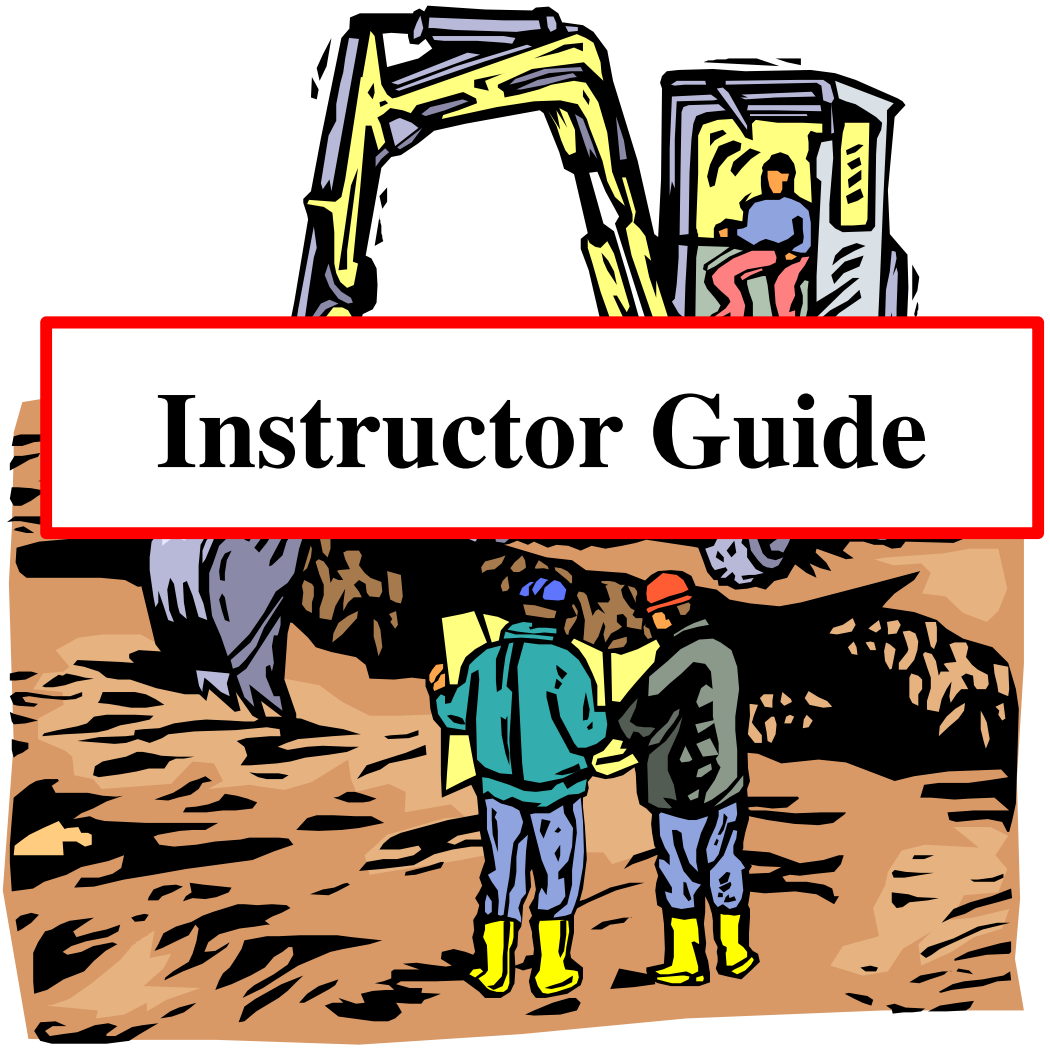
Excavation Safety



Instructor Guide

DEPARTMENT OF CONSUMER & BUSINESS SERVICES

Presented by the Public Education Section
Oregon OSHA
Department of Consumer and Business Services

Oregon OSHA
PUBLIC EDUCATION

Oregon OSHA Public Education Mission:

We provide knowledge and tools to advance
self-sufficiency in workplace safety and health

Consultative Services:

- Offers no-cost on-site assistance to help Oregon employers recognize and correct safety and health problems

Enforcement:

- Inspects places of employment for occupational safety and health rule violations and investigates complaints and accidents

Public Education and Conferences:

- Presents educational opportunities to employers and employees on a variety of safety and health topics throughout the state

Standards and Technical Resources:

- Develops, interprets, and provides technical advice on safety and health standards
- Publishes booklets, pamphlets, and other materials to assist in the implementation of safety and health rules

Questions?
Call us

Field Offices:

Portland	503-229-5910
Salem	503-378-3274
Eugene	541-686-7562
Medford	541-776-6030
Bend	541-388-6066
Pendleton	541-276-2353

Salem Central Office:
Toll Free number in English: 800-922-2689
Toll Free number in Spanish: 800-843-8086
Web site: www.orosha.org

This page left intentionally blank

Welcome!

Studies show that excavation work is one of the most hazardous types of work done in the construction industry. Injuries from excavation work tend to be of a very serious nature and often result in fatalities.

The primary concern in excavation-related work is a cave-in. Cave-ins are much more likely to be fatal to the employees involved than other construction-related accidents.

OSHA has emphasized the importance of excavation safety through outreach and inspection efforts based upon data which clearly establishes the significant risk to employees working in and around excavations. Furthermore, a high rate of injuries has continued to occur in and around excavations.

So, with that information in mind, our **goals** for today are to:

- Overview Division 3/Subdivision P *Excavations*
- Define important terms including Competent Person
- Discuss specific hazards resulting from excavation work
- Describe requirements for protective systems
- Review OSHA's soil classification methods

So, let's dig in!

Please Note: This material, or any other material used to inform employers of compliance requirements of Oregon OSHA standards through simplification of the regulations should not be considered a substitute for any provisions of the Occupational Safety and Health Act or for any standards issued by Oregon OSHA. This workbook is intended for classroom use only.

Welcome Page

Although the primary concern in excavation-related work is a cave-in, this program will also cover other dangers many do not often think of including hazardous atmospheres, underground utilities, and vehicle/mobile equipment exposure.

A good intro is to focus on these annual stats:

Cave-ins:

1000 injuries/yr

- 140 permanent disability
- 54 deaths (76%)

Struck by excavator and components:

- 50 deaths

NIOSH

Currently, OSHA has an enforcement emphasis program which allows for many excavation sites to be inspected.

Review the objectives:

- Overview Division 3/Subdivision P *Excavations*
- Define important terms including Competent Person
- Discuss specific hazards resulting from excavation work
- Describe requirements for protective systems
- Review OSHA's soil classification methods

A copy of OR-OSHA Div 3/Sub P is located in the reference section of the workbook, in addition to other informative documents. OR-OSHA also has a terrific publication titled "Excavations" Pub. #440-2174 (6/06). This publication is also referenced throughout this instructor guide.

Scope, Application, Definitions
{Division 3/Subdivision P 29 CFR 1926.650}

Scope and Application

This subpart applies to all excavations made in the earth's surface. Excavations are defined to include trenches.

Some KEY Definitions:

Competent Person means 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.

Protective System means a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or 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 means a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a “registered professional engineer” within the meaning of this standard when approving designs for “manufactured protective systems” or “tabulated data” to be used in interstate commerce.

Support System means a structure such as underpinning, bracing, or shoring, which provides support to an adjacent structure, underground installation, or the sides of an excavation.

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

Trench (Trench excavation) means a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet.

