

ENVIRONMENTAL HEALTH & SAFETY
THE UNIVERSITY OF TEXAS AT TYLER



TRENCHING AND
EXCAVATION PROGRAM

2023

Introduction:	3
Purpose:	3
Application:	3
Definitions:	3
Excavation Procedures:	6
Protective Systems:	10
Contractor Information:	14
Training:	15
Record Retention:	15
Annual Compliance Review:	15
Revisions	15
Appendix A:	16
Appendix B:	17
Appendix C:	23
Appendix D:	26
Appendix E:	29
Appendix F:	30

Introduction:

The University of Texas at Tyler Environmental Health and Safety department has developed this Trenching and Excavation Safety Program to ensure a safe work environment and to protect the health and safety of University Staff and any contractors or vendors working on University property. This program was written with guidance from OSHA guidelines, the University of Texas System Construction Safety Program, and on-site Job Hazards Analyses.

Purpose:

The purpose of the University Trenching and Excavation Program is to establish requirements for safe trenching, excavating and shoring activities at The University of Texas at Tyler. The intent is to ensure any activity involving trenching and excavating is conducted in a manner to minimize risk to employees, property, students, visitors and contractors.

Application:

This program applies to work performed by any UT Tyler employee, student, or contractor performing work that involves trenching and excavation. This program sets forth the practices required for trenches or excavations with a depth of four feet or greater along any portion of its length that will be entered by anyone on UT Tyler's campus. All excavations or trenches 4 feet or greater in depth shall be appropriately benched, shored, or sloped according to the procedures and requirements set forth in this policy. Excavations or trenches 20 feet deep or greater must have a protective system designed by a registered professional engineer.

Definitions:

Aluminum Hydraulic Shoring: a manufactured shoring system consisting of aluminum hydraulic cylinders (cross braces) used with vertical or horizontal rails designed to support sidewalls of an excavation.

Bell-Bottom Pier Hole: a shaft or footing excavation, the bottom of which is made larger than the cross section above to form a bell shape.

Benching: a method of protecting workers from cave-in by excavating the sides of an excavation to form one or more horizontal steps, usually with vertical or near-vertical surfaces between levels.

Cave-in: the movement of soil or rock into an excavation, or the loss of soil from under a trench shield or support system, in amounts large enough to entrap, bury, or otherwise injure and immobilize a person.

Competent Person: one who has been trained to identify existing and predictable hazards in the workplace, or working conditions that are unsafe for workers, and who has the authority to have these hazards corrected, stopping the work if necessary. The Designated Supervisor of an excavation is chosen by the department and serves as the Competent Person for the purposes of this program.

Cross Braces: the horizontal members of a shoring system installed from side to side of the excavation. The cross braces bear against either uprights or wales.

Excavation: any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

Faces or Sides: the vertical or inclined earth surfaces formed as a result of excavation work.

Failure: the movement or damage through breakage, displacement or permanent deformation of a structural member or connection of equipment that makes it unable to support loads.

Hazardous Atmosphere: an atmosphere that is explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, that may cause death, illness, or injury.

Kick out: the accidental movement or failure of a cross brace.

Layered Geological Strata: where soil types are configured in layers. The soil should be classified on the basis of the weakest soil layer classification. Each layer may be classified individually if a more stable layer lies below a less stable layer. (See Soil Types)

Protective System: a method of protecting workers from cave-ins or any other failures, from material that could fall or roll from an excavation face 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.

Ramp: an inclined walking or working surface that is used to gain access to one point from another. A ramp may be constructed from earth or from structural materials such as steel or wood.

Registered Professional Engineer: a person who is registered as a Professional Engineer in the state of Texas.

Soil Types:

Type A - Most stable: clay, silty clay and hardpan. No soil is Type A if it is fissured, is subject to vibration, has previously been disturbed or has seeping water.

Type B - Medium stability: silt, sandy loam, medium clay and unstable dry rock. Previously disturbed soils, except those that would be classified as Type C. Also, soil that meets the requirement of Type A soil but is fissured or subject to vibration.

Type C - Least stable; gravel, sand, loamy sand, soft clay, submerged soil or dense unstable rock, or soil from which water is freely seeping.

Sheeting: the members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.

Shield (Shield System): a structure used in an excavation that is able to withstand cave-ins and which will protect those working within the shield system. Shields can be permanent structures or portable units moved along as work progresses. Shields used in trenches are usually referred to as "trench boxes" or "trench shields."

Shoring (Shoring System): a structure that is built or put in place to support the sides of an excavation and designed to prevent cave-ins.

Sloping (Sloping System): sloping the sides of the excavation away from the excavation to protect employees from cave-ins. The required slope or angle of incline will vary with soil type, weather and surface or near surface loads that may affect the soil in the area of the trench (such as adjacent building, vehicles near the edge of the trench).

Stable Rock: natural solid mineral material that can be excavated with vertical sides that will remain intact while exposed.

Structural Ramp: a ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock are not considered structural ramps.

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

(TSF): tons per square foot

Uprights: the vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other. Uprights placed so that individual members are closely spaced, in contact with or interconnected to each other, are often called "sheeting."

Wales: horizontal members of a shoring system placed in the direction of the excavation face whose sides bear against the vertical members of the shoring system or earth (the uprights or sheeting).

Excavation Procedures

Underground Utility Impact

- Prior to any excavation or trenching operations, the project supervisor must determine if underground utilities may be present or impacted by the project. A pre-work site inspection should be completed by the site supervisor, utilities personnel, Environmental Health and Safety, and Facilities Management.
- Any underground utilities (gas, sewer, data, water, and electric lines) must be clearly marked on the surface prior to any excavating. (refer to table 1 for utility markings)
- If utilities are present or impacted by the project, the designated supervisor must arrange to have the utilities protected, removed or relocated as directed by UT Tyler Facilities.
- Excavation must be done in a manner that does not endanger the underground installations or those engaged in the work. Barricades, shoring, suspension or other means as necessary can be utilized to protect utilities left in place during excavations/trenching.

Table 1: Underground Utility Marking Colors

	RED – Electric power lines, cable, conduit and lighting cables
	YELLOW – Gas, oil, steam, petroleum or gaseous materials
	ORANGE – Communication, alarm, signal lines, cable, or conduit
	BLUE - Water
	PURPLE – Reclaimed water, irrigation, and slurry lines
	GREEN – Sewers and drain lines
	PINK – Temporary survey markings
	WHITE – Proposed excavation

Stability of Adjacent Structures

- The supervisor must take precautions as needed to protect workers, nearby buildings or other structures. A Registered Professional Engineer should evaluate these structures and recommend precautions such as shoring, bracing, or underpinning. The supervisor must ensure that the recommendations of the engineer are carried out. Plans that outline the design of such precautions approved by the engineer will be maintained on site while the work is in progress.

Protection of the Public

- Barricades, walkways, lighting and signs must be provided for the protection of the public before the start of excavation operations. Guardrails, fences or barricades will be provided adjacent to walkways, driveways and other pedestrian or vehicle thoroughfares.

Protecting Workers in Excavations

- The Supervisor must assure that workers are protected from hazards that may arise during excavation work.
- Stairs, ladders or ramps should be provided when workers enter excavations over four (4) feet deep. Two (2) or more means of exit will be provided if the excavation is more than 20 feet in length. A means of exit will be provided every 25 feet of trench length.
- A competent person, qualified in structural design, will design structural ramps used for egress or access of equipment. The ramp will be constructed in accordance with the design. Ramps with two (2) or more structural members will have the structural members that are uniform thickness and connected together to prevent displacement and will not present a tripping hazard. Ramps must have a slope of 20 degrees or less.
- Those workers exposed to vehicular traffic will wear warning vests made of high visibility material.
- No one will work underneath loads handled by lifting or digging equipment. Workers will stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials.
- A warning system will be used when mobile equipment is operated next to the edge of an excavation if the operator does not have a clear, direct view of the edge of the excavation.
- Materials and equipment should be kept at least two (2) feet from the edge of the excavation with the proper protective system in place.
- Spoil Piles that are less than four feet (4') in height shall be at least two feet (2') from the edge of any excavation. Spoil piles greater than four feet (4') in height shall add one foot (1') of distance from the excavation for every additional foot in height.
- Trench excavations should be backfilled at the end of each shift.

