

# **SLOPING AND BENCHING SYSTEMS**

## **OBJECTIVES**

Upon the completion of this section, the participant should be able to:

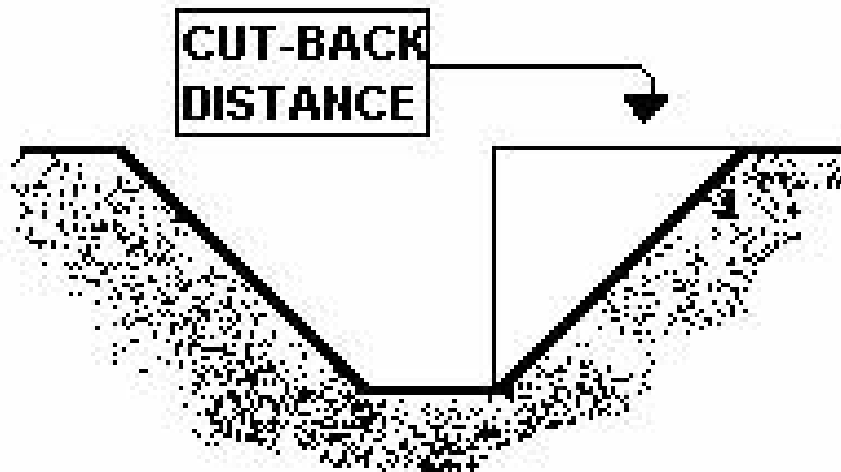
1. Describe the difference between maximum allowable slope and actual slope.
2. Observe how the angle of various sloped systems varies with soil type.
3. Evaluate layered systems to determine the proper trench slope.
4. Illustrate how shield systems and sloping systems interface in combination systems.

## SLOPING SYSTEMS

If enough surface room is available, sloping or benching the trench walls will offer excellent protection without any additional equipment. Cutting the slope of the excavation back to its prescribed angle will allow the forces of cohesion (if present) and internal friction to hold the soil together and keep it from flowing down the face of the trench. The soil type primarily determines the excavation angle.

**Sloping** a method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavations so as to prevent cave-ins.

In practice, it may be difficult to accurately determine these sloping angles. Most of the time, the depth of the trench is known or can easily be determined. Based on the vertical depth, the amount of cutback on each side of the trench can be calculated. A formula to calculate these cutback distances will be included with each slope diagram. NOTE: Remember, the beginning of the cutback distance begins at the toe of the slope, not the center of the trench. Accordingly, the cutback distance will be the same regardless of how wide the trench is at the bottom.



OSHA provides slope information based on the maximum allowable slope. To use the maximum allowable slope, site conditions must be ideal. If any signs of distress are observed, the actual slope is required to be less than the maximum allowable slope. Signs of distress that OSHA lists are:

- Development of fissures in trench face;
- Appearance of stress cracks;
- Material slumping from face;
- Bulging or heaving of the trench bottom;
- Spalling or raveling.

If this or any other condition is observed which the competent person believes would jeopardize the integrity of the trench, the steepest slope which can be used is the maximum allowable slope plus an additional 1/2H: 1V. This is the steepest actual slope. Depending upon conditions, the angle of this slope may have to be further reduced to provide adequate protection. While not as specific, the Standard states that the competent person must allow a safety factor (decrease the slope) in situations where surcharge loads, or vibration could weaken the slope walls as well.

The prescribed sloping angles and bench dimensions can be determined by using any of the following options:

1. **Assume TYPE C soil.** This gives a maximum allowable slope of 34 degrees (1.5H: 1V). No benching is allowed. Soil testing is not required.
2. **Use of Tabulated Data approved by a Registered Professional Engineer.** Data must include system selection parameters, data limits, and explanatory information. A copy of the tabulated data is required to be at the job site during construction. Soil testing required.
3. **Use a slope or benching configuration designed by a Registered Professional Engineer.** A copy of the design data is required to be at the job site during construction. Soil testing required.
4. **Use Appendix A (Soil Testing) and Appendix B (Sloping and Benching).** Soil testing required.

