AUTODESK®

AUTOCAD® CIVIL 2009 AND AUTOCAD® CIVIL 3D® 2009

Road Design Basics with AutoCAD Civil and Civil 3D

Contents

Introduction

The Autodesk civil engineering solution, made up of AutoCAD Civil 2009 software and AutoCAD Civil 3D 2009 software, provides civil engineers, designers, drafters, technicians, and surveyors with targeted solutions for a broad range of project types, including land development, transportation, and environmental.

The goal of this document is to outline the fundamentals of road design through corridors while focusing on the behavior and function of assemblies and subassemblies. This paper explores the definitions and terminologies behind points, links and shapes— essential components for corridor modeling—and also addresses how subassemblies have the capability to respond to superelevation parameters when modeling complex transportation projects. Lastly, AutoCAD Civil 2009 software and AutoCAD Civil 3D 2009 software ships with a comprehensive catalog of various assemblies that can be used for a multitude of project types including road rehabilitation, highway design, local roads, and channels. This subassembly catalog has been condensed and added as a reference appendix to allow for easier exploration while highlighting the functions of each subassembly and providing common uses.

The Corridor Model

Corridors are arguably the most powerful and sophisticated objects in AutoCAD Civil 2009 and AutoCAD Civil 3D 2009. To create a corridor, an alignment, profile, and assembly are combined to form a 3-dimensional representation of a linear feature such as a road or channel. In this document, the focus will be on utilizing corridor models for road design exclusively.

Together the alignment and profile create a 3D Chain (Figure 1) with the alignment providing the horizontal aspect (x and y) and the profile providing the vertical aspect (z/elevation). The assembly, which represents the cross-sectional shape of the road, is inserted along this 3D path at user-specified increments. Similar points on the assembly insertions are connected using corridor feature lines—establishing the edges of the 3D model in the longitudinal direction.

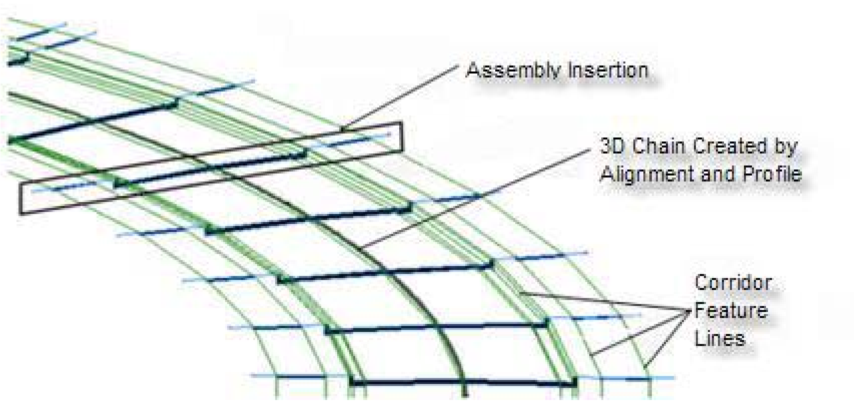


Figure 1. A 3D Chain represents an alignment and profile which control the horizontal and vertical aspects of the road. An assembly is then inserted along this path at user-defined increments and is connected longitudinally by corridor feature lines.

The corridor model serves as the “backbone” of the design and from it many useful forms of information can be derived. For example, surfaces can be derived from the corridor representing finished ground or any number of underlying surfaces. The corridor can be shown in cross section views and earthwork and material volumes can be calculated. And, as shown in the image above, the corridor can be viewed from a 3D perspective giving the designer a clearer sense of its construction when compared to a model that is purely numerical.

For any road design you begin by defining the main alignment which is typically the centerline of the road. Then you sample existing ground surface information to create a profile of the current conditions of the road centerline. This profile is then redesigned to create a smooth vertical path consisting of straight tangents and vertical curves. The resulting geometry is the design profile and at this point you have two of the three components needed to build the corridor.

Next you build one or more assemblies that match the information shown in the typical sections for the road design. The assemblies simulate the geometry and material composition of the road as well as how it should interact with existing ground, legal boundaries, and many other potential features. This interaction is automated by the subassemblies allowing slopes to change, lanes to widen, and many other variations to take place as the corridor progresses along its path.

With the three components in place you then build the corridor and assign targets to ensure that any subassemblies that interact with other drawing objects are seeking out the correct data. With this portion complete, you now have a 3D model of the road design from which you can create surfaces, generate cross-section views, calculate material volumes, and many other design tasks.

The Assembly

As stated above, the assembly (Figure 2) is one of a trio of objects that comprises the corridor model. It represents the cross-sectional composition of the road including the individual components such as curbs, lanes, and shoulders. These individual components are represented by subassemblies, which represent customizable cross-sectional components that are pieced together to create assemblies.

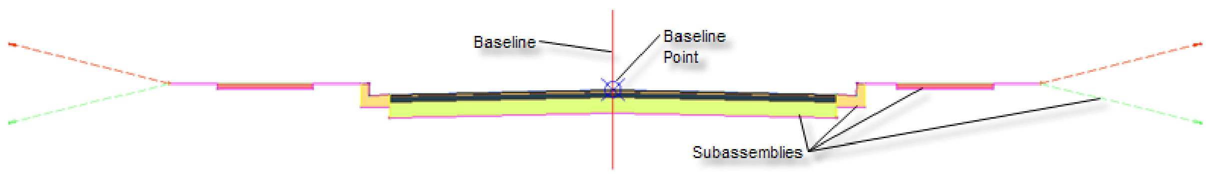


Figure 2. An assembly is made of up a combination of subassemblies such as sidewalks, curb, and lanes.

The assembly itself is actually a rather simple object, being a collection of subassemblies attached to a baseline. The baseline contains a baseline point, which is the location where the assembly will attach to the alignment-profile pair. To construct an assembly, you simply “snap” the pieces together by accessing a subassembly from a tool palette and clicking an attachment point on the assembly baseline, or on another subassembly. In this way, the complete composition of the road cross section can be represented from median to lanes to curbs to daylight and a designer can simulate a wide range of road components and behaviors.

For example, to create an assembly for a divided highway, you begin at the baseline point and simply insert the appropriate subassemblies such as a depressed median or a jersey barrier. Then, working outward, you insert subassemblies for the inside lane, outside lane, shoulder, and daylighting. As each subassembly is inserted, you can modify the input parameters to match the dimensions of the typical section of the proposed highway. In a short time, you have a fully functional assembly that represents the cross-sectional geometry and composition of the design.

For a more complex design, like an intersection, the assemblies become key parts of the model rather than the entire road cross section. In intersection design, it is common to create assemblies that represent only half of the cross section (i.e. left lane, shoulder, and daylight). In this way, each portion of the intersecting roads can be controlled independently to easily resolve the complex geometry often associated with intersections.

Subassemblies

The power and flexibility of the assembly actually resides within the subassemblies. AutoCAD Civil 2009 and AutoCAD Civil 3D 2009 provide an extensive collection of subassemblies for a wide variety of road design applications. The scope of their application ranges from very specific to very general and their functionality ranges from very sophisticated to very simple. In addition to the ones provided, custom subassemblies can be created from user-defined AutoCAD shapes or through programming. Subassemblies can be “snapped” together in thousands of combinations to model virtually any road design scenario.