Scope, Application, and Definitions

Excavations are defined to include trenches. The definition of an excavation is a man-made cut, cavity, or depression in the earth's surface (including open-face excavations). More on trenches below.

Open-face excavation

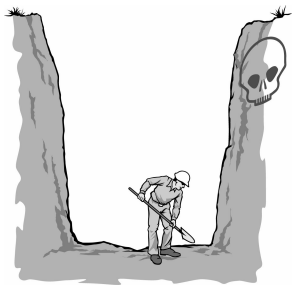
Competent Person - same "competent person" definition in OR-OSHA Div 3/Subs M, L, R, etc. Two part definition - must have authority to correct hazards on site. Only the employer can deem someone a competent person because only their employer can grant them authority. OR-OSHA Div 3/Sub P does not require the competent person to be on the job 100% of the time; however, considering the number of specific responsibilities he/she has – it wouldn't be a bad idea. The following is a summary of the specific duties required in the standard: Structural ramp design, water removal monitoring, daily inspections, removing employees from serious hazards, equipment inspection to determine continued use/removal from service, soil classification, and reducing soil surcharges.

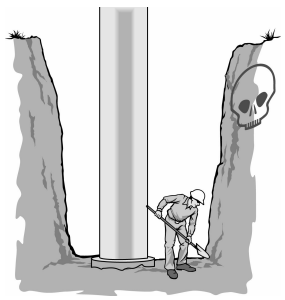
Protective System basically means anything to protects from cave-in or collapse.

Support System basically means everything that protects from cave-in or collapse besides sloping and benching systems.

Tabulated Data is the documentation confirming a safe system - whatever the system is. OSHA includes tabulated data in Appendices B, C, and D. Of course, manufacturers of protective systems as well as other sources (vendors, engineers) provide tabulated data too. *The following is from an OR-OSHA Letter of Interpretation dated 7/25/02: "You ask in your letter if tabulated data for components of shoring systems, used in excavations, is allowed to be identified by model number, or if serial numbers have to be used. There are no rules in1926.652(c)(1), (2), or (3) that specifically address how to match manufacturer's specs, recommendations, and limitations (required to be on site during construction of support, shield and other protective systems) to individual components. Like many OR-OSHA requirements, this is a performance standard. That means that as long as the information can be readily matched to the components (by model number, serial number, or some other means of positive identification), then it's acceptable."*

Trench is an excavation but it's narrow and not more than 15 ft wide at the bottom. If forms or other structures are installed in an excavation that reduce its width to less than 15 ft, measured at the bottom, the excavation is also considered a trench.





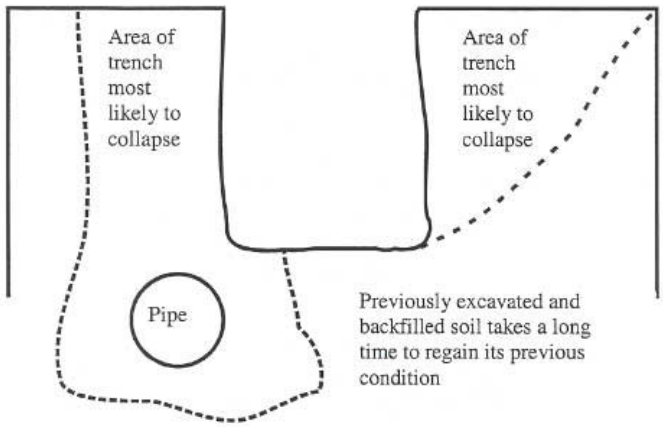
Preplanning Against Cave-Ins

One of the most important steps in avoiding cave-ins is the preplanning of excavation operations. Some of the questions that must be answered prior to digging are:

1. What types of soil will be found?
2. What are the soil moisture conditions?
3. Has the soil previously been disturbed?
4. How large will the excavation be?
5. How long will the excavation be open?
6. What kinds of weather can we expect?
7. What kinds of equipment will be on the job?
8. Will the excavation be near structures?
9. Is traffic control needed near the excavation?
10. What sources of vibration will be nearby?
11. Will water be a problem?
12. What kind of shoring? How much?
13. Underground installations?

Oftentimes, these questions are answered before the shovel hits the dirt. However, it may not be a bad idea to make this a checklist or at least considered during the toolbox talk.

1. Cohesive? Significant organic material?
2. Too wet/dry? High water table?
3. Utility? Other fill material?
4. Vehicle/pedestrian exposures??
5. Overnight? Kids nearby?
6. Rain?



7. Vibration? Mobile equipment? Superstructures that create pinch points?
8. Undermining? Rendering stability of adjacent structures?
9. Vibration? Not only high-visibility garments but traffic control plans for both external and internal traffic? OR-OSHA references ODOT's Temporary Traffic Control Handbook. Effort and focus should also be placed on internal traffic/mobile equipment. Consider this fact: Highway construction workers are killed more often by internal, construction-related traffic (NIOSH).
10. Machinery? Traffic? Pile-driving? Tools?
11. Water table??
12. Sloping? Benching (not in Type C)?
13. Underground installations?

General Requirements
{Division 3/Subdivision P 29 CFR 1926.651}

Underground Installations [29 CFR 1926.651(b)]

- Determine the estimated locations
- Contact the utility or owner
- Proceed cautiously
- Find the exact location
- Support, protect, or appropriately remove the installation in open excavations

Surface Encumbrances [29 CFR 1926.651(a)]

- Remove or support if creating a hazard to workers

What are some examples of surface encumbrances?

poles _____ *rocks* _____ *trees* _____

Access and Egress [29 CFR 1926.651(c)]

(1) Structural ramps used for access or egress of equipment must be designed by a competent person qualified in structural design.

(2) A **safe means** of entering and leaving excavations must be provided for workers. A stairway, ladder, ramp, or other of egress must be located in trench excavations

- **four** feet or more in depth, and
- require no more than **25** feet of lateral travel.

Speed Shore Corp.

Underground Installations [29 CFR 1926.651(b)]

Don't forget to support utilities that transverse across the excavation which can possibly lead to collapse.

Remember - surface markers may have been moved to accommodate mowing. They may have also been vandalized or altered.

Oregon Utility Notification Center
www.callbeforeyoudig.org
(503) 246-6699 PDX
(800) 332-2344

Surface Encumbrances [29 CFR 1926.651(a)]

"Stuff" that can fall into the trench - signs, posts, trees, boulders, pavement, etc.

Surface encumbrance?

Access and Egress [29 CFR 1926.651(c)]

In addition to the four foot depth and 25 foot lateral requirements - don't forget "safe means":

- Ladder, stairway, etc., in good condition
- No "former" extension ladders
- Stable
- No impalement hazards below

Watch for impalement hazards at base

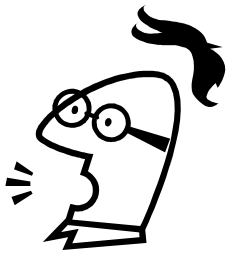
General Requirements
{Division 3/Subdivision P 29 CFR 1926.651}

Exposure To Vehicular Traffic [29 CFR 1926.651(d)]

Employees must be provided and wear warning vests or other suitable garments marked with or made of reflectrorized or high visibility material.

Exposure To Falling Loads [29 CFR 1926.651(e)]

Employees are not allowed under loads handled by lifting or digging equipment. Workers must either stand away or otherwise be protected from any vehicle being loaded or unloaded to avoid spilling or falling material.