Hazardous Atmospheres and Confined Spaces

- Workers will not be permitted to work in hazardous and/or toxic atmospheres. Such atmospheres include those with the following:
 1. Atmospheric oxygen concentration below 19.5% or above 23.5%.
 2. A combustible gas concentration greater than 10% of the lower flammable limit.
 3. Concentrations of hazardous substances that exceed those specified in the Threshold.
 4. Limit Values (TLVs) for airborne contaminants established by the American Conference of Industrial Hygienists (ACGIH).
- The above hazards are typically monitored with a confined space 4-gas air monitoring meter. Additional information regarding confined space entry and air monitoring can be found in the UT Tyler Confined Space Safety Program, available at <https://www.uttyler.edu/safety/>
- If there is any possibility that the trench or excavation could contain a hazardous atmosphere, the Designated Supervisor will ensure that atmospheric testing is

conducted before worker entry and continuously during work. Excavations near underground storage tanks or those that contain gas pipelines will be monitored. Suitable precautions will be taken as necessary to protect workers. These precautions may include the following:

1. Engineering controls such as ventilation;
2. Respiratory protection; those required to wear respiratory protection must be enrolled in the University of Texas at Tyler Protection Program. Enrollment in the program requires workers to:
 - A. Complete respiratory protection training (EH&S provides training for air purifying respirators);
 - B. Obtain a fit test provided by EH&S;
 - C. Complete a medical examination; and
 - D. Maintain annual re-certification.

Fall Protection: Fully Body Harness and Lifelines

- Trenches and excavations, which are classified as permit required confined spaces (those where atmospheric hazards exist) may be required to have rescue equipment on hand in the event of an emergency.
 1. Rescue equipment can include a full body harness and lifeline to be used to raise personnel safely from an excavation during an emergency.
 2. For additional information on rescue equipment used during confined space emergencies, consult the UT Tyler Confined Space Entry Safety Program.
- Another instance when fall protection may be necessary is for personnel working outside the excavation/trench where a fall hazard exists.
 1. If a fall hazard of 6-feet or more is present on the side of an excavation/trench, personnel standing on the top of the trench are in a position where a fall hazard exists and should be tied off using a full body harness and either a retractable lifeline or lanyard of appropriate length.
 2. For additional information regarding protection from fall hazards, please consult the UT Tyler Fall Protection Safety Program.

Personal Protective Equipment

- The Designated Supervisor will ensure that all workers wear required personal protective equipment (PPE) as detailed below. Hardhats, safety eyewear, gloves, hearing protection and fall protection devices will be furnished by the employee's supervisor. The employer must ensure that anyone conducting work in excavations wears PPE approved by the American National Standards Institute (ANSI).
- The following PPE is required during excavation/trenching activities:
 1. Personnel working in trenches or excavations will wear ANSI approved hardhats at all times.
 2. Personnel working in trenches or excavations will wear ANSI approved steel-toed shoes or boots.

3. Where there is potential for exposure to flying fragments, dust or other materials produced by drilling, sawing, sanding, grinding and similar operations will wear ANSI approved safety glasses with side shields.
4. Where there is a potential for exposure to hazards produced through welding, cutting, or brazing must wear approved eye protection or a welding face shield/helmet and must be accompanied by a hot work permit supplied by the university's Environmental Health & Safety.
5. Where fall hazards exist; or where rescue operations may be necessary, personnel must wear a full body harness and be tied off at all times to an approved lifeline or anchor point.
6. Hand protection must be made available to employees based on the hazards of the work being performed.
7. To determine the appropriate PPE to be utilized during a specific excavation or trenching activity, the supervisor should conduct a job-hazard assessment and ensure all hazard are addressed prior to personnel entering a trench.

Walkways and Guardrails

- Walkways must be provided where workers or equipment are allowed to cross over excavations.
- Guardrails must be provided on walkways used by the general public regardless of the height above the excavation.
- Guardrails must be provided on walkways used only by on-site personnel if the walkway is six (6) feet or more above lower levels. This will protect personnel on the top/edge of an excavation from a fall hazard and eliminate the need for a full body harness and tie off when working outside of the trench.
- Guardrails with toe boards must be provided when/if workers pass below a walkway.

Hazards Associated with Water Accumulation

- Anytime a trench/excavation exists, there is a potential for water to accumulate, which may pose additional hazards to personnel entering the trench/excavation.
- Personnel may not work in excavations with standing water or where water is collecting unless the Supervisor gives prior approval or instruction.
- Methods for controlling water accumulation should be provided and consist of the following if anyone must work in the excavation:
 1. Use of special support or shield systems approved by a Registered Professional Engineer.
 2. Water removal equipment, such as a water pump, used and monitored by the Supervisor or a designated employee.
 3. Use of safety harnesses and lifelines.
- Work in excavations during a rainstorm is prohibited.
- Trenches must be inspected by the Supervisor after each rain and before anyone is permitted to re-enter the excavation.

Protection of Workers from Falling Objects

- The Supervisor must ensure that workers are protected from loose rock or soil that could fall or roll from an excavation face. Protective measures may consist of:
 1. Scaling to remove loose material;
 2. Installation of barricades such as wire mesh or timber as needed to stop and contain falling material.
 3. Sloping may be used instead of barricades when practical.
- Workers must be protected from excavated materials, equipment or other objects that could pose a hazard by falling or rolling into excavation. These materials or equipment must be maintained at least two (2) feet from the edge of the excavation or otherwise restrained. Materials piled, grouped or stacked near the edge of an excavation must be stable and self-supporting.

Inspections

- The Supervisor must conduct daily inspections of excavations, adjacent area and protective systems for evidence that could result in a cave-in, failure of protective systems, hazardous atmospheres or other hazardous conditions.
- Inspections must be conducted before the start of work and as needed throughout the shift. Inspections will also be made after every rainstorm.
- Inspections are only required when the trench will be or is expected to be occupied.
- When a hazardous condition is found, exposed workers will be removed from the area until precautions have been taken to assure their safety.
- Inspections must be documented in writing and kept on-site.
- Contractors and UT Tyler employees may use the Daily Trench Inspection form located on the EHS website.

Protective Systems

Selection of Protective Systems

- Personnel working in an excavation must be protected from cave-ins by using an adequate sloping and benching system; or an adequate support or protective system.
- The only exceptions are when the excavation is made entirely in stable rock or the excavation is
 1. Less than four (4) feet in depth where examination of the ground by the Supervisor provides no indication of a potential cave-in.
- Excavations 20 feet or less: The decision tree in Appendix F (See appendix F of this Plan) will be used to determine the appropriate section of protective systems used in excavations 20 feet or less in depth.
- Excavations greater than 20 feet in depth: A registered professional engineer must design all excavations greater than 20 feet in depth.

Soil Classification

- In order to design the most appropriate protective system, the Supervisor must determine the soil type using a visual test with one or more manual tests as required by the university. Additional information regarding soil classification can be found in Appendix A – Soil Classification.
 1. Visual Test
 - A. During the visual test, the entire excavation site including the soil adjacent to the site must be observed.
 - B. The Supervisor will check for crack-line openings along the failure zone that indicate tension crack and observe the open side of the excavation for indications of layered geologic structuring.
 - C. Other conditions to look for are signs of bulging, boiling, or sloughing, as well as signs of surface water seeping from the side of the excavation or from the water table.
 2. Manual Tests
 - A. Thumb Penetration Test
 - I. The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. (This test is based on the thumb penetration test described in American Society for Testing and Materials (ASTM) Standard designation D2488 - "Standard Recommended Practice for Description of Soils (Visual - Manual Procedure).") Type A soils with an unconfined compressive strength of 1.5 psf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 psf can be easily penetrated several inches by the thumb and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a minimum the effects of exposure to drying influences. If the excavation is later exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly.
 - B. Dry Strength Test
 - I. If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it is granular (any combination of gravel, sand, or silt). If the soil is dry and falls into clumps which break up into smaller clumps, but the smaller clumps can only be broken up with difficulty, it may be clay in any combination with gravel, sand or silt. 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 un-fissured. Also, plasticity or Wet Thread Test.

