

The banner features the Bentley logo (be) and the Mid-Continent Microstation Community logo (MC<sup>2</sup>). The text is centered on a white background with a stylized orange cityscape on the right.

**be**  
BENTLEY EMPOWERED

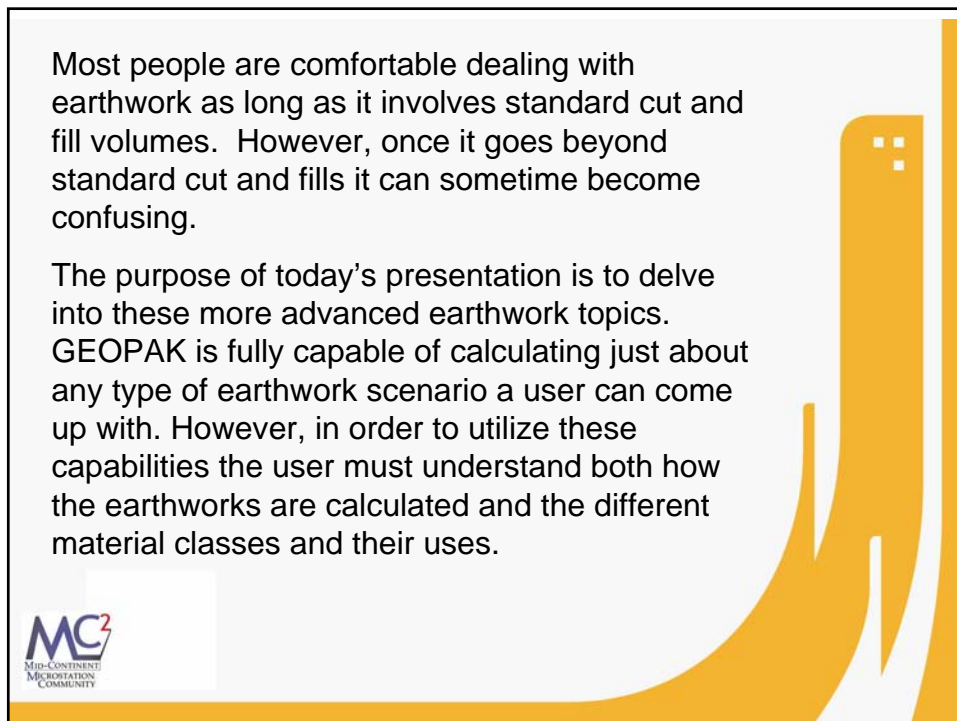
**MC<sup>2</sup>**  
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MICROSTATION  
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Summer Conference  
August 15-16, 2007  
Overland Park, Kansas

It's time for learning.

**Advanced Earthwork**

Derricke Gray – Bentley



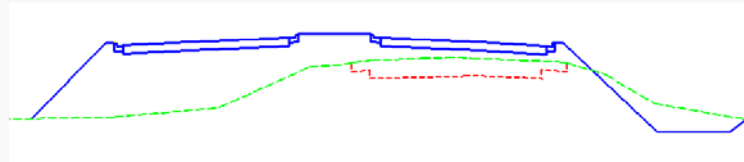
The slide contains two paragraphs of text on a white background with a stylized orange cityscape on the right. The MC<sup>2</sup> logo is in the bottom left corner.

Most people are comfortable dealing with earthwork as long as it involves standard cut and fill volumes. However, once it goes beyond standard cut and fills it can sometime become confusing.

The purpose of today's presentation is to delve into these more advanced earthwork topics. GEOPAK is fully capable of calculating just about any type of earthwork scenario a user can come up with. However, in order to utilize these capabilities the user must understand both how the earthworks are calculated and the different material classes and their uses.

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Before we go too far, let's first make sure we understand the method that GEOPAK uses to calculate earthwork. In its algorithm to calculate earthwork, GEOPAK does 3 things:

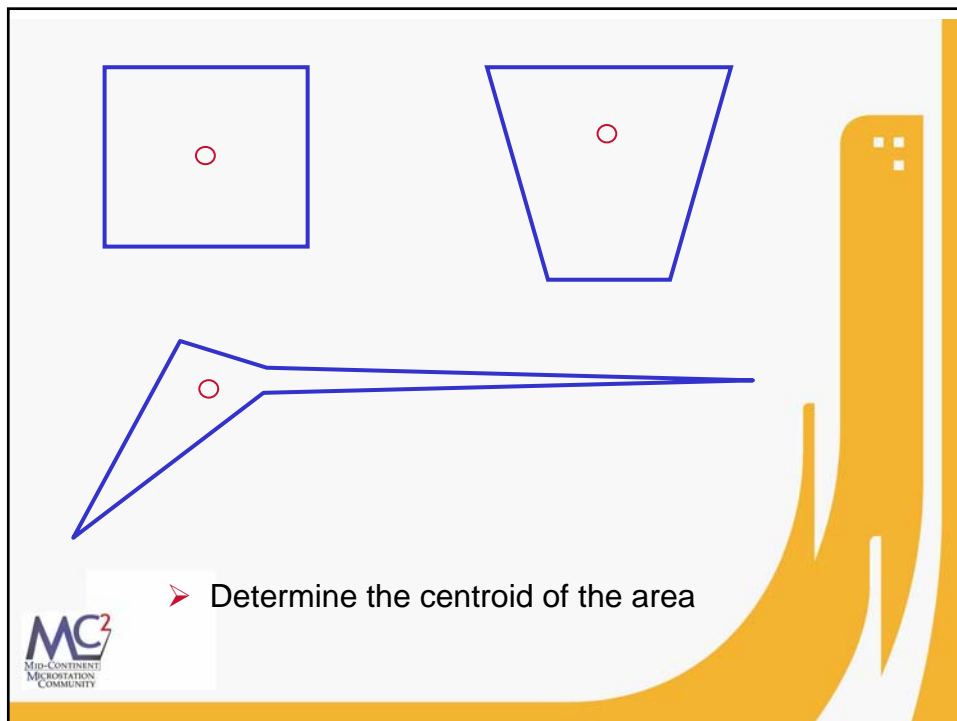
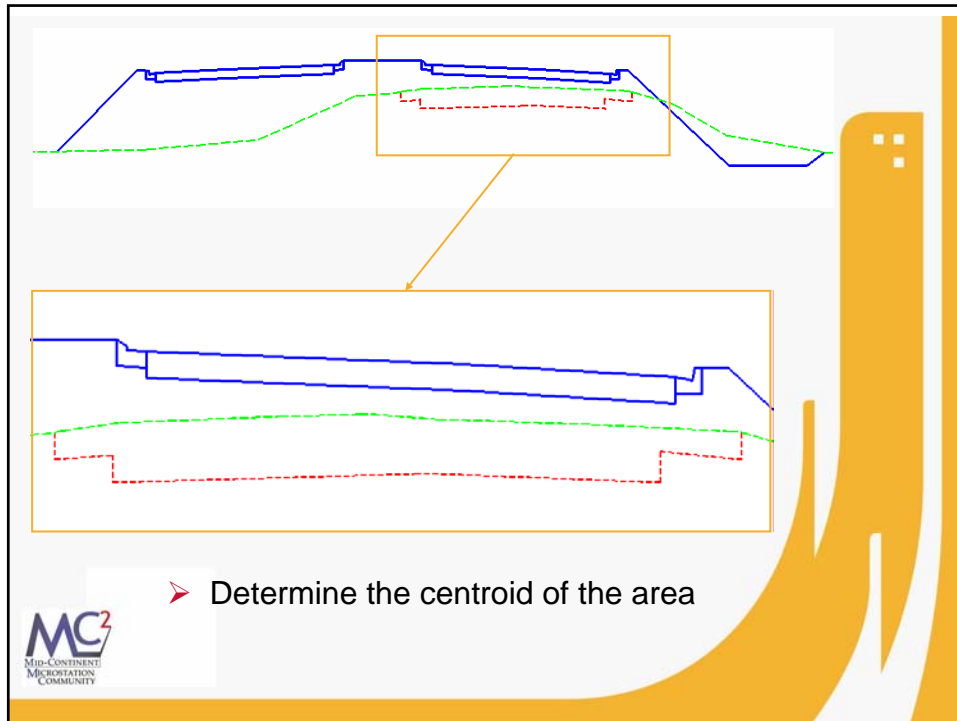