Warning System for Mobile Equipment [29 CFR 1926.651(f)]

A warning system must be utilized when mobile equipment is operated adjacent to an excavation, or when such equipment is required to approach the edge of an excavation, ***and the operator does not have clear and direct view of the edge.*** Barricades, hand or mechanical signals, or stop logs can be used.

Exposure To Vehicular Traffic [29 CFR 1926.651(d)]

High visibility apparel must allow you to contrast from all surroundings. This is a performance-based rule meaning you "perform to it". The color of your vest/shirt depends on the colors around you. Retroreflective material must be worn when natural illumination is insufficient (dusk, dawn, fog, stormy, etc.)

In addition to garments, is there a need for traffic control (i.e. signage, channeling devices, etc.)? OR-OSHA references ODOT's Temporary Traffic Control Handbook or Part 6 of the MUTCD (OR-OSHA Div 3/Sub G OAR 437-003-0420).

And don't forget internal (site) traffic! More highway construction workers are killed from internal traffic than the motoring public. Between 1992 and 1998, there were 841 work-related fatalities in the U.S. highway construction industry – 465 (55%) were vehicle- or equipment-related incidents that occurred **in** a work zone (NIOSH).

Exposure To Falling Loads [29 CFR 1926.651(e)]

Policy, training, and enforcement. Hardhats too. Consider all "struck by" or "impact" hazards here.

Emphasis should also be placed on rigging practices. On 6/10/05, a worker was killed in Portland when the wire rope rigging used to pull a trench shield disengaged from a latch-type hook attached to the quick coupler on a track hoe. Because of the hook's position when the shield was being pulled, the load was improperly applied near the opening, allowing the wire rope to disengage striking the worker in the back of his head. The manufacturer of the quick coupler device does not recommend lifting with the bucket in place and prohibits modification to the quick coupler assembly. In this case, the bucket was attached and the supplied closed eye hook was replaced with an open latch-type hook. Furthermore, the hook's latch was welded shut and the shield being pulled was wider than the trench, placing significant strain on the rigging. The deceased worker was 40 years old.

Warning System for Mobile Equipment [29 CFR 1926.651(f)]

Only when *the operator does not have clear and direct view of the edge.*

Hazardous Atmospheres

[29 CFR 1926.651(g)]

Purpose

Prevent exposure to harmful levels of air contaminants such as:

- Oxygen deficiency,
- Explosives/Flammables,
- Toxins;

and to assure acceptable atmospheric conditions through:

- Atmospheric testing,
- Removal of the substance,
- Proper ventilation,
- Respiratory protection,
- etc.

Testing and Controls

Testing is required where oxygen deficiency (less than 19.5 percent oxygen), or a hazardous atmosphere exists or could reasonably be expected to exist.

Examples include excavations in landfill areas or in locations where hazardous substances exist (i.e. utilities, tanks, contaminated soil, etc.)

When controls such as ventilation are used to reduce the level of atmospheric contaminants to an acceptable level, testing must be conducted as often as necessary to ensure continuing safety.

Emergency Rescue Equipment

Emergency rescue equipment must be readily available where hazardous atmospheric conditions exist or can reasonably be expected to develop.

NOTE: Division 3/Subdivisions D & E provide additional requirements. Additionally, workers entering bell-bottom piers or other similar deep and confined footing excavations must utilize a harness and lifeline system.

Hazardous Atmospheres [29 CFR 1926.651(g)]

Trenches are confined spaces!

Lab Safety Supply

Check for:

- Oxygen deficiency,
- Explosives/Flammables,
- Toxins;

and to ensure acceptable atmospheric conditions through:

- Atmospheric testing,
- Removal of the substance,
- Proper ventilation,
- Respiratory protection,
- etc.

Testing and Controls

Atmospheric testing is required where oxygen deficiency (less than 19.5 percent oxygen), or a hazardous atmosphere (flammable and/or toxic) exists or could reasonably be expected to exist. The competent person must be able to recognize where these conditions are expected.

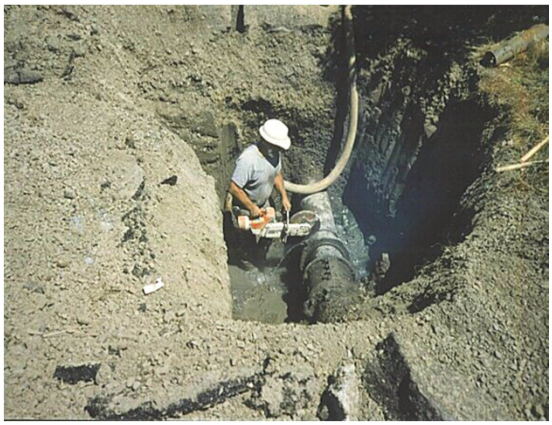
Some gases are heavier than air and can accumulate at the bottom of the trench. For example, hydrogen sulfide, carbon dioxide, and vapors from fuels are heavier than air. Other gases, like methane and carbon monoxide, are lighter than air and this is important to know when sampling.

There may also be oxygen deficient situations where purging with an inert gas had occurred (e.g. decommissioned gas lines).

Remember - sources may come from outside the trench and “creep”in or come from inside the trench (i.e. gas lines, contaminated soil, gas-powered tools/equipment, etc.).

General Requirements
{Division 3/Subdivision P 29 CFR 1926.651}

Water Accumulation [29 CFR 1926.651(h)]



Employees must be properly protected when working in excavations where water has accumulated or is accumulating. Precautions will vary with each situation but may include diversion, dewatering (well pointing) systems, special supporting systems, or water removal equipment. The competent person must monitor water removal equipment.

Water is one of the major concerns during excavation operations. The action of water in excavations can cause undermining and cave-ins.

Stability of Adjacent Structures [29 CFR 1926.651(i)]

Where the stability of adjacent buildings, walls, or other structures is endangered by excavation operations, support systems such as shoring, bracing, or underpinning must be provided to ensure stability.

Excavation below the level of the base or footing that could pose a hazard is not permitted except when:

- the excavation is in stable rock, or
- support system (underpinning) is provided, or
- Registered Professional Engineer approves.

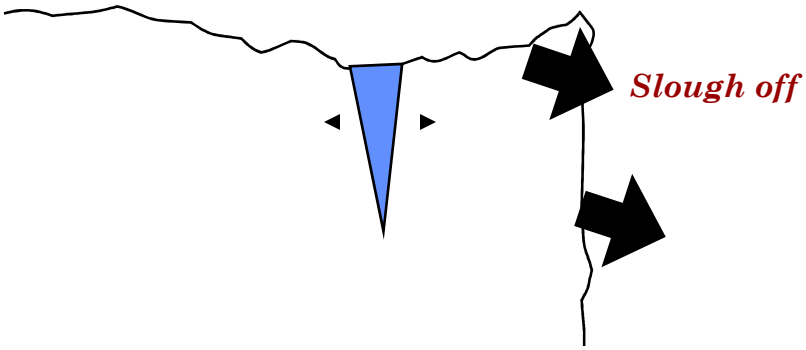
Sidewalks, pavements, and appurtenant structure must not be undermined unless a support system or another method of protection is provided to protect employees from collapse.

Water Accumulation [29 CFR 1926.651(h)]

Water is one of the major concerns during excavation operations. Water simply allows dirt to move much easier and quicker than it would normally. Think of digging in the sand on a beach.