- II. 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 material can be successfully rolled into threads without crumbling. For example, if at least a two-inch (50 mm) length of 1/8-inch thread can be held on one end without tearing, the soil is cohesive.

Specialized soil strength testing equipment including a penetrometer, shear vane or torvane may also be used to determine the unconfined compression strength of soils.

Types of Protective Systems

The following systems can be used to protect workers from cave-ins in trenches of more than four (4) feet deep. The Supervisor should select the method of protection that is most suitable for the particular job site, taking into consideration soil type and surrounding structures. If the soil is not classified, then the excavation must be sloped at an angle not steeper than one and a half horizontal to one vertical.

Sloping (See Appendix B – Sloping and Benching for additional information)

- Maximum allowable slopes for excavations less than 20 feet deep based on soil type and angle to the horizontal are as follows:

Soil Type	Height/Depth Ratio	Slope Angle
Stable Rock	Vertical	90°
Type A	¾ : 1	53°
Type B	1 : 1	45°
Type C	1 ½ : 1	34°

Benching (See Appendix B – Sloping and Benching for additional information)

- There are two types of benching:
 1. “Single, One level or step,” not exceeding 4 feet in height.
 2. “Multiple, more than one level or step” each not to exceed four feet in height.
- Benching can be used in conjunction with simple sloping. Benches must be below the maximum allowable slope for that soil type.
- Benching is not permitted in Type C soil.

Shoring

Shoring is used when the location or depth of the trench makes sloping back to the maximum allowable slope impractical. There are two basic types of shoring: timber and aluminum hydraulic. See Appendices C and D for additional information regarding shoring.

- Timber Shoring
 1. The Supervisor will use the information in the tables of Appendix C of this plan - Timber Shoring for Trenches to determine the appropriate manner to incorporate timber shoring.
 2. The members of the shoring system that are to be selected using the tables are the cross braces, the uprights, and the “Wales” where Wales are required.
 3. The Supervisor will select the size and spacing of members using the appropriate table. The selection will be based on the depth and width of the trench where the members are to be installed.
 4. In most instances, the selection is also based on the horizontal spacing of the cross braces.
 5. Where a choice is available, the horizontal spacing of the cross braces must be chosen before the size of any member can be determined.
- Hydraulic Aluminum Shoring
 1. Hydraulic shoring provides a critical advantage over timber shoring because workers do not have to enter the trench to install them. They are also light enough to be installed by one worker, they are gauge-regulated to ensure even distribution of pressure along the trench line and they can be adapted easily to various trench depths and widths.
 2. Hydraulic Shoring Support Systems must be constructed and used in accordance with all specifications, recommendations and limitations issued by the manufacturer.
 3. Hydraulic shores must be installed in accordance with Appendix D - Aluminum Hydraulic Shoring for Trenches. (See Appendix D to this plan). The Supervisor must use the tables in this standard to determine the maximum vertical and horizontal spacing that may be used with various aluminum member sizes and various hydraulic cylinder sizes.
 4. All shoring must be installed from the top down and removed from the bottom up. The Supervisor will inspect all hydraulic shoring at least once per shift for leaking hoses and/or cylinders, broken connections, cracked nipples, bent bases, and any other damaged or defective parts. This inspection will be documented in writing. The top cylinder of hydraulic shoring will be no more than two feet from the top edge of the excavation. Two feet of trench may be exposed beneath the bottom of the rail or plywood sheeting, if used.

Shielding

- Shielding differs from shoring because instead of shoring up or otherwise supporting the trench face, they are intended primarily to prevent cave-in of the trench walls. Trench boxes are generally used in open areas but may be used in combination with sloping and benching. For additional information regarding alternatives to shoring refer to Appendix E.
- The following safety measures must be followed during shielding operations:
 1. Inspect trench boxes for good condition before each use.

2. Minimize the excavated area between the outside of the trench box and the face of the trench.
3. Backfill the space between the trench box and the excavation side to prevent lateral movement of the box.
4. Ensure the trench box is extending at least 18-inches above the surrounding area if there is sloping toward the excavation. Providing a sloped area adjacent to the box
5. Ensure the shields ride two feet above the bottom of the excavation provided they are calculated to support the full depth of the excavation and there is no caving under or behind the shield.
6. Modifications to the shield must only be completed or approved by the manufacturer.
7. Workers must enter and leave the shield in a protected manner, such as by a ladder.
8. Workers may not remain in the shield while it is being moved.

Design by a Professional Engineer

- A Registered Professional Engineer may design sloping, benching, shoring and shielding systems. The design will be written and must include the following:
 1. A plan indicating the sizes, types and configurations of the materials to be used in the protective system.
 2. The identity of the Registered Professional Engineer approving the design.
 3. At least one copy of the design must be maintained at the job site during construction of the protective system.
- A Registered Professional Engineer must approve all excavations more than 20 feet in depth.

Contractor Information

- Contractors hired by the University to perform excavation or trenching operations must have their own trenching safety policies that comply with applicable federal and state OSHA regulations.
- Contractors must coordinate with Facilities and Environmental Health and Safety early in the programming and development stages to determine their project's impact to utilities and gain approval for all trenching and excavation activities indicating that the impact to utilities has been reviewed and approved before bidding the work or proceeding with excavation.
- The contractor must coordinate with UT Tyler the identification and marking of underground utilities including sewer, telecommunication, gas, water, steam electric, etc. The contractor will arrange to have these utilities protected, removed or relocated as directed by the appropriate UT Tyler department.

Training

- Training on the purpose, content and function of the Trenching and Excavation Safety Program is required for all employees who participate in trenching/excavation operations on UT Tyler property. Training can be obtained through EH&S. Records must be kept showing training dates, attendance, items covered, and name of presenter.
- Authorized Employees
 1. Authorized employees are those who have received proper training and have been “authorized” by EH&S to conduct trenching/excavation operations when necessary. Training for authorized employees shall include all applicable areas of this program. Additional training outside of this written safety program and training may be necessary including equipment specific training provided.
 - A. Affected Employees are those whose job may require being around trenches and excavations and should include all applicable areas of this safety program and training.
- Retraining
 1. Retraining or additional training is required whenever:
 - A. There is a new or revised trenching/excavating procedure.
 - B. An authorized employee's job duties change regarding trenching/excavating.
 - C. The Trenching and Excavation Program changes.
 - D. Additional unique hazards arise, such as new equipment or modified processes.
 - E. Refresher training is recommended annually.

Record Retention:

Manufacturer’s instructions, inspection, and maintenance records must be kept for as long as the equipment is in use. The trenching and excavation inspection records must be kept a minimum of 3 years. Training records for all users must be kept at a minimum of 3 years.

Annual Compliance Review

The Environmental Health and Safety department will review the program annually to determine how the program can be improved. EH&S will strive to keep all programs up to date, with accurate information that employees, and outside contractors can rely on.

Revisions

Date	Author/Reviewer	Description/Reason for Change
5/4/2021	T Bay/ P Tate	Reviewed for latest revision/updated year/added revision section
7/7/2023	T Bay/K Stapp	Changed logo, date, layout

Appendix A - Soil Classification

Type A means cohesive soils with an unconfined compressive strength of 1.5 ton per square foot (psf) (144 kPa) 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 caliche and hardpan are also considered Type A. However, no soil is Type A if:

- The soil is fissured; or
- The soil is subject to vibration from heavy traffic, pile driving, or similar effects; or
- The soil has been previously disturbed; or
- The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H: 1V) or greater; or
- The material is subject to other factors that would require it to be classified as a less stable material.

Type B means:

- Cohesive soil with an unconfined compressive strength greater than 0.5 psf (48 kPa) but less than 1.5 psf (144 kPa); or
- Granular cohesion less soils including: angular gravel (similar to crushed rock), silt, silt loam, sandy loam and, in some cases, silty clay loam and sandy clay loam.
- Previously disturbed soils except those which would otherwise be classified as Type C soil.
- Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or
- Dry rock that is not stable; or
- Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H: 1V), but only if the material would otherwise be classified as Type B.