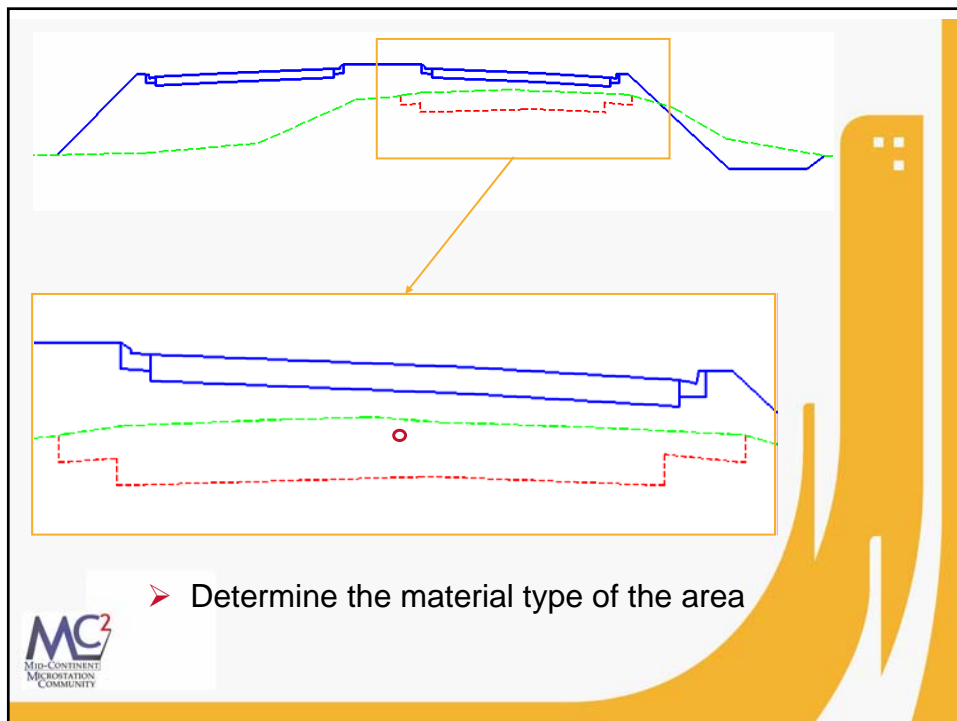
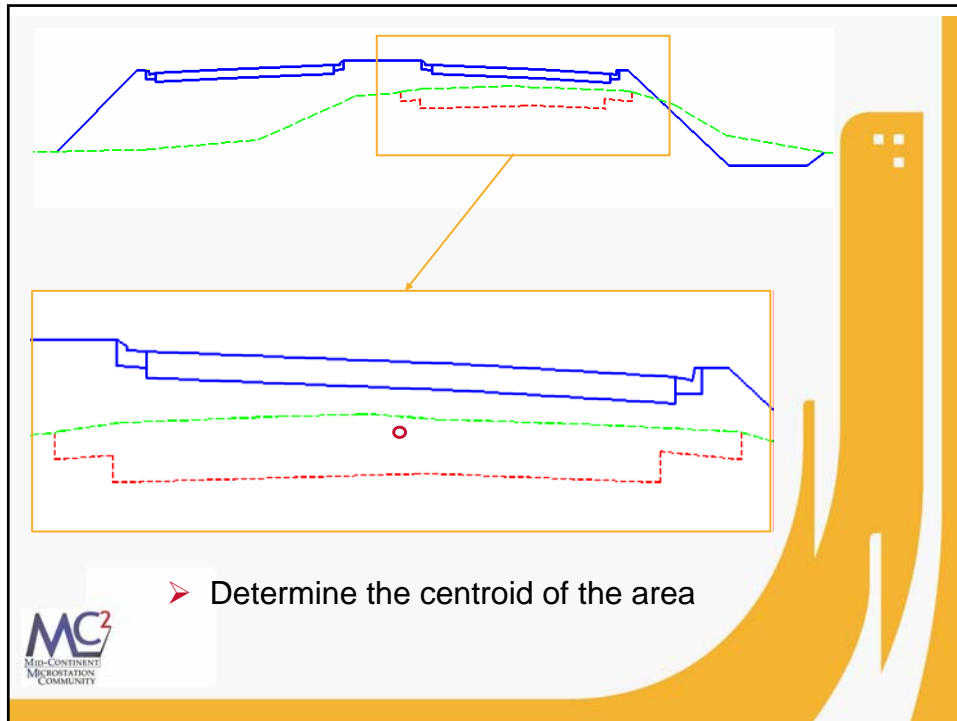
- Find an enclosed area
- Determine the centroid of the area
- Determine the material type of the area

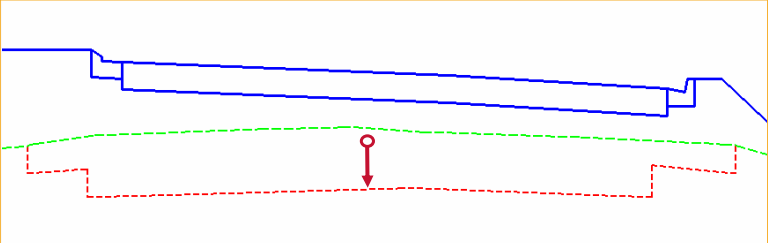


- Find an enclosed area










How does it determine the material type?

First, it intersects the graphical element directly below the centroid. It then matches the intersected symbology to the defined material types.

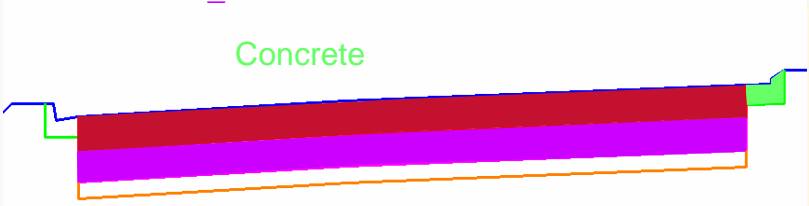
**Existing Unsuitable Material**  
soil type = EX\_PAVEMENT  
roadway exc mult factor = 1.000000  
subsoil exc mult factor = 1.000000  
fill mult factor = 1.000000  
type = line, line\_string  
lvname = XS Existing Pavement  
co = 3




**Butiminous\_Aspphalt**

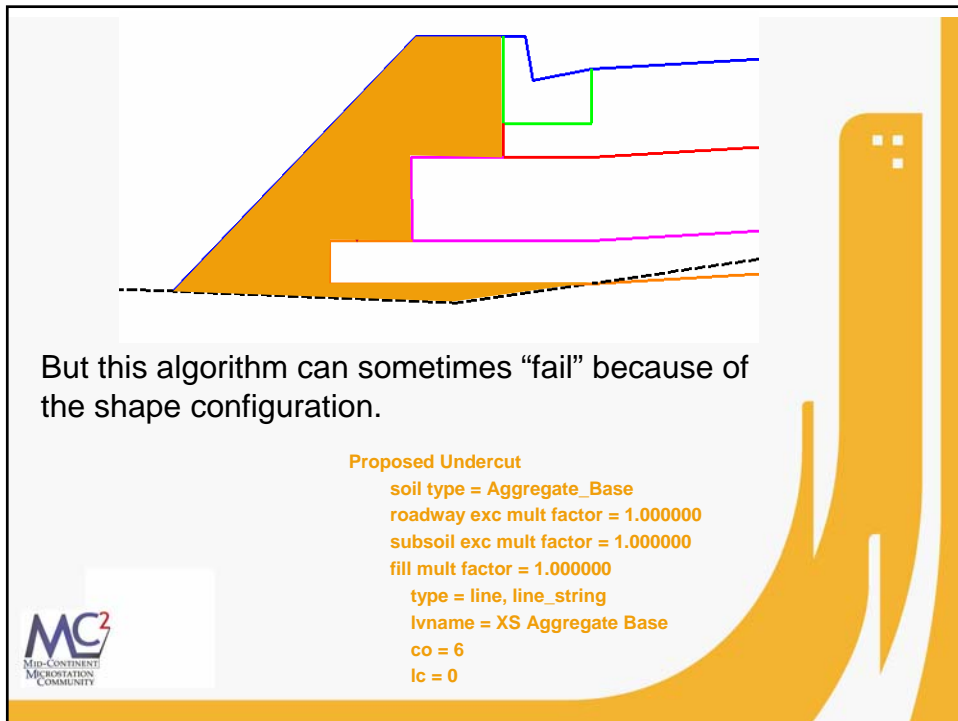
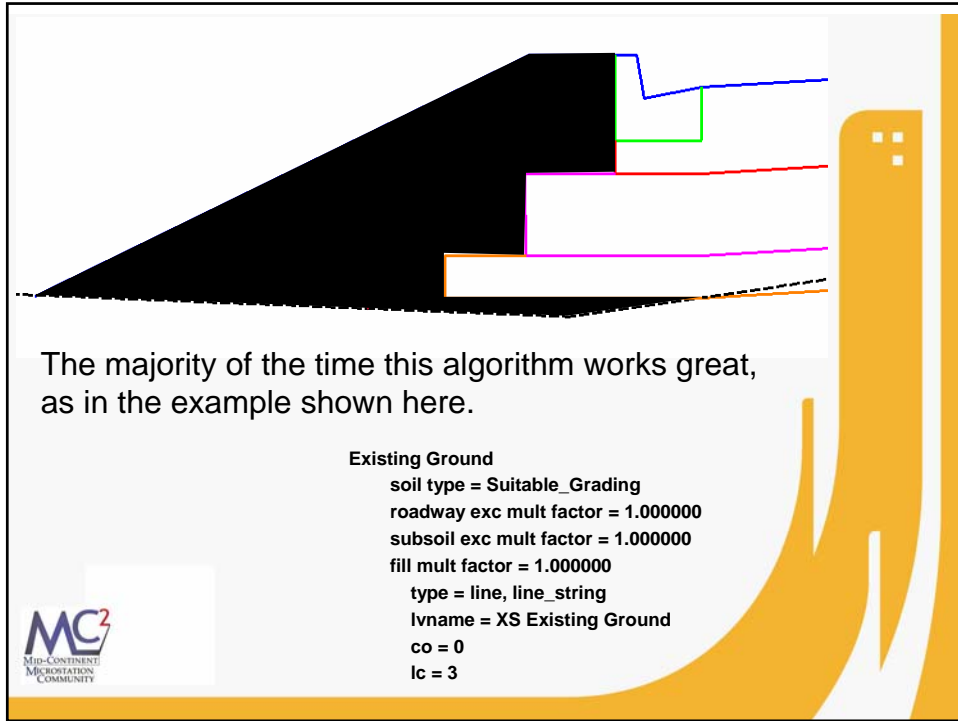
**Rock\_Base**

