Volume Problems in TIN MODEL with Single Beam Data Collected Non-Perpendicularly to the Side Slope

By Pat Sanders

That's one hell of a title! Several years ago, Charlie Stapleton of USACE-Buffalo showed me a problem with computing volumes in the TIN MODEL when using single beam data that was collected non-perpendicularly to the side slope.

To illustrate the problem, and how to fix it, I created a channel that was 2000m long, 20m deep, 400m wide with a 5:1 side slope on each side. I then created perpendicular planned lines across the channel and another set of planned lines that angled 45° to the centerline.

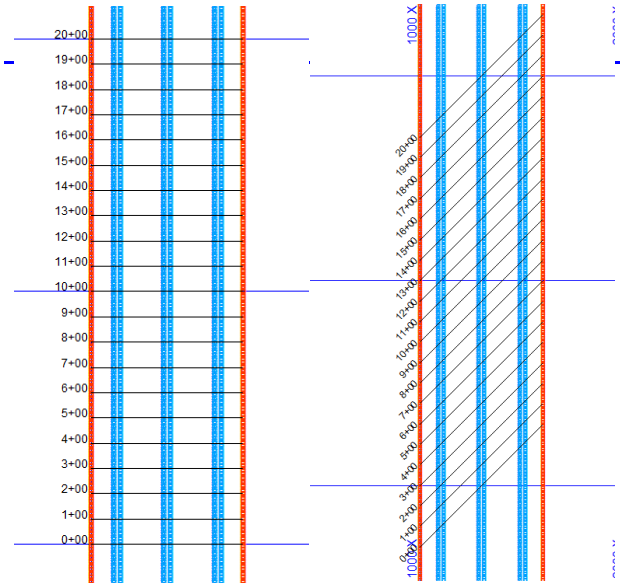


FIGURE 1. *Perpendicular Lines (left) and Angled Lines (right)*

The distance covered by each set of lines along the centerline is 2,000m.

I manually entered the template information (each line has the same design template, so it wasn't too bad) and saved the results to two separate LNW files.

I then created a set of 0m soundings along each top of bank line (shown in red) and a set of 20m soundings at each toe line and along the centerline (shown in blue). I saved the results to an XYZ file. My goal is to have the bottom cross sectional profiles match the channel template, so there would be no volume material above the design template.

To create single beam data files for each line, I took the XYZ file into the TIN MODEL program and, using each LNW file, exported separate Edited ALL Format data files.

PERPENDICULAR SINGLE BEAM FILES

I loaded the Perpendicular Single Beam files into the TIN MODEL with the appropriate planned line file, generated a surface and then ran volumes using the Philadelphia method.

FIGURE 2. *Single Beam*

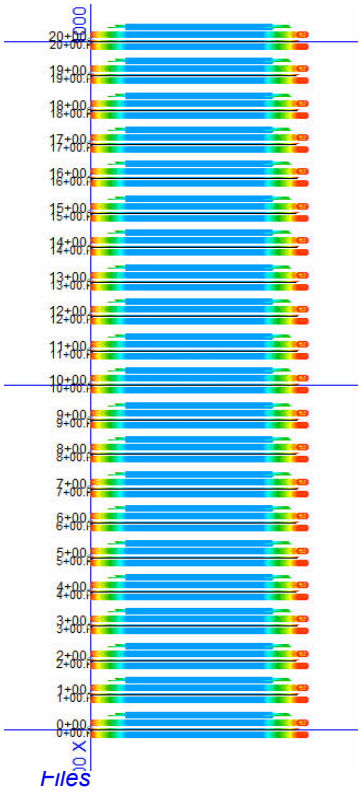
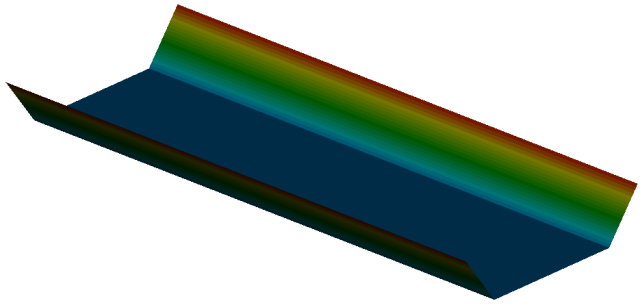


FIGURE 3. *The 3D TIN MODEL shows I know what I am doing when I 'fudge' a data set*



When I compute the volumes in the TIN MODEL using the Philadelphia Method, I get the perfect mathematical result:

Amount of Material Above Channel Design =0 cm

Amount of Material in Overdepth Region =1,200,000 cm

NON-PERPENDICULAR DATA

When I compute the volumes in the TIN MODEL using the Philadelphia Method, I get the perfect mathematical result:

FIGURE 4.