### APPENDIX B - Simple Sloping Systems for TYPE A Soil

For TYPE A soil and a trench depth of less than 20 feet, the steepest maximum allowable slope is 53 degrees from the horizontal. This translates to a 0.75H: 1V incline and is shown below.



#### Maximum Allowable Slope

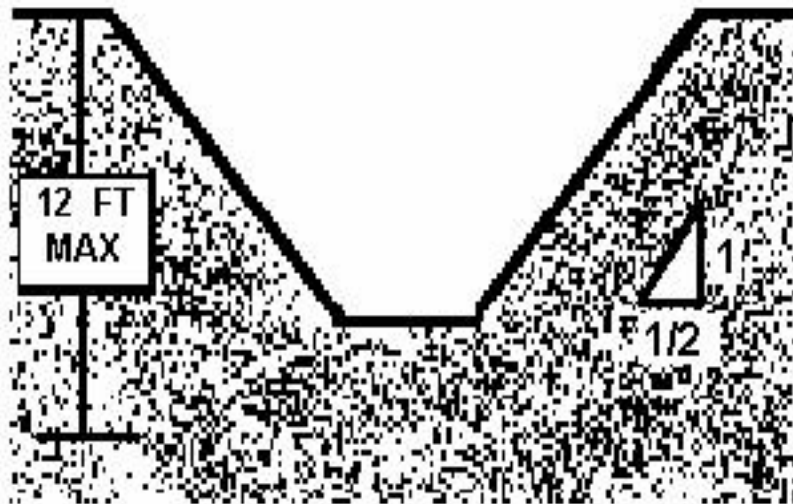
$$\text{Cut-back distance (H)} = 0.75 \times \text{Depth (V)}$$

#### Steepest Actual Slope

$$\text{Cut-back distance (H)} = 1.25 \times \text{Depth (V)}$$

Many trenches are open for such a short time that the cohesive TYPE A soil has no time to dry out. Therefore, OSHA allows for a steeper maximum allowable slope for those trenches, which are 12 feet or less in depth and will remain open for less than 24 hours.

For TYPE A soil and a trench depth of less than 12 feet for a trench open 24 hours or less, the steepest maximum allowable slope is 63 degrees from the horizontal. This translates to a 0.5H: 1V incline and is shown below.



**Maximum Allowable Slope**

$$\text{Cut-back distance (H)} = 0.5 \times \text{Depth (V)}$$

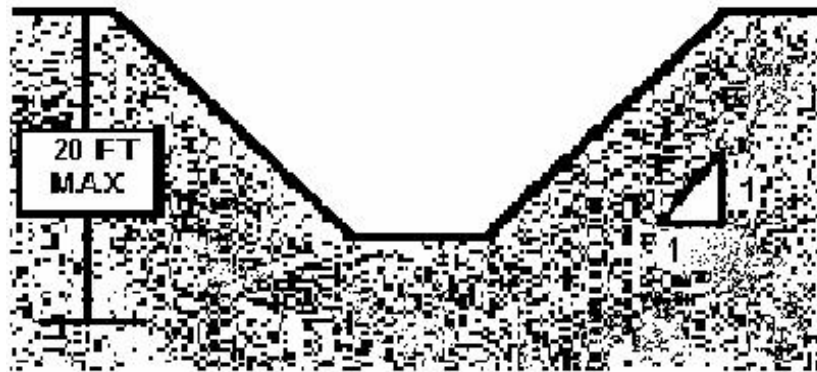
**Steepest Actual Slope**

$$\text{Cut-back distance (H)} = 1.0 \times \text{Depth (V)}$$

### APPENDIX B - Simple Sloping System for TYPE B Soil

TYPE B soil is not as stable as TYPE A, and the incline for the sloped system is not as great as it would be for TYPE A soils.

For TYPE B soil and a trench depth of less than 20 feet, the steepest maximum allowable slope is 45 degrees from the horizontal. This translates to a 1H: 1V incline and is shown below.



