

Trenching and Excavation

Montana Department of Labor and Industry
Safety and Health Bureau

(Revised 2010)

This informational booklet is intended to provide a generic, non- exhaustive overview of a particular standards-related topic. This publication does not itself alter or determine compliance responsibilities, which are set forth in OSHA standards themselves, Occupational Safety and Health Act and the Montana Safety Culture Act.

Moreover, because interpretations and enforcement policies may change over time, for additional guidance on OSHA compliance requirements, the reader should consult current administrative interpretations and decisions by the Occupational Safety and Health Review Commission and the courts.

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Introduction

The Occupational Safety and Health Administration issued its first Excavation and Trenching Standard in 1971 to protect workers from excavation hazards. Since then, OSHA has amended the standard several times to increase worker protection and to reduce the frequency and severity of excavation accidents and injuries. Despite these efforts, excavation-related accidents resulting in injuries and fatalities continue to occur.

The Montana Safety and Health Bureau has developed this guide in effort to address requirements of the standard, as well as provide information for equipment operators, workers and all others associated with trenching and excavating to help recognize hazardous conditions that could result in injury or a fatality. This guide discusses soil composition in moderate detail to provide a general overview of the various properties associated with different types of soil. A general understanding of the properties of soil is the first step in predicting the behavior of soils in varying condition. Some of the most common types of soil conditions that lead to trench and excavation failure are also discussed.

Proper trenching operations are necessary to protect the workers from soil collapse. The basic trenching operations that help make a trench safe for workers are described and illustrated. The methods of shoring installation are also discussed briefly. **This document is not intended to be used as a step-by-step guideline in the excavation process.**

OSHA revised the excavations standard in 1989, with focus on the existing standard to simplify many of the existing provisions, add and clarify definitions, eliminate duplicate provisions and ambiguous language, and give employers added flexibility in providing protection for employees. In addition, the standard provides several new appendixes. Appendix A to 1926.652 provides a consistent method of soil classification. Appendix B to 1926.652 provides sloping and benching requirements. Other appendixes (appendixes C–F) provide pictorial examples of shoring and shielding devices, timber tables, hydraulic shoring tables, and selection charts that provide a graphic summary of the requirements contained in the standard. For more information on the details of proper installation, please refer to the OSHA standard on excavation (29 CFR 1926 Subpart P, which includes 650–652 and appendixes A–F) and to the Suggested Readings in this guide.

Scope and Application

The OSHA standard applies to all open excavations made in the earth's surface, which includes trenches. According to the OSHA construction safety and health standards, 1926.650(b), a trench is referred to as a narrow excavation made below the surface of the ground in which the depth is greater than the width—the width not exceeding 15 feet (4.5 meters). An excavation is any man-made cut, cavity, trench or depression in the earth's surface formed by earth removal. This can include excavations for anything, from cellars to highways. The standard does not apply to house foundation/basement excavations (including those that become trenches by definition when formwork, foundations or walls are constructed) when all of the following conditions are present:

- The house foundation/basement excavation is less than 7 1/2 feet (2.5 meters) deep or is benched for at least 2 feet (0.61 meters) horizontally for every 5 feet (1.52 meters) or less of vertical height.
- The minimum horizontal width (excavation face to formwork/wall) at the bottom of the excavation is as wide as practicable but not less than 2 feet (0.61 meters).
- There is no water, surface tension cracks nor other environmental conditions present that reduce the stability of the excavation.
- There is no heavy equipment operating in the vicinity that causes vibration to the excavation while employees are in the excavation.
- All soil, equipment and material surcharge loads are no closer in distance to the top edge of the excavation than the excavation is deep; however, when front end loaders are used to dig the excavations, the soil surcharge load must be placed as far back from the edge of the excavation as possible, but never closer than 2 feet (0.61 meters).
- Work crews in the excavation are the minimum number needed to perform the work.
- The work has been planned and is carried out in a manner to minimize the time employees are in the excavation.

These conditions as applicable to residential construction are restated in another section of this guide, **Residential Contractors and the Excavations Standard**.

The standard provides several options for designing trench protection measures. Under certain conditions, the design of the trench protection measures must be prepared by a registered professional engineer.

Proper selection and installation of trench protection measures are very important. To comply with the standard, the employer must have a competent person: “one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.”

This competent person has critical inspection responsibilities regarding excavations. This person must inspect every excavation and protective system under his or her care daily, including areas adjacent to any excavation. Additional inspections must be conducted before starting work and as needed through a shift, for example, when any hazard-increasing occurrence (such as a rainstorm) takes place. When the competent person finds any evidence of a situation that could result in a cave-in, protective system failure or any other hazardous condition, employees are to be immediately removed from the danger area until the problem is fixed.

Many companies have established a written policy that outlines specific safe trenching practices in detail. Such a policy should ensure adequate support for the trench and frequent inspections of the excavation site to detect any change in the soil conditions. When this type of policy is enforced, all employees understand their responsibilities, which helps to avoid unsafe practices.

This document is not intended to be a guideline for compliance with all pertinent OSHA regulations but rather an overview of safe practices in trenching operations. Though the guide is not intended to be inconsistent with OSHA standards, if an area is considered by the reader to be inconsistent, the OSHA standard should be followed.

1

Common Soil Problems

This guide highlights the requirements in the updated standard for excavation and trenching operations, provides methods for protecting employees against cave-ins, and describes safe work practices for employees. A necessary first step in planning the approach to any trenching or other excavation project is to understand what could go wrong. This understanding can help avoid many of the problems associated with excavation.

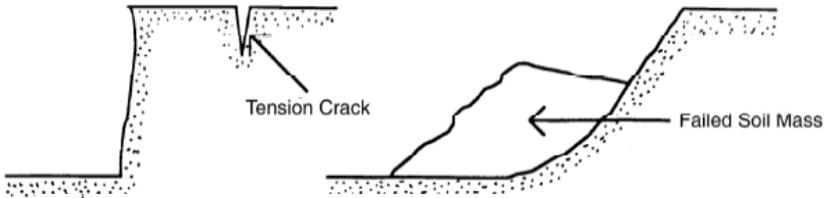
The terms **soil** and **earth** are commonly referred to in the excavation process to describe the naturally occurring materials uncovered on a project. Soil conditions vary from one site to the next. Soil may be loose or partially

cemented, organic or inorganic. However, most soils can be referred to as a mixture or an accumulation of mineral grains that are not cemented together. An exception is hard rock, which remains firm after exposure to the elements.

Soil failure is defined as the collapse of part or all of an excavation wall. The most common soil failure is typically described as an unexpected settlement, or cave-in, of an excavation. Soil sliding is the most common factor leading to soil failure.

Proper planning and supervision can avoid the unsafe working conditions caused by soil sliding. Unless such safety precautions have been implemented, sliding soil failure can occur in all types of excavations (including sloped trenches and excavations with braced trench boxes). See Figure 1.

Figure 1
Sliding Failure

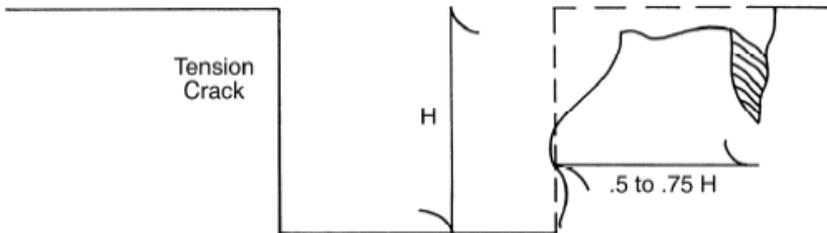


Overview: Soil Mechanics

A number of stresses and deformations can occur in an open cut or trench. For example, increases or decreases in moisture content can adversely affect the stability of a trench or excavation. The following diagrams show some of the more frequently identified causes of trench failure.

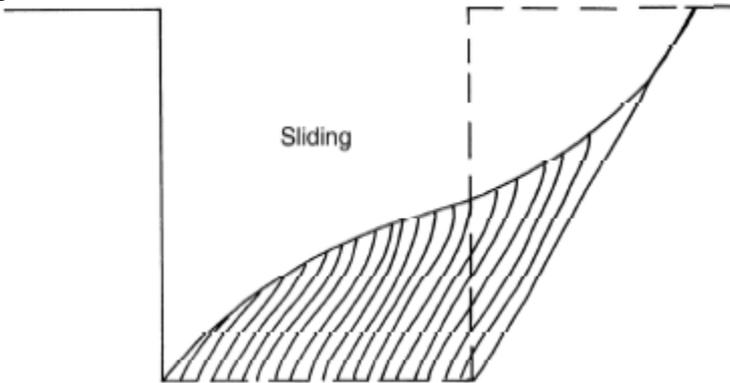
Tension cracks. Tension cracks usually form at a horizontal distance of one-half to three-quarters times the depth of the trench, measured from the top of the vertical face of the trench. See Figure 2 for additional details.

Figure 2
Tension Crack



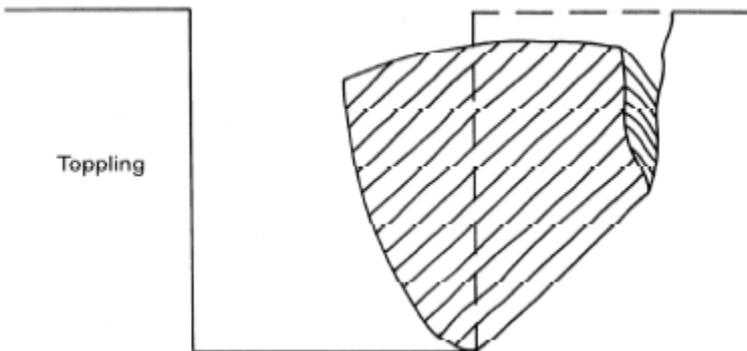
Sliding or sluffing may occur as a result of tension cracks, as illustrated in Figure 3.

Figure 3
Sliding



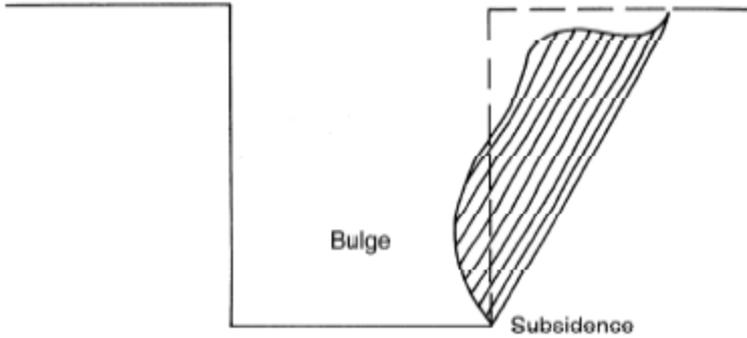
Toppling. In addition to sliding, tension cracks can cause toppling. Toppling occurs when the trench's vertical face shears along the tension crack line and topples into the excavation. See Figure 4.

Figure 4
Toppling



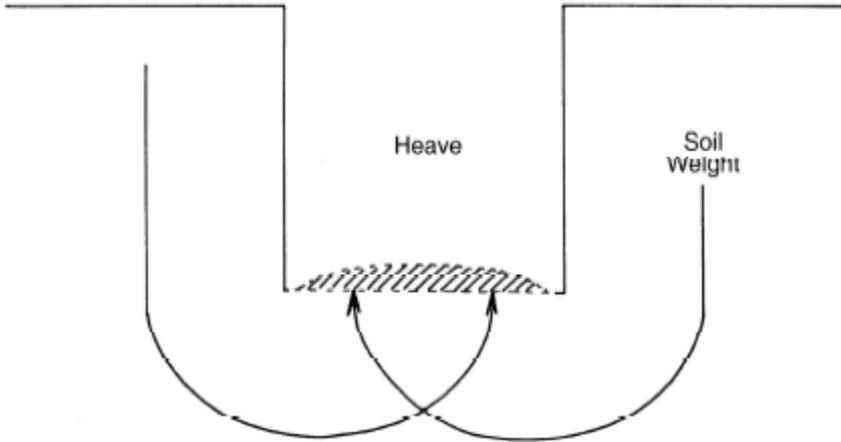
Subsidence and Bulging. An unsupported excavation can create an unbalanced stress in the soil, which, in turn, causes subsidence at the surface and bulging of the vertical face of the trench. If uncorrected, this condition can cause face failure and entrapment of workers in the trench. See Figure 5.