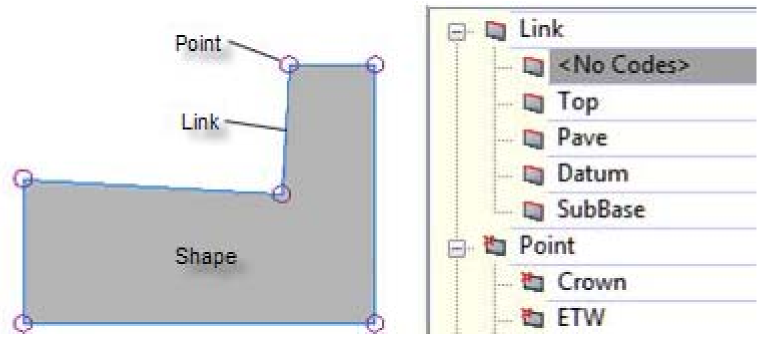


Figure 3. Subassemblies are made up of points, links and shapes. Styles can be assigned to each component, providing users with full control over display and labeling characteristics of the subassembly.

The fundamental components of subassemblies are points, links, and shapes. (Figure 3). Points are connected by links, and when three or more links enclose an area, a shape is created. Codes and styles can be assigned to all three of these types of components to control how the corridor is constructed, affect the appearance and behavior of the corridor, automate annotation, and simplify the extraction of data.

The geometry and behavior of subassemblies is controlled by *input parameters*. For example, for many of the lane subassemblies, there is a parameter called *Width* which controls the width of the lane.

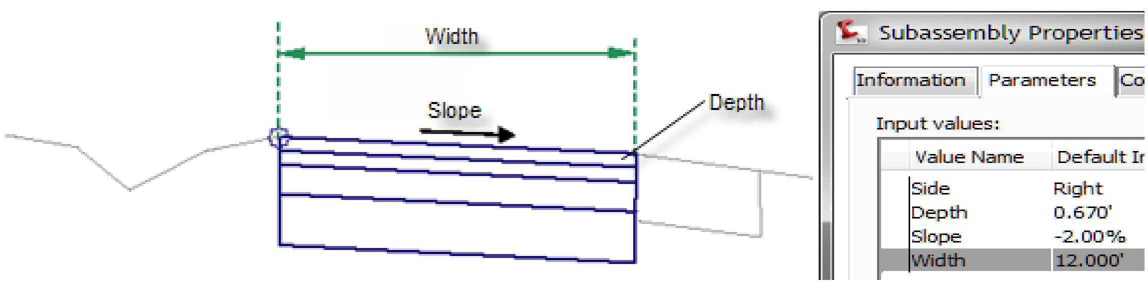


Figure 4. Input parameters allow specific components within subassemblies to be customized to fit specific project requirements. The example shown will create a lane 12’ wide with a cross slope of 2% and a material course depth of 0.67 feet for the duration of the road.

Other input parameters include the depth for each pavement course or the slope across the lane (Figure 4). The sources of the values for these parameters vary depending on the intended function of the subassembly. Some are manually entered by the user while others are derived automatically from another source of information within the drawing. For example, the *Width* parameter mentioned above can be manually entered or have its value automatically derived from an alignment representing the outer edge of the travel way. In this case, the use of the alignment is established through a *target parameter*. This ability of subassemblies to interact with other objects in the drawing and derive values automatically greatly increases the power of the corridor model.

Subassemblies can also be tied to the superelevation parameters of the alignment. For example, as the corridor is built, any subassemblies that reference superelevation information will recognize the information contained in the alignment and respond to it. For example, lanes will automatically adjust their cross-slopes through transition and full superelevation.

Leveraging Point, Link, and Shape Codes

Point, link, and shape codes—properties of a subassembly—can be used for a multitude of applications. Possibly the most important properties are point codes, as they control the creation of corridor feature lines that form the longitudinal edges of the corridor model. For example, the BasicLane subassembly assigns a code of ETW to the outer top corner (Figure 5). When the corridor is built, AutoCAD Civil 3D 2009 recognizes the matching codes between two adjacent subassemblies and draws a corridor feature line that connects them. In addition, the style that is applied to the corridor feature line can be defined by this code and automatically assigned. The result is shown in Figure 6 below. Note how the corridor feature line created by AutoCAD Civil 3D automatically connects the points coded ETW.
Note also how the style of the corridor feature line has been assigned in Corridor Properties based on this code. (Figure 7)

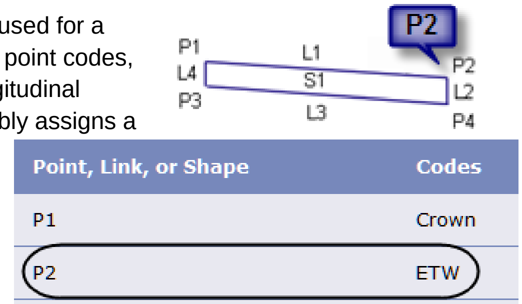


Figure 5. In the example above, P2 represents a point on the subassembly that has the name ETW (edge of travel way) assigned to it.

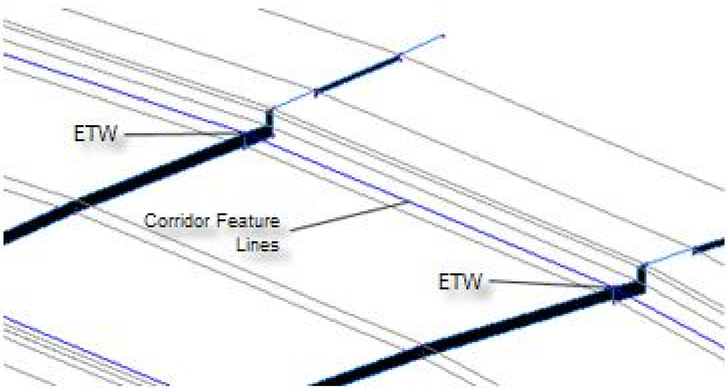


Figure 6. Corridor feature lines will automatically connect ETW points as the corridor is created.

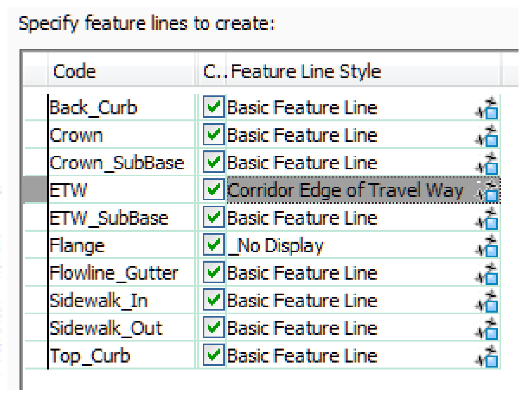


Figure 7. Each feature line can be assigned a style to control the display, for that part of the corridor.

Codes, specifically link codes, are also a powerful tool for extracting data from the corridor model including contours, cross sections, or surfaces. In the example shown in Figure 8, the Top code is used to filter out all links representing the finished ground element of each subassembly. With this approach, a corridor surface for the finished ground can be created in a matter of seconds. A similar approach can be used to generate corridor surfaces representing subsurface materials or portions of the corridor. Codes can be used to perform functions such as calculating material volumes or performing a mass haul analysis.

Codes can also be leveraged to help save considerable time by automating the annotation of corridor information. In the example shown in Figure 9, the Top_Curb code was used to automatically provide a label in all section views showing the offset and elevation of the top of curb.