#### Maximum Allowable Slope

$$\text{Cut-back distance (H)} = 1.0 \times \text{Depth (V)}$$

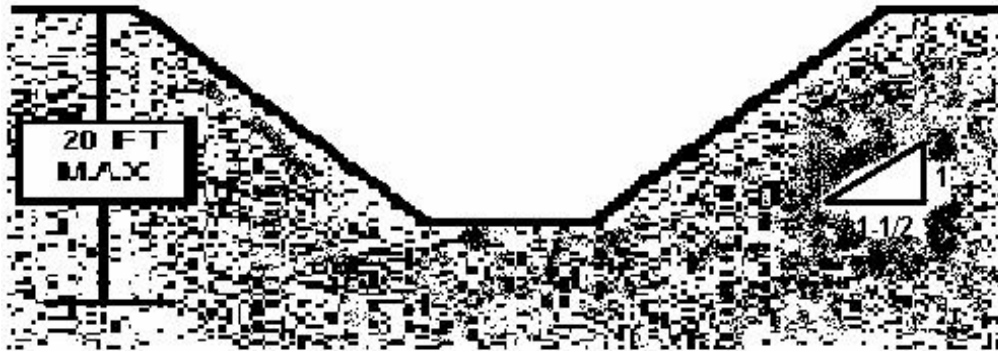
#### Steepest Actual Slope

$$\text{Cut-back distance (H)} = 1.5 \times \text{Depth (V)}$$

### APPENDIX B - Simple Sloping System for TYPE C Soil

The incline of a slope for TYPE C soil is the flattest since TYPE C soil is the least cohesive and the most flowable.

For TYPE C soil and a trench depth of less than 20 feet, the steepest maximum allowable slope is 34 degrees from the horizontal. This translates to a 1H: 1.5V incline and is shown below.



#### Maximum Allowable Slope

$$\text{Cut-back distance (H)} = 1.5 \times \text{Depth (V)}$$

#### Steepest Actual Slope

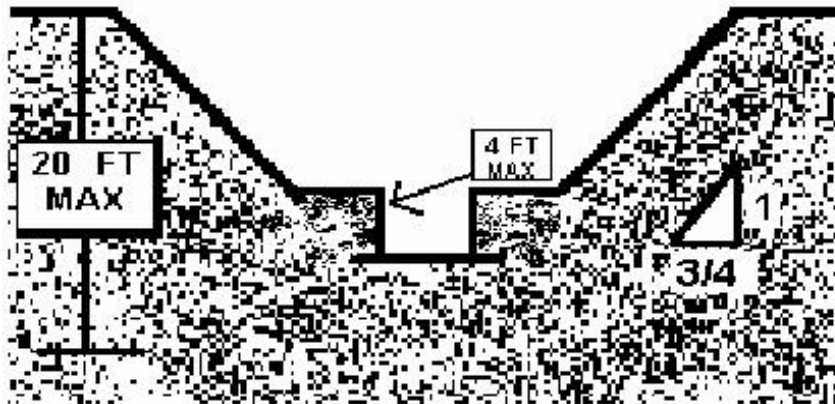
$$\text{Cut-back distance (H)} = 2.0 \times \text{Depth (V)}$$

## BENCHING SYSTEMS

Rather than excavating a flat trench face, benching leaves steps on the side of the excavation. This can either be found as a single bench at the bottom of the trench or a multiple bench system. There are really two main reasons to bench a trench rather than slope a trench. Of greatest importance is the affect it has on the weight that the buried conduit must bear. Through work done at Iowa State University, it has been shown that allowing a bench above the conduit to bear some of the lateral weight (force) of the soil can lessen soil weight, which the conduit must support.

### APPENDIX B - Bench Systems for Type A Soil

For simple bench systems in TYPE A soil and a trench depth of less than 20 feet, the steepest maximum allowable slope is 53 degrees from the horizontal. This translates to a 0.75H: 1V incline and is shown below.