Figure 5
Subsidence and Bulging



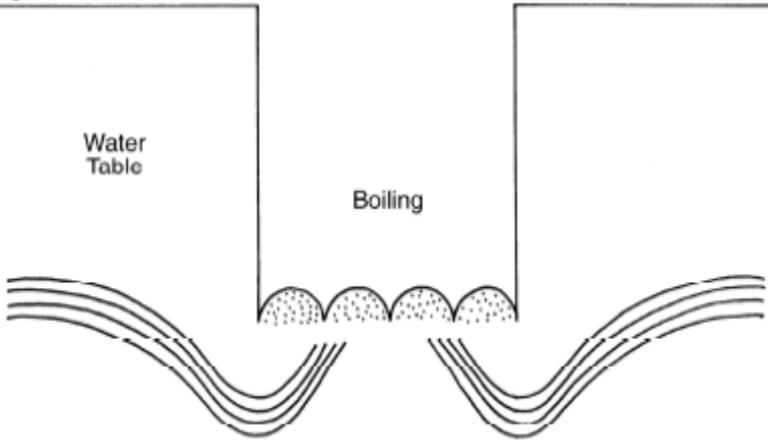
Heaving or Squeezing. Bottom heaving or squeezing is caused by the downward pressure created by the weight of adjoining soil. This pressure causes a bulge in the bottom of the cut, as illustrated in Figure 6. Heaving and squeezing can occur even when shoring or shielding has been properly installed.

Figure 6
Heaving or Squeezing



Boiling is evidenced by an upward water flow into the bottom of the cut. A high water table is one of the causes of boiling. Boiling produces a “quick” condition in the bottom of the cut and can occur even when shoring or trench boxes are used. See Figure 7.

Figure 7
Boiling



Unit Weight of Soils refers to the weight of one unit of a particular soil. The weight of soil varies with type and moisture content. One cubic foot of soil can weigh from 110 pounds to 140 pounds or more, and one cubic meter (35.3 cubic feet) of soil can weigh more than 3,000 pounds.

A safe slope can be defined as the maximum angle of the edge wall or bank of an excavation at which sliding will not occur. The unique mixtures of the different types of soil (sand, clay, silt and rock) necessitate different safe slopes from one excavation site to the next.

There are other complicating factors that can result in sliding soil failures. During an excavation, visibly different layers of soil maybe uncovered. Each of those layers may call for different safe slopes. It is essential to plan your excavation around the most gradual (rather than steepest) safe slope for all of the different soil types and layers encountered during the excavation.

Another complicating factor is that soil composition mixtures may vary significantly from one area of the project to another. During an excavation, as the soil composition changes, the safe slope for trench wall excavation also changes. Thus, across an excavation site, the slope of the bank may need to be different to provide a safe working environment.

Sliding and other modes of failure can also occur in soils that are not densely compacted. For example, a trench that is made close to a previously dug trench is very unstable. If uncompacted soil is discovered, the normal safe slope for

dense soil will not be enough to prevent sliding. Bracing or further sloping may be necessary.

If cracks are observed in rocky types of soil, sliding has already occurred. These cracks should signal that a more gradual slope for excavation is needed because the rocky soil is very susceptible to slides and other types of failure.

Excavations that have been stable for long periods are also subject to sliding types of failure. After prolonged exposure to the elements, the moisture content in the soil may increase. This increase in moisture may be due to various causes, such as rainfall or a broken water line. The extra soil moisture tends to speed up sliding soil failures.

Determining the correct safe slope can be quite difficult for certain types of soil. The OSHA standard has developed a simple method of determining safe excavation bank slopes for different soil types. This method will be discussed in more detail in a later section of this document.

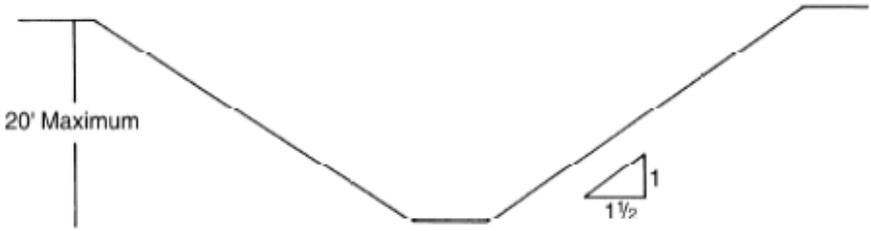
Soil failure can occur for any number of reasons. Factors that increase the chances of soil failure are:

1. excessive vibration
2. surface encumbrances
3. weather conditions

Cave-ins and Protective Support Systems

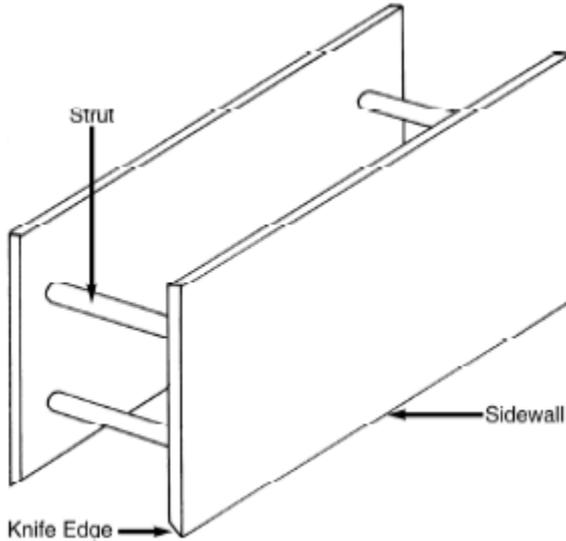
Excavation workers are exposed to many hazards, but the chief hazard is danger of cave-ins. OSHA requires that in all excavations employees exposed to potential cave-ins must be protected by sloping or benching the sides of the excavation, by supporting the sides of the excavation, or by placing a shield between the side of the excavation and the work area. Designing a protective system can be complex because of the number of factors involved—soil classification, depth of cut, water content of soil, changes due to weather and climate, or other operations in the vicinity. The standard, however, provides several different methods and approaches (four for sloping and four for shoring, including the use of shields)* for designing protective systems that can be used to provide the required level of protection against cave-ins. One method of ensuring the safety and health of workers in an excavation is to slope the sides to an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal). These slopes must be excavated to form configurations that are in accordance with those for Type C soil found in Appendix B of the standard. A slope of this gradation or less is considered safe for any type of soil. (See Figure 8).

Figure 8
Type C Soil
Simple Slope Excavation



All simple slope excavations 20 feet (6.11 meters) or less in depth must have a maximum allowable slope of 1.5:1. A second design method, which can be applied for both sloping and shoring, involves using tabulated data, such as tables and charts, approved by a registered professional engineer. These data must be in writing and must include sufficient explanatory information to enable the user to make a selection, including the criteria for determining the selection and the limits on the use of the data. At least one copy of the information, including the identity of the registered professional engineer who approved the data, must be kept at the worksite during construction of the protective system. Upon completion of the system, the data may be stored away from the jobsite, but a copy must be made available upon request to the Montana Safety and Health Bureau. Contractors may also use a trench box or shield that is either designed or approved by a registered professional engineer or is based on tabulated data prepared or approved by a registered professional engineer. Timber, aluminum or other suitable materials may also be used. OSHA standards permit the use of a trench shield (also known as a welder's hut) as long as the protection it provides is equal to or greater than the protection that would be provided by the appropriate shoring system. (See Figure 9.)

Figure 9
Trench Shield



The standard does not require the installation and use of a protective system when an excavation is made entirely in stable rock or is less than 5 feet deep (1.52 meters) and a competent person has examined the ground and found no indication of a potential cave-in.

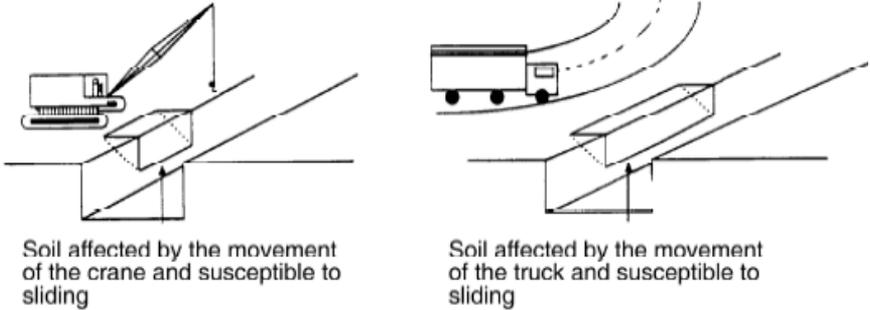
Vibrations

Any large, heavy movement near an excavation results in vibration of the surrounding soils. This movement can result in soil failure. Moving machinery, nearby traffic, pile driving and blasting all cause vibration in surrounding soils.

Vibration-related soil failures can occur in all types of soil. However, certain types of soils are more susceptible to vibration failures than others. For example, sandy soils tolerate less vibration than clay soils.

Since actual soil conditions may be a mixture of more than one soil type, it is better to play it safe when planning the slope of an excavation. Figure 10 shows typical situations where vibrations can result in soil failure.

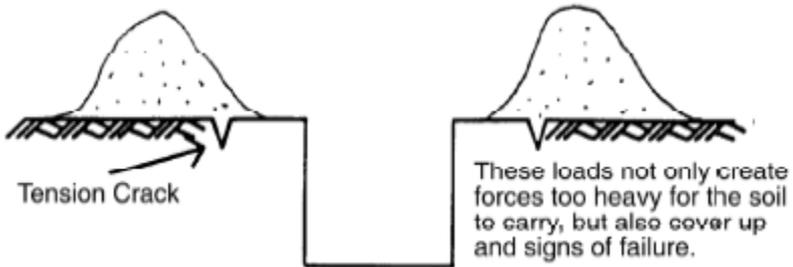
Figure 10
Two Examples of Vibration Failures



Surface Encumbrances

Heavy loads such as large equipment, heavy materials or large spoil piles can be too heavy for the soil to support, resulting in a cave-in. These loads are referred to as surface encumbrances. They pose different types of dangers (see Figure 11). For example, large spoil piles may hide tension cracks that would otherwise signal that a sliding soil failure may occur.

Figure 11
Surface Encumbrances



Existing site features such as buildings, curbs, trees, utility poles and other structures adjoining the excavation area may be considered as types of surface encumbrances. These extra loads can place more stress on the sides of an excavation than the walls can safely carry. Shoring, bracing, underpinning or some combination of safety measures should be provided, as necessary, to protect workers and to prevent movement of the soil beneath the adjacent load.

In cases where the space is limited and heavy loads must be located near an excavation, the trench walls must be braced or shored as needed to safely support this extra weight.

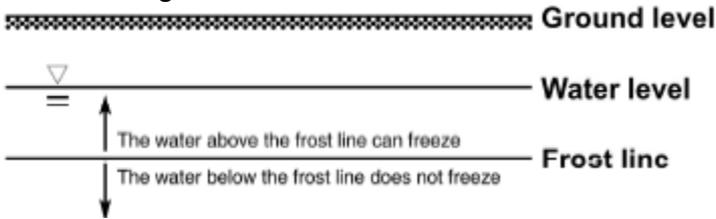
Weather Conditions

Weather is an important factor in determining soil conditions. More importantly, changing weather conditions may signal a change in the pressures exerted by the soil on the side walls of a trench.