**Concrete**



This is why you can get quantities for just about anything on a cross section, as long as you distinguish the element symbologies correctly.





Now that we know “how” the earthwork areas are calculated, let’s look at how we can use the material classes and soil types to control how the quantities are reported.

There are 6 functional classes of earthwork supported by GEOPAK. *These classes identify the function or purpose of the cross section element.*

Existing Ground Line

Proposed Finish Grade

Proposed Undercut

Existing Suitable

Existing Unsuitable

Excavation Limits



Within each class, you can have multiple soil types. The soil type is nothing more than a “name” for the material and will be used for all reporting purposes.

Existing Unsuitable Material

soil type = TOPSOIL

Existing Unsuitable Material

soil type = Existing\_Base



For each soil type you must specify the appropriate shrink/swell factors.

**Existing Unsuitable Material**

**soil type = TOPSOIL**  
**roadway exc mult factor = 1.00**  
**subsoil exc mult factor = 1.00**  
**fill mult factor = 1.00**

**Existing Unsuitable Material**

**soil type = Existing\_Base**  
**roadway exc mult factor = 1.00**  
**subsoil exc mult factor = 1.00**  
**fill mult factor = 1.00**



Also, for each soil type you must specify the graphical symbology of the cross section element.

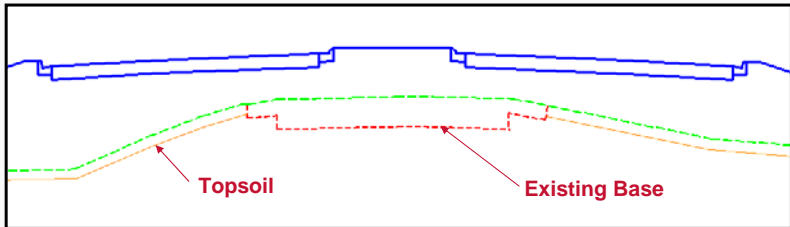
**Existing Unsuitable Material**

**soil type = TOPSOIL**  
**roadway exc mult factor = 1.00**  
**subsoil exc mult factor = 1.00**  
**fill mult factor = 1.00**  
**type = line, line\_string**  
**lvname = XS Topsoil**

**Existing Unsuitable Material**

**soil type = Existing\_Base**  
**roadway exc mult factor = 1.00**  
**subsoil exc mult factor = 1.00**  
**fill mult factor = 1.00**  
**type = line, line\_string**  
**lvname = XS Existing Base**






The diagram shows a cross-section of a road profile. At the top is a blue line representing the proposed finish grade. Below it is a green dashed line representing the existing ground line. Underneath the ground line is a red dashed line labeled "Existing Base". Below the base is an orange line labeled "Topsoil". Red arrows point from the labels to their respective lines.

Why are the classes important? It's not enough to just call something "topsoil" or "existing base". The software has to know the purpose/function of the material.

For example, do you want to excavate or fill? Is the material suitable for re-use or not?




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## Material Classes

Existing Ground Line

Proposed Finish Grade



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These are the only two material classes that are required in order to calculate earthwork:

Existing Ground Line  
Proposed Finish Grade

Specifying these two classes will give you the basic cut and fill quantities.



The soil types specified with the proposed finish grade and existing ground are important as they are used as the default fill material and default excavation material.

*Note: Always use the same name!*

Proposed Finish Grade  
soil type = **Suitable\_Grading**  
roadway exc mult factor = 1.0  
subsoil exc mult factor = 1.0  
fill mult factor = 1.0  
type = line, line\_string  
lname = XS Finish Grade

Existing Ground Line  
soil type = **Suitable\_Grading**  
roadway exc mult factor = 1.0  
subsoil exc mult factor = 1.0  
fill mult factor = 1.0  
type = line, line\_string  
lname = Existing Ground





## Material Classes

Existing Ground Line ✓

Proposed Finish Grade ✓

Existing Suitable





## Existing Suitable

Existing Suitable is defined just like the other material classes. You must define a soil type, shrink/swell factors and the proper graphical symbology.

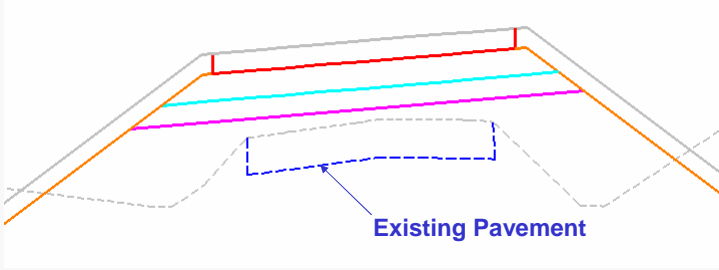
**Existing Suitable Material**

- soil type = TOPSOIL
- roadway exc mult factor = 1.0
- subsoil exc mult factor = 1.0
- fill mult factor = 1.0
- type = line, line\_string
- lvname = XS Topsoil




**Existing Suitable**

Material classified as Existing Suitable is removed **only** if its excavation is needed to build the proposed design.



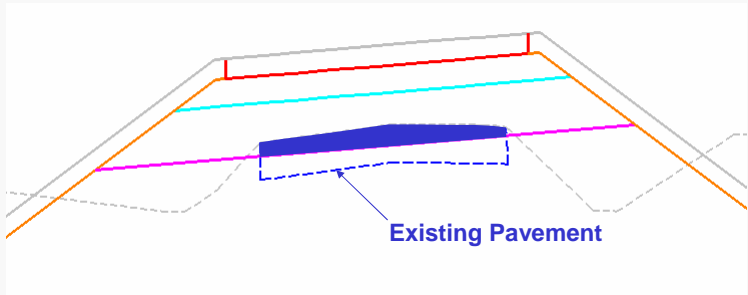
Existing Pavement

Excavation Required - None




**Existing Suitable**

Material classified as Existing Suitable is removed **only** if its excavation is needed to build the proposed design.



