Volumes for Earthwork

Quantities of earthwork are specified to be measured according to volume basis, based upon the digital terrain model and calculated by triangular volume, average end area volume from cross sections, or other methods of equivalent accuracy. Within OpenRoads Designer and OpenSite Designer, the Model Analysis and Reporting>Civil Analysis group provides more than several methods from which to choose. If corrections for curvature are specified, one of two methods will need to be used to calculate earthwork volumes: Analyze Volumes (using terrains) or Quantities Report by Named Boundary (using 3D meshes).

Analyze Volumes allows you to calculate volumes between digital terrain models, which is a triangular volume method, and usually used after you have created FG and SG terrains. You can use a shape element, named fence, or a plan named boundary to limit the area. So, Analyze Volumes may be a good method to use during construction activities with OG and SG terrains. Quantities are not reported by station because there is no corridor or geometry involved.

Element Component Quantities computes quantities directly from the 3D elements (component layers) in the corridor model. For corridor components, it may produce more accurate results than the Corridor Component Quantities tool. Corridor clipping is considered, however, cut and fill volumes are not calculated because Mat-Cut and Mat-Fill components are not typically closed shapes in a template. Element Component Quantities are not reported by station.

Corridor Component Quantities computes volumes using the Average End Area method with accuracy determined by the template drop interval (dynamic sections and the active dynamic section), key stations and critical sections used in the corridor feature definition. Corridor clipping is not considered, which can make this less accurate than methods that use digital terrain models or 3D elements. Bentley Systems states, "The tool is intended for approximate quantities and is typically used in preliminary design."

Quantities Report by Named Boundary tool may be run without a boundary selected and can be used to extract earthwork quantities (cut and fill) from the 3D model after the 3D meshes are created. Corridor meshes from template components are always included in the report. Creating the 3D solid meshes that display in the 3D model and dynamic cross section views, using Create Cut Fill Volumes, is a prerequisite to using this tool to compute cut and fill volumes.

The Quantities Report by Named Boundary can also be used with a plan named boundary group selected and with an option to “Display Clipped graphics” which will create clipped copies of the 3D meshes that lie within the selected boundaries. This option provides a way to preserve the 3D meshes (as elements in the file) along with the report.

Cross Section End Area Volumes computes volumes using the Average End Area method with accuracy determined by the civil cross section named boundaries. While it is similar to the Corridor Component Quantities which uses dynamic sections, the XS EAV method calculation is based upon permanent cross sections created with the Create Drawing tool.

Comparing Corridor Component Quantities and Cross Section End Area Volumes

One might think that Corridor Component Quantities and Cross Section End Area Volumes would provide similar results because they both use the Average End Area method, but there are several

things that you need to do to ensure that the mesh calculated (in volatile memory) for the dynamic sections matches the permanent 3D mesh element that is created for the Cut Fill Volumes. The table below shows how the corridor feature definition settings can be passed to the Place Named Boundary Civil Cross Section dialog to achieve the best match.

Dynamic Sections (CORR)	**Permanent Cross Sections (XSEC_bas)**	**Comment**
Template Drop Interval	Section Interval	CORR & XSEC_bas - If you drop templates every 10' in the corridor and cut sections every 25', you will have interpolated sections showing missing catches and edge effects in the 3D meshes.
Multiplier = 1	n/a	CORR - Design corridor feature definition uses a multiplier of 2 and only drops templates every other interval value. Final corridor feature definition uses a multiplier of 1.
Hz Cardinal Points (true)	Include Control Points (check on)	CORR - Set to true in both Design and Final feature definitions.
Vt Cardinal Points (true)	Event Point List = VtCardPts	CORR - Set to true in both Design and Final feature definitions. GEOM - Add Vertical Cardinal Points to Event Point List in GEOM file.
Densify Hz (true)	Event Point List must include Hz Densify Stations.	CORR - Set to true in both Design and Final feature definitions. Use Corridor Reports>Results Report TemplateDrops.xsl (GEOM - Add By Station Offset)
Densify Vt (true)	Event Point List must include Vt Densify Stations.	CORR - Set to false by default in both Design and Final feature definitions. If set to true, use Corridor Reports>Results Report TemplateDrops.xsl (GEOM - Add By Station Offset)
Key Stations (if present in bucket)	Event Point List must include Key Stations	CORR - Key Stations may be exported to CSV from the Corridor Objects dialog (bucket). (GEOM - Add By Station Offset)

Notes About Differences Between Corridor Component Quantities and XS End Area Volumes

Even if all settings exactly match between the corridor dynamic sections and the permanent cross sections, the quantities may be different between the two methods because the meshes are created slightly differently and for at least two more reasons - the active station setting of the dynamic cross section window and end condition failures or transitions in end conditions.

If the active dynamic section in the corridor file is set to a non-interval station, it is considered a key station, and a template drop is processed at that location for the dynamic mesh. A non-interval station in the dynamic section is easy to cause when switching to a corridor feature definition with a different template interval multiplier.

Corridor Component Quantities uses a programmatically calculated (dynamic) mesh that produces a consistently closed shape in the dynamic sections even through transitions from cut to fill, or where there are end condition failures. End condition failures may be difficult to visually locate.

If there are problems with your design, the Create Cut Fill Volumes command may create meshes that have discontinuities in transition areas. Mesh discontinuities will lead to shapes being drawn in the permanent cross sections that are not closed and do not contribute to volume quantities.

Comparison of Volume Calculation Methods

The methods described above each make their calculations differently and arrive at different values for earthwork volumes. When estimating earthwork, “equivalent accuracy” does not mean exactly match. From experience and practice I have determined that volumes may be considered of equivalent accuracy if the values are within about 5%.

In cross section end area volume calculations, the end area faces are assumed to be parallel. On the inside of a curve, the sections are not parallel, and the prism length may be significantly shorter than the interval. On the outside of a curve, the length will be longer. When a corridor’s horizontal geometry curves both to the left and to the right, and the grade is generally in either cut or fill, the curvature of the alignment itself may negate the need for correction for curvature and the end area volumes will be of equivalent accuracy to the volume of the 3D mesh.

OpenRoads Designer does not have an option to calculate a correction for curvature to end area volumes. If corrections for curvature are specified, one of two methods will need to be used to calculate earthwork volumes: Analyze Volumes (using terrains) or Quantities Report by Named Boundary (using 3D meshes).

Example

The table below shows the cut volumes calculated for a sample project (Excavation) that has a horizontal geometry with one curve to the left and both sides are in cut in the curve. The Corridor Component Quantities cut volume matches the cut volume from the XS End Area Volume Report because there are no end condition failures, and the template drops exactly match the cross section stations. With a larger cut area on the inside of the curve, the end area volume calculations are only slightly greater than what is determined from the 3D mesh. The difference is 0.25%, so they are all of equivalent accuracy.

Element Component Quantities	Corridor Component Quantities	Quantities Report by Named Boundary (none)	XS End Area Volumes Report
n/a	27286.9657 CY	27217.52 CY	27286.97 CY