Capillary effect - standing water "wicks" up and saturates the trench sidewalls as it "wicks" up the earth's *natural at-rest angle*. Think of this "wicking" effect like a bath towel draped over a bathtub with standing water or the wick on a candle. Type C soil provides a shorter wicking effect than a more cohesive, Type A soil (with a significant amount of clay).

Water (i.e. rain) can also fill tension and surface cracks at the edge of the trench causing a hydrostatic effect within this 'tube' leading to wedge failure.



Stability of Adjacent Structures

[29 CFR 1926.651(i)]

Support systems such as shoring, bracing, underpinning, screw retention systems, or other engineering must be provided to ensure stability.

Don't forget - Sidewalks and other pavements.

General Requirements
{Division 3/Subdivision P 29 CFR 1926.651}

Daily Inspections [29 CFR 1926.651(k)]

Daily inspections of excavations, adjacent areas, and protective systems must be made by a Competent Person for evidence of a situation that could result in possible cave-ins, failure of protective systems, hazardous atmospheres, or other hazardous conditions.

When? 1._____ 2._____ 3._____

What are we inspecting?

If evidence of a possible cave-in, failure in the protective system, hazardous atmosphere, or other significant concerns are found, all affected workers must be removed from the hazardous exposure until rendered safe.

Protection from Loose Rock or Soil [29 CFR 1926.651(j)]

Scale back to remove loose material or install protective barricades and place all material and equipment at least **two** feet from the edge.

Fall Protection [29 CFR 1926.651(l)]

Walkways must be provided where employees or equipment are permitted to cross over excavations.

Adequate barrier physical protection must be provided at all remotely located excavations. All wells, pits, shafts, etc., must be barricaded or covered. Backfill as soon as possible.

Daily Inspections [29 CFR 1926.651(k)]

OR-OSHA Div 3/Sub P does not require these inspections to be documented but a good idea nonetheless. Recording your inspections provides a reference so one doesn't overlook anything and can also tell the others on site that the excavation was inspected and by whom. A best practice would be to make this a checklist.

When? 1. Prior to work 2. As needed 3. After any occurrence (weather, vibration shock, etc.) that would warrant a reinspection.

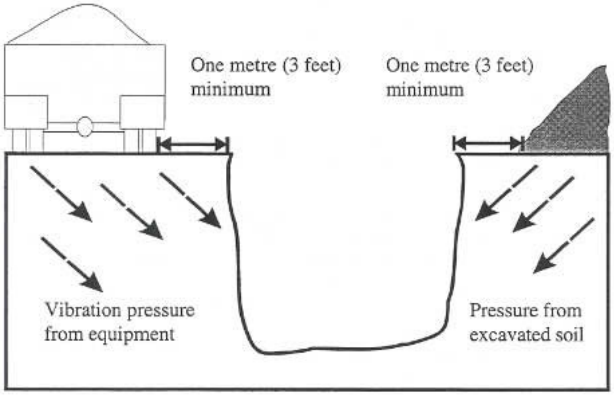
What are we inspecting? Protective system (shores, slopes, benches, supports, etc.), hazardous atmosphere (if suspected), vibration sources, water, surface encumbrances, utilities, traffic, etc.

Good sample checklists on the web (e.g. www.cdc.gov/elcosh).

Protection from Loose Rock or Soil [29 CFR 1926.651(j)]

Scale back and maintain at least 2 feet from the edge.

Note: The image on the right recommends 3 feet. The more you can recess it back – the better. Remember - the height of the spoils is added to the depth of the trench when placed at the edge.



Work Safe BC

Fall Protection [29 CFR 1926.651(l)]

Walkways must be provided where employees or equipment are permitted to cross over excavations.

Always consider fall protection for the folks on the sides of a trench or excavation and install when feasible and when it does not create a greater hazard (i.e. railings, barricades, fencing, management controls, etc.).

Soil Classification System
{Division 3/Subdivision P Appendix A}

Scope

Appendix A describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits. This appendix contains definitions, sets forth requirements, and describes acceptable visual and manual tests for use in classifying soils.

Key Definitions:

Cohesive Soil means clay, or soil with a high clay content, which has cohesive strength. Cohesive soil does not crumble, can be excavated with vertical sideslopes, and is plastic when moist. Cohesive soil is hard to break up when dry and exhibits significant cohesion when submerged.

Fissured means a soil material that has a tendency to break along definite planes of fracture with little resistance, or a material that exhibits open cracks, such as tension cracks, in an exposed surface.

Granular means gravel, sand, or silt, (coarse grained soil) with little or no clay content. Granular soil has no cohesive strength, cannot be molded when moist, and crumbles easily when dry. Some moist granular soils exhibit apparent cohesion.

Type A means cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (tsf) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam, and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as hardpan are also considered Type A. No soil can be Type A if fissured, subjected to significant vibration, or has been previously disturbed. *Refer to the definition in Appendix A for further criteria.*

Type B means cohesive soils with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf. Some examples are: granular cohesionless soils including angular gravel, silt, silt loam, sandy loam, and ,in some cases, silty clay loam and sandy clay loam. Type B also includes previously disturbed soils except those which would otherwise be classed as Type C.

Type C means cohesive soils with an unconfined compressive strength of 0.5 tsf or less. Some examples include: gravel, sand, and loamy sand. Also included may be submerged soil or soil from which water is freely seeping, and submerged rock that is not stable.

Soil Classification System

OR-OSHA's Appendix A begins on p. P-11 of the workbook.

No soil can be Type A if fissured, subjected to significant vibration, or has been previously disturbed.

Type B also includes previously disturbed soils except those which would otherwise be classed as Type C.

Many contractors assume all soil is Type C.

The following is taken from OR-OSHA's publication titled, "Excavations" Pub. #440-2174 (6/06): The type of soil is one of the factors that helps determine the stability of an excavation and the chance that it will cave in. There are three soil types that you may encounter in Oregon: (1.) Type A soil is very stable. Clay is an example. (2.) Type B soil is less stable than type A soil. Crushed rock, silt, and soils that contain an equal mixture of sand and silt are examples. (3.) Type C soil is less stable than type B soil. Gravel and sand are examples.

Soil has other qualities that affect its stability. These include *granularity, saturation, cohesiveness*, and *unconfined compressive strength*. Granularity refers to the size of the soil grains; the larger the grains, the less stable the soil. Saturation means how much water soil will absorb. Cohesiveness means how well soil holds together; clay is a cohesive soil. Unconfined compressive strength is determined by a test that shows how much pressure it takes to collapse a soil sample. For example, type A soil must have an unconfined compressive strength of at least 1.5 tons per square foot. A pocket penetrometer, shearvane, or boring tests can determine unconfined compressive strength.

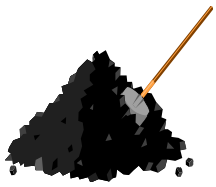
Loam is defined as soil composed of a mixture of sand, clay, silt, and organic matter.

Soil Classification System

{Division 3/Subdivision P Appendix A}

Classification of Soil and Rock Deposits

- Classification must be based on the results of at least one visual and one manual analysis conducted by a Competent Person.
- *In a layered soil system, the system must be classified in accordance with its weakest layer. However, each layer may be classified individually where a more stable soil lies under a less stable soil.*



Visual Tests

Observe samples of soil that are excavated and soil in the sides of the excavation. Estimate the range of particle sizes and the relative amounts of the particle sizes. Soil that is primarily composed of fine-grained material is cohesive material. Soil composed primarily of coarse-grained sand or gravel is granular material.

