3D GEOMETRY BASICS WITH SVOFFICE 2009

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Hi, my name is Murray Fredlund. Welcome to the session 3D Geometry Basics within the *SVOffice 2009 Next Generation geotechnical software suite*.

SVOffice and 3-Dimensional Modeling

Before starting a 3D model, it's important to understand the basic concepts of how the software allows you to create 3D geometry into a numerical model. There are two primary approaches for creating a model in SVOffice. The first approach is creating a 3D model from basic building blocks (the focus of this video). There is a second approach which involves extruding a three-dimensional model from a 2D profile model (not covered in this video).

Before creating a 3D model, the user must have a basic understanding of the way that SVOffice views 3D geometry. We're going to illustrate this for you using very simple diagrams that don't represent the complexity that can be created with the software but illustrate the basic concepts. The shown figure illustrates three regions. Regions form the first building blocks of a 3D model. In a 2D model you would create regions in 2D profile view. In 3D regions are created in **Plan View** as if you are looking at the model from the top-down. You then draw regions that act as cookie-cutter shapes that cut through all of the layers and surfaces to form zones. In the example figure, region 2 is voided on layer 4 and cuts through layers 3, 2 and 1. In each of those cases, a different **Material Property** can be defined for that region-layer combination. If no **Material Property** is defined, the region is void. In the example, the circular region in region three is a void region because there are no **Material Properties** are defined. It then becomes a sort of cut-out of the model.

Boundary conditions come into play in 3D because you can apply boundary conditions to both a surface of a region (externally and internally) as well to any sidewall to any particular line segment on a region. In the shown example, boundary conditions can be applied to any of the faces and even to the internal faces. There is no limitation on the number of regions and surfaces that can be created in a 3D model which allows for a wide variety of options.

To recap:
- 3D models are created through a combination of regions and surfaces
- Regions don't contain any elevation data but are simply 2D extrusions which cut through all surfaces in a "cookie-cutter" type fashion
- All elevation data must come from surface definitions
- Surfaces in a numerical model are typically defined at the intersection of geo-strata. For example, if you have layers of gravel, clay and silt at your site, then the surfaces would form the intersection between the geo-strata layers. If you also have existing AutoCad or As-built designs available to you then they can form the basis of surfaces and interfaces between topography and man-made structure.

There are a variety of ways to define a surface in the SVOffice software such as through:
- mathematical descriptions – using a mathematical expression to define a surface

- interlocking planes - surfaces formed from a series of planes which interlock to form a surface. These are very useful on man-made structures such as an EarthDam where you have engineered slopes at 2:1 and very regular geometry.
- a grid – allows the user to specify 3D data on a rectangular grid through a series of X and Y coordinates which can be entered into the numerical model.

Note: every 3D model must contain at least two surfaces to define its space in 3D

Building a 3D Model
The provided examples are fairly simple figures used to demonstrate basic concepts. Grids can be regular or irregular. The top figure in an example of a regular grid where the spacing between all grid lines in the x and y directions, is the same. The figure is an example of an irregular grid which contains spacing between the grid lines that is not always consistent. Regular grids useful for models with pinch-out zones where you want the grids to match up and be regular. Irregular grids are useful where you want to have more detailed definitions of the elevations in one particular area of the model. SVOffice supports both types of grids.

It's also important to note that the grid does not have to be the same resolution for every surface. In the shown example, there are three surface grids. The top grid has more resolution, the middle one has less and the bottom grid is very sparse. This typically follows the way that surface grid data is obtained. There may be detailed lidar data or detailed survey data available from the topographies and therefore the grid on the surface may a bit more complicated. Alternatively the lower surfaces might be extracted from data obtained from a borehole drilling program and the number of boreholes might be quite sparse. This would be a natural type of 3D model.

When the user is defining a 3D model they should consider what types of intersection points exist between various surfaces. For example, if there are pinch-out zones between grids then it is much easier to have every grid at the same resolution because the pinch-out algorithms work better that way. However, if there are no pinch-out zones in your model, then having a model built from grids of various resolutions is entirely acceptable. The user should also note that the density of the surface grid does not control the resolution of the mesh, in any way. There is no requirement that there be a mesh node point at every grid intersection point. If a user has a very dense grid as a surface, that does not imply a dense mesh.

The size of the grids on each surface do not have to match. It's not a requirement that they match. If they don't match, the smaller grid will be extended to the extents of the larger grid. This can be helpful in some cases, but dangerous to a certain level. You want to be clear on how your surface is being interpolated to the extents of your problem. Although this is supported in the software, it's not necessarily recommended in every circumstance.

Step One – Create Region Geometry
Let's just go through what we've talked about and create a very simple flow model. The first step is to create region geometry. In this case we've created two regions which connect to each other. These regions are defined in **Plan View** so it's as if we're looking top-down view towards our model. These regions can be drawn on the CAD control, the coordinates can be typed into the software or geometry can be imported from an AutoCAD or shape file.

Step Two – Build Surface One

Step two would be to build **Surface One**. In this case we would have Surface One that's defined. This is the lower surface. These can be built manually, from scatter data imported from AutoCAD points or from ESRI shape files. Kriging is also implemented in the software and can be used to obtain a regular surface. Here you'll note that the surface grid is rectangular and extends beyond the bounds of any of the regions of the model. It's important to note this. The extents of the model are defined by the regions that are defined, not by the surfaces. Surfaces should ideally extend slightly beyond all of the region definitions of the model.

Step Three – Build Surface Two

Step three is to build **Surface Two**. Here is where we define volume in the model. We define an upper surface (which becomes the upper surface for layer one) and becomes the lower surface for layer two. In this case we are defining this as a plane surface and therefore we're locating a point in 3D space, giving this plane a dip and a direction of dip to define it. Now we have one layer split into two parts because the region is now cut, like a cookie-cutter, through the model.

Step Four – Build Surface Three

Step four is to build the third surface. In this case we're going to input scatter data similar to survey data for a surface, an upper topology, and we could Krig that data to form a regular type of surface. The surfaces are going to have to be stacked on top of each other and layers can be thought of as building blocks moving upwards from the bottom of the model. Surfaces are always built with surface one at the bottom of the model and surfaces are built upwards.

Step Five – Apply Material Properties

In the provided example, we have four defined material zones and what we can do is apply material properties to each of these zones. Materials can come from a variety of sources. We support a variety of material constitutive models in our software and every region and layer pairing can have a different material. What we've defined is four different materials for our four different zones in this 3-D model. If you don't apply a material property to a zone, then it becomes a void area in the model. To help the user know what zones have been defined, once a material has been applied to a zone then it is colored the color of that material.

Step Six – Apply Boundary Conditions

In step six we apply boundary conditions. It's important to note that finite element models are boundary-value problems (BVP) and they must have an interface with the rest of the real world. We have to define boundary conditions on a surface or a sidewall of the 3D model. Any surface or sidewall (even internal) can have a boundary condition in the model. Once you apply a boundary condition, the boundaries are colored to show that boundary conditions are applied to that area of the model.

Step Seven - Solve

Lastly, in step seven, we can send this to the solver for a solution. The results are then visualized (as show in the example picture) from our backend visualization engine. In this case, the water table is colored blue, increasing pore-water pressures are colored darker blue and the brown zones represent unsaturated areas. In this 3D model it's divided up using a tetrahedral mesh and

the solver also has automatic mesh generation and refinement which can be used to identify critical areas where the model can focus numerical analysis.

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