#### Maximum Allowable Slope

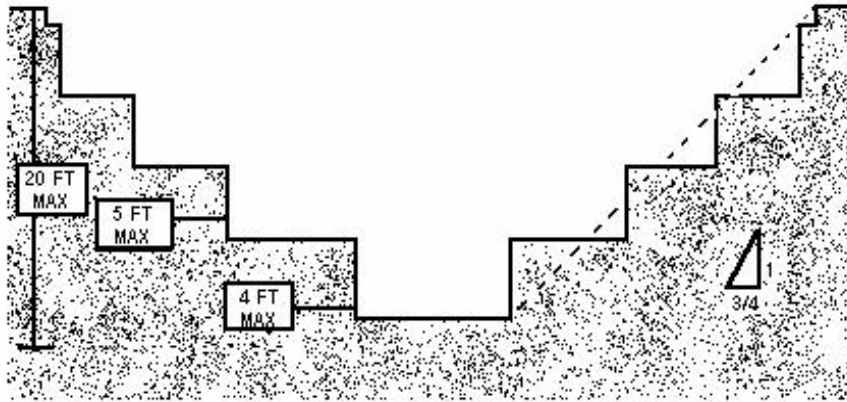
$$\text{Cut-back distance (H)} = .75 \times \text{Depth (V)}$$

#### Steepest Actual Slope

$$\text{Cut-back distance (H)} = 1.25 \times \text{Depth (V)}$$



For multiple bench systems in TYPE A soil and trench depth of less than 20 feet, the steepest maximum allowable slope is 53 degrees from the horizontal. This translates to a 0.75H: 1V incline and is shown below.



**Maximum Allowable Slope**

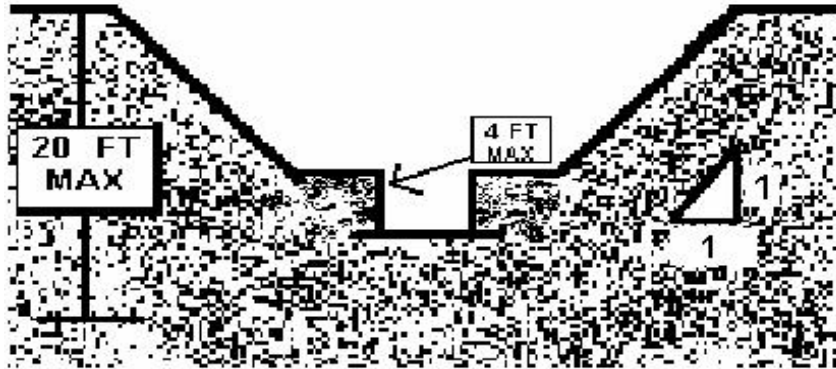
Cut-back distance (H) = .75 x Depth (V)

**Steepest Actual Slope**

Cut-back distance (H) = 1.25 x Depth (V)

**APPENDIX B - Bench Systems for TYPE B Soil**

For simple bench systems in TYPE B soil and trench depth of less than 20 feet, the steepest maximum allowable slope is 45 degrees from the horizontal. This translates to a 1H: 1V incline and is shown below.



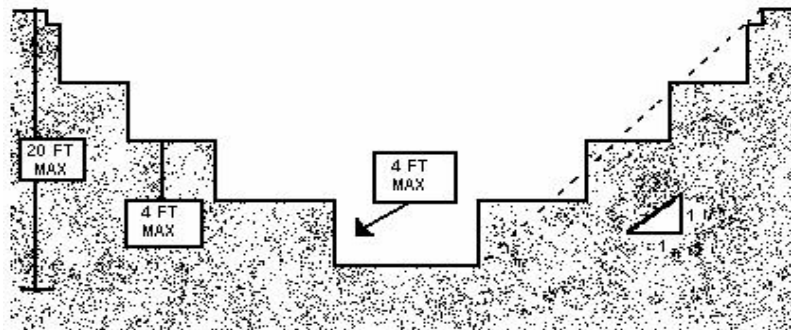
**Maximum Allowable Slope**

Cut-back distance (H) = 1.0 x Depth (V)

**Steepest Actual Slope**

Cut-back distance (H) = 1.5 x Depth (V)

For multiple bench systems in TYPE B soil and a trench depth of less than 20 feet, the steepest maximum allowable slope is 45 degrees from the horizontal. This translates to a 1H: 1V incline and is shown below.