Observe soil as it is excavated. Soil that remains in clumps when excavated is cohesive. Soil that breaks up easily and does not stay in clumps is granular.

Observe the side of the opened excavation and the surface area adjacent to the excavation. Crack-like openings such as tension cracks could indicate fissured material. If chunks of soil spill off a vertical side, the soil could be fissured. Small spills indicate moving ground and can pose potentially hazardous situations.

Observe the area adjacent to the excavation to identify previously disturbed soil (i.e. evidence of existing utility and other underground structures).

Observe the opened side of the excavation to identify layered systems. Examine layered systems to identify if the layers slope toward the excavation. Estimate the degree of slope of the layers.

Observe the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides, or the location of the water table level.

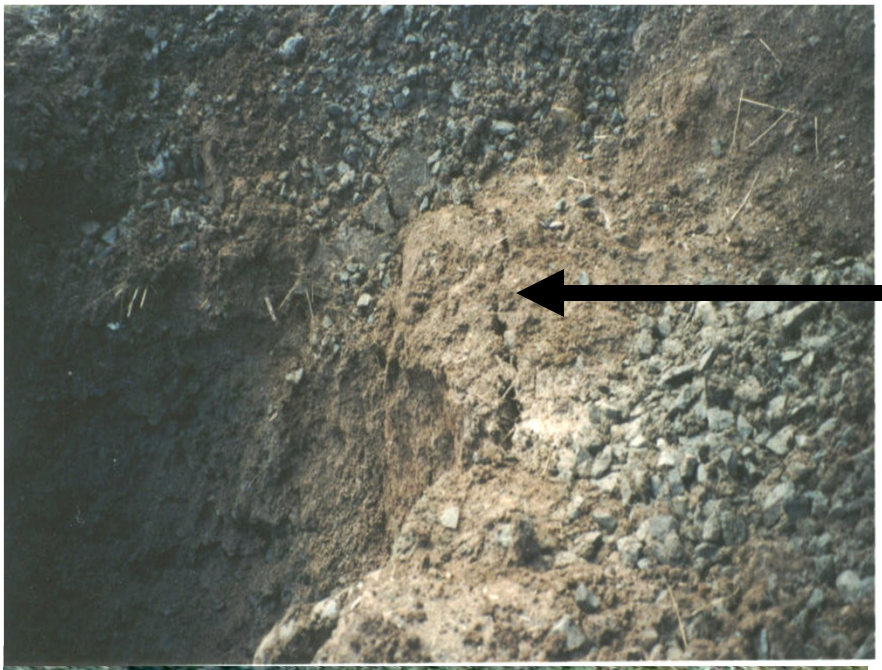
Observe the area adjacent to the excavation and the area within the excavation for sources of vibration that may affect the stability of the excavation face.

Soil Classification System

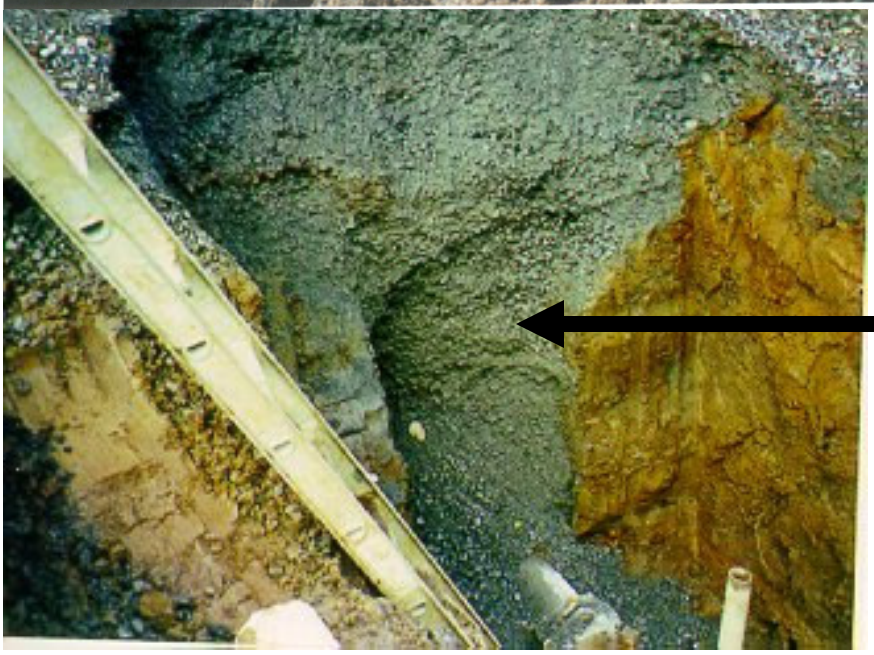
All of these visual tests can be accomplished in a very short amount of time if the competent person is watching the soil being excavated.

The seven visual tests are pretty self-explanatory. Much judgment rests with the competent person.

The following are a few examples:

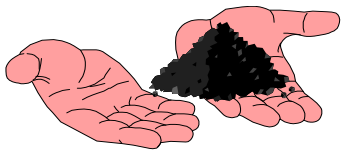


Observe the side of the opened excavation and the surface area adjacent to the excavation. Crack-like openings such as tension cracks could indicate fissured material.



Observe the area adjacent to the excavation to identify previously disturbed soil (i.e. evidence of existing utility, prior fill material).

Soil Classification System
{Division 3/Subdivision P Appendix A}



Manual Tests

Plasticity and Pat Test - Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as 1/8 inch in diameter. Cohesive soil can be successfully rolled into threads without crumbling. If at least a 2 inch length of 1/8 inch thread can be held on one end without tearing, the soil is cohesive.

Spread a 1/8 or 1/4 inch thick sample of wet soil on the palm of the hand. Wipe the surface of the sample with a finger to remove visible water. With the palm facing up, slap the back of the hand moderately 5 to 10 times. If water rises to the surface of the sample (surface will appear shiny), then the soil is mostly cohesionless silt or sand. If no water appears, then the soil is mostly cohesive clay.

Dry Strength - Granular soil, when dry, crumbles on its own or with moderate pressure into individual grains or powder. Soils with clay content, when dry, crumbles into clumps which break up into smaller clumps but the smaller clumps can only be broken with significant force. If the dry soil breaks into clumps which do not break up into small clumps and which can only be broken with difficulty, and there is no visual indication the soil is fissured, the soil may be considered unfissured.

Thumb Penetration - The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. This test should be conducted on an undisturbed soil sample as soon as practical after excavating to reduce the chance of air drying the sample. If later the trench is exposed to moisture (rain, flooding, etc.), the soil classification must also be changed.

Type A soils can be readily indented by the thumb. However, they can be penetrated by the thumb only with very great effort.

Type C soils can be easily penetrated several inches by the thumb and can be molded by light finger pressure.

Other Strength Tests Estimates of unconfined compressive strength of soils can also be obtained by use of a pocket penetrometer or a hand-operated shearvane.

Other tests can include drying and sedimentation.

Soil Classification System

Common tests include plasticity, thumb penetration, and pocket penetrometer. The following is taken from OR-OSHA's publication titled, "Excavations" Pub. #440-2174 (6/06):

Plasticity test. Shape a sample of moist soil into a ball and try to roll it into threads about 1/8-inch in diameter. Cohesive soil will roll into 1/8-inch threads without crumbling.

Dry strength test. Hold a dry soil sample in your hand. If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it's granular. If the soil breaks into clumps that are hard to break into smaller clumps, it may be clay combined with gravel, sand, or silt.

