Roundabout Design Using
AutoCAD® Civil 3D® 2010 Intersection Tools

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CV214-1   Learn how to leverage the new intersection design tools from AutoCAD Civil 3D 2010 for use in a roundabout design project. These tools were primarily designed for standard four-way and T-intersections, but this class will help you harness the power of these new tools in a totally different design context.

About the Speaker:

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Objective

The objective of this class is to try to demystify the new intersection tools by attempting to use them in a roundabout design project. This class will focus on the modeling aspect of the roundabout design process, including:

- Alignments and profiles for incoming and outgoing road segments
- Using offset alignments and profiles to control cross fall slopes
- Creating custom assemblies adding them to an assembly set
- Using the intersection tools
- Adding splitter islands
- Creating corridor surfaces for rendering

Different types of roundabouts

There are many different types of roundabouts, all of which can be modeled using AutoCAD Civil3D. However, the geometry will directly impact the method that should be used to model the roundabout. The method that will be presented in this class is the simplest one: it will leverage the power of the new intersection tools that were added to Civil3D 2010. Unfortunately, these new features can only be used to model simple roundabouts like this one:
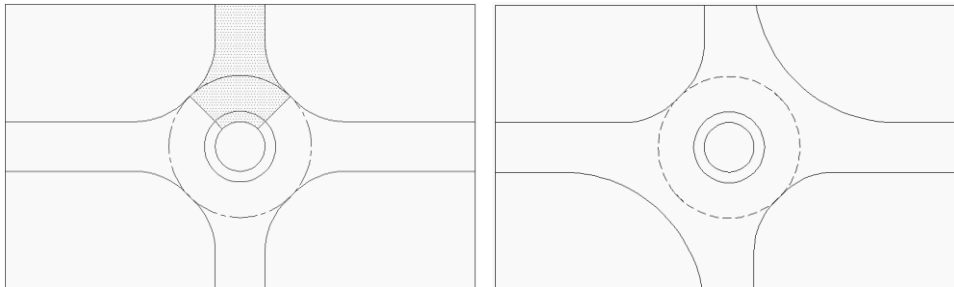
In the first image, the hatch represents one intersection between the main alignment (roundabout) and the secondary road. In the second image, the larger radius of the bypass lanes creates a widening in the roundabout – it then becomes almost impossible to model the junction of the road with the roundabout alignment using intersection tools because no clear-cut intersection regions can be defined.

Preparing your template

Some settings should be modified within your DWT before starting a roundabout design project. This will save you some time during the modeling and design phases.

1. **Turn off selection preview**
    This is something I always do upfront when working with corridor models. Basically, a corridor is made up of multiple feature lines, links and points overlapping each other. When hovering your cursor over a large corridor model, the cursor will tend to hang or slow down

because it needs to regenerate the object as a whole (and a corridor model is a rather large object). To turn off selection preview:

▪ Enter "OP" at the command line and hit the Enter key
▪ Go to the Selection tab
▪ Turn off these two options:
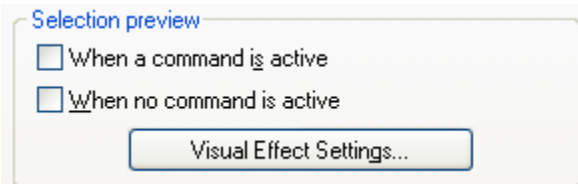
2. **Change your default corridor frequency settings for intersection modeling**
A roundabout is essentially a curve with a very short radius. Therefore, if you want your model to show up correctly, you should probably change your frequencies (by default, the metric template has 25m intervals, which is way too big).

Settings Tab → Intersection → Commands → Double click on "CreateIntersection"

Under "Assembly Insertion Default", change these 3 parameters:
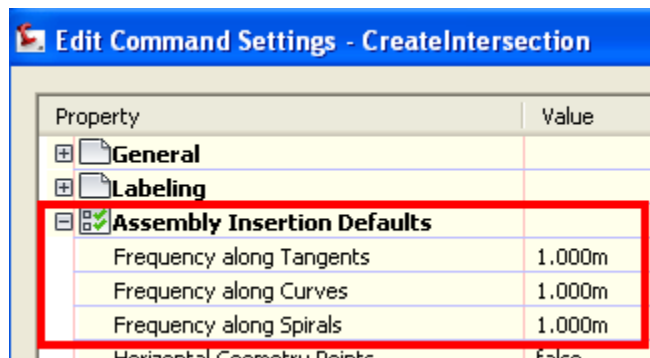
3. **Change your offset alignment default settings for intersections**
In the same window, make sure to change Offset Length Options to "Alignment Start to End".
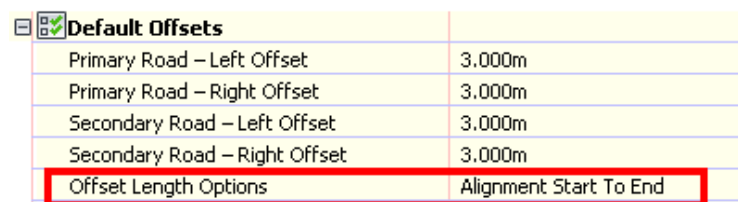
We will get back to why this is important in just a few minutes.

4. **Name templates for various objects**
   Different objects will be created when we start modeling the roundabout, for example:

   - Intersections
   - Offset Alignments
   - Profiles for edge of pavement

   If you want to make it simpler down the road, you may want to change these name templates to the following (still under the "CreateIntersection" command settings):

   We will get back to why this is important in just a few minutes.

What exactly is the new intersection object?

You will notice that a new object category called Intersections has been added to the Prospector in Civil3D 2010.
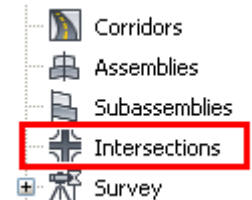
The intersection object is not a 3D element: it is simply the collection of set parameters for the automatic generation of your corridor model. Here is a list of parameters that can be set:

- Intersection type
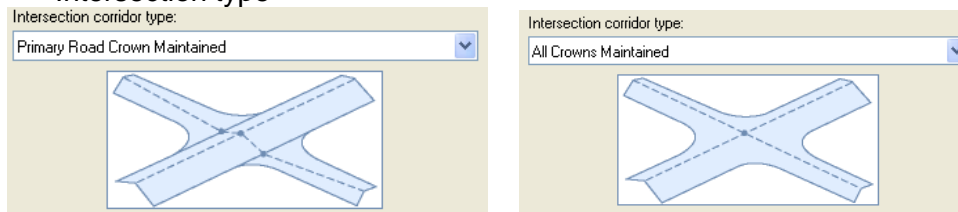
- Curb return radiuses and profiles
- Lane slopes (or edge profiles)
- Assemblies to be applied to each independent region of the intersection
  - Grouped into an assembly set, which can be saved to an XML file

Under the following directory, standard assemblies have been grouped under assembly sets for use in standard intersection modeling:

C:\Documents and Settings\All Users\Application Data\Autodesk\C3D 2010\enu\Assemblies\

Be careful when using metric assemblies!