Excess water from rain or melting snow interacts with the soil, increasing the pressure on the excavation and shoring system. For instance, a rainstorm can turn a stable trench wall that required only light bracing into a mass of loose soil that requires heavy bracing.

Freezing usually indicates a rather stable ground condition, unless the frost line is exceeded during excavation. The frost line phenomenon is depicted in Figure 12. If you excavate or shore frozen ground, be aware that another potential problem exists—thawing. A sudden thaw can be as dangerous as a rainstorm.

Figure 12
Region of Soil Freezing



Excessively dry conditions can also be dangerous. As moisture content decreases, some dry soils lose their ability to stick together. This lack of cohesion may result in a sliding type of soil failure. In many of the situations described above, dewatering or extra shoring may be required as necessary to ensure the safety of your workers. See Figures 16 and 17 in Part 2 for more information about dewatering.

2

Soil Types and Pressures

Soil Characteristics

The OSHA excavations standard recognizes and allows a variety of soil classification systems under certain conditions. A special simple soil classification system used by OSHA for excavation planning and protection is included in the standard. If that classification system is strictly followed, trench protection systems can be designed for many situations without the approval of a registered professional engineer.

In the soil classification system used by OSHA, the terms used to identify soil types are drawn largely from another system, commonly used for construction in Montana, called the United Soil Classification System. Both systems are based upon the engineering properties of soils and are concise and easily associated with actual soil behavior. The OSHA system can be applied in the laboratory or the field. The terms used for classification are based upon the soil particles, including the quantity of the various sizes of soil particles and the qualities or characteristics of the very fine grains. The principal types of soil may be divided into two general classes according to grain size. Coarse-grained soils are gravel and sand. Fine-grained soils are silt and clay.

The composition or texture of a soil is a critical factor in its stability. The more cohesive the soil particles, the more the entire soil mass tends to stick together rather than crumble. However, it is important to remember the time element involved in cuts. If an excavated cut is to be left open for long periods of time, cohesive forces may not withstand exposure to weather conditions. When fresh fill dirt is not properly compacted, subsequent excavations in the same area result in almost no cohesion properties; thus, a greater width may be required to maintain a stable slope.

The soil found at a site is usually a mixture of one or more of the basic types listed below. From the amounts of each soil type blended together to form the actual soil conditions, descriptive soil terms are combined in the order of lowest content to highest content. For example, soil classified as “silty clay” is a mixture of mostly clay with noticeable but lesser amounts of silt. The single term “loam” is used to describe a mixture of clay, sand and silt.

The types of soil found most often include:

Soil Type	Characteristics of Soil Type
Clay	Clay is a very, very fine-grained soil. In general, water moves very slowly through clay. Large amounts of rainfall may pond on the surface and evaporate before being absorbed.
Sand	Sand is a granular soil. The shape of individual grains may be round or angular. Sandy soils tend to have large pores, allowing faster groundwater absorption. In most situations, sandy soil is the easiest to compact with vibration.
Silt	Silt has properties intermediate between fine sand and clay. Silt is the most sensitive to changes in soil moisture content. Silt tends to crumble with drying.

Determination of Soil Type

By grouping different types of soils (described above) according to requirements for safe excavation, the excavation standard has defined four soil classifications (provided below). For a detailed explanation of OSHA classification system, please see Appendix A of the excavation standard. OSHA categorizes soil and rock deposits into four types, A through D, as follows:

Stable Rock is natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed. It is usually identified by a rock name such as granite or sandstone. Determining whether a deposit is of this type may be difficult unless it is known whether cracks exist and whether or not the cracks run into or away from the excavation.

Type A soils are cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (144 kPa) or greater. Examples of Type A cohesive soils are clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. (No soil is Type A if it is fissured, is subject to vibration of any type, has previously been disturbed, is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical or greater, or has seeping water.)

Type B soils are cohesive soils with an unconfined compressive strength greater than 0.5 tons per square foot (48 kPa) but less than 1.5 (144 kPa). Examples of Type B soils are angular gravel; silt; silt loam; previously disturbed soils unless otherwise classified as Type C; soils that meet the unconfined compressive strength or cementation requirements of Type A soils but are fissured or subject to vibration; dry unstable rock; and layered systems sloping into the trench at a slope less than four horizontal to one vertical (only if the material would be classified as a Type B soil).

Type C soils are cohesive soils with an unconfined compressive strength of 0.5 tons per square foot (48 kPa) or less. Type C soils include granular soils such as gravel, sand and loamy sand, submerged soil, soil from which water is freely seeping, and submerged rock that is not stable. Also included in this classification is material in a sloped, layered system where the layers dip into the excavation or have a slope of four horizontal to one vertical or greater.

Layered geological strata. Where soils are configured in layers, i.e., where a layered geologic structure exists, the soil must be classified on the basis of the soil classification of the weakest soil layer. Each layer may be classified individually if a more stable layer lies below a less stable layer, i.e., where a Type C soil rests on top of stable rock.

The standard also contains other important criteria that must be examined to classify soils properly.

Important: (1.) The laboratory testing process and compressive strength calculations must be conducted under the direction of a registered professional engineer. The OSHA standard requires that the excavation protection system be designed by a registered professional engineer when the depth of the excavation exceeds 20 feet or where unusual site conditions exist. (2.) The manual field testing alternative permitted under the standard does not require the approval of a registered professional engineer under certain specific conditions. However, at least one visual test and one manual test are required to classify soil according to the OSHA method. The specific manual and visual field tests are listed and described in the standard.

Test Equipment and Methods for Evaluating Soil Type

Many kinds of equipment and methods are used to determine the type of soil prevailing in an area, as described below.

Pocket Penetrometer. Penetrometers are direct-reading, spring-operated instruments used to determine the unconfined compressive strength of saturated cohesive soils. Once pushed into the soil, an indicator sleeve displays the reading. The instrument is calibrated in either tons per square foot or kilograms per square centimeter. However, penetrometers have error rates in the range of ± 20 –40 percent.

1. **Shearvane (Torvane).** To determine the unconfined compressive strength of the soil with a shearvane, the blades of the vane are pressed into a level section of undisturbed soil, and the torsional knob is slowly turned until soil failure occurs. The direct instrument reading must be multiplied by 2 to provide results in tons per square foot or kilograms per square centimeter.
2. **Thumb Penetration Test.** The thumb penetration procedure involves an attempt to press the thumb firmly into the soil in question. If the thumb makes an indentation in the soil only with great difficulty, the soil is probably Type A. If the thumb penetrates no further than the length of the thumb nail, it is probably Type B soil, and if the thumb penetrates the full length of the thumb, it is Type C soil. The thumb test is subjective and is therefore the least accurate of the three methods.
3. **Dry Strength Test.** Dry soil that crumbles freely or with moderate pressure into individual grains is granular. Dry soil that falls into clumps that subsequently break into smaller clumps (and the smaller clumps can be broken only with difficulty) is probably clay in

combination with gravel, sand or silt. If the soil breaks into clumps that do not break into smaller clumps (and the soil can be broken only with difficulty), the soil is considered unfissured unless there is visual indication of fissuring.

Plasticity or Wet Thread Test. This test is conducted by molding a moist sample of the soil into a ball and attempting to roll it into a thin thread approximately 1/8 inch (3 millimeters) in diameter (thick) by 2 inches (50 millimeters) in length. The soil sample is held by one end. If the sample does not break or tear, the soil is considered cohesive.

Visual Test. A visual test is a qualitative evaluation of conditions around the site. In a visual test, the entire excavation site is observed, including the soil adjacent to the site and the soil being excavated. If the soil remains in clumps, it is cohesive; if it appears to be coarse-grained sand or gravel, it is considered granular. The evaluator also checks for any signs of vibration.

During a visual test, the evaluator should check for crack-line openings along the failure zone that would indicate tension cracks, look for existing utilities that indicate that the soil has previously been disturbed, and observe the open side of the excavation for indications of layered geologic structuring.

The evaluator should also look for signs of bulging, boiling or sluffing, as well as for signs of surface water seeping from the sides of the excavation or from the water table. If there is standing water in the cut, the evaluator should check for “quick” conditions. In addition, the area adjacent to the excavation should be checked for signs of foundations or other intrusions into the failure zone, and the evaluator should check for surcharging and the spoil distance from the edge of the excavation.

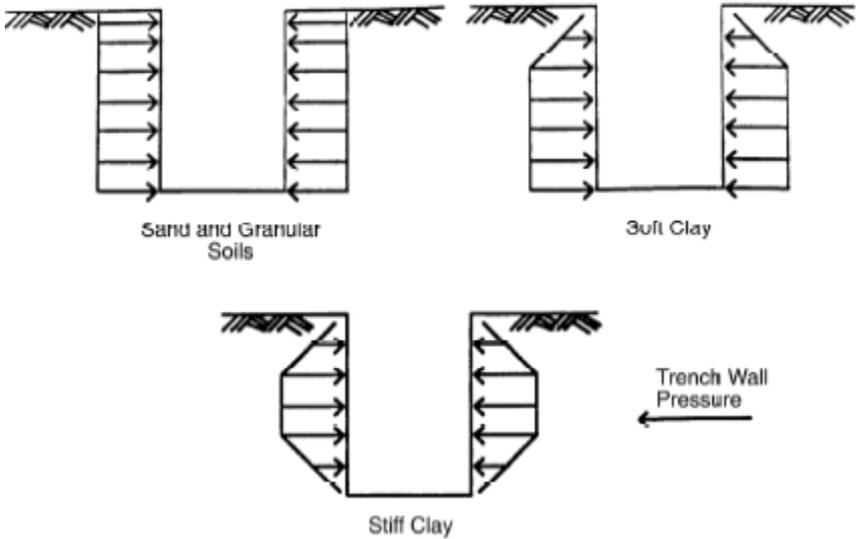
Earth Pressures

An appreciation of the need for shoring can be based on an understanding of earth pressures. The amount of earth pressure exerted upon the side wall of any excavation depends upon the weight and depth of the soil that it supports.

Earth pressure distributions vary with the type of soil, depth of excavation and moisture conditions. Example distributions are shown in Figure 13.

The center of the earth pressures is normally found between one-half and two-thirds of the depth of a simple excavation. However, additional earth pressures result from surface encumbrances and differences in soil layer cohesiveness. All of these factors influence the actual center of pressure at an excavation site.

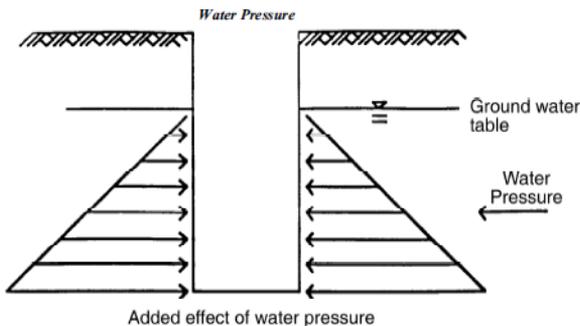
Figure 13
Pressure Distributions on the Side Walls of an Excavation



As a general rule of thumb, the center of pressure will be at a lower depth when cohesion is poor (as in fresh fill dirt, water-bearing sand or loose ground). Where cohesion is high, the center of pressure will be higher (as in good compact soil). The location of the center of pressure can change after a cut is made unless support is provided to prevent earth movement.

Regardless of the soil type, as the depth of the trench increases, the magnitude of pressures on the full height of the excavation also increases. The presence of ground water adds hydrostatic pressure against the walls of the trench as shown in Figure 14.