Thumb penetration test. This test roughly estimates the unconfined compressive strength of a sample. Press your thumb into the soil sample. If the sample resists hard pressure, it may be Type A soil. If it's easy to penetrate, the sample may be type C.

Pocket penetrometers offer more accurate estimates of unconfined compressive strength. These instruments estimate the unconfined compressive strength of saturated cohesive soils. When pushed into the sample, an indicator sleeve displays an estimate in tons per square foot or kilograms per square centimeter.

Ben Meadows Co.

Requirements for Protective Systems
{Division 3/Subdivision P 29 CFR 1926.652}

Protective Systems [29 CFR 1926.652(a)]

Employees in excavations must be protected from cave-ins by an adequate protective system except when:

- excavations are made entirely in stable rock; or
- excavations are less than 5 feet deep **and** a Competent Person determines there is no indication of a potential cave-in.

Stable Rock *means natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving-in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.*

Selection of Protective Systems

Protective systems must have the capacity to resist all loads without failure.

Protective systems are divided into two categories:

- Sloping and benching systems
- Support systems, shield systems, and other protective systems

The use of either of these two categories of protective systems requires the choice of one of four design options.

NOTE: Protective systems for excavations over 20 feet in depth must be designed by a registered professional engineer.

Speed Shore Corp.

Protective Systems [29 CFR 1926.652(a)]

Excavations and trenches less than five feet deep must still be sloped, benched, or otherwise supported when a Competent Person determines there is indication of a cave-in.

Be careful not to get caught up on just the five foot depth requirement. Consider work practices in a shallow trench as well (i.e. working hunched over or on hands and knees).

Selection of Protective Systems

Protective systems are divided into two categories and include four choices in each:

1. Sloping and benching systems; and
2. …everything else.

The basic systems for protecting employees from cave-ins are *sloping*, *benching*, *shoring*, and *shielding*. The system that you should use depends on factors such as soil type and water content, excavation depth and width, the nature of the work, and nearby activities that could increase the risk of a cave-in. The competent person has the responsibility for considering these factors and for determining the appropriate protective system. A registered professional engineer must design protective systems for all excavations that are more than 20 feet deep.

(from OR-OSHA's publication titled, "Excavations" Pub. #440-2174 (6/06)).

Requirements for Protective Systems
{Division 3/Subdivision P 29 CFR 1926.652}

Sloping and Benching Options [29 CFR 1926.652(b)]

The four options include:

1. Sloped no steeper than 1 1/2:1 (34 degrees); or
2. Maximum allowable slopes and configurations per Appendix A & B; or
3. Designs using other tabulated data; or
4. Design by a registered professional engineer.

Option 1 allows excavations sloped at an angle no steeper than 1 1/2:1 (34 degrees).

- This sloping option must be in accordance with the configurations shown for Type C soil in Appendix B (sloping & benching).

Option 2 allows sloping and configurations in accordance with the conditions and requirements in Appendix A (soils) and Appendix B (sloping & benching).

Soil or Rock Type	Maximum allowable slopes for Excavations Less than 20 feet deep.
Stable Rock *Type A* *Type B* *Type C*	*Vertical (90 degrees)* *3/4 : 1 (53 degrees)* *1 : 1 (45 degrees)* *1 1/2 : 1 (34 degrees)*

Option 3 allows designs of sloping or benching systems from other tabulated data.

- Must identify the parameters effecting the selection of the slope or bench system, limitations, and any other necessary explanatory information aiding the user in selecting correctly.
- Must be kept on the jobsite during construction of the system.

Option 4 allows approval from a registered professional engineer.

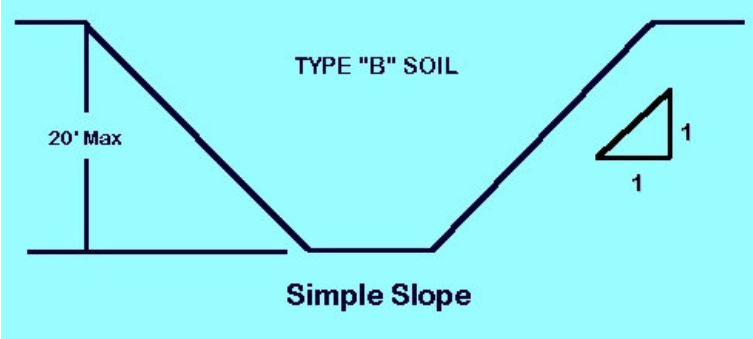
- Must include the same criteria as described above in Option 3.

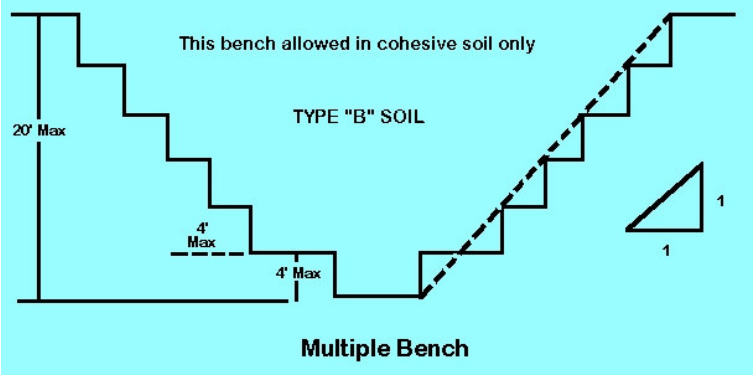
Sloping and Benching Options [29 CFR 1926.652(b)]

The four options include:

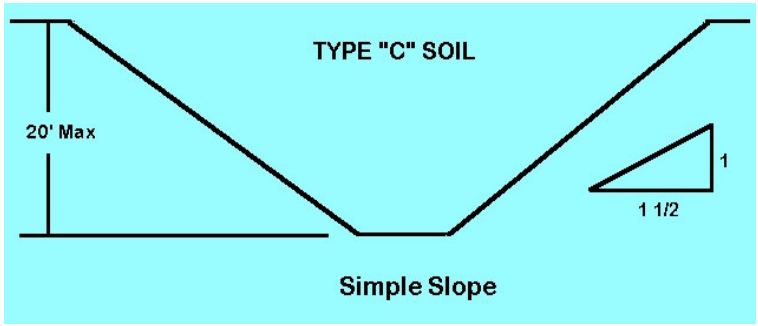
1. Slope to Type C soil (34 degrees); or
2. Slope per OSHA's Appendix A (soil classification) & B (slope & bench configurations); or
3. Designs using other tabulated data; or
4. Design by a registered professional engineer.

OR-OSHA's Appendix B begins on p. P-15 of the workbook.





Benched slopes are permitted only in type A and type B soils.



Requirements for Protective Systems
{Division 3/Subdivision P 29 CFR 1926.652}

Support, Shield, and other Protective System Options [29 CFR 1926.652(c)]

The four options include:

1. Designs using Appendix A and Appendix C or Appendix D; or
2. Designs using manufacturer's tabulated data; or
3. Designs using other tabulated data; or
4. Design by a registered professional engineer.

Option 1 allows the use of Appendices A **and** C, or D.

- Appendix A is soil classification
- Appendix C is timber shoring
- Appendix D is aluminum hydraulic shoring

Option 2 allows the use of manufacturer's tabulated data.

- Must be in accordance with all manufacturer's specifications, recommendations, and limitations. Deviations can only be approved by the manufacturer.
- Data must be in writing and kept at the jobsite during construction of the protective system.