One set has been supplied for countries driving on the left-hand side of the road….

An assembly set is basically a collection of links to separate assembly files.
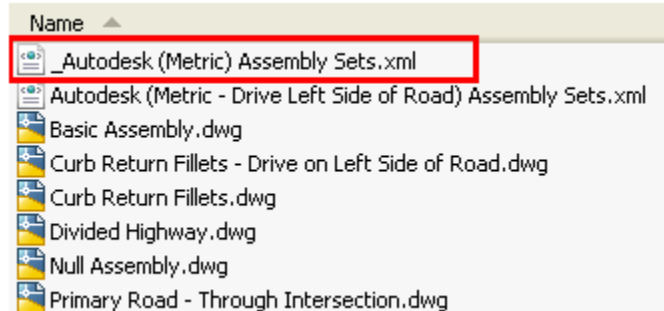

```xml
<?xml version="1.0" encoding="UTF-8" ?>
<!-- An assebly set is a collection of assemblies that can be applied to a
corridor regions based on type -->
<AssemblySet>
  <AssemblySetType Name="SimpleHoldMainRoadCrown">
    <RegionTypes>
      <MainRoadTypicalSection DisplayName="Primary Road Full Section"
        AssemblyName="Primary Road Full Section" AssemblyPath="%
        AECCCONTENT_DIR%\Assemblies\Metric\Primary Road Full Section.dwg" />
      <SideRoadTypicalSection DisplayName="Secondary Road Full Section"
        AssemblyName="Secondary Road Full Section" AssemblyPath="%
        AECCCONTENT_DIR%\Assemblies\Metric\Secondary Road Full
        Section.dwg" />
      <ThroughRoad DisplayName="Primary Road - Through Pavement"
        AssemblyName="Primary Road - Through Intersection" AssemblyPath="%
        AECCCONTENT_DIR%\Assemblies\Metric\Primary Road - Through
        Intersection.dwg" />
      <CurbReturnSection DisplayName="Curb Return Fillets" AssemblyName="Curb
        Return Fillets" AssemblyPath="%AECCCONTENT_DIR%
        \Assemblies\Metric\Curb Return Fillets.dwg" />
```

In the case of a roundabout, the main difference resides in the primary road assemblies.

On the left hand side of the primary road, we have a central landscaped area, and a mountable apron for trucks. Standard assemblies supplied by Autodesk for intersection modeling will need to be adjusted to account for these elements.
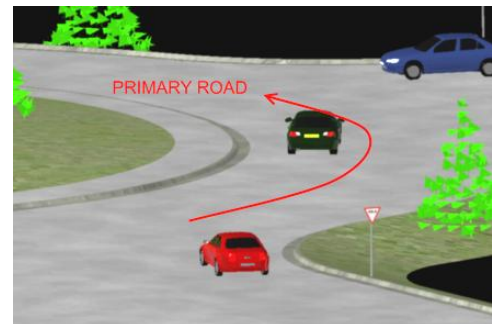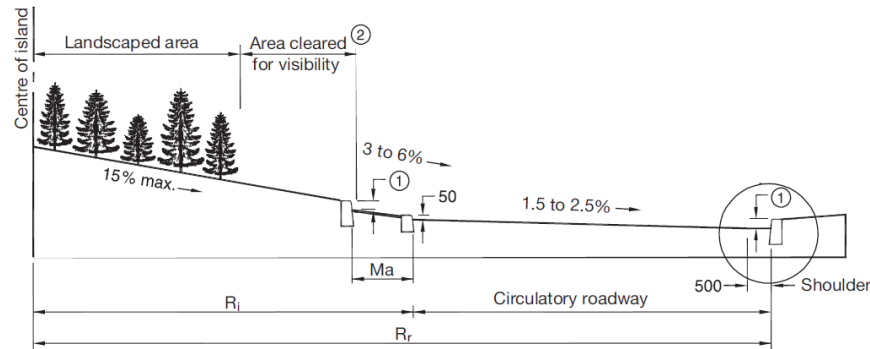
Fig. 4.7-1 Typical Cross-Section of a Roundabout (Ref.: Transports Québec, Roundabouts – A Different Type of Management Approach, 2005)

In the dataset for this class, you will find a folder called "AU2009_ROUNDABOUTS". Simply place this folder and its contents in your C:\ directory. This folder contains modified assemblies accounting for the mountable apron and the landscaped area.

- Primary Road Part Section - Daylight Left.dwg
- Primary Road Full Section.dwg
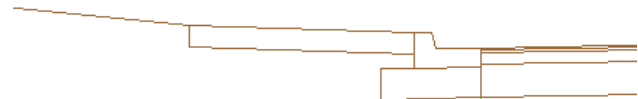
Geometry

The first step in creating a roundabout is to decide on the geometry. What is the radius? How many connecting roads are there? What are the curb return radiuses at the different junction points? You may not have answers to all of these questions during the preliminary design phase. Then simply use default values – Civil3D creates a dynamic model which can be modified later on in the design process.

Open ROUNDABOUT1.dwg

Start off by creating a new alignment for your roundabout. Typically, we specify the outside edge of pavement but in the current example, I decided to treat this 2-lane roundabout as a standard road, meaning that it will have its centerline alignment between the two lanes. It really doesn't make any difference – if you want to specify the outside edge alignment, your left offset edge of pavement width will be larger and your right offset will be very close to zero.