Type C means:

- Cohesive soil with an unconfined compressive strength of 0.5 psf (48 kPa) or less; or
- Granular soils including gravel, sand, and loamy sand; or
- Submerged soil or soil from which water is freely seeping; or
- Submerged rock that is not stable; or
- Material in a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H: 1V) or steeper.

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

Wet soil - means soil that contains significantly more moisture than moist soil, but in such a range of values that cohesive material will slump or begin to flow when vibrated. Granular material that would exhibit cohesive properties when moist will lose those cohesive properties when wet.

Appendix B – Sloping and Benching

Slope Configurations

(All slopes stated below are in the horizontal to vertical ratio)

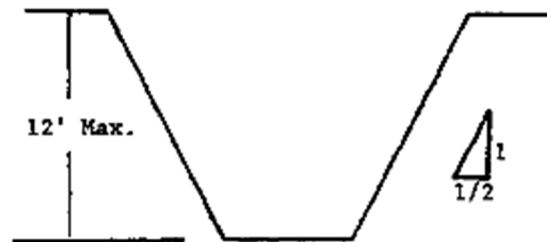
B-1.1 Excavations made in Type A soil.

1. All simple slope excavation 20 feet or less in depth shall have a maximum allowable slope of $\frac{3}{4}$:1.



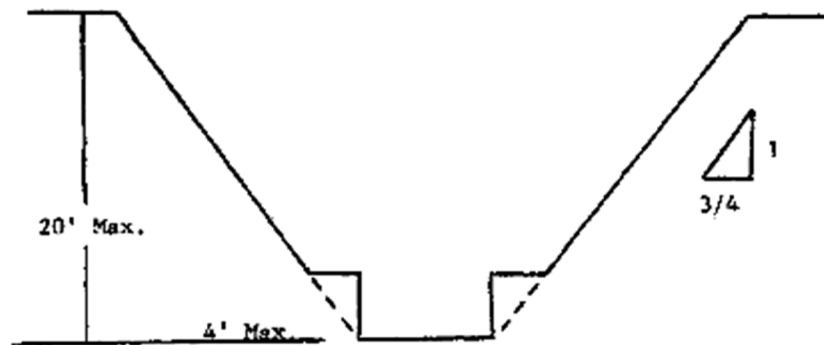
SIMPLE SLOPE -- GENERAL

Exception: Simple slope excavations which are open 24 hours or less (short term) and which are 12 feet or less in depth shall have a maximum allowable slope of $\frac{1}{2}$:1.



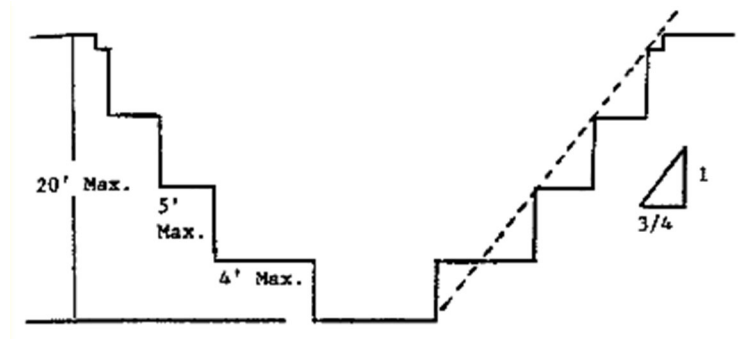
SIMPLE SLOPE -- SHORT TERM

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of $\frac{3}{4}$ to 1 and maximum bench dimensions as follows:



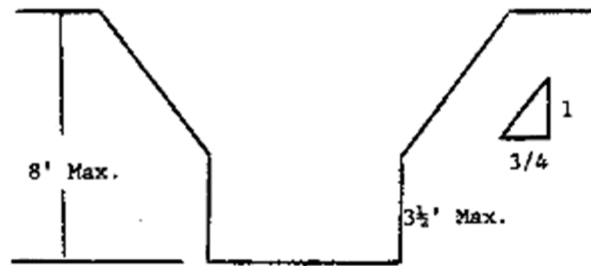
SIMPLE BENCH

Appendix B – Sloping and Benching (PG. 2)



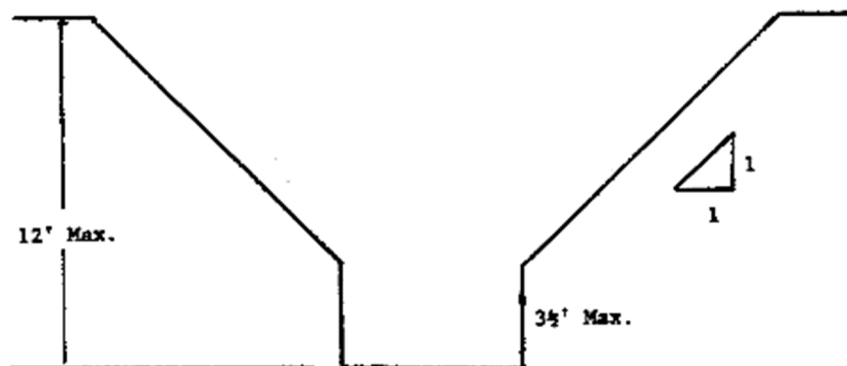
MULTIPLE BENCH

3. All excavations 8 feet or less in depth which have unsupported vertically sided lower portions shall have a maximum vertical side of 3½ feet.



UNSUPPORTED VERTICALLY SIDED LOWER PORTION -- MAXIMUM 8 FEET IN DEPTH)

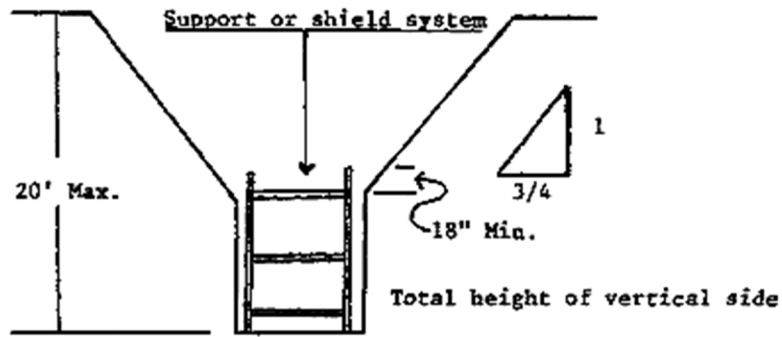
All excavations more than 8 feet but not more than 12 feet in depth with unsupported vertically sided lower portions shall have a maximum allowable slope of 1:1 and a maximum vertical side of 3½ feet.



UNSUPPORTED VERTICALLY SIDED LOWER PORTION -- MAXIMUM 12 FEET IN DEPTH)

All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded shall have a maximum allowable slope of ¾:1. The support or shield system must extend at least 18 inches above the top of the vertical side.

Appendix B – Sloping and Benching (PG.3)

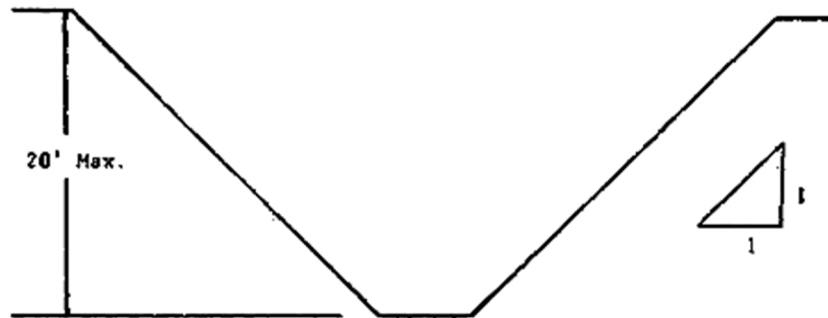


SUPPORTED OR SHIELDED VERTICALLY SIDED LOWER PORTION

4. All other simple slope, compound slope, and vertically sided lower portion excavations shall be in accordance with the other options permitted under § 1926.652(b).