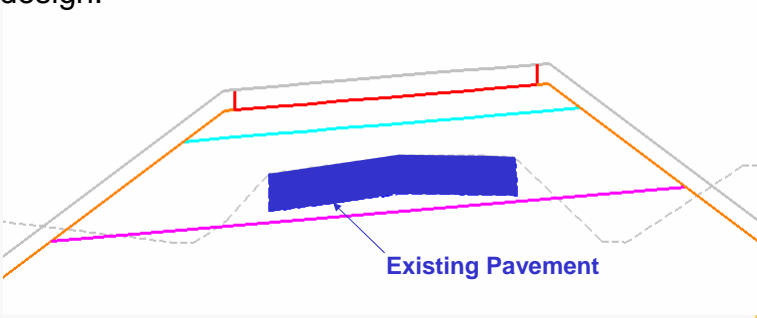
Existing Pavement

Excavation Required - Partial



**Existing Suitable**

Material classified as Existing Suitable is removed **only** if its excavation is needed to build the proposed design.



Excavation Required - All

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**Existing Suitable**



The classification of Existing Suitable does **not** affect whether material is reused. That is controlled by soil type nomenclature.

*Note: We'll discuss this in more detail after we cover the Proposed Undercut classification.*

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## Material Classes

- Existing Ground Line ✓
- Proposed Finish Grade ✓
- Existing Suitable ✓
- Existing Unsuitable

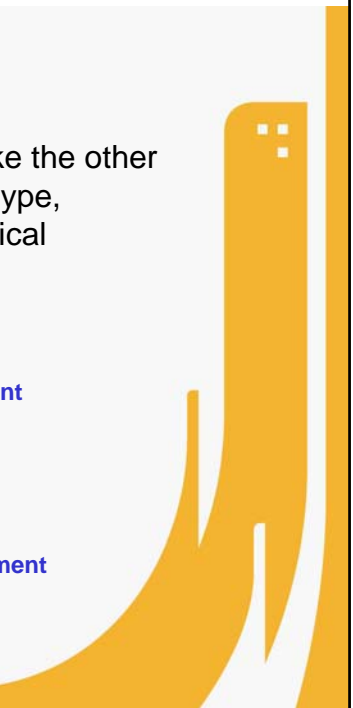



## Existing Unsuitable

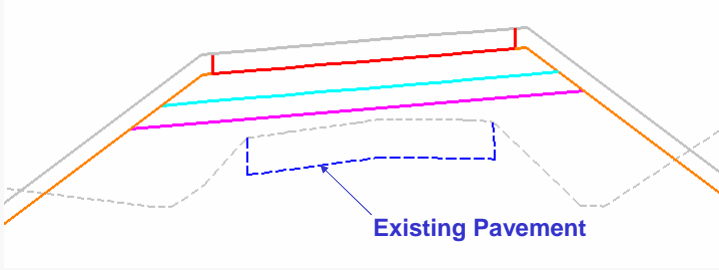
Existing Unsuitable is also defined just like the other material classes. You must define a soil type, shrink/swell factors and the proper graphical symbology.

**Existing Unsuitable Material**

- soil type = Bituminous\_Pavement
- roadway exc mult factor = 1.0
- subsoil exc mult factor = 1.0
- fill mult factor = 1.0
- type = line, line\_string
- lvname = XS Existing Bit Pavement




**Existing Unsuitable**  
By default, material classified as Existing Unsuitable is removed **only** if its excavation is needed to build the proposed design.

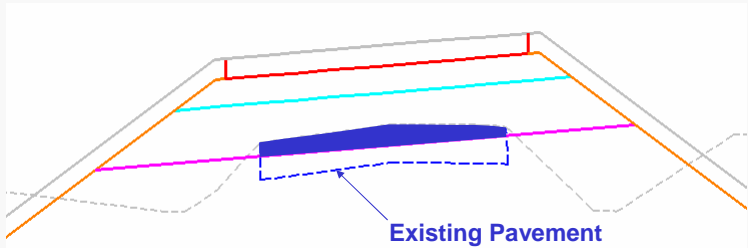


Existing Pavement

Excavation Required - None




**Existing Unsuitable**  
By default, material classified as Existing Unsuitable is removed **only** if its excavation is needed to build the proposed design.



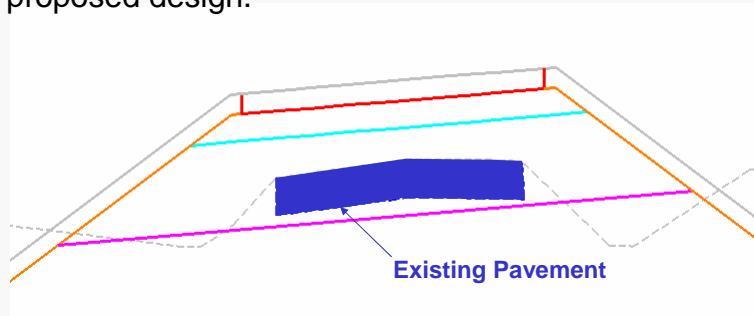
Existing Pavement

Excavation Required - Partial



### Existing Unsuitable

By default, material classified as Existing Unsuitable is removed **only** if its excavation is needed to build the proposed design.



Excavation Required - All



### Existing Unsuitable

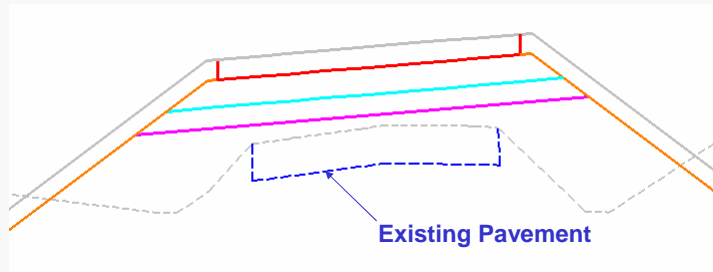
The classification of Existing Unsuitable does **not** affect whether material is reused. That is controlled by soil type nomenclature.

*Note: We'll discuss this in more detail after we cover the Proposed Undercut classification.*



### Existing Unsuitable

There are times when you want to “force” the excavation of Existing Unsuitable material, such as in the example below.



One way to do this is to use  
Excavation Limits.



### Material Classes

- Existing Ground Line ✓
- Proposed Finish Grade ✓
- Existing Suitable ✓
- Existing Unsuitable ✓
- Excavation Limits



## Excavation Limits

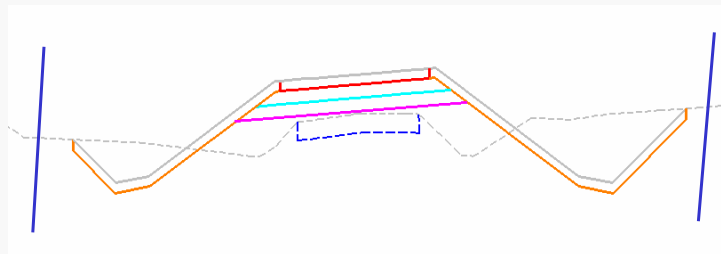
Excavation Limits are short lines drawn onto the cross sections. They are defined differently from the other material classes. They only require a graphical symbology. No soil type or shrink/swell factors are needed.

Excavation Limits  
type = line  
lvname = XS Excavation Limits



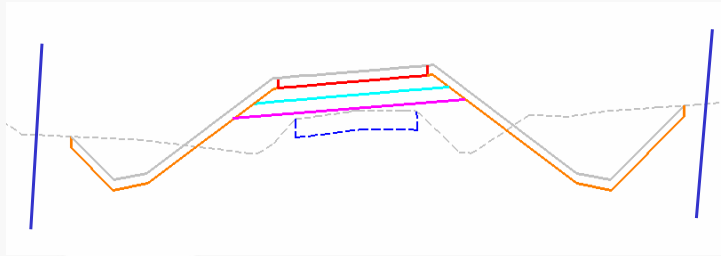
There are 3 rules to be aware of when using Excavation Limits.

***Rule #1 - Excavation limits must be used in pairs on a required section. An odd number of limits is not supported.***



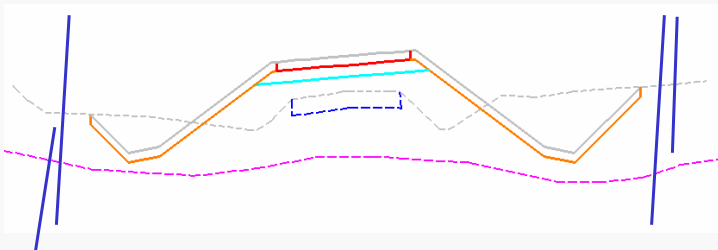
There are 3 rules to be aware of when using  
Excavation Limits.

**Rule #2 - The limits must be lines. Any other  
element types (line\_strings, curves, curve\_strings,  
arcs, etc.) are not supported.**



There are 3 rules to be aware of when using  
Excavation Limits.