**Maximum Allowable Slope**

Cut-back distance (H) = 1.0 x Depth (V)

**Steepest Actual Slope**

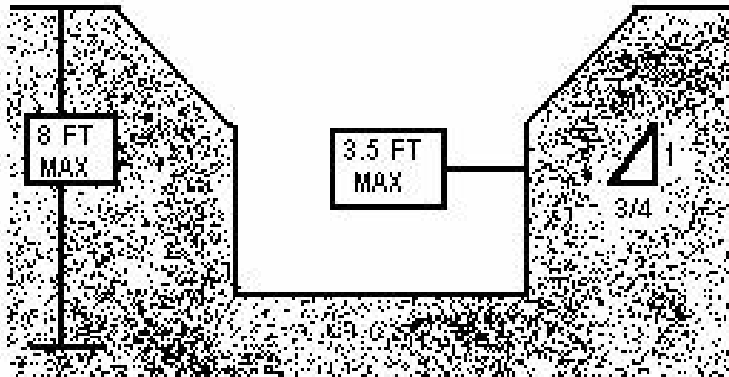
Cut-back distance (H) = 1.5 x Depth (V)

## COMBINATION SLOPED/BENCHED SYSTEMS

A variation on the sloping and benching concept yields this hybrid, which is widely used. In this combination, the bottom of the trench face is vertical. Toward the top, the trench face is sloped back.

### APPENDIX B - Combination Systems for TYPE A Soil

For combination slope/bench systems in TYPE A soil and a trench depth of less than 8 feet, the steepest maximum allowable slope is 53 degrees from the horizontal. This translates to a 0.75H: 1V incline and is shown below. The maximum height of the vertical lower portions 3.5 feet.



#### Maximum Allowable Slope

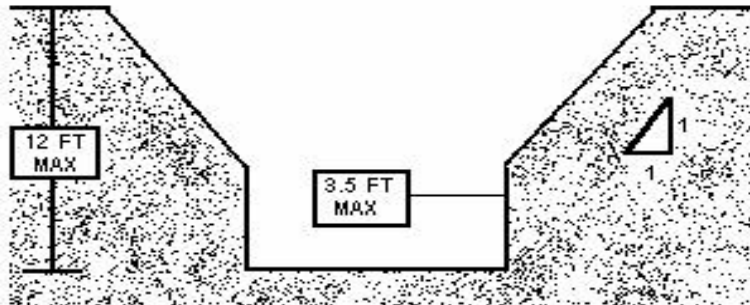
$$\text{Cut-back distance (H)} = .75 \times \text{Depth (V)}$$

#### Steepest Actual Slope

$$\text{Cut-back distance (H)} = 1.25 \times \text{Depth (V)}$$

This system is favorable from a pipe weight-loading standpoint and can be quickly excavated. It allows short trench boxed or shields systems to be used in deeper trenches. Further, in TYPE A soils, the vertical portion at the bottom can remain unsupported. Therefore, a relatively deep trench can be excavated with minimal sloping.

For combination slope/bench systems in TYPE A soil and a trench depth greater than 8 feet but less than 12 feet, the steepest maximum allowable slope is 45 degrees from the horizontal. This translates to a 1H: 1V incline and is shown below. The maximum height of the vertical lower portion is 3.5 feet.