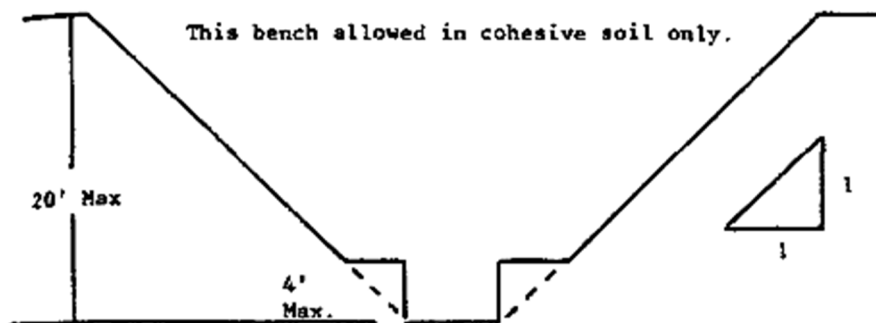
B-1.2 Excavations Made in Type B Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1.



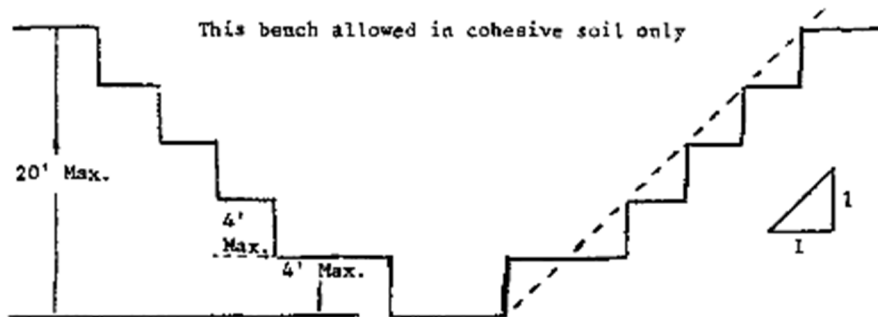
SIMPLE SLOPE

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1 and maximum bench dimensions as follows:



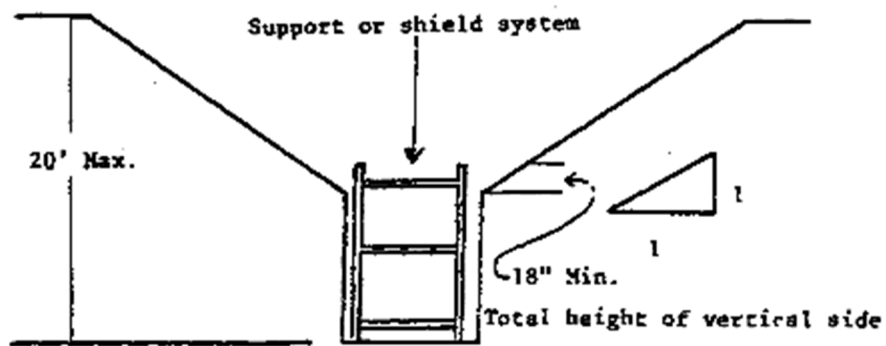
Appendix B – Sloping and Benching (PG.4)

SINGLE BENCH



MULTIPLE BENCH

3. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1:1.



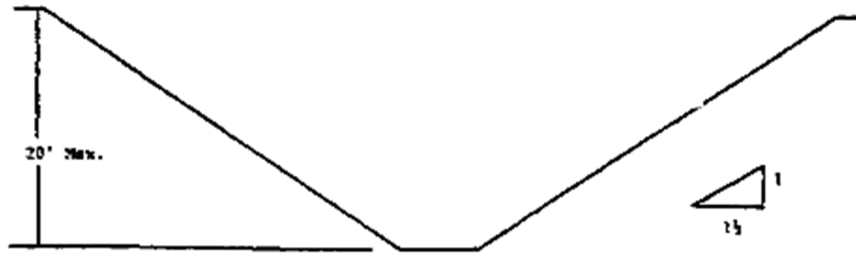
VERTICALLY SIDED LOWER PORTION

4. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

B-1.3 Excavations Made in Type C Soil

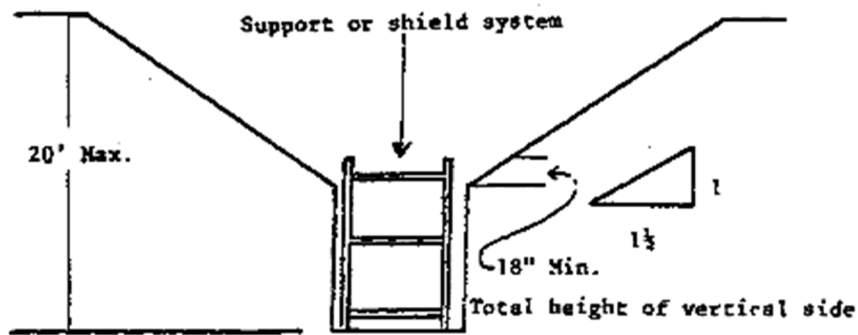
1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1½:1.

Appendix B – Sloping and Benching (PG.5)



SIMPLE SLOPE

2. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1½:1.