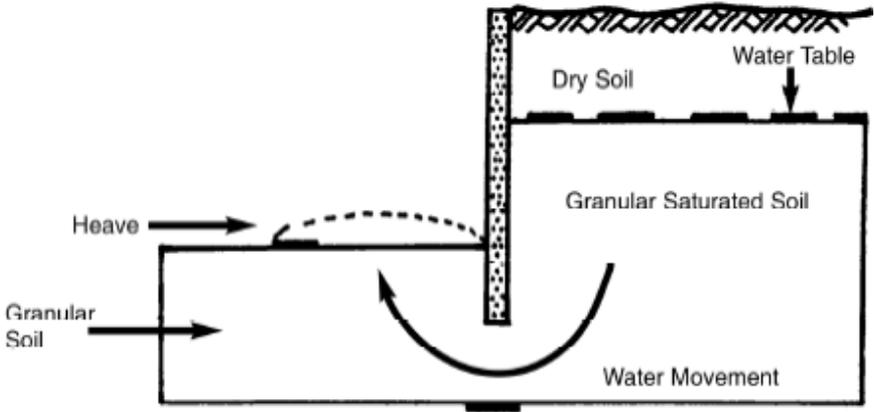
Figure 14
Water Pressure



Effects of Water and Remedies

The natural water table can cause many types of problems. For example, trenches excavated below the natural water table in sandy soils and soft clay are highly susceptible to heaving, as illustrated in Figure 15. Heaving is the seepage of water at the bottom of the trench causing the soil to be pushed upward. This heaving is a signal that a failure may occur.

Figure 15
Heaving

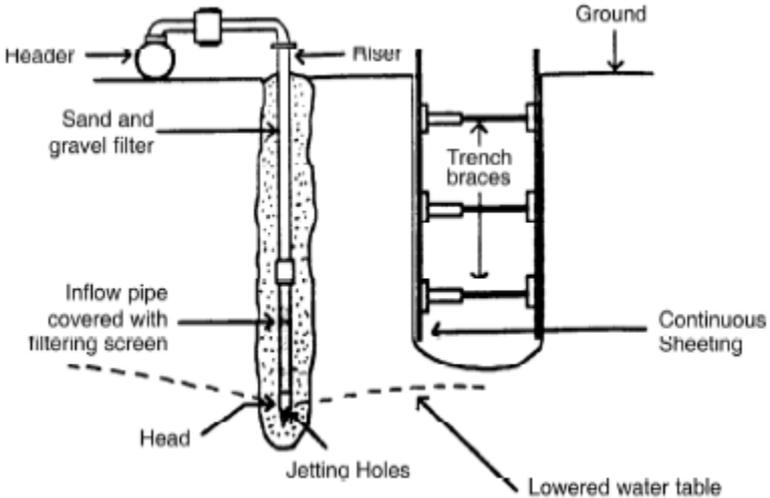


Wet conditions at the bottom of a trench may present another problem. If the bottom of the trench begins to puff and bubble and the earth rises, a quicksand condition is occurring. This is also a signal that a failure may occur.

If heaving or quicksand conditions are expected, dewatering should be considered prior to beginning an excavation. Dewatering drastically reduces the presence of water and the additional pressure it causes. Without dewatering, heavier timbers would be needed to support the extra pressures caused by the water. The two most frequently used dewatering systems are well-points and sump pumps.

The well-point system (illustrated in Figure 16) is a very popular method of dewatering. Located on a line 2 or 3 feet, or further, behind the sheeting, well-points are inserted to the depth of the excavation with spacing between the wellpoints varying from 3 to 8 feet.

Figure 16
Well-Point



Well-points are pipes with a point at the lower end and a screen or filter over perforations along 3 or 4 feet of the lower ends of the pipes. There are two types of well-points:

- _ hose driven with a maul
- _ those that are jetted in

The selection of the size of the well-points and the required spacing are based upon site conditions and the type of excavation to be accomplished.

Above the ground, well-point pipes are connected by piping to a high-capacity pump. Pumping keeps the water level below the bottom of the excavation so that only a moist soil condition will be encountered within the excavation.

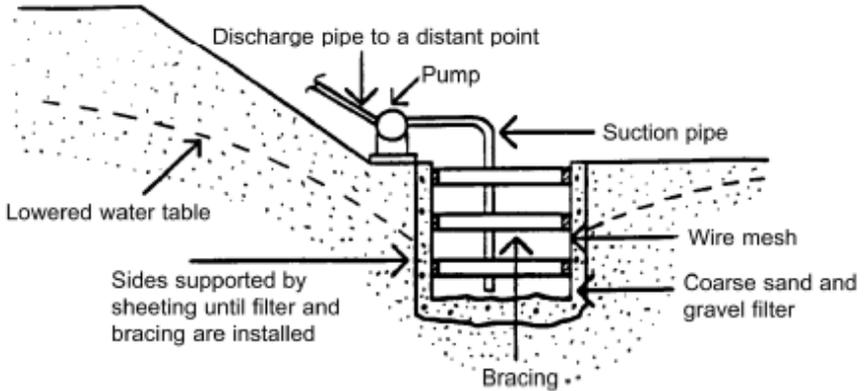
The well-point system should have a capacity sufficient to remove any inflow of water as quickly as it occurs. The depth limit of this method's practical effectiveness is approximately 15–20 feet, although the theoretical limit is just under 34 feet since the method depends upon pumping suction. Greater depths can be achieved by arranging well-points into two or more vertical stages, or by deep-well pumping, that is, locating the pump at a lower elevation.

Dewatering does not permit any substantial excavation without providing ground support. Although the dewatered soil will usually be firmer than it was

before dewatering, working conditions may still be unsafe. Shoring, or bank walls at a safe slope, should be used in dewatered ground in the same manner as in any other excavation.

The second common type of dewatering system is the sump pump as depicted in Figure 17.

Figure 17
Sump Pump



Sump pumping, as contrasted with well-pointing, has several advantages. Sump pumps:

- can be installed quickly by inexperienced labor
- require less space and cause less interference on the site
- can be added or removed easily to meet required pumping capacity
- can be started by simply switching on the power supply because no balancing or turning is required
- do not freeze in cold weather because of the fast, high volume flow of water
- may be removed from one sump and used elsewhere if needed
- usually cost less than well-points

3

Methods of Protection

Several methods of protecting workers in trench excavations are available. Some methods are preferred over others depending on the site specifics and circumstances. The various protection methods available include:

1. sloping and benching

2. shoring (spaced sheeting, close sheeting)
3. trench shield
4. other occasionally used systems

Each of these techniques is introduced briefly below and will be discussed in more detail in the pages that follow.

Materials and Equipment

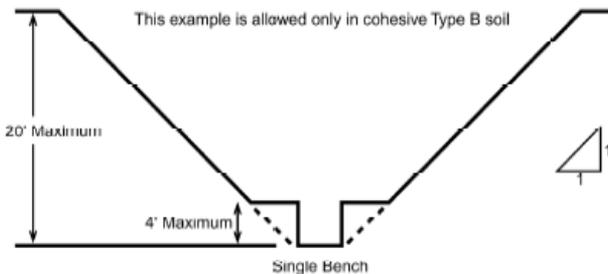
The employer is responsible for the safe condition of materials and equipment used for protective systems. Defective and damaged materials and equipment can result in the failure of a protective system and cause excavation hazards. To avoid possible failure of a protective system, the employer must ensure that:

1. Materials and equipment are free from damage or defects.
2. Manufactured materials and equipment are used and maintained in a manner consistent with the recommendations of the manufacturer and in a way that will prevent employee exposure to hazards.
3. While in operation, damaged materials and equipment are examined by a competent person to determine if they are suitable for continued use. If materials and equipment are not safe for use, they must be removed from service. These materials cannot be returned to service without the evaluation and approval of a registered professional engineer.

Sloping and Benching

One method of ensuring the safety and health of workers in a trench or excavation is to slope the sides of the trench in accordance with OSHA standards. Figure 18 illustrates sloping and benching alternatives that are permitted for certain soil types. The safe slope for the banks of an excavation varies with different soil types, as discussed earlier, and must be determined on each individual project.

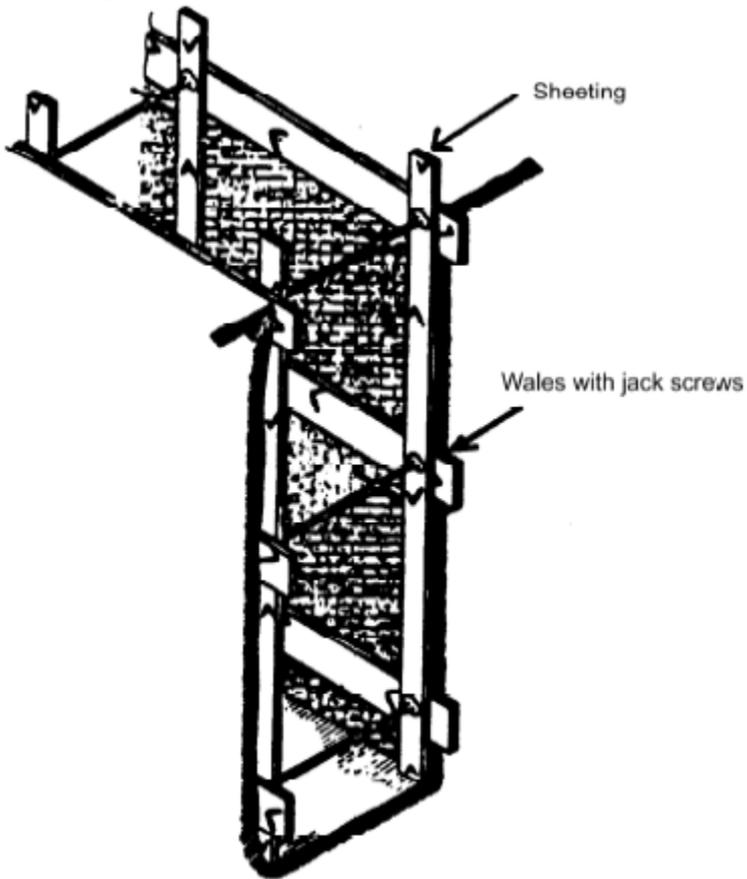
Figure 18
Sloping and Benching



Spaced Sheeting

Another popular method of protection is called spaced sheeting. It is also referred to as spot shoring. This method, shown in Figure 19, involves placing spaced timber shores, bracing, trench jacks, piles or other materials in a manner strong enough to resist the pressures surrounding the excavation. Sheeting consists of vertical planks used around the boundary of the proposed excavation. Horizontal braces extend between the vertical planks to support the sheeting. The horizontal trench braces may be wooden or telescoping metal pipes. The metal braces are typically used when the width of the trench exceeds 5 feet. It is important to remember that all materials selected for use must be in good condition.

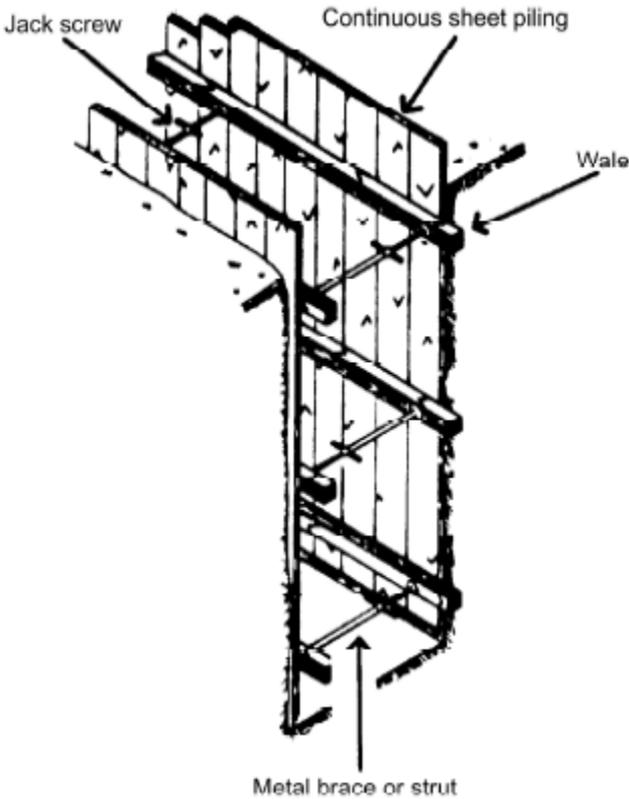
Figure 19
Spaced Sheeting



Close Sheeting

This method involves the placement of continuous solid sheeting along the entire length of a trench excavation. An example is shown in Figure 20. The same types of materials used in spaced sheeting can be used in close sheeting. Timber sheeting or steel sheet piles may be selected for use depending on the circumstances. As a general rule of thumb, steel sheeting becomes more cost effective when the depth of a planned excavation exceeds 15 feet. Each of the major components of this system has been labeled in Figure 20. Cleats may also be used to fasten the struts to the wales and prevent slipping or falling out.