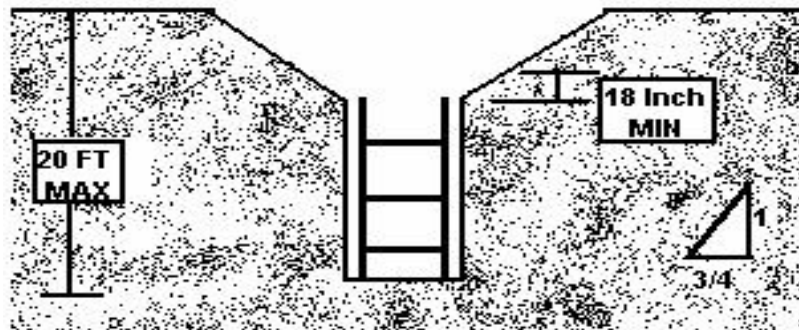
**Maximum Allowable Slope**

Cut-back distance (H) = .75 x Depth (V)

**Steepest Actual Slope**

Cut-back distance (H) = 1.25 x Depth (V)

For combination slope/bench systems in TYPE A soil and a trench depth of less than 20 feet, the steepest maximum allowable slope is 53 degrees from the horizontal. It is allowed only if a trench supports or shield is used. This translates to a 0.75H: 1V incline and is shown below. The trench shield must extend at least 18 inches above the top of the vertical side.



**Maximum Allowable Slope**

Cut-back distance (H) = .75 x Depth (V)

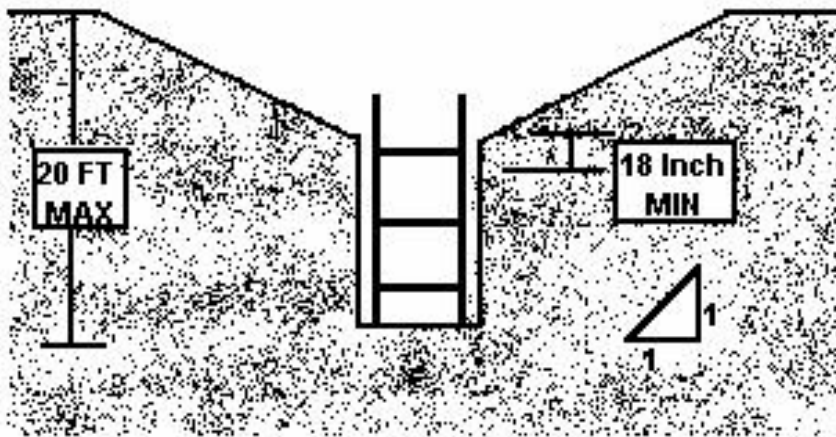
**Steepest Actual Slope**

Cut-back distance(H)=1.25xDepth(V)

### APPENDIX B - Combination System for TYPE B Soil

The only option for combination systems in TYPE B or TYPE C soils are when a support or shield system guards the vertical side.

For combination slope/bench systems in TYPE B soil and a trench depth of less than 20 feet, the steepest maximum allowable slope is 45 degrees from the horizontal is allowed only if a trench support or shield is used. This translates to a 1H: 1V incline and is shown below. The trench shield must extend at least 18 inches above the top of the vertical side.



#### Maximum Allowable Slope

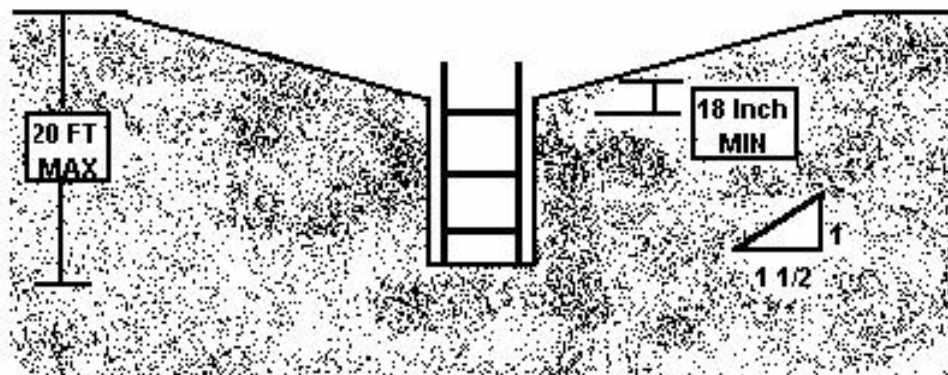
$$\text{Cut-back distance (H)} = .75 \times \text{Depth (V)}$$