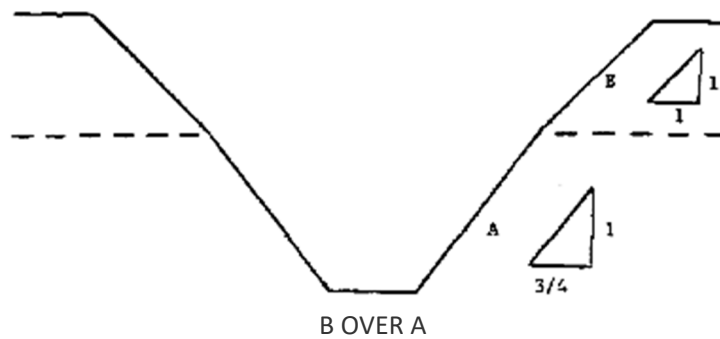


VERTICAL SIDED LOWER PORTION

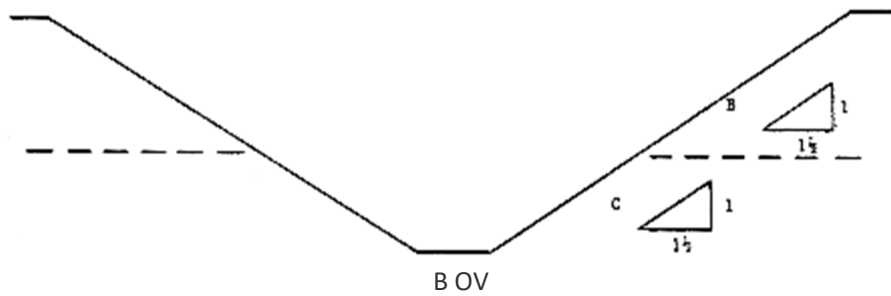
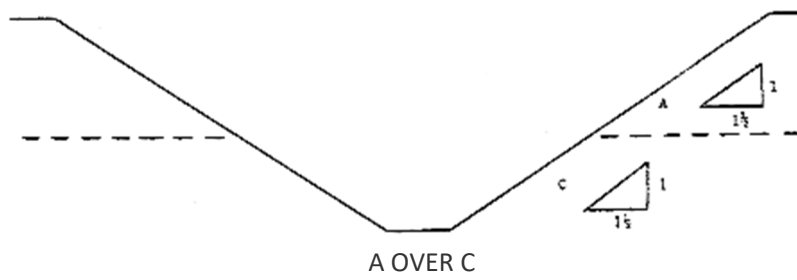
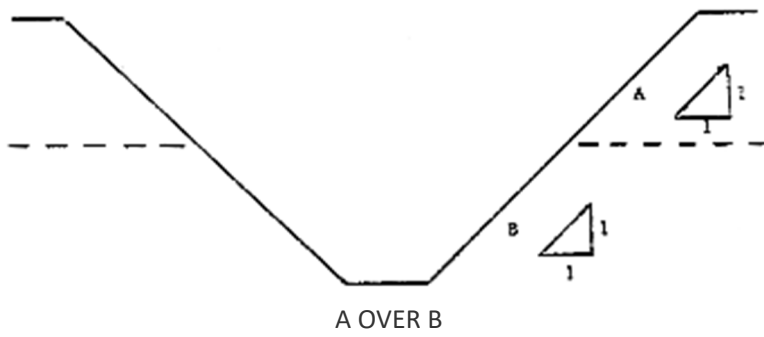
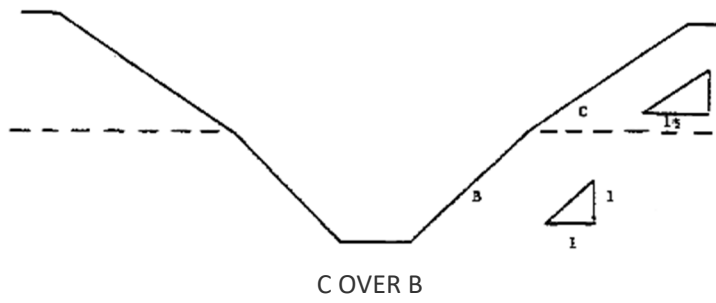
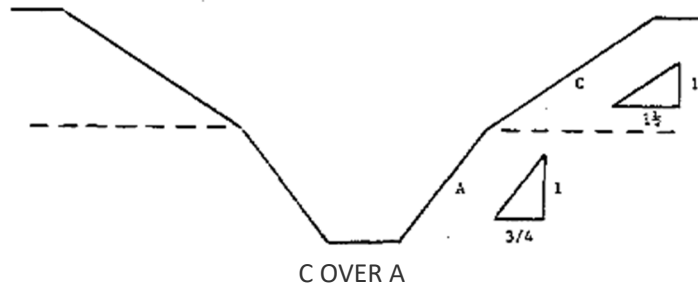
3. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

B-1.4 Excavations Made in Layered Soils

1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below.



Appendix B – Sloping and Benching (PG.6)



Appendix C – Timber Shoring for Trenches

TABLE C - 1.1 Timber Trench Shoring - Minimum Timber Requirements* SOIL TYPE A P _a = 25 X H + 72 PSF (2 FT. SURCHARGE)														
DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES			UPRIGHTS			
	Horizontal Spacing (Ft.)	WIDTH OF TRENCH (FT.)					VERTICAL SPACING (FT.)	SIZE (INCHES)	VERTICAL SPACING (FT.)	MAX. ALLOWABLE HORIZ. SPACING (FT.)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	4	5	6	8
5 to 10	Up to 6	4x4	4x4	4x6	6x6	6x6	4	Not Req'd	—				2x6	
	Up to 8	4x4	4x4	4x6	6x6	6x6	4	Not Req'd	—					2x8
	Up to 10	4x6	4x6	4x6	6x6	6x6	4	8x8	4			2x6		
	Up to 12	4x6	4x6	6x6	6x6	6x6	4	8x8	4				2x6	
10 to 15	Up to 6	4x4	4x4	4x6	6x6	6x6	4	Not Req'd	—					3x8
	Up to 8	4x6	4x6	6x6	6x6	6x6	4	8x8	4		2x6			
	Up to 10	6x6	6x6	6x6	6x8	6x8	4	8x10	4			2x6		
	Up to 12	6x6	6x6	6x6	6x8	6x8	4	10x10	4				3x8	
15 to 20	Up to 6	6x6	6x6	6x6	6x8	6x8	4	6x8	4	3x6				
	Up to 8	6x6	6x6	6x6	6x8	6x8	4	8x8	4	3x6				
	Up to 10	8x8	8x8	8x8	8x8	8x10	4	8x10	4	3x6				
	Up to 12	8x8	8x8	8x8	8x8	8x10	4	10x10	4	3x6				
Over 20	See NOTE 1.													

TABLE C - 1.2 Timber Trench Shoring - Minimum Timber Requirements* SOIL TYPE B P _a = 45 X H + 72 PSF (2 FT. SURCHARGE)														
DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES			UPRIGHTS			
	Horizontal Spacing (Ft.)	WIDTH OF TRENCH (FT.)					VERTICAL SPACING (FT.)	SIZE (INCHES)	VERTICAL SPACING (FT.)	MAX. ALLOWABLE HORIZ. SPACING (FT.)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3		
5 to 10	Up to 6	4x6	4x6	6x6	6x6	6x6	5	6x8	5			2x6		
	Up to 8	6x6	6x6	6x6	6x8	6x8	5	8x10	5			2x6		
	Up to 10	6x6	6x6	6x6	6x8	6x8	5	10x10	5			2x6		
	See Note 1													
10 to 15	Up to 6	6x6	6x6	6x6	6x8	6x8	5	8x8	5		2x6			
	Up to 8	6x8	6x8	6x8	8x8	8x8	5	10x10	5		2x6			
	Up to 10	8x8	8x8	8x8	8x8	8x10	5	10x12	5		2x6			
	See Note 1													
15 to 20	Up to 6	6x8	6x8	6x8	8x8	8x8	5	8x10	5	3x6				
	Up to 8	8x8	8x8	8x8	8x8	8x10	5	10x12	5	3x6				
	Up to 10	8x10	8x10	8x10	8x10	10x10	5	12x12	5	3x6				
	See Note 1													
Over 20	See NOTE 1.													

Appendix C – Timber Shoring for Trenches (PG. 2)

TABLE C - 1.3 Timber Trench Shoring - Minimum Timber Requirements* SOIL TYPE C P _A = 80 X H + 72 PSF (2 FT. SURCHARGE)														
DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **													
	CROSS BRACES						WALES			UPRIGHTS				
	Horizontal Spacing (Ft.)	WIDTH OF TRENCH (FT.)					VERTICAL SPACING (FT.)	SIZE (INCHES)	VERTICAL SPACING (FT.)	MAX. ALLOWABLE HORIZ. SPACING (FT.)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE				
5 to 10	Up to 6	6x8	6x8	6x8	8x8	8x8	5	8x10	5	2x6				
	Up to 8	8x8	8x8	8x8	8x8	8x10	5	10x12	5	2x6				
	Up to 10	8x10	8x10	8x10	8x10	8x10	5	12x12	5	2x6				
	See Note 1													
10 to 15	Up to 6	8x8	8x8	8x8	8x8	8x10	5	10x12	5	2x6				
	Up to 8	8x10	8x10	8x10	8x10	8x10	5	12x12	5	2x6				
	See Note 1													
	See Note 1													
15 to 20	Up to 6	8x10	8x10	8x10	8x10	8x10	5	12x12	5	3x6				
	See Note 1													
	See Note 1													
	See Note 1													
Over 20	See NOTE 1.													

TABLE C - 2.1 Timber Trench Shoring - Minimum Timber Requirements* SOIL TYPE A P _A = 25 X H + 72 PSF (2 FT. SURCHARGE)														
DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **													
	CROSS BRACES						WALES			UPRIGHTS				
	Horizontal Spacing (Ft.)	WIDTH OF TRENCH (FT.)					VERTICAL SPACING (FT.)	SIZE (INCHES)	VERTICAL SPACING (FT.)	MAX. ALLOWABLE HORIZ. SPACING (FT.)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	4	5	6	8
5 to 10	Up to 6	4x4	4x4	4x4	4x4	4x6	4	Not Req'd	Not Req'd				4x6	
	Up to 8	4x4	4x4	4x4	4x6	4x6	4	Not Req'd	Not Req'd					4x8
	Up to 10	4x6	4x6	4x6	6x6	6x6	4	8x8	4			4x6		
	Up to 12	4x6	4x6	4x6	6x6	6x6	4	8x8	4				4x6	
10 to 15	Up to 6	4x4	4x4	4x4	6x6	6x6	4	Not Req'd	Not Req'd				4x10	
	Up to 8	4x6	4x6	4x6	6x6	6x6	4	6x8	4		4x6			
	Up to 10	6x6	6x6	6x6	6x6	6x6	4	8x8	4			4x8		
	Up to 12	6x6	6x6	6x6	6x6	6x6	4	8x10	4		4x6		4x10	
15 to 20	Up to 6	6x6	6x6	6x6	6x6	6x6	4	6x8	4	3x6				
	Up to 8	6x6	6x6	6x6	6x6	6x6	4	8x8	4	3x6	4x12			
	Up to 10	6x6	6x6	6x6	6x6	6x8	4	8x10	4	3x6				
	Up to 12	6x6	6x6	6x6	6x8	6x8	4	8x12	4	3x6	4x12			
Over 20	See NOTE 1.													