Figure 20
Close Sheeting

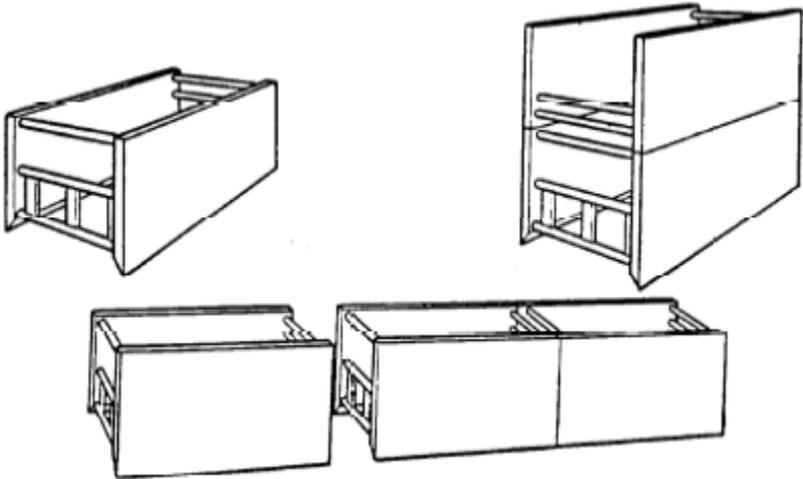


Trench Shield

Contractors also may use a trench shield, a prefabricated movable structure often composed of steel plates welded to a heavy steel frame (see Figure 21). Some trench shields are composed of aluminum or fiberglass. OSHA standards

permit the use of a trench shield as long as the protection it provides is equal to or greater than the protection that would be provided by the appropriate shoring system. Employees must know to work only within the protection of the shield. Also, if a slide starts, workers must know that they should not run out of the shield into the path of the slide.

Figure 21
Trench Shield



Other Systems

Some other systems that are used occasionally include:

- Freezing the moist or saturated soil by the circulation of low-temperature brine through piping driven into the soil
- Injection of chemical or other grouting into the soil to solidify and fill cracks and space surrounding the individual soil particles to solidify the soil mass

Installation and Removal of Protective Systems

To ensure the safety of the workers and the integrity of the job, it is essential to install the various types of trench protection properly. The standard requires the following procedures for the protection of employees when installing support systems:

- Securely connect members of support systems.
- Safely install support systems.

- Never overload members of support systems.
- Install other structural members to carry loads imposed on the support system when temporary removal of individual members is necessary.

In addition, the standard permits excavation of 2 feet (0.61 meters) or less below the bottom of the members of a support or shield system of a trench if:

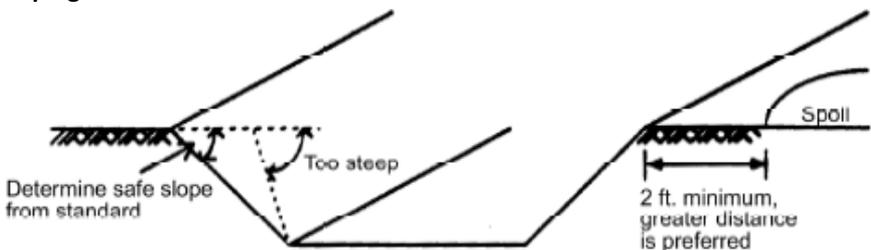
- The system is designed to resist the forces calculated for the full depth of the trench.
- There are no indications, while the trench is open, of a possible cave-in below the bottom of the support system.

Also, the installation of support systems must be closely coordinated with the excavation of trenches. As soon as work is completed, the excavation should be back-filled as the protective system is dismantled. After the excavation has been cleared, workers should slowly remove the protective system from the bottom up, taking care to release members slowly.

Sloping and Benching

As mentioned earlier, one method of trench protection can be accomplished by sloping the sides of the trench to the safe angle specified by OSHA excavation standards. The trench is sloped **on both sides**. The safe angle to slope the sides of an excavation varies with different kinds of soil and must be determined on each individual project. When an excavation has a high water table condition, silty material or loose boulders, or when it is being dug in areas where erosion, deep frost or sliding is apparent, the safe angle is more gradual (that is, flatter) (see Figure 22).

Figure 22
Sloping



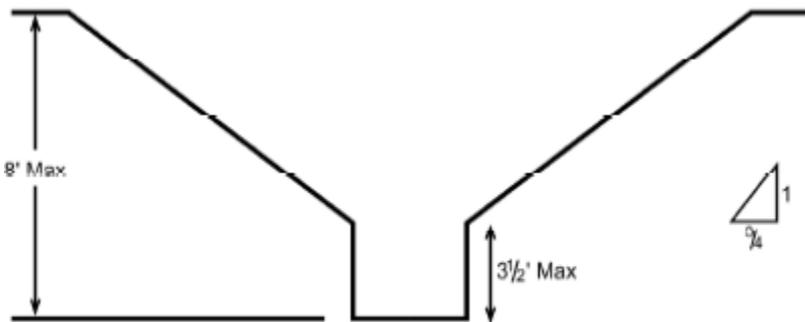
Problems Associated With Sloping and Benching

1. The spoil accumulated from digging a trench must be placed above and away from the side walls of the excavation. Otherwise, the weight

of the spoil might create an unsafe condition. OSHA requires that the spoil be kept 2 feet or more from the edge of the excavation or prevented from falling or rolling into the excavation by the use of retaining devices. This procedure usually requires a wide storage area.

2. Wide excavation areas can expose footings or cause damage to the walls of an adjacent structure and thereby pose additional hazards to employees.
3. Wide excavation areas can expose or place utilities (such as electric power, telephone, water, gas, storm drain or sewer lines) above the angle for a safe slope, causing the unsupported collapse and failure of the utility line.
4. Wide areas of excavation require the use of large equipment. There may also be hazards in the movement of the equipment across a larger excavation. For example, excavation under or adjacent to electric power lines creates a serious hazard to workers and the public.
5. To prevent the collapse of an unsupported bench in an excavation 8 feet or less in depth, the allowable height of a bench at the base of an excavation must be 3 1/2 feet or less. The collapse of one bench can cause a lower bench to fail in a situation where multiple benches have been excavated. For Type A soil, for example, the standard requires that multiple benches have an overall slope (from the top of one side of an excavation to the bottom) of 3/4 horizontal to 1 vertical (see Figure 23).

Figure 23
Unsupported Vertically Sided Lower Portion—Maximum Eight Feet in Depth



All excavations more than 8 feet but not more than 12 feet in depth with unsupported vertically sided lower portions must have a maximum allowable slope of 1:1 and a maximum vertical side of 3 1/2 feet.

The contractor should first make a determination of the soil types at the excavation site using the soil classification system used by OSHA or one of the

27

other acceptable methods described in the standard. Next, the contractor should consider potential sloping and benching problems, such as those described above. Finally, after considering all other protection that may be necessary to ensure safe working conditions, the contractor can determine if sloping (and possibly benching) is the best method to use at that site. Figure 24 defines the maximum allowable slopes for excavations less than 20 feet deep. This figure is shown as Table B-1 in the standard.

Figure 24
Maximum Allowable Slopes

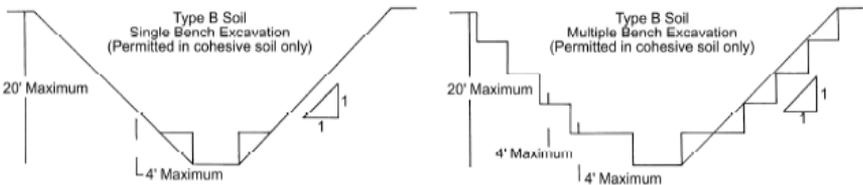
Soil or rock type	Maximum allowable slopes (H:V) ¹ for excavations less than 20 feet deep ³	
Stable rock	Vertical	(90°)
Type A ²	¾:1	(53°)
Type B	1:1	(45°)
Type C	1½:1	(34°)

Notes:

- ¹ Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.
- ² A short-term maximum allowable slope of ¾H:1V (53°) is allowed in excavations in Type A soil that are 12 feet (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 m) in depth shall be 1½H:1V (53°).
- ³ Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer.

Benching. There are two basic types of benching: simple and multiple. The type of soil determines the horizontal to vertical ratio of the benched side. As a general rule, the bottom vertical height of the trench must not exceed 4 feet (1.2 meters) for the first bench. Subsequent benches may be up to a maximum of 5 feet (1.5 meters) vertical in Type A soil and 4 feet (1.2 meters) in Type B soil to a total trench depth of 20 feet (6.0 meters). All subsequent benches must be below the maximum allowable slope for that soil type. For Type B soil the trench excavation is permitted in cohesive soil only (see Figure 25).

Figure 25
Excavation Made in Type B Soil



The OSHA excavations standard provides four options for design and installation of a sloped excavation. See Figure 26.

Option 1. Excavations must be sloped at an angle not steeper than 11/2 horizontal to 1 vertical (34 degrees). The exact configuration of the sides must also conform to other requirements (described in Appendix B of the standard) for sloping of Type C soil.

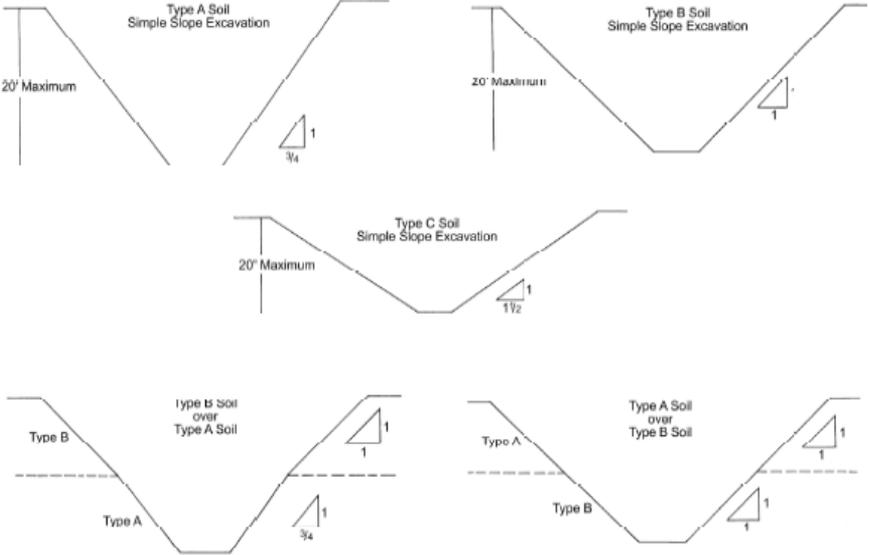
Option 2. The design and installation may be performed in accordance with the soil classification system used by OSHA (Appendix A of the standard), followed by the appropriate sloping requirements listed in Appendix B of the standard.