#### Steepest Actual Slope

$$\text{Cut-back distance (H)} = 1.25 \times \text{Depth (V)}$$

## APPENDIX B - Combination System for TYPE C Soil

For combination slope/bench systems in TYPE C soil and a trench depth of less than 20 feet, the steepest maximum allowable slope is 34 degrees from the horizontal is allowed only if a trench support or shield is used. This translates to a 1.5H: 1V incline and is shown below. The trench shield must extend at least 18 inches above the top of the vertical side.



### Maximum Allowable Slope

$$\text{Cut-back distance (H)} = .75 \times \text{Depth (V)}$$

### Steepest Actual Slope

$$\text{Cut-back distance (H)} = 1.25 \times \text{Depth (V)}$$

## LAYERED SYSTEMS

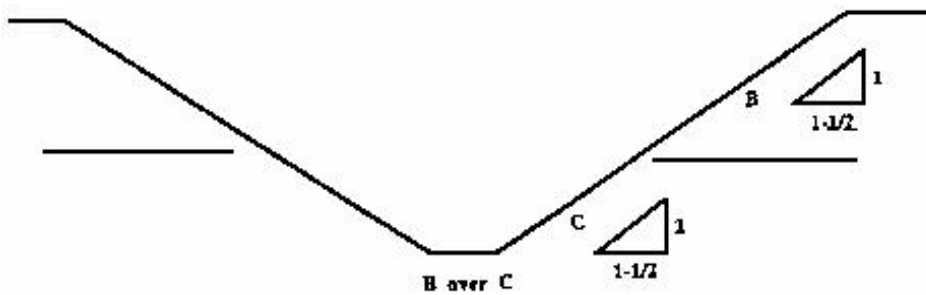
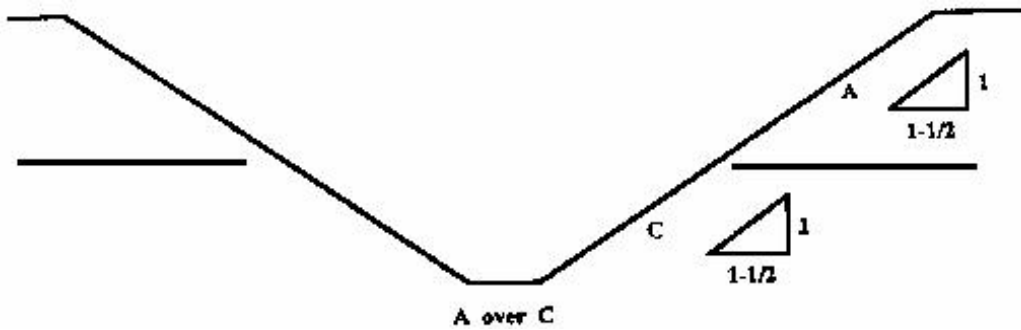
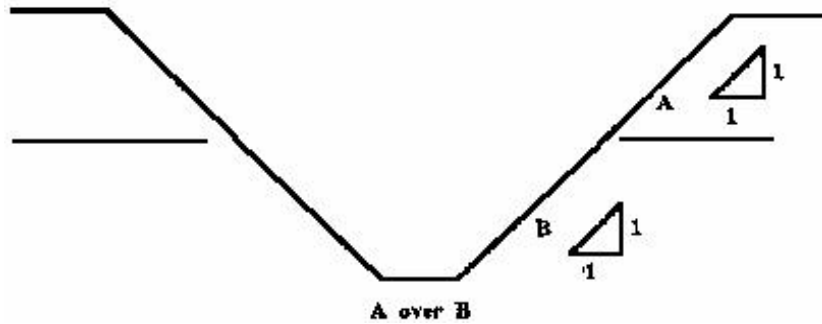
Digging in layered systems is essentially like digging two separate trenches one on top of the other. In Appendix B, OSHA recognizes systems composed of only two layers. If more than two layers are encountered, sloping should be designed to deal with the weakest soil type.