Home Tab → Create Design Panel → Alignment drop down → Alignment Creating Tools

In this case, we will be using the Fixed Curve (Center Point-through point) simply because we will be tracing over an existing aerial photo. But of course, you could just as well specify a fixed radius.
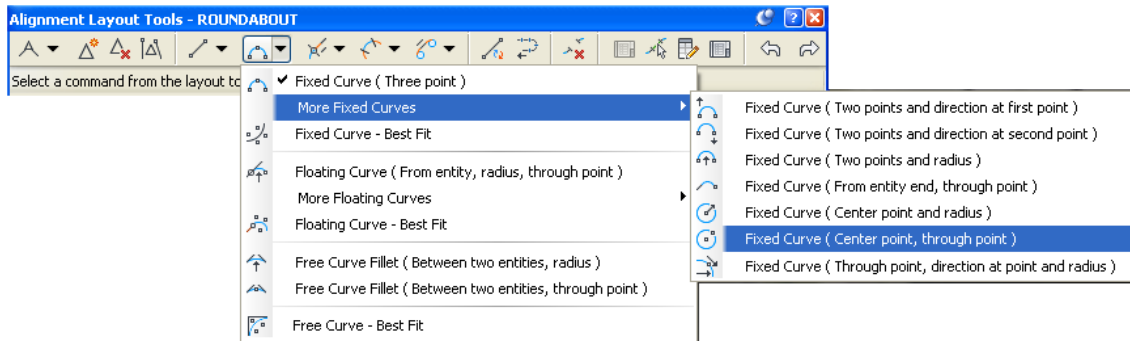
One thing you have to make sure is that start point of your roundabout alignment is in between two secondary roads. If the 0+000 is left within an intersection region, the intersection wizard will not be able to compute the intersection regions correctly.
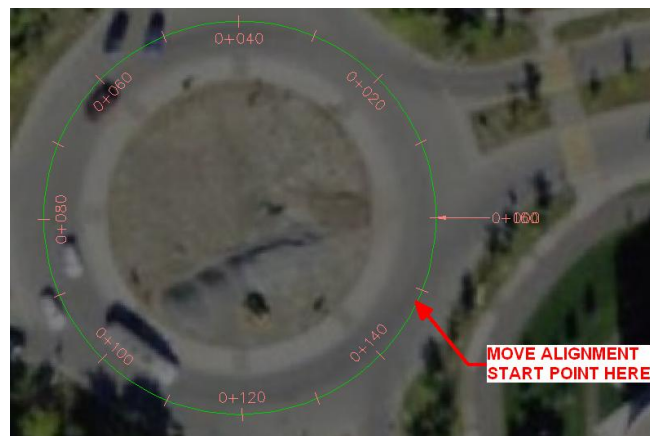
Then we should create secondary road alignments. I chose to create one centerline alignment for each secondary road, which means the alignment will run right through the splitter islands. We will get back to splitter islands towards the end of the class.

Note that alignments should start (or end) at the intersection with the roundabout alignment.

Once your alignments are finished, generate an existing ground profile and create a profile view for each alignment, including the roundabout alignment.

The next step is determining the proposed elevation of the roundabout. During the preliminary design phase, there is no need to be exact: just create a proposed profile for each alignment, at arbitrary elevations.

Open ROUNDABOUT2.dwg

Finally! Now is the time to start using the intersection tools. Go to the Home Tab of the ribbon, under the Create Design panel and hit ⬛ Intersection

When asked to select an intersection point, zoom in to the intersection of Commerce East and the roundabout main alignment, and click on the intersection of the two alignments.

The following window will show up:
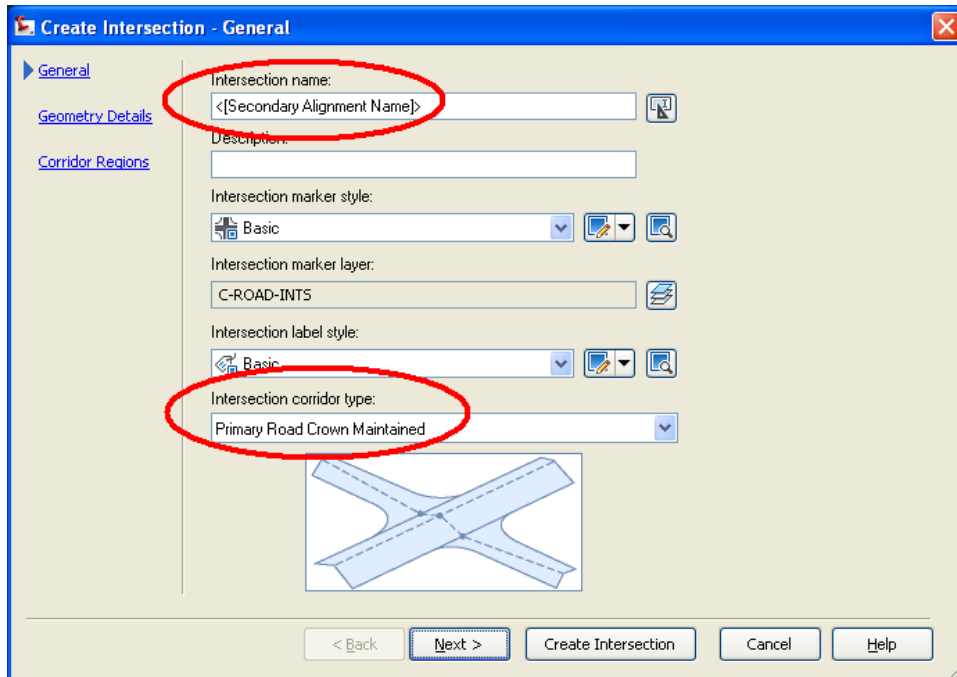
Notice that the intersection name will be based on the secondary alignment, which is exactly what we want. In standard Civil3D templates, you will often find name templates to include both the primary and secondary roads – in the case of a roundabout, there is no point in mentioning the primary alignment name (roundabout).

Also make sure to select "Primary crown maintained" as the intersection corridor type. You don't want you roundabout slope to change at every junction point with a secondary road. It should remain constant all around.

Click Next.