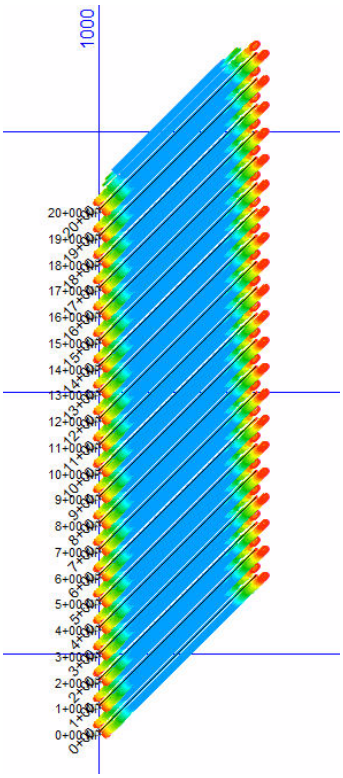
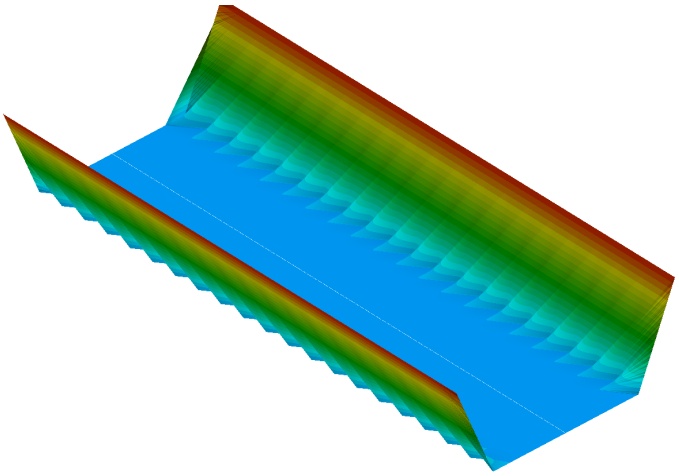


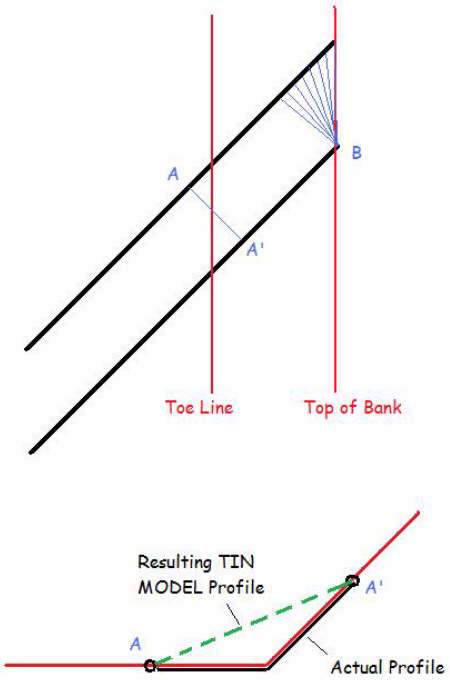
FIGURE 5.



Amount of Material Above Channel Design = 242,700 cm (OUCH!)

Amount of Material in Overdepth Region = 1,196,182 cm

:The TIN MODEL result has 242,700 cm of material that does not really exist! If you take a close look at the 3D model, you will see the presence of 'scallops' where each data file runs up the side slope. These 'scallops' are an artifact resulting from the creation of Delaunay triangles in the TIN MODEL. Delaunay triangles are created without considering the channel geometry.