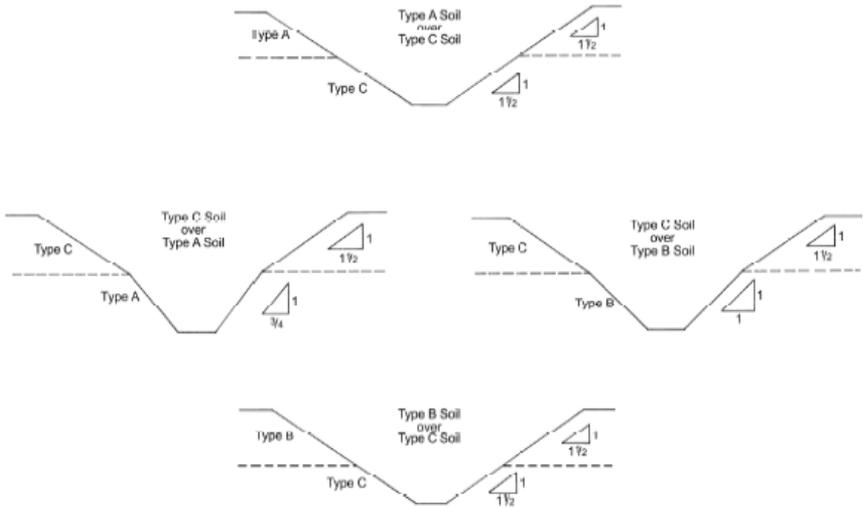
Option 3. The excavation design and installation of the sloping approach can be performed in accordance with tabulated data (such as tables and charts) approved for use by a registered professional engineer.

Option 4. Sloping and benching systems not utilizing options 1, 2 or 3 (above) must be approved by a registered professional engineer.

Additional considerations and other important requirements for proper selection of a sloping system are contained in the standard.

Figure 26
Slope Configurations: Excavations in Layered Soils





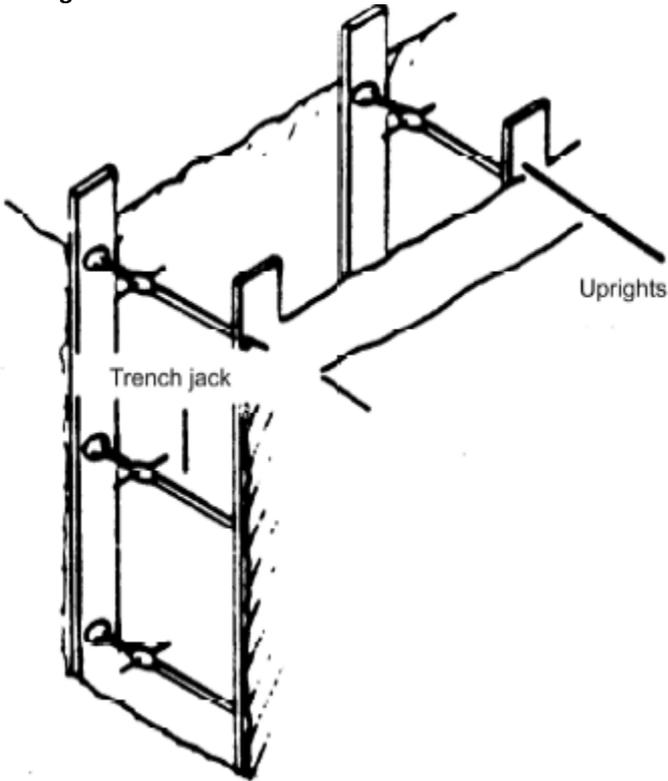
In case of an emergency, workers must be able to leave the trench quickly. According to OSHA regulations, when employees are required to be in trenches 4 feet deep or more, adequate means of exit, such as a ladder or steps, must be provided and located so as to require no more than 25 feet of lateral travel.

Support Systems, Shield Systems and Other Protective Systems

When a trench is excavated, employees who are to work in the excavation must be protected from cave-ins. In addition to the bracing described earlier, the contractor should consider excavating a wider area than the minimum necessary. Such additional excavation provides a more comfortable working environment in the trench. In addition, this extra working area may provide a means for workers to escape unexpected crises, such as falling objects or debris. Another common sense strategy for safety in trenches requires managers to reduce risk by limiting the number of workers in the trench at all times. The only workers allowed in the trench should be those who are absolutely needed to perform the task at hand.

As the trench is backfilled, the braces and planks can be removed for reuse. If installed and removed properly, vertical planks and trench braces may be used several times. Spaced sheeting is shown in Figure 27.

Figure 27
Spaced Sheeting

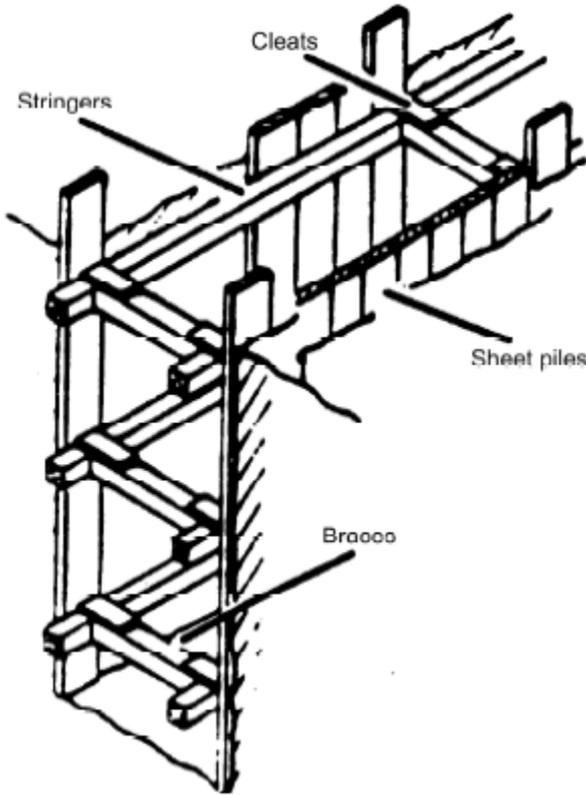


Close Sheeting

When the soil is unstable, the excavation should be supported along the entire area of the exposed trench walls. This can be done by installing continuous sheeting that extends the full depth of the trench, as depicted in Figure 28. Tables have been provided in the standard for the selection of timber sizes for various excavation depths and widths. The timber sizes listed in the tables are for general reference only and are not adequate for all soil conditions. Be sure to read the information that explains how to reference the tables properly.

Very unstable soil conditions will require the sheeting to be driven prior to digging, with the bracing installed as excavation proceeds. If steel sheeting is used, a pile driver will be necessary for installation. For wooden sheeting, a pneumatic hammer is often used. The sheeting should extend one foot above the surrounding ground to help prevent pipe, tools or equipment from falling into the trench.

Figure 28
Close Sheetting



Trench Shields

OSHA regulations allow the use of portable trench boxes or shields in lieu of fixed shoring systems as long as an equivalent or greater level of employee protection is provided. In deeper trenches, the trench shield approach is often the safest. The shields may be made with top and bottom sections for adaptability to deep and shallow excavations.

Trench boxes or shields:

- may be production type or custom made of steel, aluminum or other equivalent material
- must be regularly inspected and properly maintained
- must be properly used under the direction of a competent person

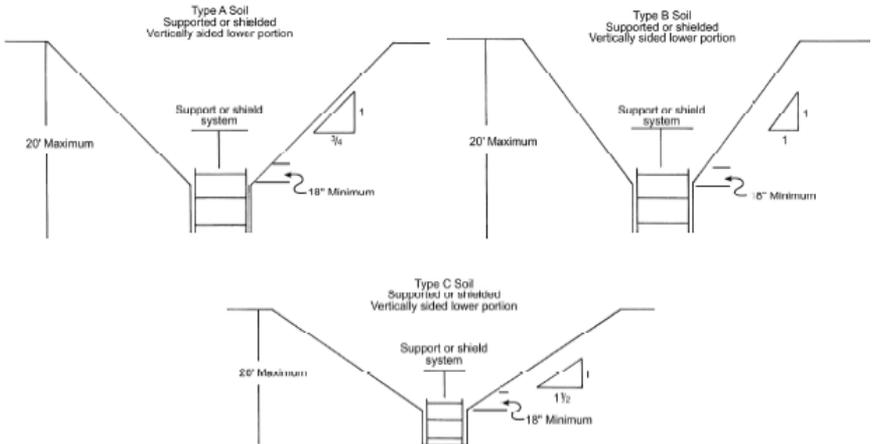
Trench boxes are different from shoring because, instead of shoring up or otherwise supporting the trench face, they are intended primarily to protect

workers from cave-ins and similar incidents. The excavated area between the outside of the trench box and the face of the trench should be as small as possible. The space between the trench boxes and the excavation side are backfilled to prevent lateral movement of the box. Shields may not be subjected to loads exceeding those which the system was designed to withstand.

Combined use. Trench boxes are generally used in open areas, but they also may be used in combination with sloping and benching. The box should extend at least 18 inches (0.45 meters) above the surrounding area if there is sloping toward excavation. This can be accomplished by providing a benched area adjacent to the box.

Earth excavation to a depth of 2 feet (0.61 meters) below the shield is permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench and there are no indications while the trench is open of possible loss of soil from behind or below the bottom of the support system. Conditions of this type require observation on the effects of bulging, heaving and boiling as well as surcharging, vibration, adjacent structures, etc., on excavating below the bottom of a shield. Careful visual inspection of the conditions mentioned above is the primary and most prudent approach to hazard identification and control. See Figure 29.

Figure 29
Slope and Shield Configurations

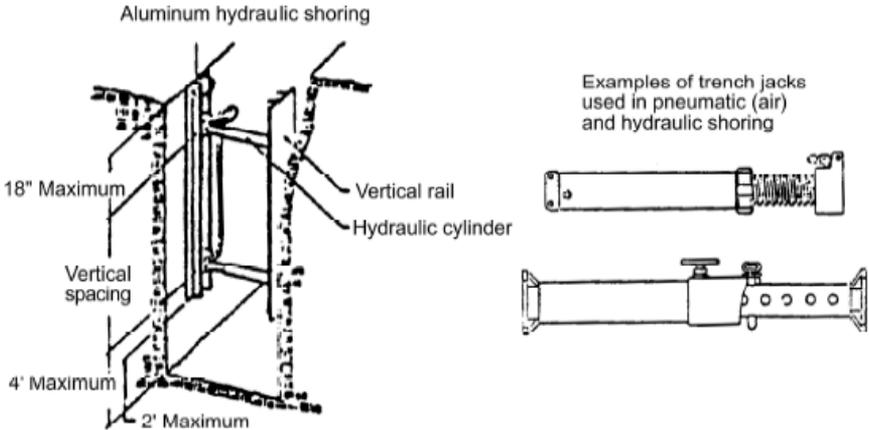


Examples of Other Systems

Many shoring systems are introduced to the marketplace each year. The structural supporting members are typically made of wood or metal. For most of these systems, the horizontal trench jacks or braces are activated using air or hydraulic pumps. These types of systems are illustrated in Figure 30.