**Rule #3 - The endpoint should not be within an  
area where earthwork quantities are needed.**



**Match better!**



**Excavation Limits** have several uses:

#1 Force the excavation of unsuitable material.

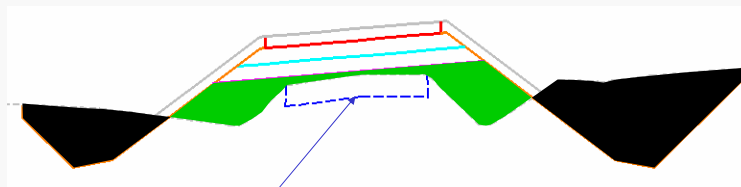
#2 As their names suggests, they are used to determine the actual "limits" of the excavation of unsuitable material.

#3 Delineate specific earthwork processing areas on a cross section.



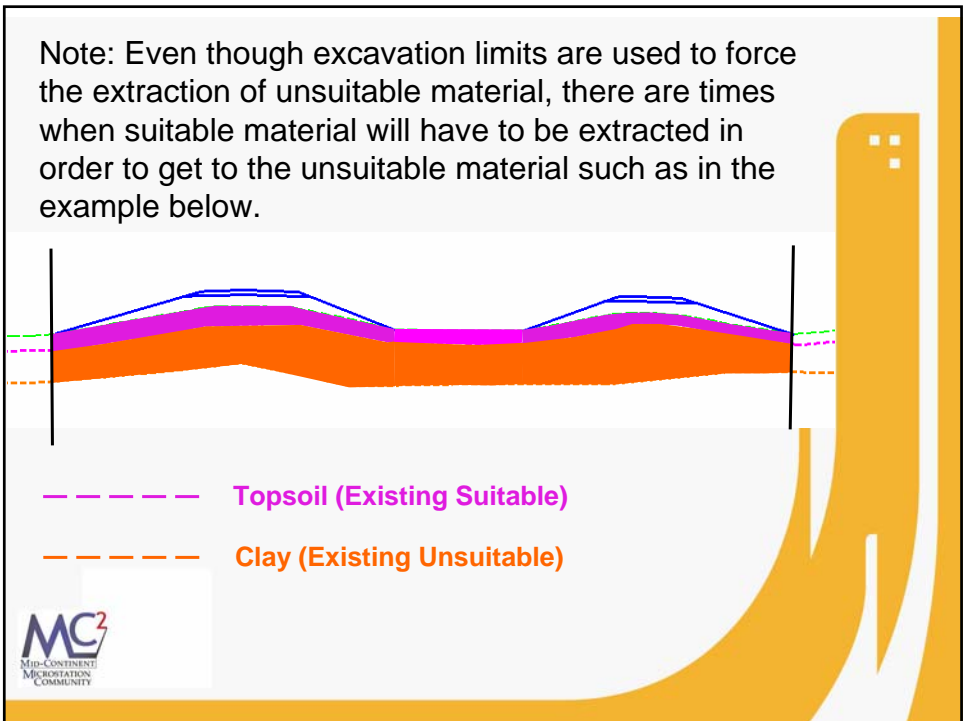
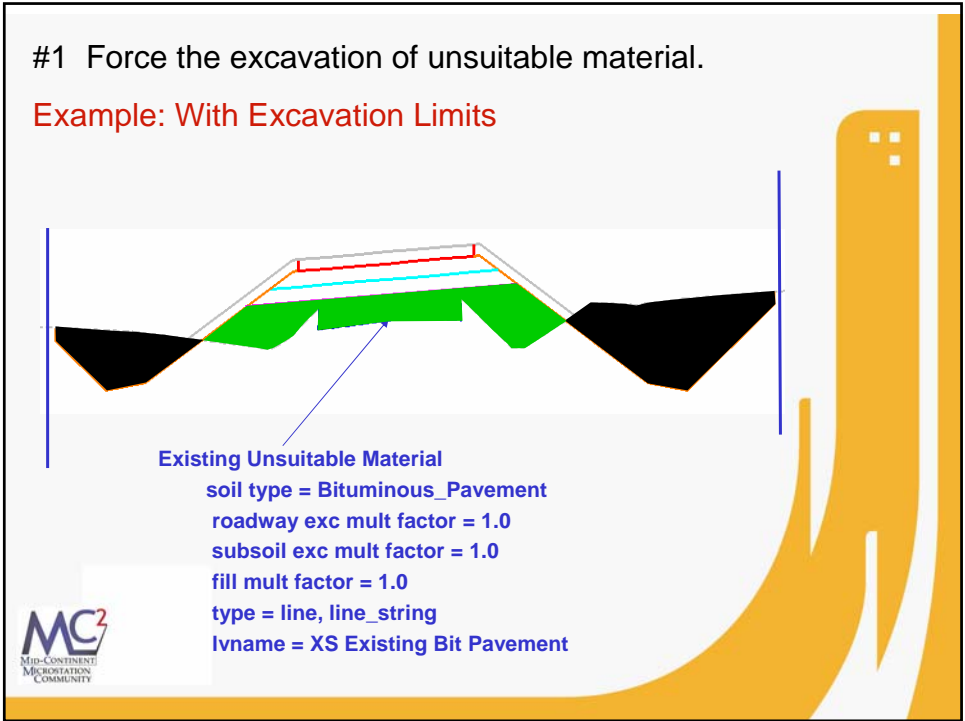
#1 Force the excavation of unsuitable material.

**Example: Without Excavation Limits**

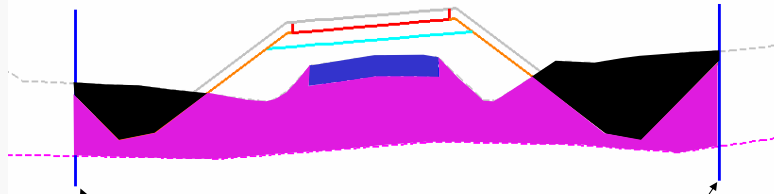


**Existing Unsuitable Material**  
soil type = Bituminous\_Pavement  
roadway exc mult factor = 1.0  
subsoil exc mult factor = 1.0  
fill mult factor = 1.0  
type = line, line\_string  
lvname = XS Existing Bit Pavement





#2 As their names suggests, they are used to determine the actual "limits" of the excavation of unsuitable material.



The unsuitable material will only be excavated within the confines of the defined Excavation Limits.