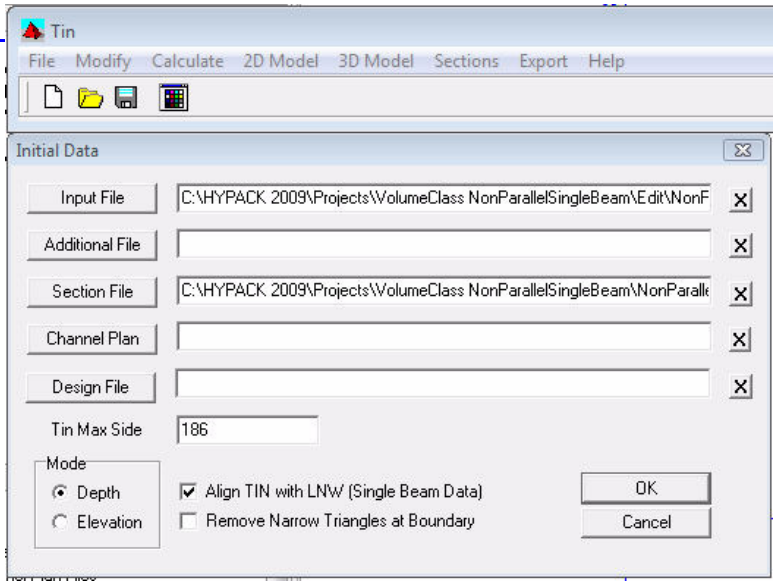
An example of what is happening is shown in the figure to the left. Point B, at the very top of the side slope can be used for hundreds of triangles. Since Point B is usually VERY shallow, it influences the surface in any triangle which has it as a vertex.

Next, take a look at the triangle vertex A-A'. The TIN MODEL has the depth at Point A and Point A' and assumes a straight-line interpolation along the line. The result is the dashed green line (bottom figure), where reality is actually the black line. The TIN MODEL has created material that does not exist!

HOW CAN WE FIX IT?

In the Setup window for the TIN MODEL there is a setting that reads 'Align TIN with LNW (Single Beam Data). This instructs the TIN MODEL to stop making Delaunay triangles and to proportion the triangles based on distance along the line.

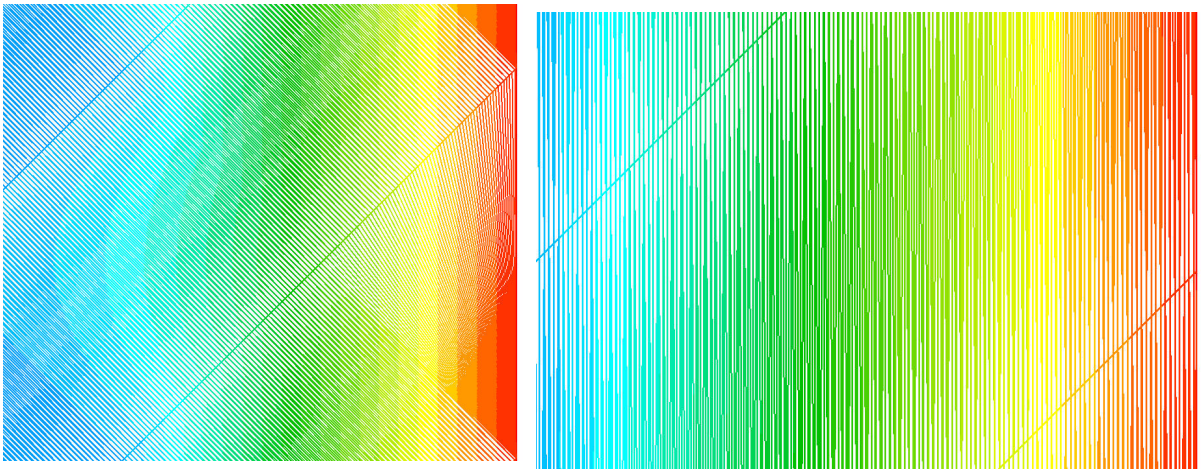
FIGURE 6. *TIN Setup Dialog*



One point along the top of the triangle will no longer be used for hundreds of triangles.

Take a look at the resulting triangles for the two cases. .

FIGURE 7. *The Delaunay triangles (left), Non-Delaunay Triangles (right)*



I have color-coded the depths, so that you can see how the light-blue is pushed outward from the sideslope in the Delaunay example, but things look much better in the non-Delaunay example.

When I run the volume quantities using the Non-Perpendicular lines, I now get:

Amount of Material Above Channel Design = 2,605 cm

Amount of Material in Overdepth Region =1,196,793 cm

It's not perfect, but it's a hell of a lot better than if we don't adjust the TIN MODEL for the non-Delaunay triangles.

IN SUMMARY

If you run your single beam data perpendicular to the side slopes, you should not have any adverse results in the TIN MODEL.

If you run your single beam data non-perpendicularly up the side slopes, you should:

- Set up the TIN MODEL to generate non-Delaunay triangles as described in the article.
- Or, use the CROSS SECTIONS AND VOLUMES program. It gives the exact result for both the perpendicular and non-perpendicular data files! (This is one of the few cases where I would recommend users to rely on CSV instead of the TIN MODEL.)