In the following dialog box, you will be asked to enter various parameters. We will go through each one of them.
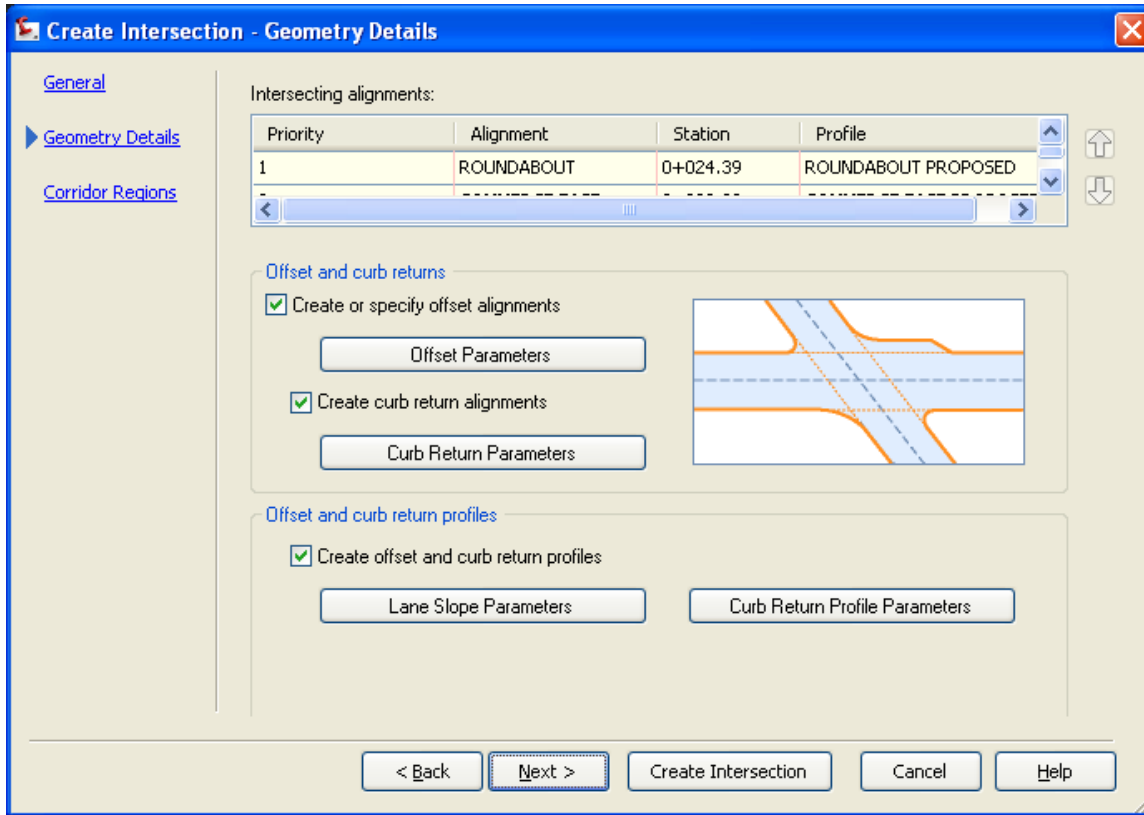
Offset Parameters:

Offsets parameters allow you to specify a width for your main and secondary roads. You can either use an existing alignment or ask Civil3D to create a new one. In this case, no offset alignments were created in our project – we will therefore specify offset values (left and right) for each alignment.

ROUNDABOUT alignment:

      Left and right offsets = 5m

      * Remember I chose to trace my alignment on the centerline, i.e. in between the two lanes of the roundabout. We will therefore have two 5m lanes.

COMMERCE EAST alignment:

Left and right offsets = 8m

Curb Return Parameters:

Under the curb returns parameters, you can specify the radius of the fillet between the edge of pavement of the main and secondary roads. Notice we have two different quadrants for which we have control over.

You can also specify turn lane parameters. For now, we will not add any turn lanes, but this can be always be modified later in the process.

For the COMMERCE EAST intersection, make sure to change your radiuses to 8m for both quadrants.
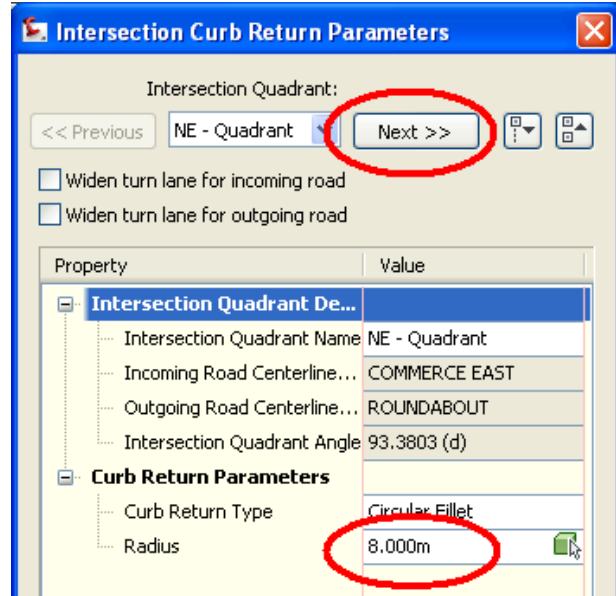
Lane Slope Parameters:

This is where you can specify the superelevation (or cross fall) for you roundabout and its incoming roads. The default value will be set to -2% for left and right offsets of both the roundabout and secondary road alignments. Make sure you change the left edge cross fall to +2% for the roundabout alignment only.
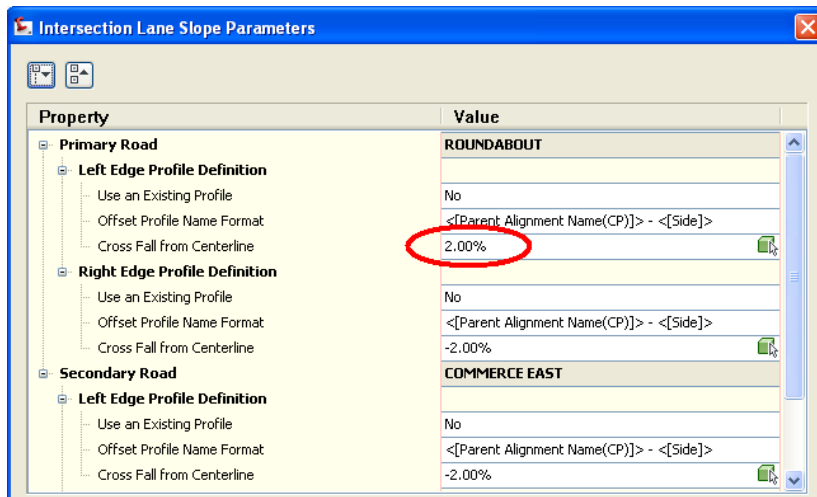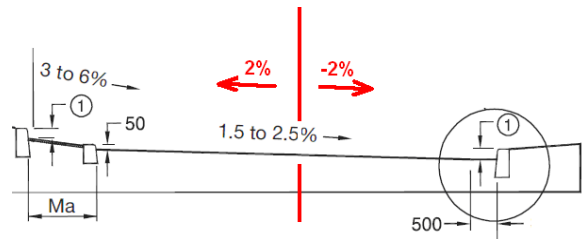
Curn Return Profile Parameters:

Curb return profile parameters allow users to extend the curb return profile on a certain distance along the edge of pavement of the main and secondary roads. In this case, I decided not to use this functionality:
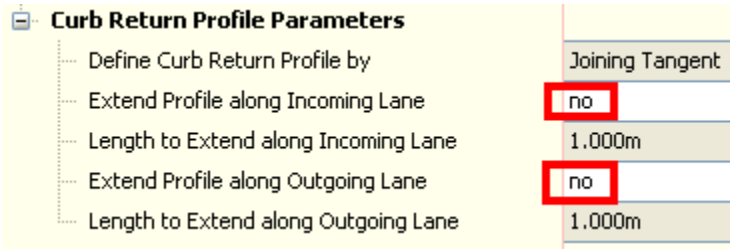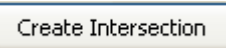

Click Next

In the last dialog box, make sure to browse to the location of the assembly set:

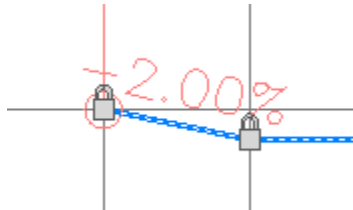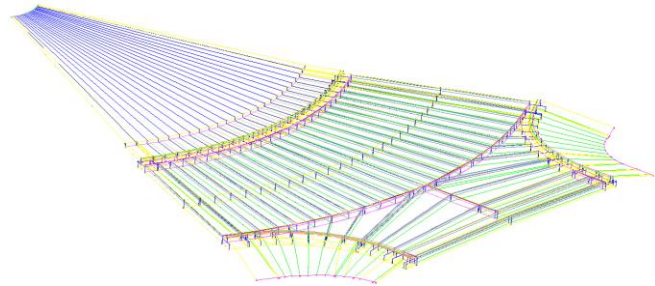C:\AU2009_ROUNDABOUTS_Autodesk (Metric) Roundabout Assembly Sets.xml
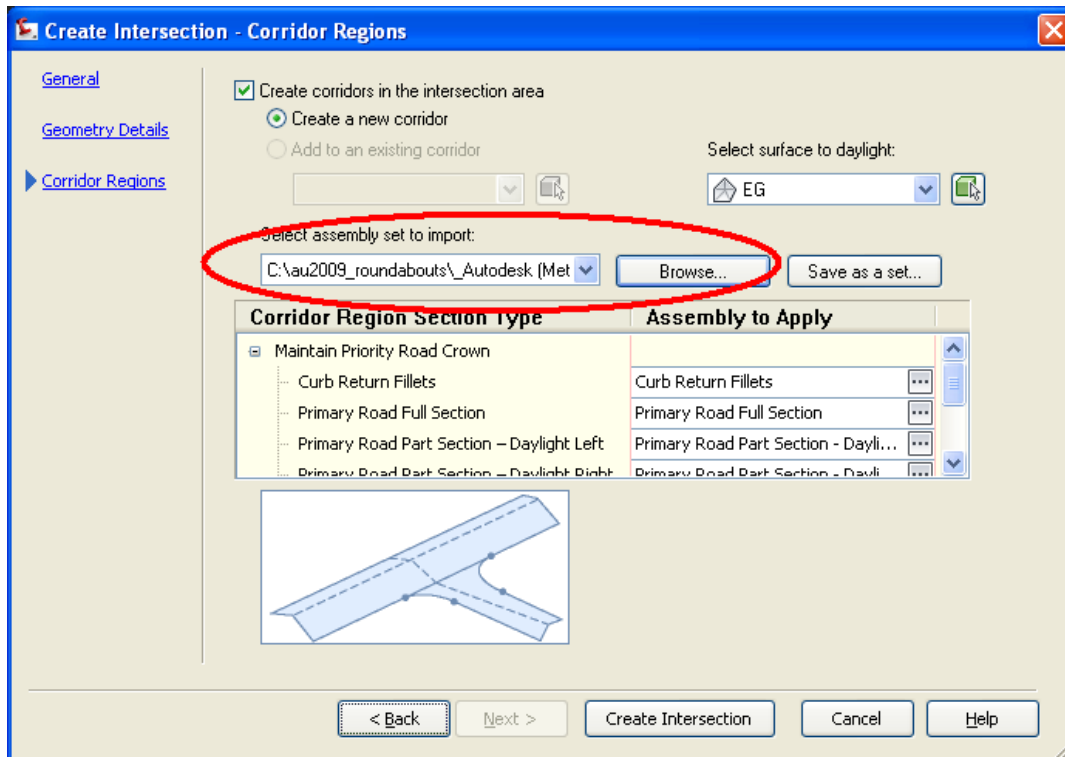
Make sure that the daylight surface is set to EG and click on Create Intersection

The first intersection of the roundabout is now created and should look like this:

Notice that new assemblies have been imported to the current drawing from the assembly set.

Also note that your proposed profiles have been matched and locked to your main road profile. You can clearly see the 2% cross slope from the roundabout alignment in your secondary road profile.

SECOND INTERSECTION

Now let's create a second intersection.

Launch the Intersection tool: go to the Home Tab of the ribbon, under the Create Design panel and hit   Intersection

Click on the intersection point of alignments COMMERCE NORTH and ROUNDABOUT.

Click Next on the first dialog box. We will once again use the "Primary Crown Maintained" intersection type.

Now be careful!

Offset Parameters:

When creating the first intersection, we deliberately created offset alignments from beginning to end of our centerline roundabout alignment. Instead of asking Civil3D to create a separate alignment and profile for each left and right edge of pavement for every intersection, we will simply reuse the first one. This will also simplify the process if we ever need to change our roundabout lane offsets.

Make sure you specify the ROUNDABOUT-Left and ROUNDABOUT-Right alignments as the offset alignment definition.

| Primary Road	ROUNDABOUT
Left Offset Alignment Definition	
Use an Existing Alignment	Yes
Alignment Name	ROUNDABOUT-Left-5.000
Offset Value	**Varies**
Right Offset Alignment Definition	
Use an Existing Alignment	Yes
Alignment Name	ROUNDABOUT-Right-5.000
Offset Value	**Varies**

For the secondary roads, we will use the default 8m offset, left and right. New offsets alignments will therefore be created.

Curb Return Parameters:

For every other intersection in this roundabout, I will use 10m fillets for my curb returns.