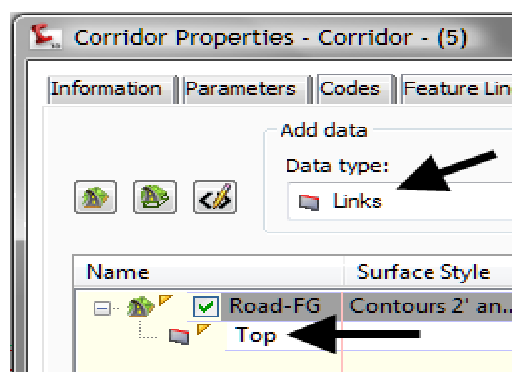


Figure 8. Codes can also be used when creating or extracting data from the corridor model. This example shows a finished grade surface reading the Top codes to create contours from the model.

Figure 9. This example shows Top_Curb codes being used to label cross sections. Offsets and elevations are automatically derived from the corridor model and conform to company or jurisdictional CAD standards.

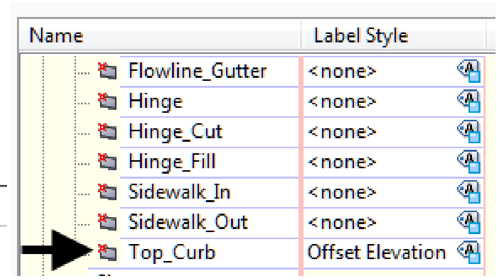


Figure 10. Code set styles can be setup to automatically label specific points such as flow line, top of curb, crown, etc.

With this capability, you can integrate codes, labels, and styles so that your design is labeled automatically with the content and formatting required by your company standards, a client's standards or a given local jurisdiction (Figure 10).

AutoCAD Civil 3D 2009 software manages all of the codes that can be associated with a corridor through the use of a code set. Within the code set, the codes are organized by type (link, point, and shape).

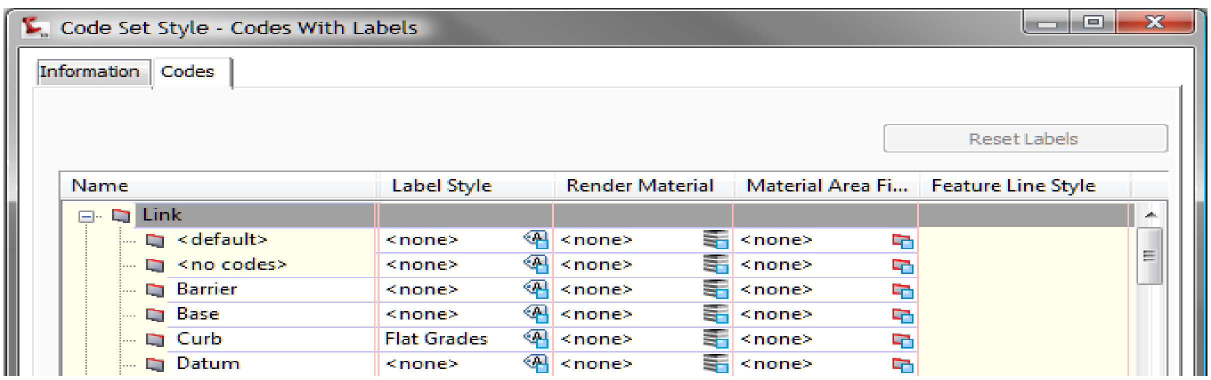


Figure 11. In addition to being used for automatically labeling cross sections and plan sets, code set styles can be easily configured for visualization purposes.

Each code can be assigned a label style to create the effect discussed above. In addition, each link code can be assigned a render material for visualization purposes and a material area fill for hatching within the drawing (Figure 11). Each point code can be assigned a feature line style so that corridor feature lines can be matched up with their functions. For example, corridor feature lines passing through the Top_Curb code shown above could be assigned a style that displays them on the curb layer (Figure 6). Capitalizing on this potential for automation can greatly improve the efficiency of displaying and documenting the road design throughout the design cycle.

Leveraging Targets

Many AutoCAD Civil 3D 2009 subassemblies have the ability to interact with other objects in the drawing through target parameters. For instance, all daylighting subassemblies function through a surface target parameter. Their job is to seek out and intersect with a given surface according to the instructions provided in the input parameters.

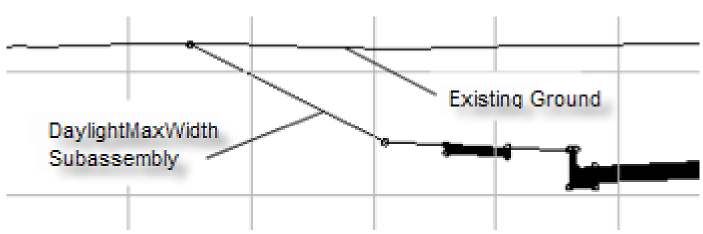


Figure 12. Daylight subassemblies use a surface target parameter to seek out and intersect surfaces based on input parameters. For example, DaylightMaxWidth Subassembly analyzes whether a cut or fill situation exists, and then uses input parameters to tie into a surface.

Many different daylighting scenarios can be modeled using the daylight subassemblies provided with AutoCAD Civil 3D 2009. For example, the DaylightMaxWidth subassembly shown in Figure 12 will seek out a surface and tie to it while maintaining a given width for the daylight embankment.

Other daylight subassemblies can automatically create benches, ditches and berms, and/or adjust slope depending on the material being excavated. The table in the Appendix shows a complete list of the daylighting subassemblies that are available and some of their more common uses.

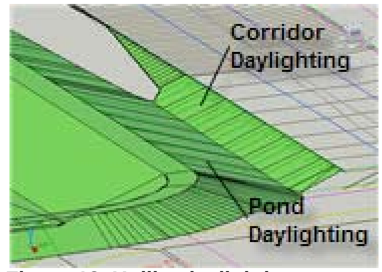
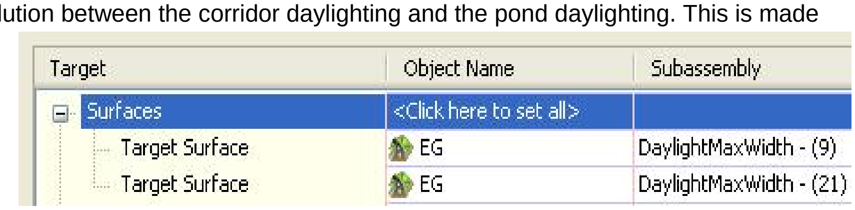


Figure 13. Unlike daylighting methods, grading projections can clean up on each other and provide easy solutions for complex designs.

Daylighting can also be accomplished through feature lines and grading projections. Instead of using a daylight subassembly, it is possible to use the grading creation tools in AutoCAD Civil 3D 2009 to project slopes from a corridor feature line. This can be especially advantageous when slope projections need to be perpendicular to a feature of the road rather than the centerline. It also allows you to take advantage of the ability of AutoCAD Civil 3D grading projections to “clean up” interior corners and interact with one another. Figure 13 shows how AutoCAD Civil 3D can automatically calculate the solution between the corridor daylighting and the pond daylighting. This is made possible through the use of grading projection from a feature line that is dynamically linked to the corridor.