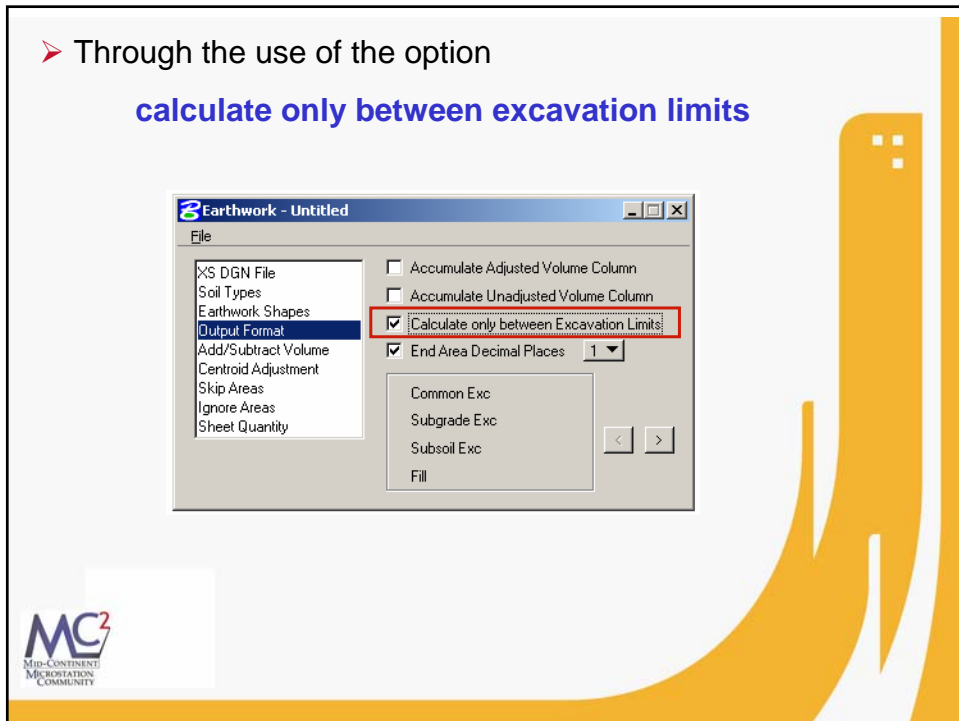
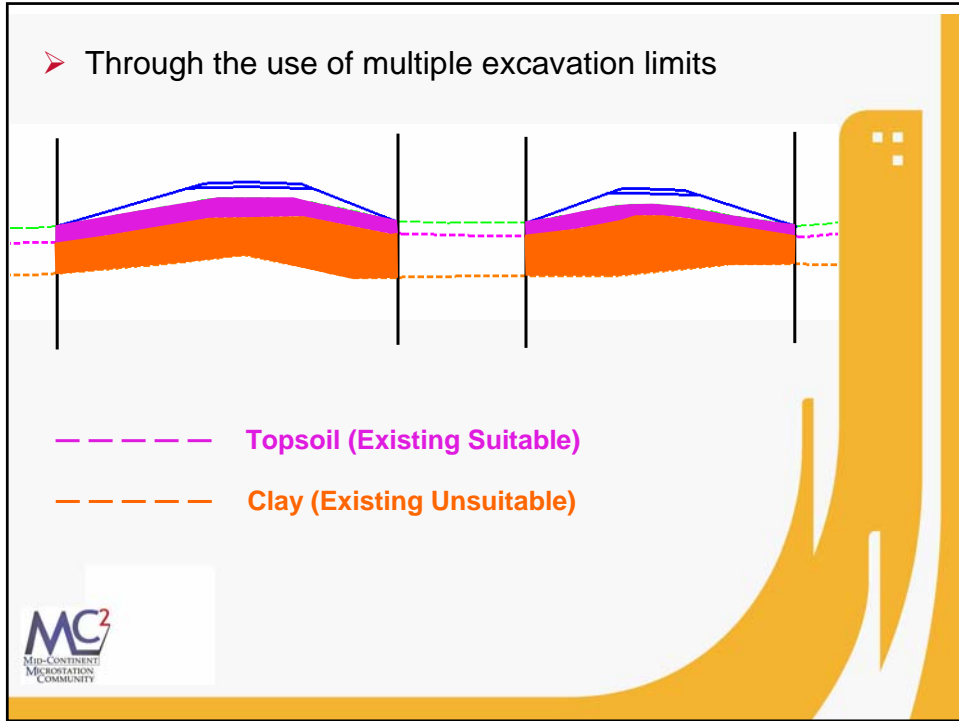


#3 Delineate specific earthwork processing areas on a cross section. This can be done in two ways:

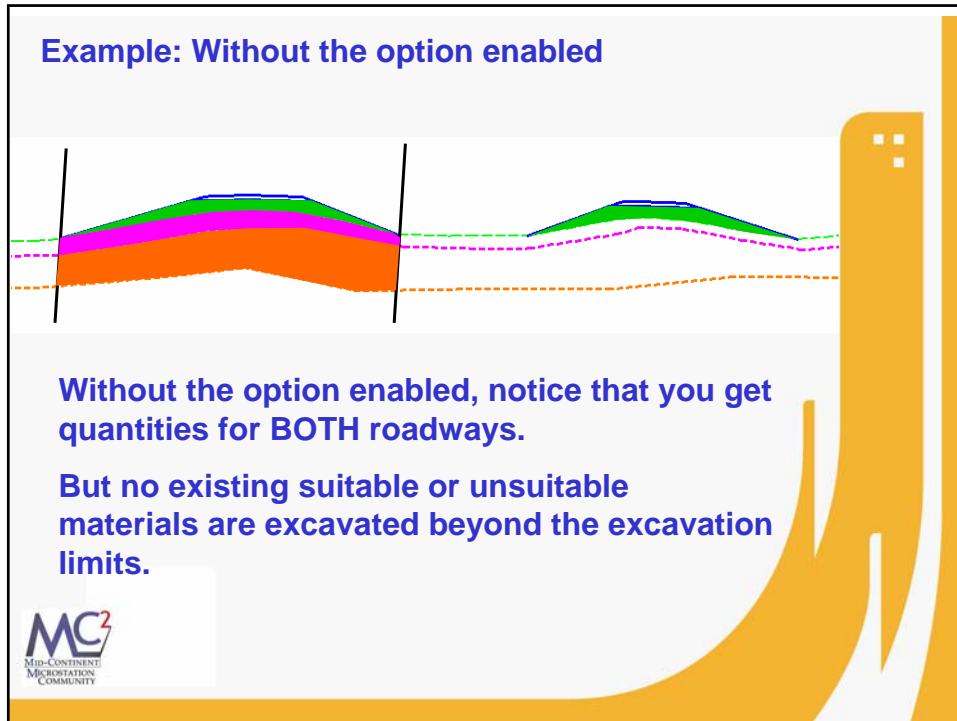
- Through the use of multiple excavation limits
- Through the use of the option

**calculate only between excavation limits**





**Example: Without the option enabled**

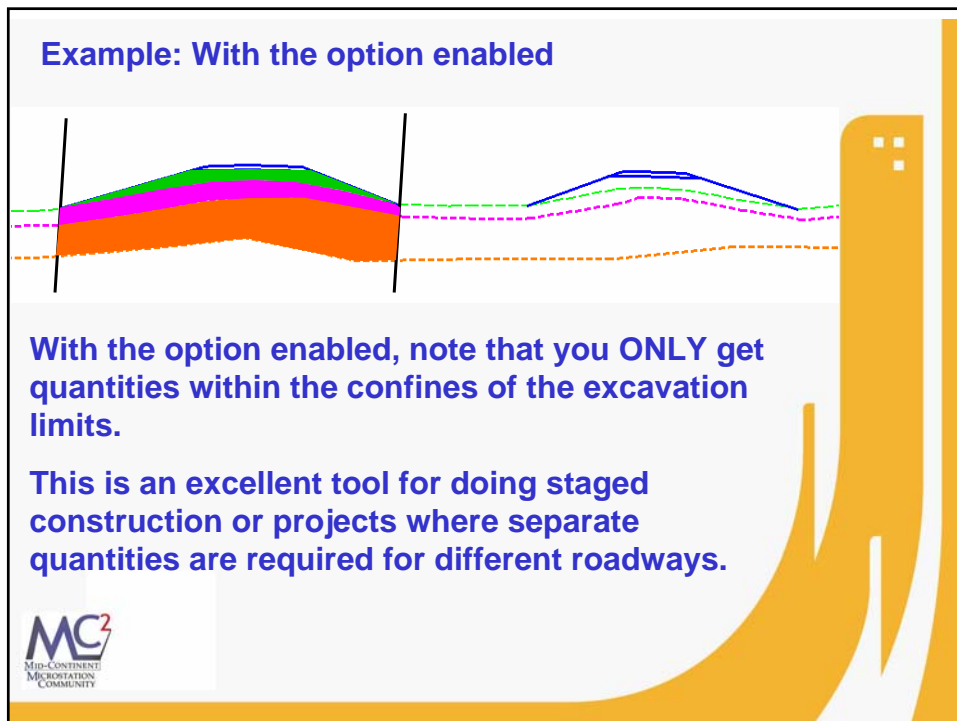


**Without the option enabled, notice that you get quantities for BOTH roadways.**

**But no existing suitable or unsuitable materials are excavated beyond the excavation limits.**

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**Example: With the option enabled**





**With the option enabled, note that you ONLY get quantities within the confines of the excavation limits.**

**This is an excellent tool for doing staged construction or projects where separate quantities are required for different roadways.**

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MICROTATION  
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## Material Classes