Appendix C – Timber Shoring for Trenches (PG. 3)

TABLE C - 2.2 Timber Trench Shoring - Minimum Timber Requirements* SOIL TYPE B P _A = 45 X H + 72 PSF (2 FT. SURCHARGE)														
DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **													
	CROSS BRACES						WALES			UPRIGHTS				
	Horizontal Spacing (Ft.)	WIDTH OF TRENCH (FT.)					VERTICAL SPACING (FT.)	SIZE (INCHES)	VERTICAL SPACING (FT.)	MAX. ALLOWABLE HORIZ. SPACING (FT.)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3	4	6
5 to 10	Up to 6	4x6	4x6	4x6	6x6	6x6	5	6x8	5			3x12 4x8		4x12
	Up to 8	4x6	4x6	6x6	6x6	6x6	5	8x8	5		3x8		4x8	
	Up to 10	4x6	4x6	6x6	6x6	6x8	5	8x10	5			4x8		
	See Note 1													
10 to 15	Up to 6	6x6	6x6	6x6	6x8	6x8	5	8x8	5	3x6	4x10			
	Up to 8	6x8	6x8	6x8	8x8	8x8	5	10x10	5	3x6	4x10			
	Up to 10	6x8	6x8	8x8	8x8	8x8	5	10x12	5	3x6	4x10			
	See Note 1													
15 to 20	Up to 6	6x8	6x8	6x8	6x8	8x8	5	8x10	5	4x6				
	Up to 8	6x8	6x8	6x8	8x8	8x8	5	10x12	5	4x6				
	Up to 10	8x8	8x8	8x8	8x8	8x8	5	12x12	5	4x6				
	See Note 1													
Over 20	See NOTE 1.													

TABLE C - 2.3 Timber Trench Shoring - Minimum Timber Requirements* SOIL TYPE C P _A = 80 X H + 72 PSF (2 FT. SURCHARGE)														
DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **													
	CROSS BRACES						WALES			UPRIGHTS				
	Horizontal Spacing (Ft.)	WIDTH OF TRENCH (FT.)					VERTICAL SPACING (FT.)	SIZE (INCHES)	VERTICAL SPACING (FT.)	MAX. ALLOWABLE HORIZ. SPACING (FT.)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3	4	6
5 to 10	Up to 6	6x6	6x6	6x6	6x6	8x8	5	8x8	5	3x6				
	Up to 8	6x6	6x6	6x6	8x8	8x8	5	10x10	5	3x6				
	Up to 10	6x6	6x6	8x8	8x8	8x8	5	10x12	5	3x6				
	See Note 1													
10 to 15	Up to 6	6x8	6x8	6x8	8x8	8x8	5	10x10	5	4x6				
	Up to 8	8x8	8x8	8x8	8x8	8x8	5	12x12	5	4x6				
	See Note 1													
	See Note 1													
15 to 20	Up to 6	8x8	8x8	8x8	8x10	8x10	5	10x12	5	4x6				
	See Note 1													
	See Note 1													
	See Note 1													
Over 20	See NOTE 1.													

Appendix D – Aluminum Hydraulic Shoring for Trenches

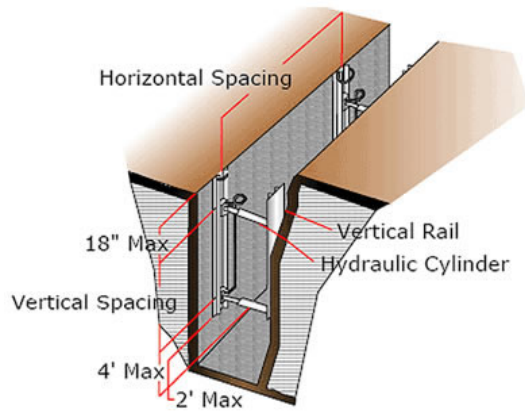


Figure NO. 1 – Vertical aluminum hydraulic shoring (spot bracing)

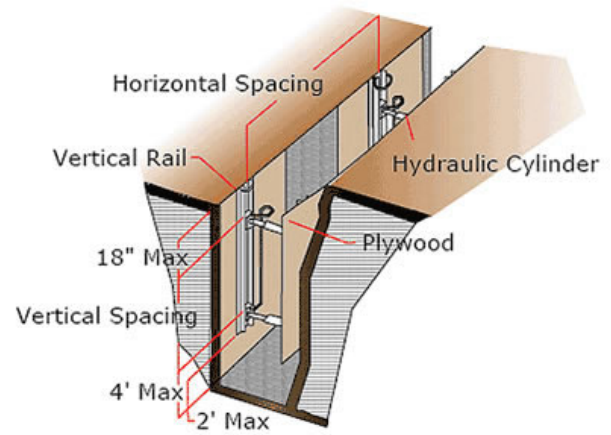


Figure NO. 2 – Vertical aluminum hydraulic shoring (with plywood)

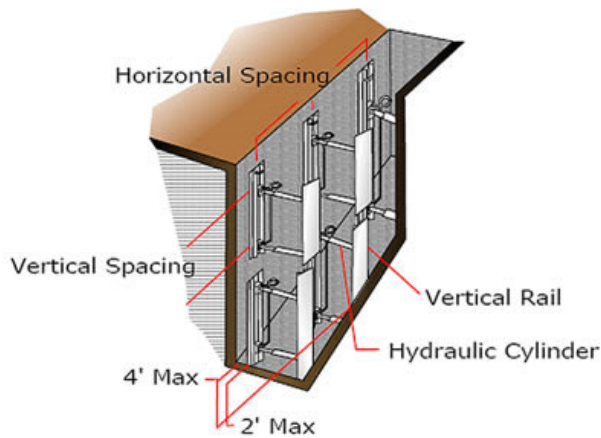


Figure NO. 3 – Vertical aluminum hydraulic shoring (stacked)

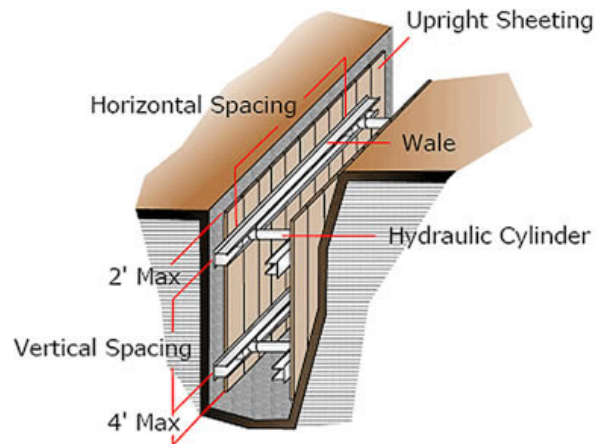


Figure NO. 4 – Vertical aluminum hydraulic shoring (typical)

Appendix D – Aluminum Hydraulic Shoring for Trenches (PG. 2)

TABLE D - 1.1: Aluminum Hydraulic Shoring– Vertical Shores for SOIL TYPE A					
Depth of Trench (Feet)	HYDRAULIC CYLINDERS				
	Max Horizontal Spacing (Feet)	Max Vertical Spacing (Feet)	Width of Trench (Feet)		
			Up to 8'	Over 8' & Up to 12'	Over 12' & Up to 15'
Over 5' & Up to 10'	8'	4'	2 Inch Diam.	2 Inch Diam.- See Note (2)	3 Inch Diam.
Over 10' & Up to 15'	8'				
Over 15' & Up to 20'	7'				
Over 20'	See Note (1)				