Target	Object Name	Subassembly
Surfaces	<Click here to set all>	
Target Surface	EG	DaylightMaxWidth - (9)
Target Surface	EG	DaylightMaxWidth - (21)

Figure 14. In order for a daylight subassembly to function properly, a target surface is assigned within the corridor properties.

Part of the process of constructing the corridor model is to assign the actual targets for subassemblies that utilize target parameters. As shown in the Figure 14, a target surface of EG has been assigned to the DaylightMaxWidth subassembly within the corridor.

Other subassemblies utilize width or offset target parameters to change shape as they progress through the corridor. A turning lane, for example, can be accomplished by using the BasicLaneTransition subassembly along with an alignment target representing the edge of the travel way. As the alignment moves away from the road centerline, the subassembly widens to create the additional lane. Figure 15 shows the final result when this approach is used.

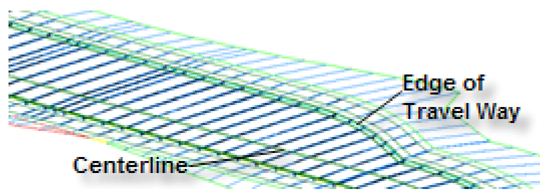


Figure 15. Specific subassemblies can use alignments, profiles, polylines, feature lines, or survey figures as targets to control the shape of the corridor.

Slope or elevation targets can be utilized for some assemblies to control the vertical aspect of the corridor geometry. For instance, in the example show in Figure 15 a profile could be applied to the edge of the travel way to control its elevation at the same time the alignment is controlling its horizontal position. And finally, certain subassemblies can target a marked point, allowing them to seek out a specific location on another subassembly and connect to it. LinkBetweenPoints for instance, is often used in the area between a ramp and highway as the two merge. This subassembly will seek out a marked point on the ramp and automatically create a swale between the two roadways.

Superelevation

Many subassemblies have the capability of responding to superelevation parameters. Superelevation is the banking effect of the road as it curves causing the edge to the outside of the curve to be higher in elevation than the inside. The superelevation parameters themselves are actually applied to the corridor baseline alignment and the subassemblies that possess superelevation functionality derive the information from there (Figure 16). Superelevation parameters can be found by accessing the alignment properties and clicking the Superelevation tab.

No.	S. Station	Description	Left Side Outside Shoulder	Outside Lane	Inside Lane	Inside Shoulder	Inside Shoulder
1	0+00.00'	Begin alignment	-5.000%	-2.000%	-2.000%	2.000%	2.000%
2	1+90.60'	End normal crown	-5.000%	-2.000%	-2.000%	2.000%	2.000%
3	3+16.00'	End normal crown	-5.000%	-2.000%	-2.000%	2.000%	2.000%
4	3+99.50'	Level crown	-5.000%	-2.000%	-2.000%	2.000%	0.000%
5	4+83.10'	Reverse crown	-5.000%	-2.000%	-2.000%	2.000%	-2.000%

Figure 16. Superelevation parameters can be applied during the layout of the horizontal alignment. Subassemblies can then use these values as the superelevation is being applied throughout the design.

The superelevation parameters consist of eight separate cross slope values that represent inside and outside shoulders and lanes on both sides of the road. The values can be entered manually or calculated automatically based on AASHTO tables used by AutoCAD Civil 3D 2009 software. If your design does not apply AASHTO design standards, you can use the Design Criteria Editor to create tables that meet nearly any design standard. Custom tables can be saved, then shared throughout your organization and used on future projects.

As AutoCAD Civil 3D 2009 builds the corridor, any subassemblies that possess superelevation functionality will read these values and respond as needed. Civil 3D automatically calculates key stations such as end normal crown, reverse crown, and begin full super, and creates additional corridor sections at those locations to ensure accurate transitioning. Figure 17 shows a corridor as it progresses through each key superelevation station.

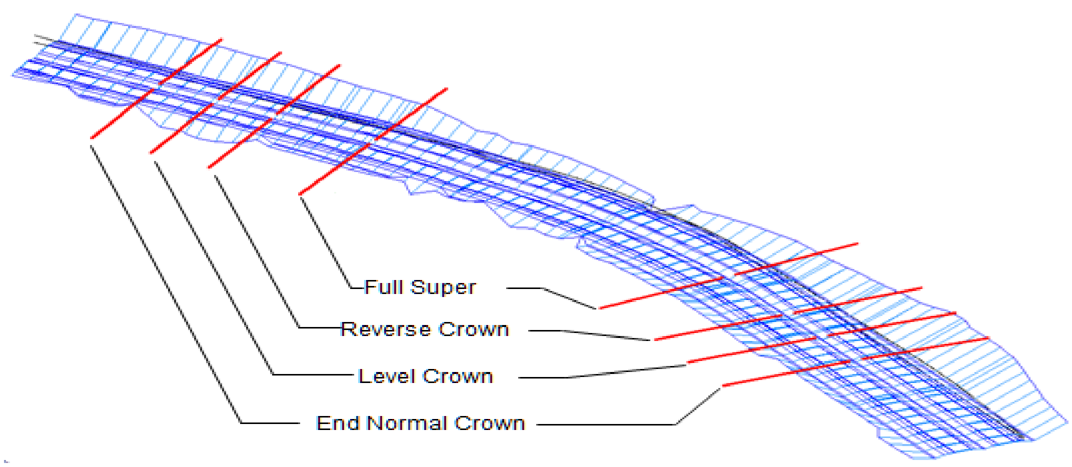


Figure 17. An example of superelevation being applied to a divided highway.

As an example, Figure 18 shows how the LaneOutsideSuper subassembly uses the Outside Lane column to obtain its cross slope. The section view shows how, as the corridor enters superelevation transition, the outside edge of the subassembly gradually tilts upward until it reaches full superelevation. It will maintain that configuration for a specified distance and finally transition downward as the corridor passes beyond the curve.

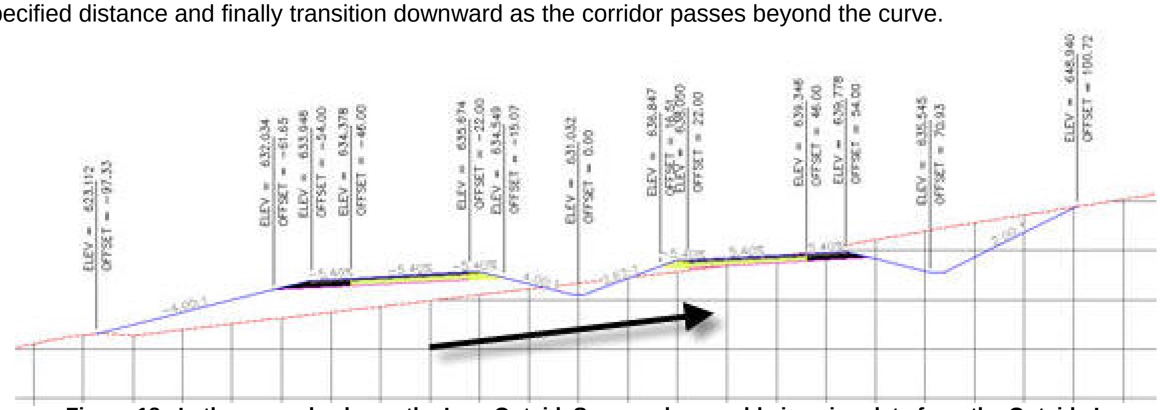


Figure 18. In the example above, the LaneOutsideSuper subassembly is using data from the Outside Lane column, in the Alignment properties.