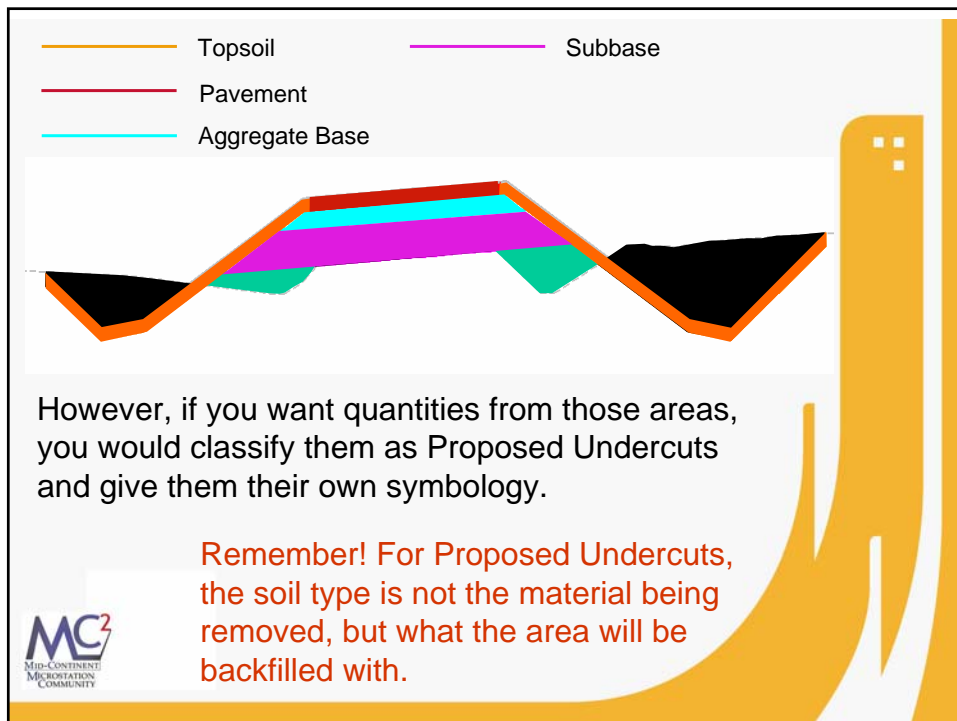
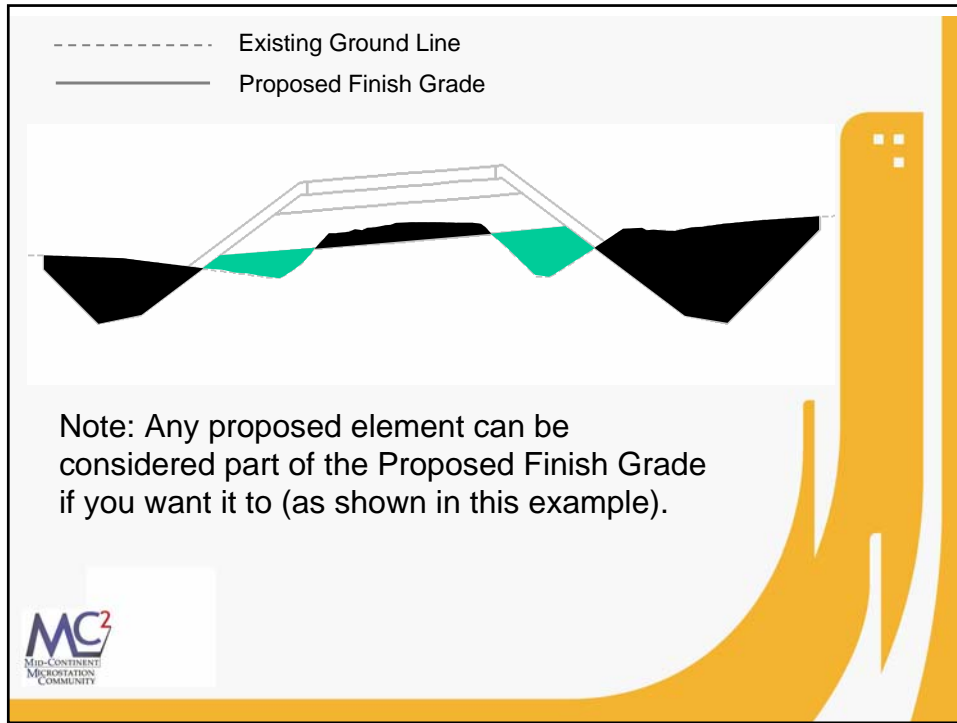
- Existing Ground Line ✓
- Proposed Finish Grade ✓
- Existing Suitable ✓
- Existing Unsuitable ✓
- Excavation Limits ✓
- Proposed Undercut

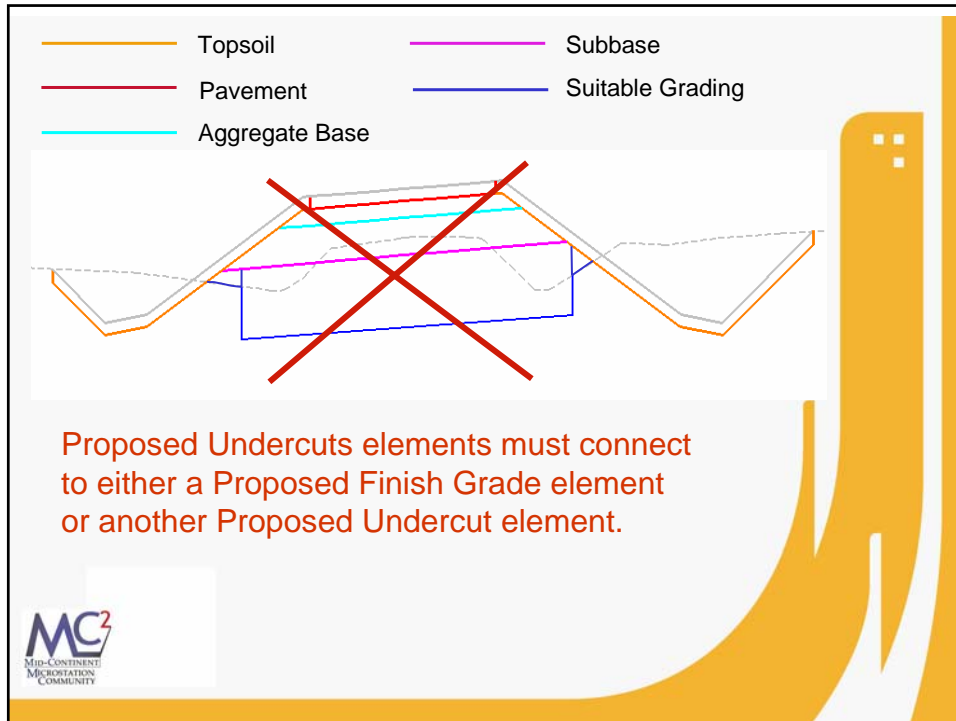


## Proposed Undercut

- Proposed undercuts are used to define any proposed component which is not part of the proposed finished grade.
- The soil type is not the material being removed, but what the area will be backfilled with.
- All proposed undercuts must tie to another proposed undercut or proposed finish grade, not to existing ground.

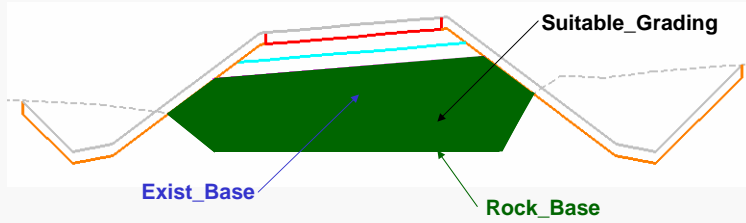






- Proposed Undercuts** have 3 uses:
1. To excavate existing material and replace/backfill with another.
  2. To calculate a quantity for a material layer (e.g. pavement layer).
  3. To re-use material.
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**1. To excavate existing material and replace/backfill with another.**



Process Cross Sections Display

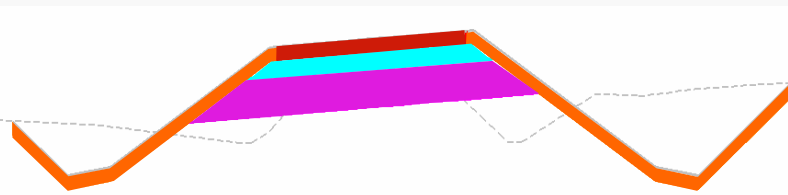
172+00.00 SUITABLE GRADING				
Excavation	82.50	0	0	1.00
Subsoil Exc	0.00	0	0	1.00
Fill	0.00	0	0	1.00
ROCK BASE				
Excavation	0.00	0	0	1.00
Subsoil Exc	0.00	0	0	1.00
Fill	60.13	0	0	1.00
EXIST BASE				
Excavation	3.66	0	0	1.00
Subsoil Exc	0.00	0	0	1.00
Fill	0.00	0	0	1.00
Mass ordinate for EXIST_BASE = 4058				

Buttons: Continue,  Pause On Each Section,  Maintain Relative Window, Abort Run



**2. To calculate a quantity for a material layer (e.g. pavement layer).**

- Topsoil
- Pavement
- Aggregate Base
- Subbase




### 3. To re-use material.

\* From previous slide

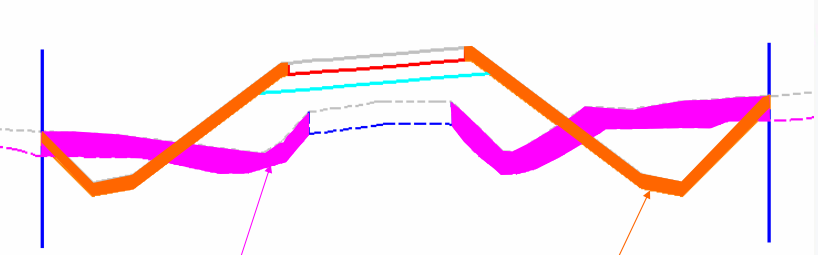
**Existing Suitable/Unsuitable**

The classification of Existing Suitable/Unsuitable does **not** affect whether material is reused. That is controlled by soil type nomenclature.