TABLE D - 1.2: Aluminum Hydraulic Shoring– Vertical Shores for SOIL TYPE B					
Depth of Trench (Feet)	HYDRAULIC CYLINDERS				
	Max Horizontal Spacing (Feet)	Max Vertical Spacing (Feet)	Width of Trench (Feet)		
			Up to 8'	Over 8' & Up to 12'	Over 12' & Up to 15'
Over 5' & Up to 10'	8'	4'	2 Inch Diam.	2 Inch Diam.- See Note (2)	3 Inch Diam.
Over 10' & Up to 15'	6.5'				
Over 15' & Up to 20'	5.5'				
Over 20'	See Note (1)				

Appendix D – Aluminum Hydraulic Shoring for Trenches (PG. 3)

TABLE D - 1.3: Aluminum Hydraulic Shoring– Waler Systems for SOIL TYPE B											
Depth of Trench (Feet)	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
	Vertical Spacing (Feet)	Section Modulus (In ³)	Width of Trench (Feet)						Max. Horiz. Spacing (On Center)		
			Up to 8'		Over 8', Up to 12'		Over 12', Up to 15'		Solid Sheet	2 Ft	3 Ft
			Horiz. Spacing	Cylinder Diam.	Horiz. Spacing	Cylinder Diam.	Horiz. Spacing	Cylinder Diam.			
Over 5' & Up to 10'	4'	3.5"	8.0'	2" dia	8.0'	2" dia (Note 2)	8.0'	3" dia	n/a	n/a	3"x12" Upright
		7.0"	9.0'	2" dia	9.0'	2" dia (Note 2)	9.0'	3" dia			
		14.0"	12.0'	3" dia	12.0'	3" dia	12.0'	3" dia			
Over 10' & Up to 15'	4'	3.5"	6.0'	2" dia	6.0'	2" dia (Note 2)	6.0'	3" dia	n/a	3"x12" Upright	n/a
		7.0"	8.0'	3" dia	8.0'	3" dia	8.0'	3" dia			
		14.0"	10.0'	3" dia	10.0'	3" dia	10.0'	3" dia			
Over 15' & Up to 20'	4'	3.5"	5.5'	2" dia	5.5'	2" dia (Note 2)	5.5'	3" dia	3"x12" Upright	n/a	n/a
		7.0"	6.0'	3" dia	6.0'	3" dia	6.0'	3" dia			
		14.0"	9.0'	3" dia	9.0'	3" dia	9.0'	3" dia			
Over 20'	See Note (1)										

TABLE D - 1.4: Aluminum Hydraulic Shoring– Waler Systems for SOIL TYPE C											
Depth of Trench (Feet)	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
	Vertical Spacing (Feet)	Section Modulus (In ³)	Width of Trench (Feet)						Max. Horiz. Spacing (On Center)		
			Up to 8'		Over 8', Up to 12'		Over 12', Up to 15'		Solid Sheet	2 Ft	3 Ft
			Horiz. Spacing	Cylinder Diam.	Horiz. Spacing	Cylinder Diam.	Horiz. Spacing	Cylinder Diam.			
Over 5' & Up to 10'	4'	3.5"	6.0'	2" dia	6.0'	2" dia (Note 2)	6.0'	3" dia	3"x12" Upright	n/a	n/a
		7.0"	6.5'	2" dia	6.5'	2" dia (Note 2)	6.5'	3" dia			
		14.0"	10.0'	3" dia	10.0'	3" dia	10.0'	3" dia			
Over 10' & Up to 15'	4'	3.5"	4.0'	2" dia	4.0'	2" dia (Note 2)	4.0'	3" dia	3"x12" Upright	n/a	n/a
		7.0"	5.5'	3" dia	5.5'	3" dia	5.5'	3" dia			
		14.0"	8.0'	3" dia	8.0'	3" dia	8.0'	3" dia			
Over 15' & Up to 20'	4'	3.5"	3.5'	2" dia	3.5'	2" dia (Note 2)	3.5'	3" dia	3"x12" Upright	n/a	n/a
		7.0"	5.0'	3" dia	5.0'	3" dia	5.0'	3" dia			
		14.0"	6.0'	3" dia	6.0'	3" dia	6.0'	3" dia			
Over 20'	See Note (1)										

Appendix E – Alternatives to Timber Shoring

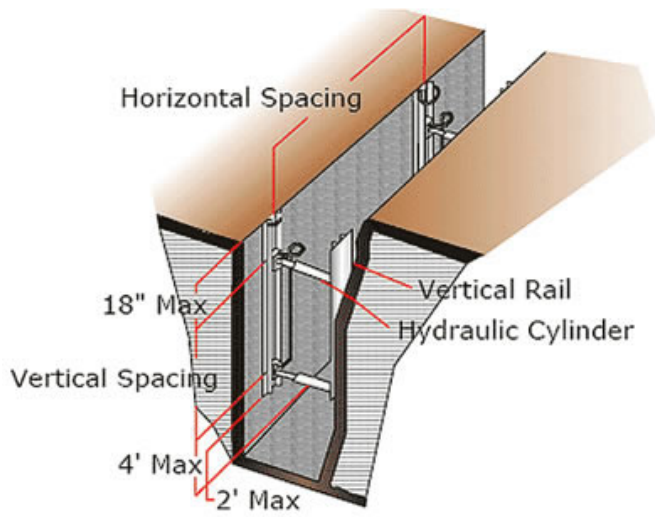


Figure NO. 1 – Aluminum Hydraulic Shoring

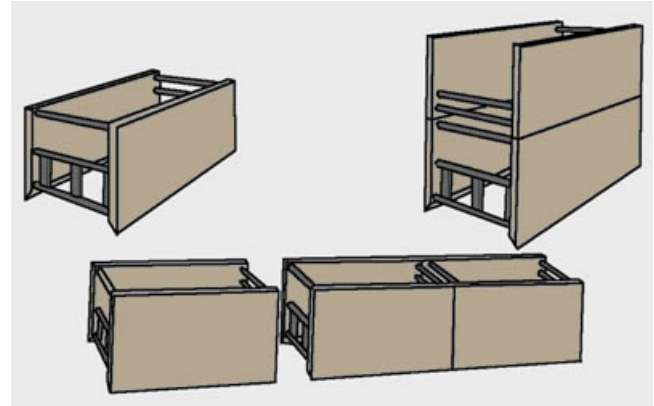


Figure NO. 2 – Trench Shields

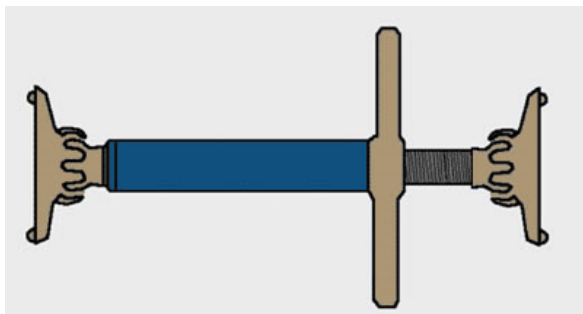


Figure NO. 3 – Trench Jacks (Screw Jacks)

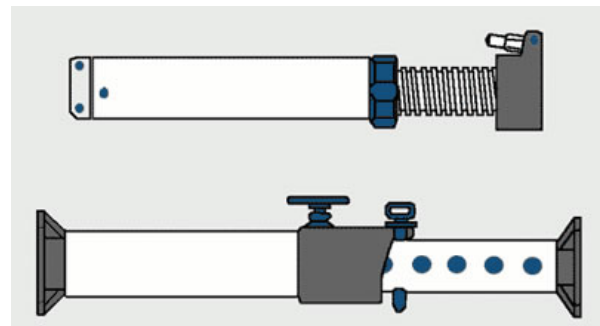


Figure NO. 4 – Pneumatic/Hydraulic Shoring

Appendix F – Selection of Protection Systems