Conclusion

The AutoCAD Civil 3D 2009 corridor model can make building, annotating, and analyzing your road design more efficient—especially when all of the benefits of subassemblies are leveraged. This document has given you an overview of the core components that AutoCAD Civil 2009 and AutoCAD Civil 3D 2009 use when modeling roads and highlighted the fundamental building blocks required when piecing together assemblies and subassemblies. By thoroughly understanding the subassemblies and their functions, you will be able to construct more effective corridor models more efficiently. In addition, by leveraging points, links, shape codes and target parameters, you can create corridor models that are tailored to your designs needs—while helping to automate many road design tasks such as automatically labeling and updating cross sections.

This paper has also exposed the capabilities of AutoCAD Civil 2009 and AutoCAD Civil 3D 2009 for transportation type projects—identifying how subassemblies can respond to the banking effect of the road throughout the design. Superelevation is used all over the world on a multitude of project types and when used in conjunction with the model-centric capabilities offered in the Autodesk Civil Engineering Solutions software, it provides engineers with a valuable resource for creating compelling designs for years to come.

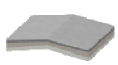
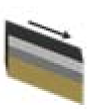
About the Author
Engineered Efficiency, Inc. is a CAD consultancy and software vendor that has been involved in the testing, training, and implementation of AutoCAD Civil 3D since its initial release in 2003. EE has worked with end-users across North America to successfully implement Civil 3D and regularly presents at Autodesk University. EE has authored several works on Civil 3D, including *Mastering AutoCAD Civil 3D 2009*; AOTC Civil 3D *Solution Series* courseware including *Residential Grading*, *Designing Intersections and Cul-de-Sacs*, and *Creating and Managing Plan Sets*; and several AutoCAD Civil 3D whitepapers. Engineered Efficiency, Inc. can be reached online at www.eng-eff.com.

Appendix

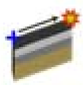
AutoCAD Civil 2009 and AutoCAD Civil 3D 2009 Subassembly Tables

The following tables can be used as a guide when selecting subassemblies for different types of design scenarios. Each subassembly is listed with a brief description and one or more common uses. The meaning of the codes in the Ref column can be found at the end of the appendix. These codes refer to specific functionality possessed by each subassembly as well as where the subassemblies can be found in the AutoCAD Civil 3D 2009 catalog.

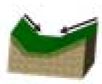
Highway Design (New Construction): Lanes

Image	Name	Description	Common Uses	Ref:
	CrownedLane	A crowned lane with separate subbase slope control and the ability to control the location of the subbase crown.	Crowned road where subgrade slope and crown needs to be controlled independently.	H,V,VS, SE,MC *SB*
	GenericPavement- Structure	A simple pavement structure with user-definable point, link, and shape codes.	Any pavement course.	H,V,SE UD TD-L SU-L
	LaneBrokenBack	Two travel lanes with independent cross-slopes.	Highways with multiple lanes in one travel direction.	H,V, SE,MC *TD-L*
	LaneFromTapered- Median1	Maintains the cross slope of the lane while extending it inward to create a left turn lane. Works in conjunction with an alignment defining the median edge.	Medians with left turn lanes.	H,V, SE,MC *TD-L* *SU-L*
	LaneFromTapered- Median2	Similar to LaneFromTaperedMedian1 except that it allows for two lanes outside the median.	Medians with left turn lanes – multiple lanes in one travel direction.	H,V, SE,MC *TD-L* *SU-L*
	LaneInsideSuper	Lane that responds to Inside Lane superelevation value.	Multi-lane roads with superelevation.	H,V, SE,MC *TD-L*
	LaneInsideSuper- LayerVaryingWidth	Lane that responds to Inside Lane superelevation value and allows independent widths for each pavement course. Up to 10 different courses can be specified.	Pavement structures requiring more than four courses with varying widths.	H,V, SE,MC *TD-L*
	LaneInsideSuper- MultiLayer	Similar to LaneInsideSuper except that there are additional available pavement courses.	Pavement structures requiring more than four courses.	H,V, SE,MC, VS *TD-L*
	LaneOutsideSuper	Lane that responds to Outside Lane superelevation value. This subassembly is commonly used for general-purpose lane creation.	All road lanes.	H,V, SE,MC *TD-L* *SU-L*
	LaneOutsideSuper- LayerVaryingWidth	Lane that responds to Outside Lane superelevation value and allows independent widths for each pavement course. Up to 10 different courses can be specified.	Pavement structures requiring more than four courses with varying widths.	H,V, SE,MC *TD-L*

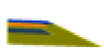
Highway Design (New Construction): Lanes

	LaneOutsideSuper-MultiLayer	Similar to LaneOutsideSuper except that there are additional available pavement courses.	Pavement structures requiring more than four courses.	H,V, SE,MC, VS *TD-L*
	LaneOutsideSuper-WithWidening	Automatically widens lane in superelevated regions using a formula based on the radius of the curve and the length of the wheelbase.	Highways where lane widening is required when in superelevation.	H,V, SE,MC *TD-L*
	LaneTowardCrown	Creates a lane that slopes downward from the crown to the centerline by applying the negative of the outside lane superelevation value from the opposite side of the road.	Multi-lane roads with superelevation.	H,V, SE,MC *TD-L*
	ShapeTrapezoidal	Generic shape with user-defined geometry and codes.	Irregular-shaped pavement courses and other structures.	H,V,VS, SE,UD *TD-L* *SU-L*

Highway Design (New Construction): Medians

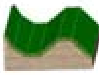
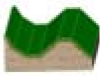
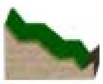
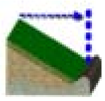
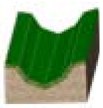
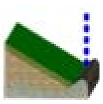
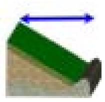
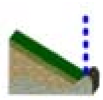
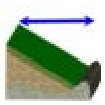
Image	Name	Description	Common Uses	Ref:
	MedianConstant-SlopeWithBarrier	Flush median with independent left and right jersey barriers and subsurface courses that can be set to match the structure of abutting lanes.	Divided roads or highways where asymmetrical barriers are needed.	H,V, SE,E, VS *TD-M* *SU-M*
	MedianDepressed	Depressed median between an attachment point and marked point with various parameters to control ditch geometry.	Divided roads or highways requiring a depressed median.	*TD-M* *SU-M*
	MedianDepressed-ShoulderExt	Depressed Median with various options for superelevation rotation and subgrade extension.	Divided roads or highways requiring a depressed median.	H,V,E, SE,ES *TD-M*
	MedianDepressed-ShoulderVert	Similar to MedianDepressedShoulderExt except that shoulder termination is vertical rather than extending under the ditch slope. There is also a parameter to incorporate interior turn lanes.	Divided roads or highways requiring a depressed median.	H,V,SE, VS *TD-M*
	MedianFlushWith-Barrier	Creates a median that is flush with adjacent lanes and can include an optional jersey barrier. Subsurface courses that can be set to match the structure of abutting lanes.	Divided roads or highways.	H,SE, MC *TD-M* *SU-M*
	MedianRaised-ConstantSlope	Creates a cap for a raised median between the attachment point and a marked point. The cross slope of the top of the median is constant at a given section.	Divided roads or highways where curbs define the edges of the median.	*TD-M* *SU-M*
	MedianRaisedWith-Crown	Similar to MedianRaisedConstantSlope except that the median cap is crowned by applying slope values either manually or through superelevation.	Divided roads or highways where curbs define the edges of the median.	SE *TD-M* *SU-M*