Option 3 allows the use of *other* tabulated data.

- Must identify the parameters effecting the selection, limitations, and any other necessary explanatory information aiding the user in selecting correctly.
- Must be kept at the jobsite during construction of the protective system.

Option 4 allows approval from a registered professional engineer.

- The design must be in writing and kept at the jobsite during construction of the system.

Support, Shield, and other Protective System Options [29 CFR 1926.652(c)]

The four options include:

1. Designs using OSHA's Appendix A (soil classification) & C (timber shoring) or D (aluminum hydraulic shoring); or
2. Designs using manufacturer's tabulated data; or
3. Designs using other tabulated data; or
4. Design by a registered professional engineer.

OR-OSHA's Appendix C begins on p. P-23 of the workbook and Appendix D begins on p. P-33 of the workbook.

The following is taken from OR-OSHA's publication titled, "Excavations" Pub. #440-2174 (6/06): Shoring and shielding systems prevent cave-ins in excavations with or without sloped or benched faces. The safest way to install and remove them is from outside the excavation.

Shores are vertical or horizontal supports that prevent the faces of an excavation from collapsing. Vertical shores are called uprights. They're easy to install, relatively inexpensive, and often used in stable soil or in shallow excavations that have parallel faces. Vertical shores must be sized for the excavation's dimensions and soil type.

Horizontal shores are called *walers*. Walers are often used when unstable soil makes sloping or benching impractical and when sheeting is necessary to prevent soil from sliding into the excavation.

Shields provide employees a safe work area by protecting them from collapsing soil. Shields don't prevent cave-ins but "shield" workers if a face does collapse. They are usually placed in the excavation by heavy equipment.

Shoring and shielding systems are available from manufacturers in a variety of dimensions, usually aluminum or steel, or they can be custom-built from *tabulated data* approved by a registered professional engineer. Manufacturers will also provide tabulated data with their systems that includes engineering specifications, depth ratings, special instructions, and system limitations. Only by carefully studying and understanding the manufacturer's tabulated data can the competent person choose the correct protective system.

Requirements for Protective Systems
{Division 3/Subdivision P 29 CFR 1926.652}

Materials & Equipment [29 CFR 1926.652(d)]

- Materials and equipment used for protective systems must be free from damage or defects that might impair their proper function.
- Manufactured materials and equipment used for protective systems must be used and maintained in a manner that is consistent with manufacturer specifications.
- A Competent Person shall examine damaged material or equipment to evaluate its suitability for continued use.

Installation and Removal [29 CFR 1926.652(e)]

- Support system members are to be securely connected to prevent sliding, falling, kickouts, or other predictable failures.
- Installation should begin at the top and progress to the bottom of the excavation. Removal shall begin at the bottom and progress to the top.
- Members shall be released slowly so as to note any indication of possible failure of the system or the excavation.
- Backfilling shall progress together with the removal of support systems.

Trench Support [29 CFR 1926.652(e)(2) & (g)(2)]

- Material may be dug to a level no more than 2 feet below the bottom members of a support system if the system is designed to resist the forces calculated to the full depth of the trench, and there is no indication of soil loss from behind or below the bottom of the support system.

Sloping/Benching [29 CFR 1926.652(f)]

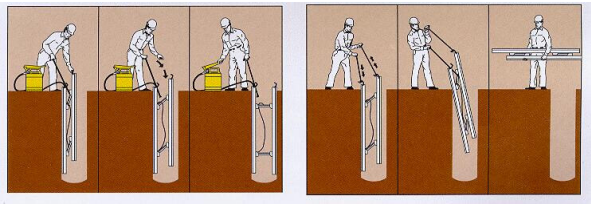
- Employees may not work on the faces of slopes or benches above other workers unless the workers at the lower level are protected from the hazard of falling, rolling, or sliding material or equipment.

Shield System [29 CFR 1926.652(g)]

- Shields shall be installed in a way that will restrict lateral or other hazardous movement of the shield in the event of sudden lateral pressures.

Requirements for Protective Systems [CFR 1926.652(d-g)]

Installation should begin at the top and progress to the bottom of the excavation. Removal shall begin at the bottom and progress to the top. Members shall be released slowly so as to note any indication of possible failure of the system or the excavation.



American Shoring Inc.

Shield System [29 CFR 1926.652(g)]

Shields shall be installed in a way that will restrict lateral or other hazardous movement of the shield in the event of sudden lateral pressures. Vague rule - judgment call! They must be snug and/or backfilled around. Shields are not designed to withstand significant lateral forces.

American Shoring Inc.

The following is from a Federal OSHA Letter if Interpretation, dated 10/20/99. The question is whether the Federal OSHA standard addresses the issue of how far a trench shield can be from a trench wall. ***ANSWER*** *– "…(if) a shield were used to provide (cave-in) protection, §1926.652(g)(1)(ii) would require the shield to be "...installed in a safe manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads." Therefore, although our standard does not set a maximum distance between a shield box and a trench face, an employer would be required to ensure that, in the event of a collapse of the face, the shield would not move laterally. Trench work is frequently performed with limited room for maneuver, which means that workers can be injured with just a little movement by a trench shield."*

"The closer a properly constructed trench shield is to the trench wall, the less chance there is that it could be dislodged by a lateral force. As a practical matter, unless the shield were braced to prevent this type of movement, in most instances an employer would have to keep the shield quite close to the face. The employer's competent person would have to make the determination of whether the shield was close enough to the wall to ensure that there would be no lateral movement."

Be sure the shield is designed to be pulled.

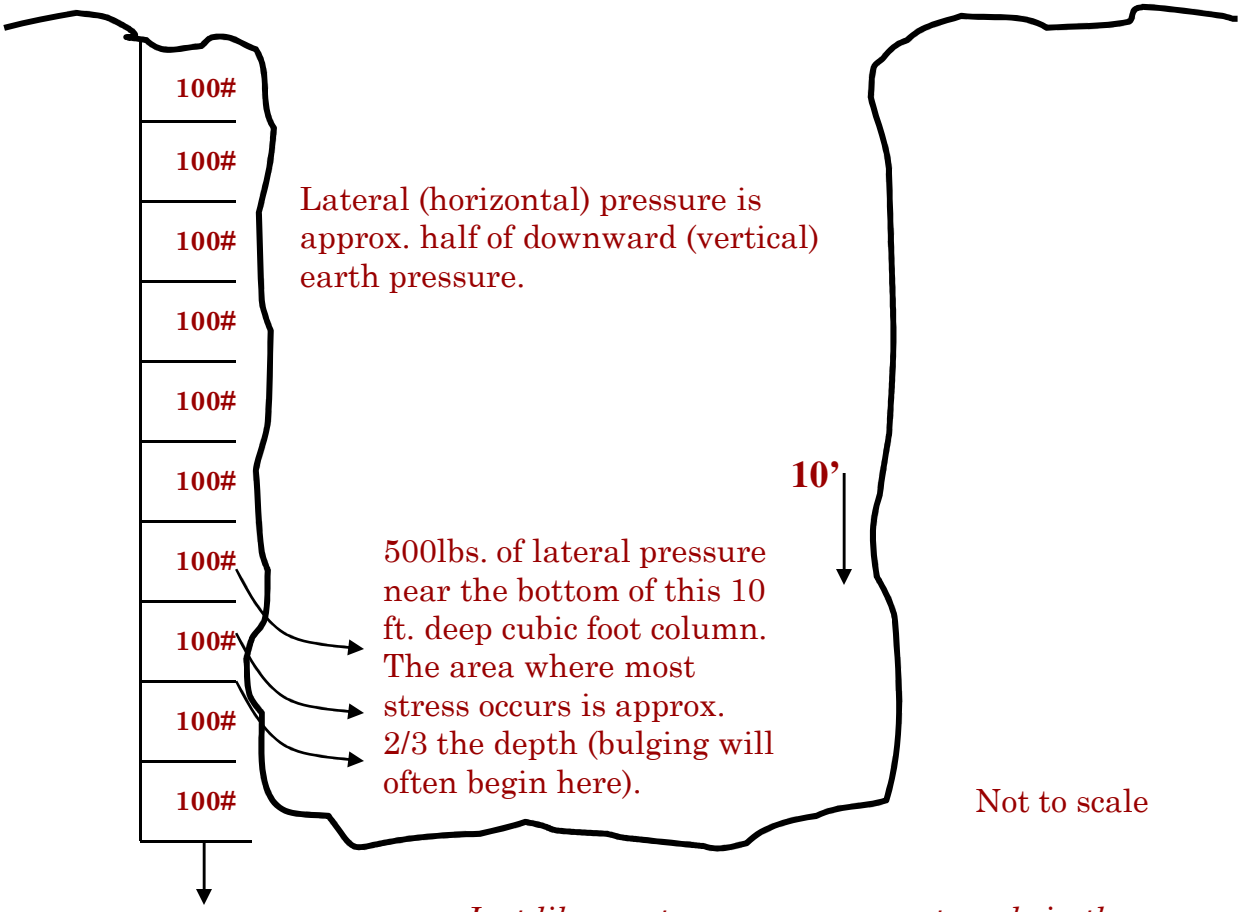
Again, remain cognitive of safe rigging practices.