Figure 30

Air Shoring or Hydraulic Shoring



Shoring Types

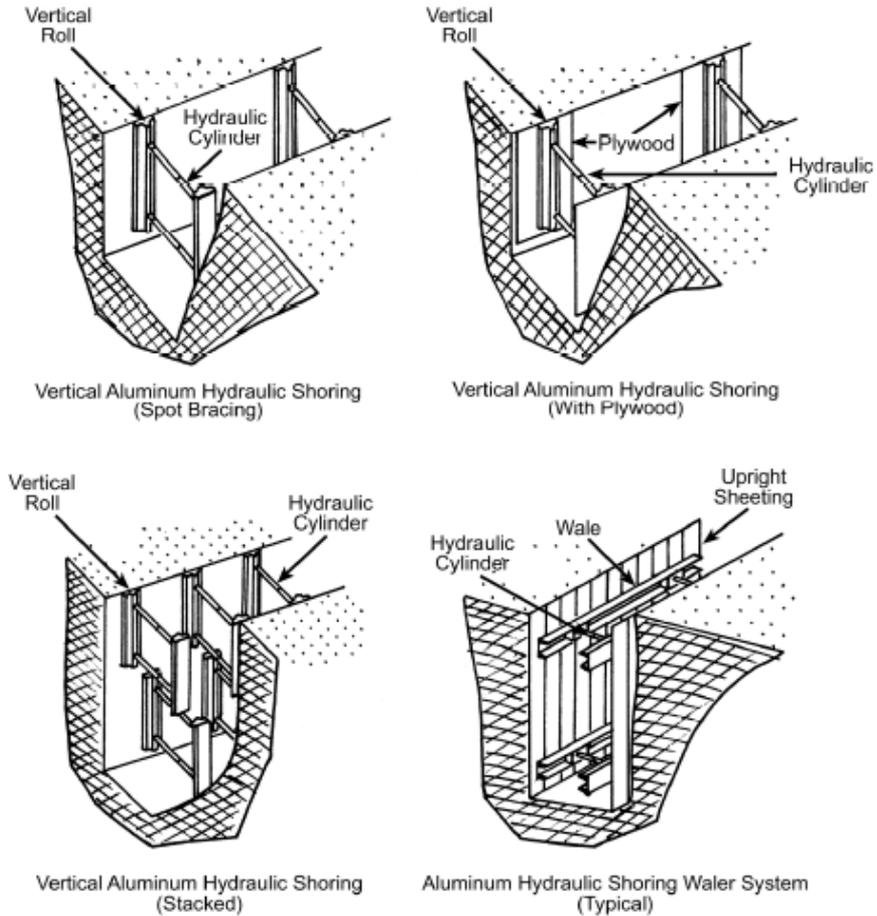
Shoring is the provision of a support system for trench faces used to prevent movement of soil, underground utilities, roadways and foundations. Shoring or shielding is used when the location or depth of the cut makes sloping back to the maximum allowable slope impractical. Shoring systems consist of posts, wales, struts and sheeting. There are two basic types of shoring, timber and aluminum hydraulic. See Figures 31 and 32.

Hydraulic shoring. The trend today is toward the use of hydraulic shoring, a prefabricated strut and/or wale system manufactured of aluminum or steel. Hydraulic shoring provides a critical safety advantage over timber shoring because workers do not have to enter the trench to install or remove hydraulic shoring. Other advantages of most hydraulic systems are that they:

- Are light enough to be installed by one worker;
- Are gauge-regulated to ensure even distribution of pressure along the trench line;
- Can have their trench faces “preloaded” to use the soil’s natural cohesion to prevent movement; and
- Can be adapted easily to various trench depths and widths.

All shoring should be installed from the top down and removed from the bottom up. Hydraulic shoring should be checked at least once per shift for leaking hoses and/or cylinders, broken connections, cracked nipples, bent bases, and any other damaged or defective parts.

Figure 31
Shoring Variations: Typical Aluminum Hydraulic Shoring Installations

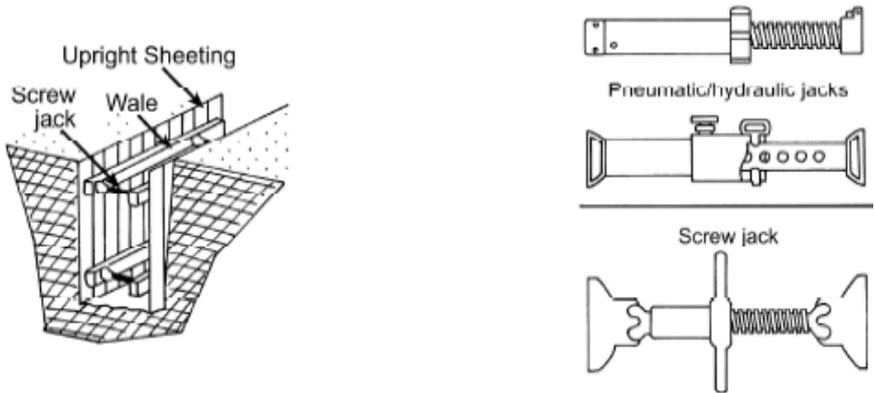


Pneumatic shoring works in a manner similar to hydraulic shoring. The primary difference is that pneumatic shoring uses air pressure in place of hydraulic pressure. A disadvantage to the use of pneumatic shoring is that an air compressor must be on site. Air shoring involves using compressed air instead of hydraulic fluid to expand the trench jacks into position. Using the air type of system, pins are put in place to lock the jacks when a desired level of stability

has been achieved. For the removal of this trenching system, air is again injected into the jacks to extend them, allowing the pin to be removed. These types of jacks are popular since they are cleaner than hydraulic jacks and there is no danger from the leakage of fluids or other lubrication.

1. Screw jacks. Screw jack systems differ from hydraulic and pneumatic systems in that the struts of a screw jack system must be adjusted manually. This creates a hazard because the worker is required to be in the trench in order to adjust the strut. In addition, uniform “preloading” cannot be achieved with screw jacks, and their weight creates handling difficulties.
2. Single-cylinder hydraulic shores. Shores of this type are generally used in a water system, as an assist to timber shoring systems, and in shallow trenches where face stability is required.
3. Underpinning. This process involves stabilizing adjacent structures, foundations and other intrusions that may have an impact on the excavation. As the term indicates, underpinning is a procedure in which the foundation is physically reinforced. Underpinning should be conducted only under the direction of and with the approval of a registered professional engineer.

Figure 32
Shoring Variations



The excavations standard provides four options for the design of support systems, shield systems and other protective systems. A summary of the options follows.

Option 1. The soil conditions encountered at the site must first be classified using the soil classification system used by OSHA (Appendix A of the standard). Based on the soil classification and other project conditions, the contractor

may select a timber shoring system using the information contained in Appendix C or an aluminum hydraulic shoring system using the information contained in Appendix D. The information contained in Appendix D should only be used when the manufacturer's data for an hydraulic system are not available. The information in Appendix D includes tables that detail the maximum vertical and horizontal spacings that may be used with various aluminum member sizes and various hydraulic cylinder sizes.

Option 2. The manufacturer's tabulated data provided with commercially available support systems, shield systems or other protective systems may be used if jobsite conditions and methods of use are in strict accordance with the design intent of the system.

Option 3. Other tabulated data, such as tables and charts, prepared by a registered professional engineer for use under the conditions at the site may be used for the design of support systems, shield systems and other protective systems.

Option 4. Support systems, shield systems and other protective systems not using options 1, 2 or 3 (above) must be approved by a registered professional engineer.

There is other important information in the standard that must be reviewed to execute one of these design options correctly.

Other Hazards

Falls and Equipment

In addition to cave-in hazards and secondary hazards related to cave-ins, there are other hazards from which workers must be protected during excavation-related work. These hazards include exposure to falls, falling loads and mobile equipment. To protect employees from these hazards, OSHA requires the employer to take the following precautions:

- Keep materials or equipment that might fall or roll into an excavation at least 2 feet (0.61 meters) from the edge of excavations, or have retaining devices, or both.
- Provide warning systems such as mobile equipment, barricades, hand or mechanical signals, or stop logs to alert operators of the edge of an excavation. If possible, keep the grade away from the excavation.
- Provide scaling to remove loose rock or soil or install protective barricades and other equivalent protection to protect employees against falling rock, soil or materials.

- Prohibit employees from working on faces of sloped or benched excavations at levels above other employees unless employees at lower levels are adequately protected from the hazard of falling, rolling or sliding material or equipment.
- Prohibit employees under loads that are handled by lifting or digging equipment. To avoid being struck by any spillage or falling materials, require employees to stand away from vehicles being loaded or unloaded. If cabs of vehicles provide adequate protection from falling loads during loading and unloading operations, the operators may remain in them.

Water Accumulation

The standard prohibits employees from working in excavations where water has accumulated or is accumulating unless adequate protection has been taken. If water removal equipment is used to control or prevent water from accumulating, the equipment and operations of the equipment must be monitored by a competent person to ensure proper use.

OSHA standards also require that diversion ditches, dikes or other suitable means be used to prevent surface water from entering an excavation and to provide adequate drainage of the area adjacent to the excavation. Also, a competent person must inspect excavations subject to runoffs from heavy rains.

Hazardous Atmospheres

Under this provision, a competent person must test excavations greater than 4 feet (1.22 meters) in depth as well as ones where oxygen deficiency or a hazardous atmosphere exists or could reasonably be expected to exist, before an employee enters the excavation. If hazardous conditions exist, controls such as proper respiratory protection or ventilation must be provided. Also, controls used to reduce atmospheric contaminants to acceptable levels must be tested regularly. Where adverse atmospheric conditions may exist or develop in an excavation, the employer also must provide and ensure that emergency rescue equipment, (e.g., breathing apparatus, a safety harness and line, basket stretcher, etc.) is readily available. This equipment must be attended when used.

When an employee enters bell-bottom pier holes and similar deep and confined footing excavations, the employee must wear a harness with a lifeline. The lifeline must be securely attached to the harness and must be separate from any line used to handle materials. Also, while the employee wearing the

lifeline is in the excavation, an observer must be present to ensure that the lifeline is working properly and to maintain communication with the employee.

Access and Egress

Under the standard, the employer must provide safe access and egress to all excavations. According to OSHA regulations, when employees are required to be in trench excavations 4 feet deep (1.22 meters) or more, adequate means of exit, such as ladders, steps, ramps or other safe means of egress, must be provided and be within 25 feet (7.62 meters) of lateral travel. If structural ramps are used as a means of access or egress, they must be designed by a competent person if used for employee access or egress, or a competent person qualified in structural design if used by vehicles. Also, structural members used for ramps or runways must be uniform in thickness and joined in a manner to prevent tripping or displacement.

5

Worker Training and Jobsite Safety

Suggested Company Policy

One of the most important responsibilities of field and office management is planning for safety. Most on-the-job problems and accidents directly result from improper planning. Correcting mistakes in shoring and/or sloping after work has begun slows down the operation, adds to the cost and increases the possibility of an excavation failure.

Contractors should develop safety checklists to make certain that there is enough information about the jobsite and that all needed items, such as safety equipment, are on hand.

To help ensure safety in trenching and excavations, these specific conditions should be taken into account:

- Soil types and layers
- Traffic
- Nearness of structures and their condition
- Surface and ground water conditions
- The water table elevation
- Overhead and underground utilities
- Weather

These and other conditions can be determined by jobsite studies, observations, test borings and consultations with local officials and utility companies.

Underground installations—sewer, telephone, water, fuel and electric lines—that may be encountered in the excavation must be located before starting the job. If underground installations are uncovered, OSHA regulations require that they be properly supported. The contractor must contact the utility companies involved and inform them of the proposed work before starting the trench or excavation.

Companies should establish a safety and health program. This important aspect of the work is put into place before the job starts. Field and office personnel should become familiar with the company policies and guidelines outlined in their company safety program. The program is often put in writing to solidify and communicate the company's position with regard to jobsite safety. Additionally, OSHA has specific training requirements for all employees who are required to enter confined or enclosed spaces.

Cooperation from supervisors, employee groups and individual employees is necessary to ensure that safety policies are implemented effectively. In addition, each supervisor must understand his or her degree of responsibility for providing a safe working environment.

The cooperation of all employees requires their recognition of safety hazards and the necessary safety precautions. Employees should be trained in the following areas:

1. Hazards associated with trenching and excavating
2. Soil identification
3. Safe slopes for different soil types and conditions
4. Proper installation and shoring
5. Stress patterns on trench walls from soil and spoil, equipment, and vibration caused by equipment and traffic
6. Effects of adjacent buried utilities, building foundations and lengthy exposure to the elements on trench side walls and other excavations
7. Effects on trench and excavation conditions from severe weather, such as excess water, freezing temperatures, unexpected heat or prolonged drying
8. Recognition of buried drums, containers, tanks and wells

Employees should be trained to follow proper procedures to involve the electrical power company, health department, and other agencies upon the discovery of unforeseen objects such as wells, sewage disposal systems, cemeteries, and historic or architectural artifacts.