Highway Design (New Construction): Shoulders

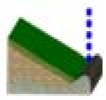
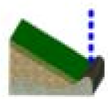
Image	Name	Description	Common Uses	Ref:
	ShoulderExtendAll	Shoulder with all courses extended to the daylight slope.	Shoulders where all courses extend to the daylight slope.	H,SE, MC,ES *TD-S* *SU-S*
	ShoulderExtend-Subbase	Shoulder with subbase extended to the daylight slope. Each course can be assigned an independent extension into the daylight slope as well.	Shoulders where only the subbase material extends to the daylight slope.	H,SE,E, MC,ES *TD-S* *SU-S*
	ShoulderMultiLayer	Similar to ShoulderExtendSubbase with additional base and subbase courses. The top two pavement courses have variable extensions into the daylight slope.	Shoulders requiring more than 4 courses where the base and subbase material extends to the daylight slope.	H,SE,E, MC,ES, VS *TD-S*
	ShoulderMultiSurface	Similar to ShoulderMultilayer except that it includes independent paved and earthen shoulder areas. All courses are extended to the daylight slope.	Shoulders with paved and earthen areas.	H,SE,E *TD-S*
	ShoulderVertical-Subbase	Shoulder with subbase materials terminating at the edge of the shoulder, with an optional unpaved area outside of the shoulder that can be inserted based on cut/fill and superelevation conditions.	Shoulders that require an unpaved widening when in cut or on the high side of superelevation.	H,D,MC, SE *TD-S* *SU-S*
	ShoulderWith-SubbaseInterlaced	Shoulder which allows the adjacent lane pavement structure to be extended into the shoulder material and interlaced with the shoulder subbase material.	Shoulders requiring subbase material to be interlaced with base material.	H,SE,E MC,ES *TD-S* *SU-S*
	ShoulderWithSubbase-InterlacedAndDitch	ShoulderWithSubbaseInterlaced plus a parabolic ditch.	Shoulders with an integrated ditch.	H,SE,E MC,ES *TD-S* *SU-S*

Highway Design (New Construction): Bridge and Rail

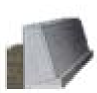
Image	Name	Description	Common Uses	Ref:
	BridgeBoxGirder1	Box girder bridge section with optional half-barriers.	Small bridges and overpasses.	H,SE *TD-B*
	BridgeBoxGirder2	Two-chamber box girder bridge section with optional half-barriers.	Small bridges and overpasses.	H,SE *TD-B*
	RailSingle	Railroad section including rails, ballast, and sub-ballast.	Railroads.	*TD-B*

Highway Design (New Construction): Daylight				
Image	**Name**	**Description**	**Common Uses**	**Ref:**
	DaylightRockCut	Daylights using two target surfaces (existing ground and rock) with varied slope and ditch solutions based on conditions encountered.	Daylighting for deep cuts.	D,LM *SB*
	DaylightBasin	Creates a basin in a cut situation or a basin, berm, and fill slope for a fill situation. Basin walls are comprised of two slope segments whereas ditches only contain one.	Daylighting where a basin or ditch is required.	D,V,LM, OD *TD-D*
	DaylightBasin2	Similar to DaylightBasin except that the berm is optional in a fill condition and the berm and basin widths can be controlled by an alignment.	Daylighting where a basin or ditch is required.	H,D,V, LM,OD *TD-D* *SU-D*
	DaylightBench	Creates cut of fill slopes with repeating benches as needed.	Large cut or fill slopes where benching is required.	D,LM *TD-D*
	DaylightInsideROW	Daylights using a typical slope as long as the daylight is within the ROW limits. If the daylight falls outside the ROW, the slope can be steepened or held based on other parameters.	Subdivision road daylighting.	D,H,LM *TD-D* *SU-D*
	DaylightGeneral	Generalized daylight solution providing many parameters to create a basin, ditch, or simple daylight condition. It also includes an optional guardrail.	General purpose daylighting.	D,LM, OD *TD-D* *SU-D*
	DaylightMaxOffset	Typical slope is applied unless a steeper slope is needed to stay within a maximum offset from the baseline.	Daylighting within a boundary or obstacle.	H,D,LM *TD-D* *SU-D*
	DaylightMaxWidth	Similar to DaylightMaxOffset except that the width of the daylight area is used instead of an offset from the baseline.	Daylighting within a boundary or obstacle.	H,D,LM *TD-D* *SU-D*
	DaylightMinOffset	Typical slope is applied unless a less steep slope is needed to stay outside of a minimum offset from the baseline.	Daylighting outside of a boundary or obstacle.	H,D,LM *TD-D* *SU-D*
	DaylightMinWidth	Similar to DaylightMinOffset except that the width of the daylight area is used instead of an offset from the baseline.	Daylighting outside of a boundary or obstacle.	H,D,LM *TD-D* *SU-D*
	DaylightMultiIntercept	Daylighting that forces the cut or fill slope to pass through the surface multiple times to intersect at a more distant location.	Daylighting in "rough" terrain where a different intercept point may be needed.	D,LM *TD-D*
	DaylightMultiple-Surface	Allows varying cut slopes depending on the material type being excavated. Up to three surfaces can be specified (i.e. topsoil, clay, rock).	Deep cuts where multiple material types are encountered.	D,LM *TD-D* *SU-D*

Highway Design (New Construction): Daylight

	DaylightStandard	Daylighting which applies one of 3 preset slopes (Flat, Medium, and Steep) based on conditions. It creates a ditch in cut situations and an optional guard rail for widening or steep fill conditions.	General purpose daylighting.	D,OD, LM *TD-D* *SU-D*
	DaylightToOffset	Daylights from the attachment point to a given offset from the baseline.	Daylighting directly to a boundary or feature.	H,D,LM *TD-D* *SU-D*
	DaylightToROW	Similar to DaylightToOffset except that an offset adjustment can be applied so that daylighting occurs a given distance within or beyond the ROW offset.	Daylighting directly to a boundary or feature.	H,D,LM *TD-D* *SU-D*

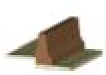
Highway Design (New Construction): Channels and Retaining Walls

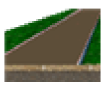
Image	**Name**	**Description**	**Common Uses**	**Ref:**
	Channel	Trapezoidal channel with optional lining and backslope links. Marked points are placed at the ends of the backslopes so that other corridor components can be tied to them.	Roadside channels.	H,V *CR*
	ChannelParabolic-Bottom	Similar to Channel except that the bottom is parabolic in shape.	Roadside channels.	H,V *CR*
	Ditch	Flat or V-shaped ditch with user-defined horizontal and vertical control parameters and an optional lining material depth. A parameter can control whether the ditch is inserted in cut, fill, or either condition.	Roadside ditches.	H,V,D *CR*
	RetainWallTapered	Retaining wall with one tapered side and an optional key. The vertical side is always faced to the low side and the elevation of the footing is based on a target surface and specified cover requirement.	Retaining walls.	V,D *CR*
	RetainWall-TaperedWide	Similar to RetainWallTapered but typically used for high retaining walls (18 ft or higher).	High retaining walls.	V,D *CR*
	RetainWallTieToDitch	Retaining wall with optional barrier, shoulder, walk area, and the ability to tie to an existing ditch.	Urban areas where the retaining wall is adjacent to a ditch or walk.	V,D,SE, MC *CR*
	RetainWallToLowSide	Similar to RetainWallTapered except that all of the footing is located under the high fill side.	Retaining wall where there is limited space on the low fill side for the footing.	V,D *CR*
	RetainWallVertical	Similar to RetainWallTapered except that both sides of the wall are vertical.	Vertical retaining walls.	V,D *CR*

