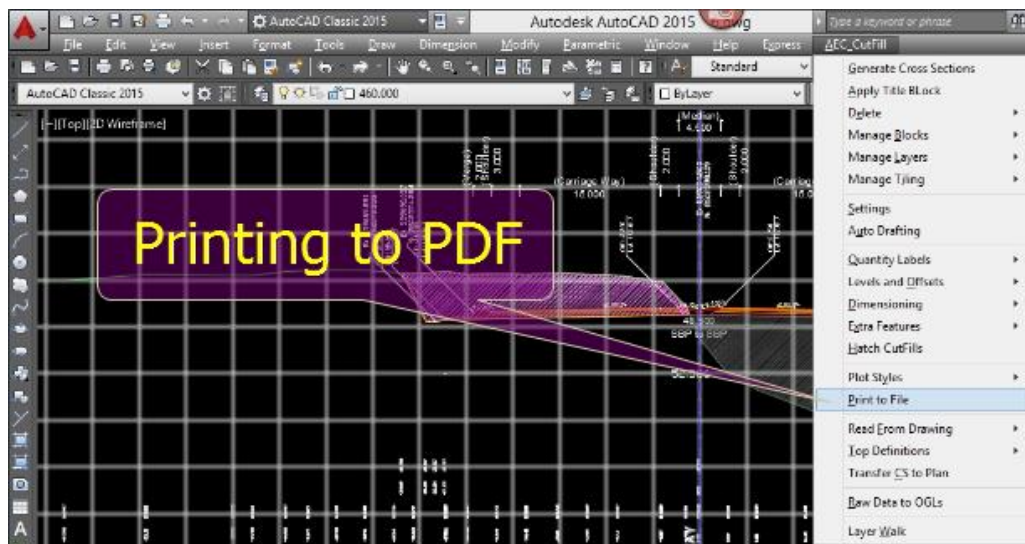
## 2.3 Plot Styles

58. Program enables to set plot styles to every line that has been generated during design. Choose line type, line type scale, line weight and color as shown in the following slides. We can apply the plot styles so defined globally in seconds.



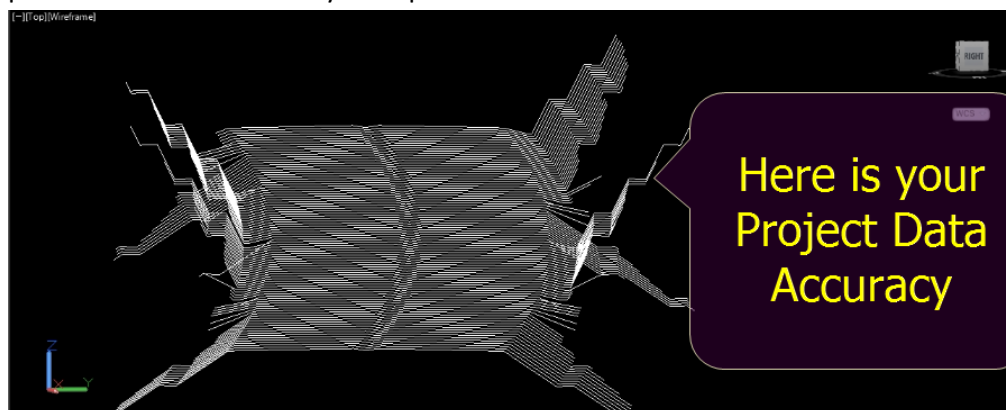
## 2.4 Printing Soft format

59. Easy and simple to generate prints out in PDF or other soft formats. We can set several self-explanatory options to generate prints-out for a range of cross-sections to your project folder.
60. We can simply select the same title block the project length under consideration was configured, which can fit to the paper size we chose to generate prints-out.



## 2.5 Plot2Plan in 3D

61. Your project cross-sections can be transferred to plan alignment if you had supplied coordinates in the FRL file. System creates a new AutoCAD file and saves at a file path indicated when prompted. Open the drawing file Plot2Plan to view your cross sections on 3D plan.
62. Use AutoCAD Orbit command to see effect and accuracy of your data supplied and data generated as per project configurations. What you see is what you get. No more words to prove the solution accuracy and speed of cross-section creation.



## 2.6 Progressive Levels

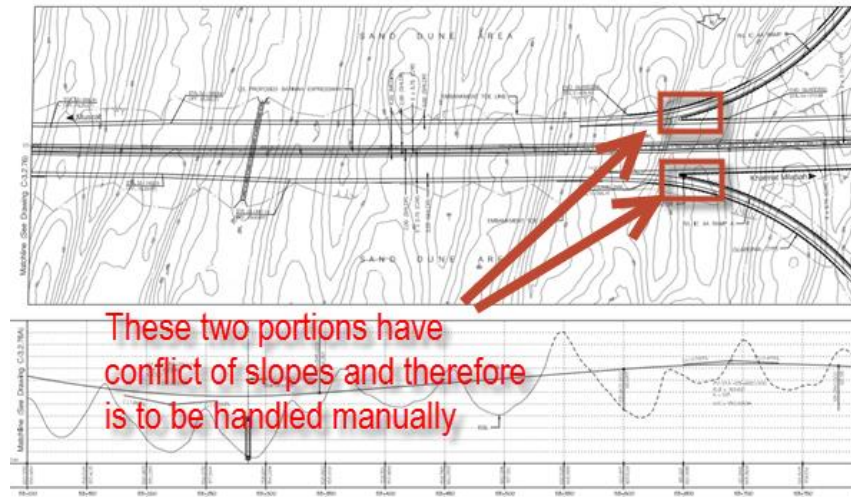
63. During the entire project execution, progressive levels can be plotted on the approved cross-sections if they are generated from 6D Cut-and-FILL program. The program maintains a drawing database and interacts with progress levels and restricts to within the boundaries the approved sections and returns quantities for preparing Interim invoices to the clients.
64. Slope protection works can be designed and drawn on to the cross-sections for the stretches you need them to have. Quantities are returned to excel files of these protections works.

## 3 Disadvantages

65. This is not a highway alignment design software like Bentley MX Roads or Autodesk Civil 3D. Therefore road designs cannot be performed using this software. Most contractors are not

expected to perform highway designs and therefore this application is not suitable for alignment designs.

66. This solution cannot handle transition areas where certain portion of a highway, for example, a lane is branching off from the main line where slopes of multiple carriage ways conflict as shown in the image below. Such length are to be manually edited after generating from using the program.



67. The solution cannot handle round-about portion of the road that may consist hardly 2-5% depending on project nature. For such areas manual cross-section creation process is resorted.