Lane Slope Parameters:

For the first intersection, we created two edge of pavement profiles – the left one at a +2% cross grade and the right one at a -2% cross grades. These profiles already exist from beginning to end of our roundabout alignment. Once again, there is no point in creating a new edge of pavement profile – simply reuse the ones created in the first intersection!
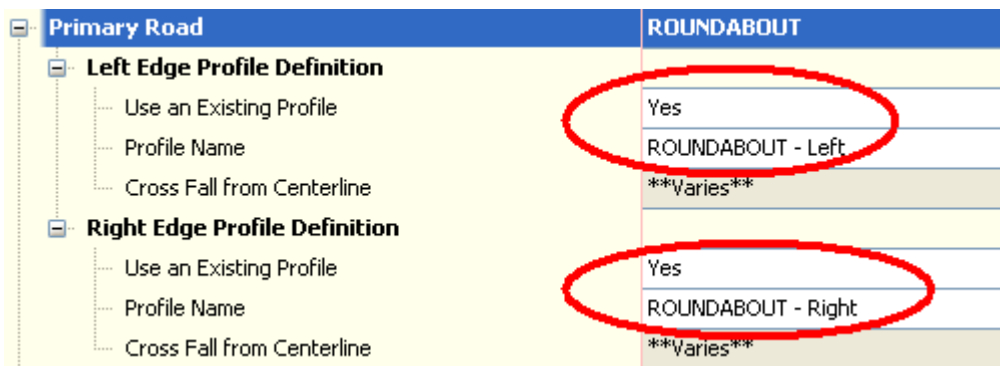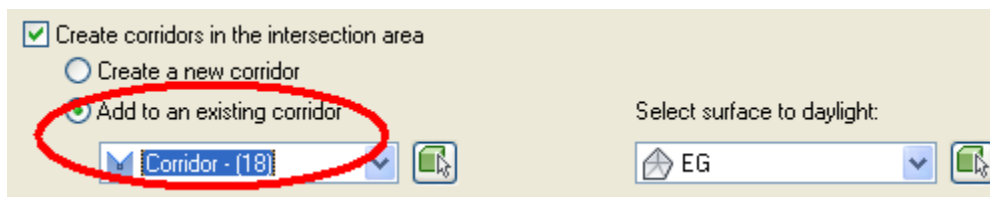

Curn Return Profile Parameters:

We will leave the default values, as for the first intersection.

Click Next.

In the last dialog box, make sure you add this new intersection to the same corridor as the first. You want your roundabout model to be a unique corridor. Also make sure you daylight to the existing ground surface. Once it is done, click on Create Intersection.

Your corridor 3D model should now look somewhat like this:
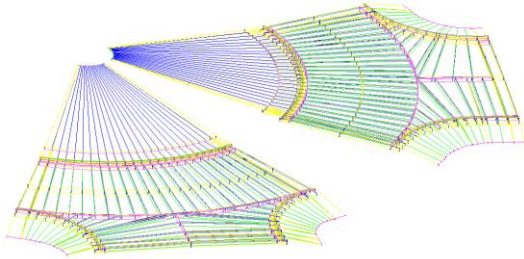
Repeat the steps from the second intersection for the third and forth, which should leave you with this:
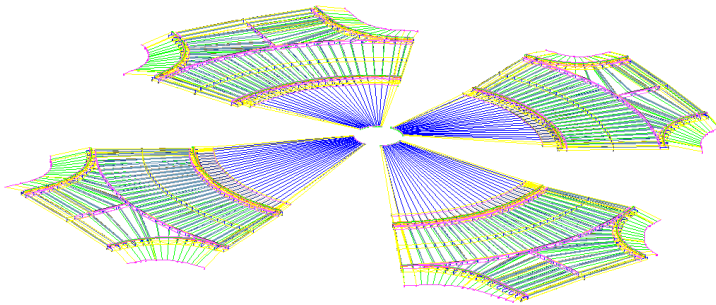
MODYFYING THE GEOMETRY OF AN INTERSECTION

What if you need to add a turn lane for the incoming road? It's simple! Click on the intersection marker of the intersection that needs to be modified. The marker is the symbol located directly on the intersection point.
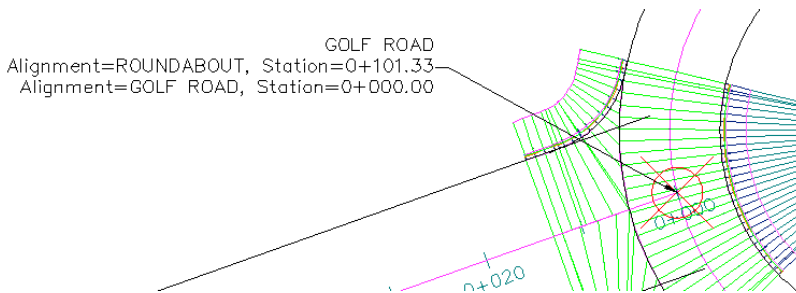
A contextual tab will appear in the ribbon. Many different options will be available from the "Modify" Panel. In order to add a turn lane, you must edit the Curb Return Parameters by clicking on this button:

To add a turn lane, you will need to check the "Widen turn lane for incoming road" option.

You may also want to modify you transition details from the "Widening at Incoming Lane" section of the window.

Once you entered the desired parameters, you will need to recreate your corridor regions using this button:
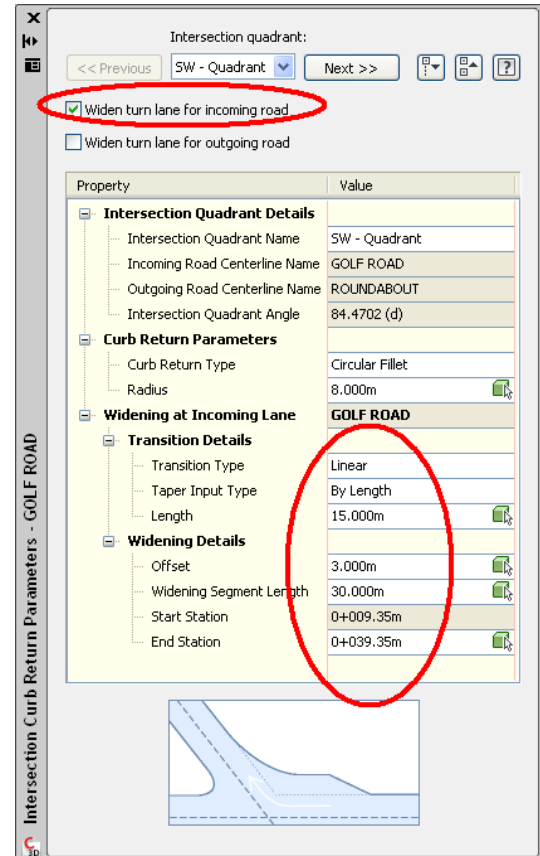
FILLING IN THE GAPS

In order to fill in the gaps between the intersections, simply stretch you corridor regions using the grips as shown in the following screen capture. Of course, you will need to rebuild your corridor model once you are done.