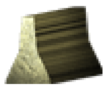
Highway Design (New Construction): Channels and Retaining Walls

	SideDitch	Simple ditch with parameters for bottom width, sideslopes, and optional foreslope. You can also specify a ditch wall depth for lined ditches.	Roadside ditches.	*CR*
	SideDitchUShape	U shaped ditch with variable wall thicknesses. Benches can be specified inside and outside the ditch as well as an optional foreslope link.	Concrete-lined ditches or channels.	*CR*
	SideDitchWithLid	Similar to SideDitchUShape except that a lid can be included and the side slopes of the ditch controlled through input parameters.	Concrete-lined ditches or channels with grates or lids.	*CR*
	SimpleNoiseBarrier	Creates a trapezoidal nose barrier with the ability to tie the back of the barrier into an existing surface. A topsoil thickness may be applied.	Noise barriers or berms.	D,UD *CR*

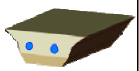
Road Rehab and Widening

Image	**Name**	**Description**	**Common Uses**	**Ref:**
	OverlayBrokenBack-BetweenEdges	Creates a four-lane crowned overlay between existing gutter flange points on either side.	Overlay of four-lane road.	H,D,V *RE* *TD-R*
	OverlayBrokenBack-OverGutters	Similar to OverlayBrokenBackBetweenEdges except that the overlay extends over the gutter to the curb flowline on each side.	Overlay of four-lane road.	H,D,V *RE* *TD-R*
	OverlayCrown-BetweenEdges	Creates a crowned road surface between two existing edges of pavement.	Resurfacing a road with poor crown definition.	H,D,V *RE* *TD-R*
	OverlayMedian-Asymmetrical	Widens a divided highway by extending the travel lanes inward along their existing cross slopes. An asymmetrical barrier is provided that resolves the elevation difference caused by extending the slopes inward.	Widening a divided highway to the inside.	H,D,V *RE* *TD-R*
	OverlayMedian-Symmetrical	Similar to OverlayMedianAsymmetrical except that the cross slopes are adjusted so that the extend lanes meet at the centerline.	Widening a divided highway to the inside.	H,D,V *RE* *TD-R*
	OverlayMillAndLevel1	Provides milling or leveling as needed, which is then topped with an overlay of user-specified depth. The overlay slope can be set to match existing, set to match superelevation, or entered manually.	Single lane pavement overlay (not crowned).	H,D *RE* *TD-R*
	OverlayMillAndLevel2	Similar to OverlayMillAndLevel1 except that it is intended for a crowned roadway. Rather than a single overlay slope, two slopes define the crown of the road.	Two-lane pavement overlay (crowned).	H,D *RE* *TD-R*

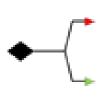
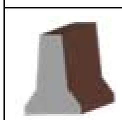
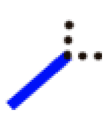
Road Rehab and Widening				
	OverlayParabolic	Creates a parabolic overlay between two existing pavement edges.	Overlay of urban road.	H,D,V *RE* *TD-R*
	OverlayWidenFrom-Curb	Similar to OverlayWidenMatchSlope1 except that it extends inward from a curb flange.	Overlay and widen from curb inward.	H,D,V, MC *RE* *TD-R*
	OverlayWidenMatch-Slope1	Overlays the existing road, then provides widening at a cross slope that matches the existing road.	Overlay and widen on one side.	H,D,MC *RE* *TD-R*
	OverlayWidenMatch-Slope2	Similar to OverlayWidenMatchSlope1 except that it widens on two sides.	Overlay and widen on both sides.	H,D,MC *RE* *TD-R*
	OverlayWidenWith-Super1	Similar to OverlayWidenMatchSlope1 except that the cross slope is set according to superelevation.	Overlay and widen with superelevation.	H,D *RE* *TD-R*
	StrippingPavement	Strips pavement to a given depth starting at the attachment point and working inward to the baseline.	Pavement removal.	D *TD-D*
	StrippingTopsoil	Strips topsoil to a given depth from the attachment point to a given stripping width.	Topsoil removal.	H,D *TD-D*
	UrbanReplaceCurb-Gutter1	Replaces an existing curb and gutter and can tie the edge of a sod strip to the existing inside edge of a sidewalk. Vertical placement of the curb is controlled by allowable mill and/or overlay and allowable ranges of slopes for the sod strip.	Curb replacement.	H,D,V, VS *RE* *TD-R*
	UrbanReplaceCurb-Gutter2	Similar to UrbanReplaceCurbGutter1 except that the vertical placement of the curb is controlled by a profile.	Curb replacement.	H,D,V, VS *RE* *TD-R*
	UrbanReplace-Sidewalk	Replaces an existing sidewalk by beginning at the outside edge and extending inward at a given width and slope.	Sidewalk replacement.	H,D,V *RE* *TD-R*

Urban Design				
Image	**Name**	**Description**	**Common Uses**	**Ref:**
	BasicBarrier	A simple jersey barrier which can be adjusted in size and shape through a number of parameters.	Highway medians, traffic control during construction.	*GS*
	BasicCurbAndGutter	A simple curb and gutter in which the height and width of the curb and gutter can be adjusted through a number of parameters. The gutter slope can also be set. It is a “rigid” shape with no target parameters.	All road and parking lot curbing.	*GS*
	LaneParabolic	Creates a simple parabolic shape where the crown height, width, and slope can be adjusted. Slope is calculated using a “string line” attached to left ETW and right ETW.	Any road design where parabolic lane is required.	*TD-L* *SU-L*
	BasicLane	A simple lane with no subsurface courses. Available parameters control width, depth, and slope. It is a “rigid” shape with no target parameters.	Any road design where there is a constant lane width and no material volumes are needed.	*GS*
	BasicShoulder	A simple shoulder with no subsurface courses. Available parameters control width, depth, and slope. It is a “rigid” shape with no target parameters.	Any road design where there is a constant shoulder width and no material volumes are needed.	*GS*
	BasicCurb	Simple rectangular curb.	Any road design.	*GS*
	BasicGuardrail	Simple guardrail structure.	Any road design.	*GS*
	BasicLaneTransition	Simple lane in which the width and outside elevation can be controlled through target parameters.	Turning lanes.	H,V *GS*
	BasicSideSlopeCut-Ditch	Daylighting that creates an optional flat or v-shaped ditch in a cut condition and a simple fill slope in a fill condition.	Simple daylighting.	D,LM, OD *GS*
	BasicSidewalk	Simple rectangular sidewalk section with optional buffer areas on either side.	Residential and urban roads with sidewalks.	*GS*
	TrenchPipe1	Creates a flat-bottom trench with equal sideslopes and up to three layers of backfill material. The vertical placement of the trench is controlled by a profile which typically represents the pipe to be installed.	Pipeline excavation.	D *TD-U* *SU-U*
	TrenchPipe2	Builds trench around one or two pipe networks. Width of the trench is determined by a user-specified width and minimum pipe cover.	Pipeline excavation.	D,P *SB*