An example of a company safety and health program in action is a written policy that ensures that all employees in all excavations will be protected from cave-ins. All company personnel will be expected to do their part to enforce this policy.

On-the-Job Follow-Up

Once the job gets underway, each employer should keep itself informed of the safety aspects of the project as well as the progress of the work. This is called on-the-job follow-up and involves a series of inspections to detect hazards and correct jobsite situations before cave-ins or other accidents occur. When management requires daily reports, acts on the reports and makes personal visits to the jobsite, it may feel more confident that everyone is meeting job safety responsibilities.

Special Health and Safety Considerations

Competent person. The designated competent person should have and be able to demonstrate the following:

Training, experience and knowledge of:

- soil analysis;
- use of protective systems; and
- requirements of 29 CFR Part 1926 Subpart P.

Ability to detect:

- conditions that could result in cave-ins;
- failures in protective systems;
- hazardous atmospheres; and
- other hazards including those associated with confined spaces.

Authority to take prompt corrective measures to eliminate existing and predictable hazards and to stop work when required.

Surface crossing of trenches. Surface crossing of trenches should be discouraged; however, if trenches must be crossed, such crossings are permitted only under the following conditions:

Vehicle crossings must be designed by and installed under the supervision of a registered professional engineer.

Walkways or bridges must be provided for foot traffic. These structures must:

- have a safety factor of 4;

- have a minimum clear width of 20 inches (0.51 meters);
- be fitted with standard rails; and
- extend a minimum of 24 inches (0.61 meters) past the surface edge of the trench.

Ingress and egress. Access to and exit from the trench require the following conditions:

Trenches 4 feet or more in depth should be provided with a fixed means of egress. Spacing between ladders or other means of egress must be such that a worker will not have to travel more than 25 feet laterally to the nearest means of egress. Ladders must be secured and extend a minimum of 36 inches (0.9 meters) above the landing. Metal ladders should be used with caution, particularly when electric utilities are present.

Exposure to vehicles. Procedures to protect employees from being injured or killed by vehicle traffic include:

Providing employees with and requiring them to wear warning vests or other suitable garments marked with or made of reflectorized or high-visibility materials. Requiring a designated, trained flagperson along with signs, signals and barricades when necessary.

Exposure to falling loads. Employees must be protected from loads or objects falling from lifting or digging equipment. Procedures designed to ensure their protection include:

Employees are not permitted to work under raised loads. Employees are required to stand away from equipment that is being loaded or unloaded. Equipment operators or truck drivers may stay in their equipment during loading and unloading if the equipment is properly equipped with a cab shield or adequate canopy.

Warning systems for mobile equipment. The following steps should be taken to prevent vehicles from accidentally falling into the trench:

Barricades must be installed where necessary. Hand or mechanical signals must be used as required. Stop logs must be installed if there is a danger of vehicles falling into the trench. Soil should be graded away from the excavation; this will assist in vehicle control and channeling of run-off water.

Hazardous atmospheres and confined spaces. Employees must not be permitted to work in hazardous and/or toxic atmospheres. Such atmospheres include those with:

Less than 19.5 percent or more than 23.5 percent oxygen; combustible gas concentration greater than 20 percent of the lower flammable limit; and concentrations of hazardous substances that exceed those specified in the Threshold Limit Values for Airborne Contaminants established by the American Conference of Governmental Industrial Hygienists.

All operations involving such atmospheres must be conducted in accordance with OSHA requirements for occupational health and environmental controls (see Subpart D of 29 CFR 1926) for personal protective equipment and for lifesaving equipment (see Subpart E, 29 CFR 1926). Engineering controls (e.g., ventilation) and respiratory protection may be required.

When testing for atmospheric contaminants, the following should be considered:

- Testing should be conducted before employees enter the trench and should be done regularly to ensure that the trench remains safe. The frequency of testing should be increased if equipment is operating in the trench. Testing frequency should also be increased if welding, cutting or burning is done in the trench.
- Employees required to wear respiratory protection must be trained, fit-tested and enrolled in a respiratory protection program. Some trenches qualify as confined spaces. When this occurs, compliance with the Permit-Required Confined Space Standard is also required.

Emergency rescue equipment. Emergency rescue equipment is required when a hazardous atmosphere exists or can reasonably be expected to exist.

Requirements are as follows:

- Respirators must be of the type suitable for the exposure. Employees must be trained in their use, and a respirator program must be instituted.
- Attended (at all times) lifelines must be provided when employees enter bell-bottom pier holes, deep confined spaces or other similar hazards.
- Employees who enter confined spaces must be trained.

Standing water and water accumulation. Methods for controlling standing water and water accumulation must be provided and should consist of the following if employees are permitted to work in the excavation:

- Use of special support or shield systems approved by a registered professional engineer
- Water removal equipment, i.e., well pointing, used and monitored by a competent person
- Safety harnesses and lifelines used in conformance with 29 CFR 1926.104
- Surface water diverted away from the trench
- Employees removed from the trench during rainstorms
- Trenches carefully inspected by a competent person after each rain and before employees are permitted to re-enter the trench

Inspections. A competent person must inspect the trench and document any findings. The following guide specifies the frequency and conditions requiring inspections:

- Daily and before the start of each shift
- As dictated by the work being done in the trench
- After every rainstorm
- After other events that could increase hazards, e.g. snowstorm, windstorm, thaw, earthquake, etc.
- When fissures, tension cracks, sloughing, undercutting, water seepage, bulging at the bottom or other similar conditions occur
- When there is a change in the size, location or placement of the spoil pile
- When there is any indication of change or movement in adjacent structures

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Safety Checklist

FOR A SAFE JOBSITE TRENCHING OPERATION, THE ANSWER TO EACH OF THE FOLLOWING SHOULD BE **YES**.

YES NO

General Protection Requirements

- Are all walkways, runways and sidewalks clear of excavated material or other obstructions?
- Are all undermined sidewalks shored to carry a minimum live load of 125 pounds per square foot?
- Are planks laid parallel to the length of walk and fastened together against displacement if used for raised walkways, runways or sidewalks?
- Are planks uniform in thickness?

YES NO

- Are cleats on ramps provided when ramps are used in lieu of steps?
- Are all employees engaged in excavation, trenching and shoring provided with the appropriate training and personal protective equipment?
- Are employees exposed to vehicular traffic wearing warning vests marked with or made of reflectorized or high visibility material?
- Are employees prohibited from being under suspended loads handled by lifting and other heavy equipment?
- Are daily inspections made of excavations, trenching and shoring?
- If evidence of possible cave-ins or slides is apparent, does all work stop until the necessary precautions have been taken to safeguard all the employees?

Specific Excavation Requirements

- Prior to opening an excavation and/or trench, has an effort been made to determine if any underground installations will be encountered?
- Did you contact utility companies before excavating?
- Did you remove all trees, boulders and other surface encumbrances before excavating?
- Are the walls and faces of all excavations in which employees are exposed to danger from moving ground guarded by a shoring system, ground sloping or some other equivalent means?
- Are excavations inspected by a competent person after every rainstorm or other hazard-increasing occurrence to determine if additional protection against slides and cave-ins is necessary?
- Did you store or retain excavated or other materials at least 2 feet or more from the edges of the excavation?
- Do sides, slopes and faces of all excavations meet accepted engineering requirements by tiering, barricading, rock bolting, wire meshing or other equally effective means?
- When excavations are in excess of 20 feet in depth, was the support system designed by a registered professional engineer?
- Are all materials used for sheeting, piling, cribbing, bracing, shoring and underpinning in good serviceable condition?
- Is the timber used for this purpose free of large or loose knots?
- Are diversion ditches, dikes or other suitable means used to prevent surface water from entering an excavation and to provide adequate drainage to the area?
- When heavy equipment, material or objects are on a level above and near an excavation, are the sides of the excavation sheet-piled, shored and braced?

YES NO

- When mobile equipment is used or is adjacent to excavations, are stop logs or barricades installed?
- Are adequate barriers provided at all remotely located excavations? Are all wells, pits, shafts, etc., adequately covered?
- On completion of the operation, are all temporary wells, pits, shafts, etc., backfilled?
- If possible, are dust conditions kept to a minimum?
- In locations where oxygen deficiency or gaseous conditions are possible, is the air in the excavation tested?
- Where employees and/or equipment are required to cross over excavations, are walkways or bridges with standard guardrails provided?
- Do ladders used in excavation operations meet the OSHA requirements, and are ladders sufficient in number?
- Are ladders or other means of exiting the trench provided and located so as to require no more than 25 feet of lateral travel by employees to use them?

Specific Trenching Requirements

- Are all banks more than 5 feet high shored or laid back to a stable slope?
- Are the sides of trenches or embankments in Type B soil 4 feet or more in depth shored, sheeted, braced, benched, sloped or otherwise sufficiently supported?
- Are sides of trenches or embankments in Type A soil shored or otherwise supported when the excavation is 4 feet deep?
- When excavations or trenches are located near backfills or where they are subjected to vibrations from railroad or highway traffic or machinery operation, are precautions such as shoring and bracing taken to prevent slides or cave-ins?
- Is the excavation braced and shored as soon as it is opened?
- Are all crossbraces or jacks placed in true horizontal position?
- Are the vertical braces properly spaced and secured to prevent sliding, falling or kickouts?
- Where trench boxes or shields are used, are they designed and constructed in a manner that will provide protection for the employees?
- Do backfilling and removal of trench supports progress together from the bottom of the trench?
- Are jacks or braces released slowly?

YES NO

- In unstable soil, are ropes used to pull out jacks or braces from above, after employees are safely away from the trench?

Glossary

Accepted engineering practices are procedures compatible with the standards of practice required of a registered professional engineer.

Adjacent structure stability refers to the stability of the foundations of adjacent structures whose location may create surcharges, changes in soil conditions or other disruptions that have the potential to extend into the failure zone of the excavation or trench.

Competent person is an individual who is capable of identifying existing and predictable hazards or working conditions that are hazardous, unsanitary or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate or control these hazards and conditions.

Excavation. An excavation is any man-made cut, cavity, trench or depression in an earth surface that is formed by earth removal. A trench is a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth of a trench is greater than its width, and the width (measured at the bottom) is not greater than 15 feet (4.6 meters). If a form or other structure installed or constructed in an excavation reduces the distance between the form and the side of the excavation to 15 feet (4.6 meters) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

Hazardous atmosphere is an atmosphere that by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen-deficient, toxic or otherwise harmful may cause death, illness or injury to persons exposed to it.

Ingress and egress mean “entry” and “exit,” respectively. In trenching and excavation operations, they refer to the provision of safe means for employees to enter or exit an excavation or trench.

Protective system refers to a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, and from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

Registered professional engineer is a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer who is registered in any state is deemed to be a registered professional engineer within the meaning of Subpart P when approving designs for manufactured protective systems or tabulated data to be used in interstate commerce.

Support system refers to structures such as underpinning, bracing and shoring that provide support to an adjacent structure or underground installation or to the sides of an excavation or trench.

Subsurface encumbrances include underground utilities, foundations, streams, water tables, transformer vaults and geological anomalies.

Surcharge means an excessive vertical load or weight caused by spoil, overburden, vehicles, equipment or activities that may affect trench stability.

Tabulated data are tables and charts approved by a registered professional engineer and used to design and construct a protective system.

Underground installations include, but are not limited to, utilities (sewer, telephone, fuel, electric, water and other product lines), tunnels, shafts, vaults, foundations and other underground fixtures or equipment that may be encountered during excavation or trenching work.

Unconfined compressive strength is the load per unit area at which soil will fail in compression. This measure can be determined by laboratory testing, or it can be estimated in the field using a pocket penetrometer, by thumb penetration tests or by other methods.

Acknowledgments

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This guide is intended to be consistent with all existing OSHA standards; therefore, if an area is considered by the reader to be inconsistent with a standard, then the OSHA standard must be followed instead of this guide.