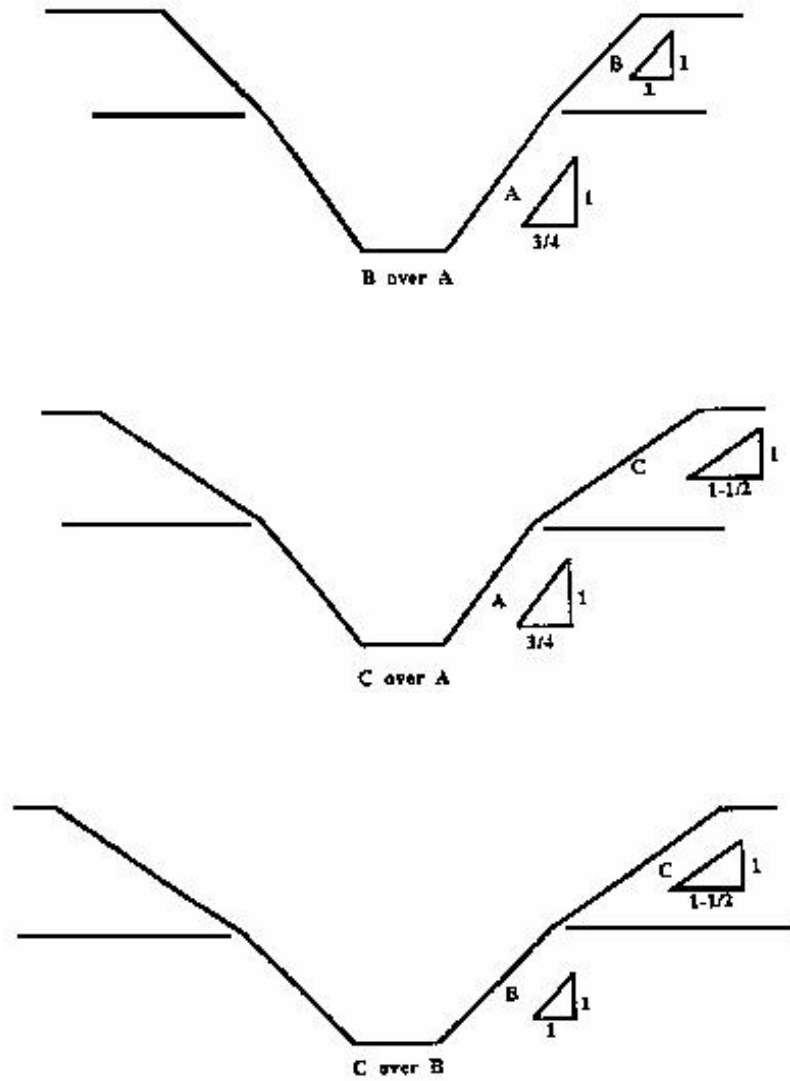
Two themes run through the layered soils sloping criteria:

1. If the stronger soil is below the weaker soil, the sloping for each layer is the same as the simple slope for that soil type.

- If the stronger soil is above the weaker soil, the entire system is sloped according to the weaker soils simple slope.

The following diagrams will illustrate layered system sloping angles. When calculating cutback distances, assume that the toe of the top layer is that point on the trench face where the top layer begins.





Surcharge loads must be placed at least 2 feet back from the edge of the trench. When spoil or surcharge loads are placed at the top of sloped or benched systems, they must stay at least 2 feet back of from the edge. Further, the center of the spoil pile can be no closer than the imaginary line formed by the continuation of the slope. This is true for positioning outriggers on heavy equipment as well.