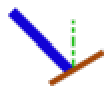
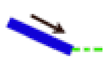
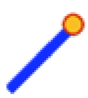
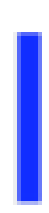
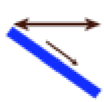
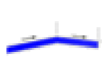
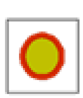
Urban Design

	TrenchPipe3	Similar to TrenchPipe2 except that it utilizes two target surfaces (existing ground and rock) and applies a different sideslope depending on which condition is encountered.	Pipeline excavation.	D,P *SB*
	TrenchWithPipe	Creates a stone-filled drain structure with a circular pipe inside. The vertical placement of the trench is set at the attachment point and the depth can be entered manually or controlled by a profile.	Subdrains.	V *TD-U* *SU-U*
	UrbanCurbAndGutter-General	Creates a standard curb and gutter shape with input parameters for the dimensions. Also includes a subbase shape with user-defined subbase slope and extension.	Urban or residential curbs.	VS,E *TD-U* *SU-U*
	UrbanCurbAndGutter-Valley1	Creates a flat-bottomed valley curb and gutter shape with input parameters for the dimensions. Also includes a subbase shape with user-defined subbase slope and extension.	Urban or residential curbs.	VS,E *TD-U* *SU-U*
	UrbanCurbAndGutter-Valley2	Similar to UrbanCurbAndGutter-Valley1 except that the bottom is sloped.	Urban or residential curbs.	VS,E *TD-U* *SU-U*
	UrbanCurbAndGutter-Valley3	Similar to UrbanCurbAndGutter-Valley1 except that the bottom is sloped beneath the gutter, then becomes flat beneath the curb.	Urban or residential curbs.	VS,E *TD-U* *SU-U*
	UrbanSidewalk	Creates a concrete sidewalk at a given cross slope with inside and outside grass boulevards.	Urban or residential sidewalks.	H *TD-U* *SU-U*

Generic Links and Marked Points

Image	**Name**	**Description**	**Common Uses**	**Ref:**
	ConditionalCutOrFill	A special subassembly that applies selected subassemblies based on whether there is a cut or fill condition. It adds no actual geometric data to the assembly.	General purpose.	D *SB*
	LinkMulti	General purpose subassembly to add a series of connected links.	Medians, curbs, other irregular structures.	UD *GS* *SU-G* *TD-G*
	LinkOffsetAnd-Elevation	Creates a link from the attachment point to a user specified offset (from the baseline) and elevation. Offset and elevation can be controlled by target parameters.	General purpose.	H,V,UD, OL *GS* *TD-G* *SU-G*

Generic Links and Marked Points

	LinkOffsetAndSlope	Creates a link from the attachment point to a user specified offset (from the baseline) at a given slope.	General purpose.	H,V,UD, OL,SE *GS* *TD-G* *SU-G*
	LinkOffsetOnSurface	Creates a link from the attachment point to a target surface at a given offset (from the baseline).	General purpose.	H,D,OL, UD *GS* *TD-G* *SU-G*
	LinkSlopeAndVertical-Deflection	Creates a link from the attachment point to a given vertical direction along a given slope.	General purpose.	V,OL, UD *GS* *TD-G* *SU-G*
	LinkSlopesBetween-Points	Creates intersecting links between the attachment point and a marked point. An optional ditch width can be assigned to create a flat link in the middle.	Ditch between adjacent or merging roadways.	UD *GS* *TD-G* *SU-G*
	LinkSlopeToElevation	Creates a link from the attachment point to a given elevation along a given slope.	General purpose.	SE,V, OL,UD *GS* *TD-G* *SU-G*
	LinkSlopeToSurface	Creates a link from the attachment point to a given surface along a given slope.	Simple daylighting.	D,SE, OL,UD *GS* *TD-G* *SU-G*
	LinkToMarkedPoint	Creates a link from the attachment point to a marked point.	General purpose.	OL,UD *GS* *TD-G* *SU-G*
	LinkVertical	Creates a vertical link from the attachment point to a given vertical deflection or profile.	General purpose.	V,OL, UD *GS* *TD-G* *SU-G*
	LinkWidthAndSlope	Creates a link from the attachment point to a given width along a given slope.	General purpose.	H,V,OL, UD,SE *GS* *TD-G* *SU-G*
	LotGrade	Creates different lot grading variations based on whether the general slope of the lot is up or down.	Lot grading.	H,V *GS* *TD-G* *SU-G*
	MarkPoint	Creates a marked point which can be targeted by certain subassemblies.	General purpose.	UD *GS* *TD-G* *SU-G*

Subassembly Functionality References	
Ref:	**Description**
H	Responds to width or offset target (Widening)
V	Responds to slope or elevation target (Independent Profile)
D	Responds to surface target (daylighting or matching)
E	Variable pavement course extensions
SE	Responds to superelevation
VS	Variable subgrade cross slope
ES	Subgrade of shoulder is extended to fill slope or ditch slope
UD	User-definable point, link, and/or shape codes
MC	Multiple-course pavement structure
LM	Lining material names and thicknesses can be assigned based on slope values
OD	Final daylight link can be omitted for cases where the corridor needs to be left in an incomplete state.
OL	Omit link – this feature can be used to create a new attachment point without adding the link to the model.
P	Can use a pipe network as a target

Subassembly Catalog Section References	
Ref:	**Description**
CR	C3D Imperial/Metric Channel and Retaining Wall Subassembly Catalog
GS	C3D Imperial/Metric Getting Started Subassembly Catalog
TD-B	C3D Imperial/Metric Transportation Design Subassembly Catalog – Bridge and Rail
TD-G	C3D Imperial/Metric Transportation Design Subassembly Catalog – Generic
TD-M	C3D Imperial/Metric Transportation Design Subassembly Catalog – Medians
TD-S	C3D Imperial/Metric Transportation Design Subassembly Catalog – Shoulders
TD-D	C3D Imperial/Metric Transportation Design Subassembly Catalog – Daylight
TD-L	C3D Imperial/Metric Transportation Design Subassembly Catalog – Lanes
TD-R	C3D Imperial/Metric Transportation Design Subassembly Catalog – Rehab
TD-U	C3D Imperial/Metric Transportation Design Subassembly Catalog – Urban
GE	C3D Imperial/Metric Generic Subassembly Catalog
SU-D	C3D Imperial/Metric Subdivision Roads Subassembly Catalog – Daylight
SU-L	C3D Imperial/Metric Subdivision Roads Subassembly Catalog – Lanes
SU-S	C3D Imperial/Metric Subdivision Roads Subassembly Catalog – Shoulders
SU-G	C3D Imperial/Metric Subdivision Roads Subassembly Catalog – Generic
SU-M	C3D Imperial/Metric Subdivision Roads Subassembly Catalog – Medians
SU-U	C3D Imperial/Metric Subdivision Roads Subassembly Catalog – Urban
RE	C3D Imperial/Metric Rehab Subassembly Catalog
SB	Subscription subassemblies