Note that if you ever need to change you intersection parameters, for example to add a turn lane or to modify your curb return radiuses, you will be required to repeat this step.
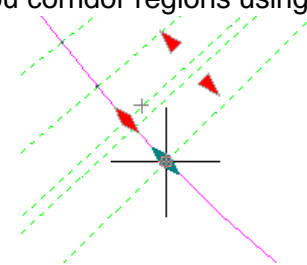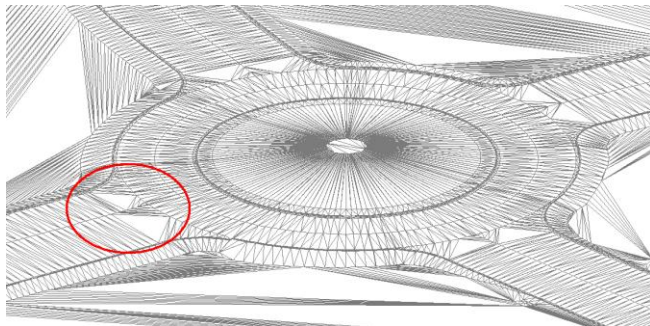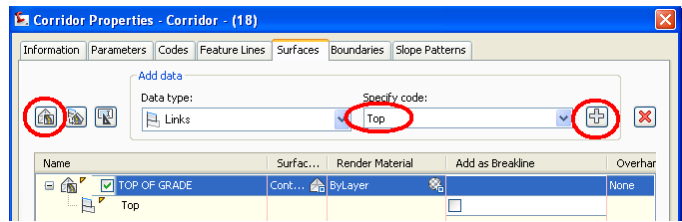
Now here is your updated roundabout model:
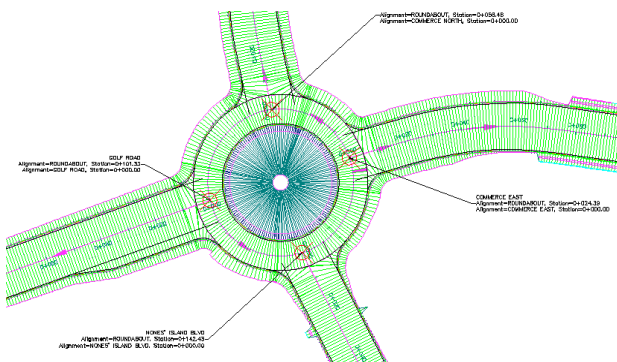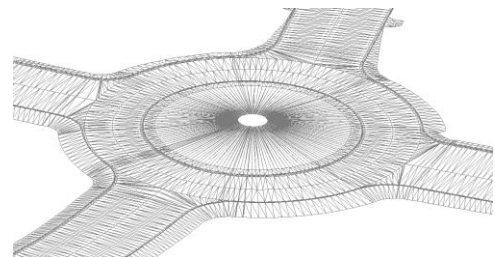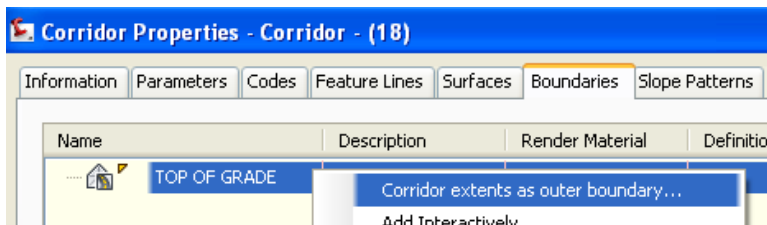
CREATING A TOP OF GRADE SURFACE

In your corridor properties, go to the Surfaces Tab. Click on "Create a Corridor Surface" and rename it "Top Of Grade". Then add the Top Link to the corridor surface using the ⊕ button.

Here is what your surface will look like:

You will notice some triangles are swapped when compared to the corridor links. If you want to correct you surface, simply check the "add as breakline" option from the Surfaces Tab of the Corridor Properties.

You can also see that your surfaces goes way beyond the limits of the corridor model. Adding a surface boundary to a corridor model as complex as this one would have been a pain in previous versions of Civil3D. However, in Civil3D 2010, a new function allows you to use the corridor extends as the outer boundary of your corridor surface.

MODIFYING CROSS GRADES

For design and validation purposes, you may want to add slope labels to your top of grade surface to make sure changes are applied correctly.

Say you want to change the cross grade of your roundabout alignment to -3% in order to slow down traffic. Remember we used a single offset alignment and profile for the edge of pavement of the roundabout, which means that modifying one intersection will impact   on all others. Select any intersection marker in the drawing area, and click on the   Lane Slopes button from the ribbon.

Change the Cross Fall values to +3% and -3%. This will change the elevation of the ROUNDABOUT-Left and ROUNDABOUT-Right profiles. Notice here that profile names do not include the cross fall slope, which is a good thing. We would not want our profile to be named "+2%" and "-2%" when applying a 3% slope…

You will need to change stretch your corridor regions again.

SUPERELEVATION ON INCOMING ROADS

You do have to be careful if you need to add superelevation on curves on incoming roads. As you may know, there are three different methods in order to specify the cross fall of a road at any given station:

1. Using the default value set in the subassembly
2. By calculating superelevation transitions under the alignment properties
3. By specifying target offsets and elevation for the edge of pavement (offset alignment and profile)

What you need to know is that (2) overrides (1) and that (3) overrides (2). When using intersection tools from Civil3D 2010, you are in fact always using offset alignments and profiles for the edge of pavement (method 3). Therefore, even if you did calculate superelevation transitions under your alignment properties, this will have no impact on your corridor model. You will need to split your corridor regions and remove the target profiles for the edge of pavement elevation for our superelevation to be taken into consideration.

 Open ROUNDABOUT3.dwg

SPLITTER ISLANDS

As was previously mentioned, I deliberately chose not to account for my splitter islands in the main corridor model for the sake of simplicity. I will be treating them as a separate corridor model.

First of all, I will start by tracing the outlines of the splitter islands using standard polylines. In this case, I will be inserting a block at every intersection point.

I will be converting each one of these polylines into a separate alignment using the Create Alignment from Objects tool.
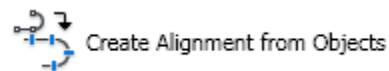

Make sure all your alignments run in the same direction, with the curb on the inside of the alignment. This will make things easier down the road.