Only manufactured shear pins when stacking compatible shields.

Workers must be protected from the hazard of cave-ins when entering or exiting the areas protected by shields.

Workers must not be allowed in shields when shields are being installed, removed, or moved vertically.

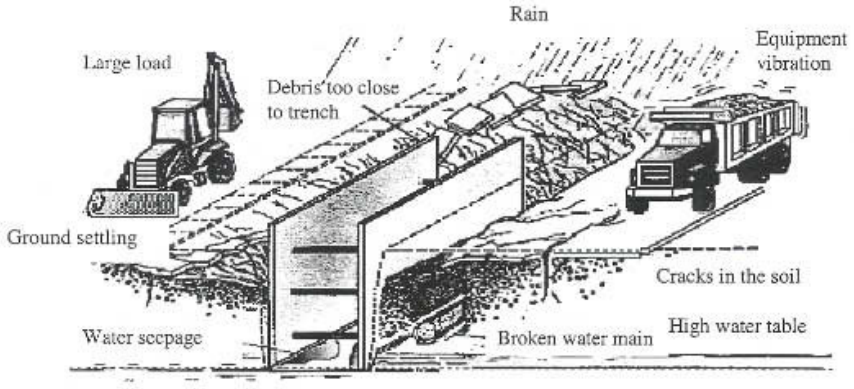
Assuming soil weight at approx. 100 lbs/cu. ft.



Just like a cut on our arm - a cut made in the earth's surface will eventually "heal". All trenches and excavations will eventually cave-in. We just don't know when.

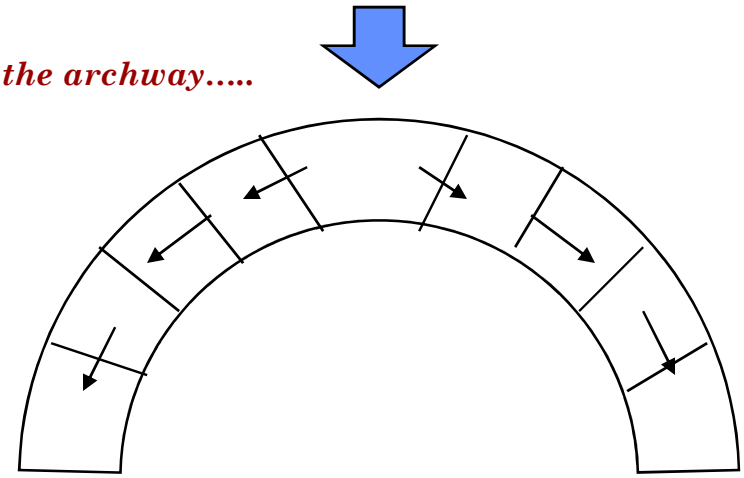
How long trench walls stand depend primarily on soil type and weight, moisture, and organic material.

There are already naturally occurring forces attempting to cave in the trench. In addition, other factors are involved to promote the cave-in such as super imposed loads at the edge of the trench (spoils pile, excavating equipment), fissures and tension cracks, vibration, water, and previous disturbed soils.



How Hydraulic Shoring Works

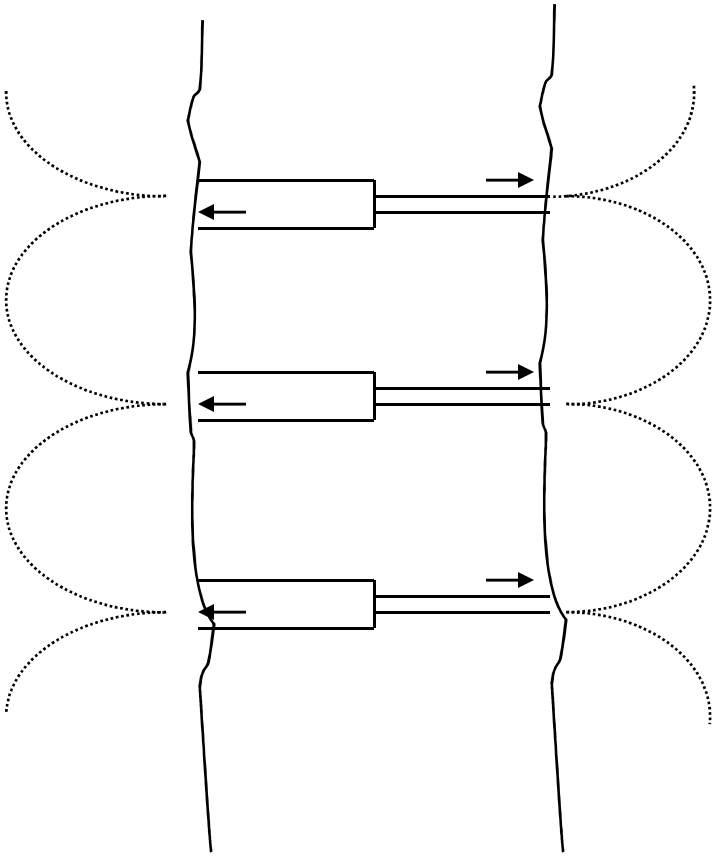
Like the design of the archway…..



Vertical pressure attempts to knock the top keystone out; however, by design, the top keystone applies pressure to the others and equilibrium is maintained.

Hydraulic shoring creates this 'arching' effect and counters (pushes back) the earth's lateral forces:

Lateral Forces



Lateral Forces

Top view

Not to scale

In Compliance with the Americans with Disabilities Act (ADA), this publication is available in alternative formats by calling the OR-OSHA Public Relations Manager at (503) 378-3272 (V/TTY).