*Note: We'll discuss this in more detail after we cover the Proposed Undercut classification.*



### 3. To re-use material.



171+00.00 SUITABLE_GRADING						
Excavation	18.74	0	0	1.00		
Subsoil Exc	0.00	0	0	1.00		
Fill	51.30	0	0	1.00	-7577	
TOPSOIL						
Excavation	14.39	0	0	0.90		
Subsoil Exc	11.43	0	0	0.90		
Fill	12.90	0	0	0.95	-7577	
Mass ordinate for TOPSOIL = 1852						
EXIST_BASE						
Excavation	0.00	0	0	1.00		
Subsoil Exc	6.10	0	0	1.00		
Fill	0.00	0	0	1.00	-7577	
Mass ordinate for EXIST_BASE = 3900						

Process Cross Sections Display

Continue  Pause On Each Section  Maintain Relative Window Abort Run

## Excavation Types

### ➤ Common Excavation

*Excavation volumes that are not backfilled with an earthwork material. This includes the excavation required for cut sections as well as for pavement thickness, shoulder thickness, etc.*

### ➤ Subgrade Excavation

*Excavation volumes that are backfilled with an earthwork material.*

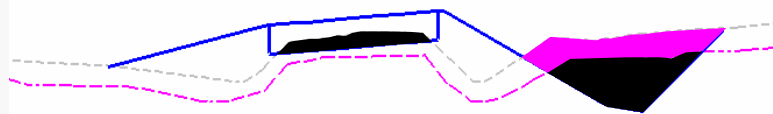
### ➤ Subsoil Excavation

*Excavation required to remove unsuitable material either 1) down to the bottom of the proposed template or 2) down to the bottom of the unsuitable material layer in cases where excavation limits are defined.*



### ➤ Common Excavation

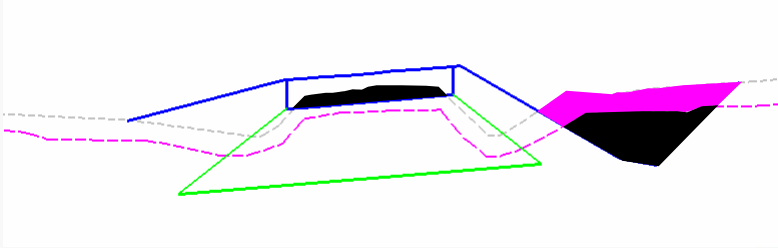
*Excavation volumes that are not backfilled with an earthwork material. This includes the excavation required for cut sections as well as for pavement thickness, shoulder thickness, etc.*




Process Cross Sections Display					
171+00.00	SUITABLE GRADING				
	Common Exc	10.39	1340	1340	1.00
	Subgrade Exc	0.00	0	0	1.00
	Subsoil Exc	0.00	0	0	1.00
	Fill	16.90	2208	2208	1.00 -10047
	TOPSOIL				
	Common Exc	11.71	1073	965	0.90
	Subgrade Exc	0.00	0	0	0.90
	Subsoil Exc	0.00	0	0	0.90
	Fill	0.00	0	0	0.95 -10047
	Mass ordinate for TOPSOIL = 8437				



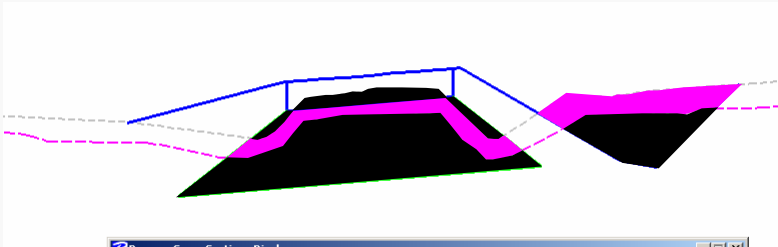
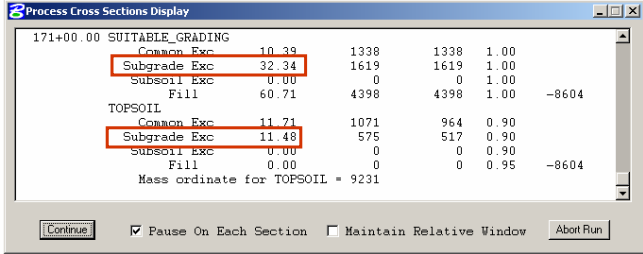
➤ **Subgrade Excavation**  
*Excavation volumes that are backfilled with an earthwork material.*



**Proposed Undercut**  
 soil type = Suitable\_Grading  
 roadway exc mult factor = 1.0  
 subsoil exc mult factor = 1.0  
 fill mult factor = 1.0  
 type = line, line\_string  
 lvsname = XS Proposed Undercut




➤ **Subgrade Excavation**  
*Excavation volumes that are backfilled with an earthwork material.*

Station	Material	Excavation Volume	Subsoil Volume	Fill Volume	Factor	Offset
171+00.00	SUITABLE_GRADING					
	Common Exc	10.39	1338	1338	1.00	
	Subgrade Exc	32.34	1619	1619	1.00	
	Subsoil Exc	0.00	0	0	1.00	
	Fill	60.71	4398	4398	1.00	-8604
	TOPSOIL					
	Common Exc	11.71	1071	964	0.90	
	Subgrade Exc	11.48	575	517	0.90	
	Subsoil Exc	0.00	0	0	0.90	
	Fill	0.00	0	0	0.95	-8604
Mass ordinate for TOPSOIL = 9231						

Buttons: [Continue]  Pause On Each Section  Maintain Relative Window [Abort Run]



➤ **Subsoil Excavation**  
*Excavation required to remove unsuitable material either 1) down to the bottom of the proposed template or 2) down to the bottom of the unsuitable material layer in cases where excavation limits are defined.*

**Excavation Limits**  
 lname = XS Excavation Limits

➤ **Subsoil Excavation**  
*Excavation required to remove unsuitable material either 1) down to the bottom of the proposed template or 2) down to the bottom of the unsuitable material layer in cases where excavation limits are defined.*

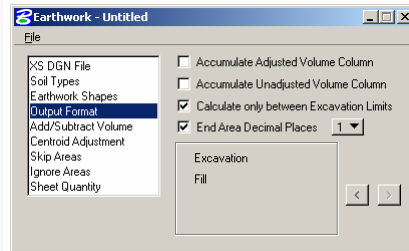
Process Cross Sections Display

171+00.00 SUITABLE_GRADING				
Common Exc	10.39	1337	1337	1.00
Subgrade Exc	32.34	1618	1618	1.00
Subsoil Exc	0.00	0	0	1.00
Fill	69.57	5145	5145	1.00 -16872
TOPSOIL				
Common Exc	11.71	1071	964	0.90
Subgrade Exc	11.48	574	517	0.90
Subsoil Exc	8.85	748	674	0.90
Fill	0.00	0	0	0.95 -16872
Mass ordinate for TOPSOIL = 16668				

Pause On Each Section
  Maintain Relative Window

## Excavation Types

- **If you don't care about breaking your excavation quantities out separately, you can combine them.**



combine common exc + subgrade exc + subsoil exc



## Questions?

I was sleeping during your presentation. Could you go over it again?





The banner features the Bentley logo (a blue square with 'be' in white) and the Mid-Continent Microstation Community logo (the letters 'MC' in blue with a red '2' as a superscript, above the text 'MID-CONTINENT MICROSTATION COMMUNITY'). The background is light gray with a stylized orange and white city skyline on the right. The text is arranged in a white box on the left.

**be**  
BENTLEY EMPOWERED

**MC<sup>2</sup>**  
MID-CONTINENT  
MICROSTATION  
COMMUNITY

Summer Conference  
August 15-16, 2007  
Overland Park, Kansas

It's time for learning.

**Advanced Earthwork**

Derricke Gray – Bentley