The next step is to create a surface profile on the top of grade surface of your roundabout corridor, on each one of your splitter island profile. There is however no need to create a profile view:
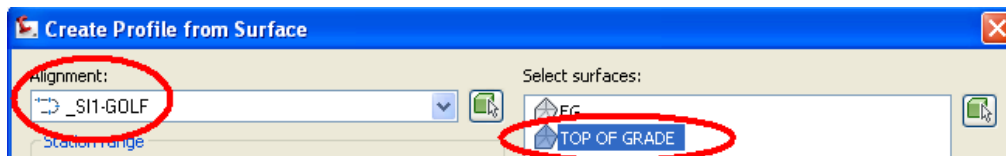

We will now need to create an assembly for our splitter islands. This is rather simple. Start off by clicking on the Create Assembly button from the Home tab of the ribbon. Give it a name ("Splitter Island"), and insert the marker in the drawing.
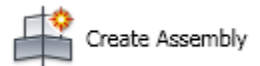
Add a basic curb subassembly to the right-hand side of the marker. Set the Depth Below parameter to 0m and Depth to 0.15m.

Then create a new Splitter Island corridor, using the splitter island alignment and assembly, and the top of grade profile. You will also need to change your frequencies to a smaller interval value.
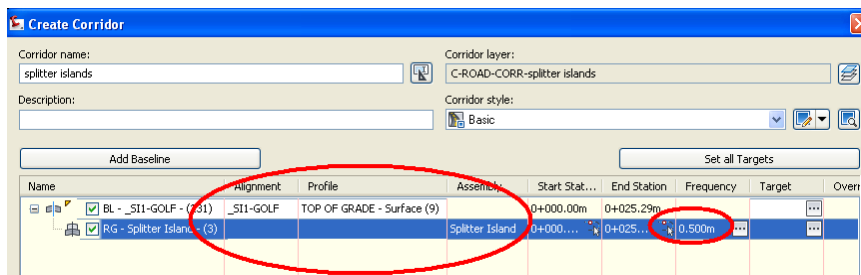
You will need to add every splitter island alignment as a new baseline to the splitter island corridor.

You can then generate a splitter island surface by adding the Top link and Bottom_Curb feature line to the surface.

You will then need to delete triangle lines in between the splitter islands.
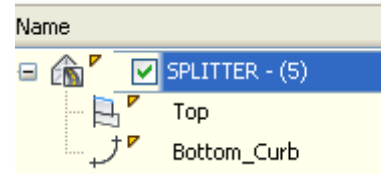
Open ROUNDABOUT4.dwg

<u>CREATE A FINAL SURFACE</u>

To create final contours, which will include the roundabout model, the splitter islands and the existing ground, you will need to create a new surface in which you will paste the all of the above-mentioned surfaces.

NEVER paste your corridor surface to the existing ground!

Remember that Civil3D creates a dynamic model: when an object is changed, it will impact on other objects that depend on it. Pasting a corridor surface to the existing ground will create a circular reference. It will hang or crash the application.

<u>RENDERING AND VISUALISATION</u>

Civil3D has some very nice visualization tools that are often overlooked. You can easily dress up your final model for presentations user render functionalities.

First of all, you may want to add a few cars, light posts, trees and road signs in your 3D model. Simply turn on your Multiview blocks tool palette. It contains tons of 3D elements that can easily be inserted in your Civil3D project.
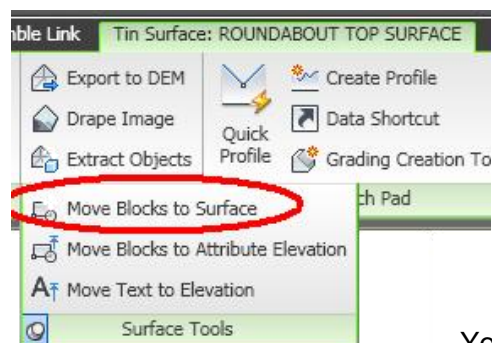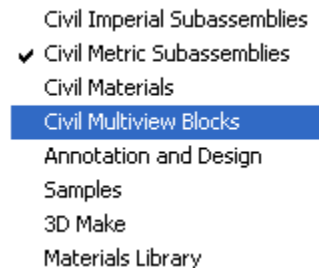
Once inserted in plan view, you will need to make sure the block has the appropriate elevation. Click on your final surface contours, and choose the "Move Blocks to Surface" option from the Surface Tools panel. This will allow you to move all your blocks to your surface model, in one single click on your mouse.

You can then orbit your model in 3D and place it as you wish. Then type RENDER at the command line. The render window will pop up.
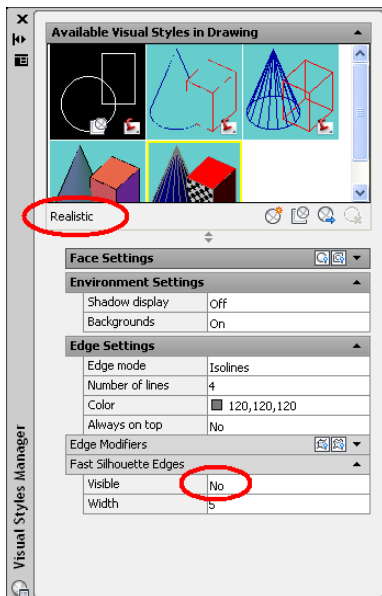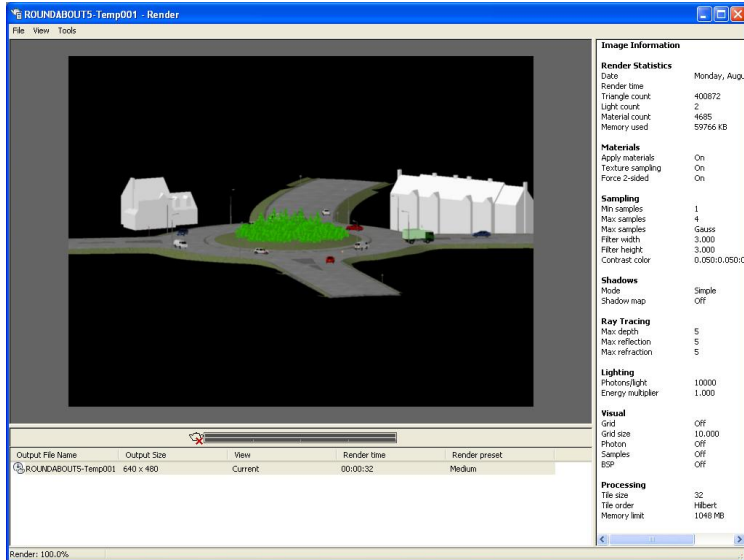
Note that to achieve this kind of result, you will need to turn off edges under the Realistic visual style. (command: VISUALSTYLES)