UNIVERSITY OF
NORTHERN COLORADO

Environmental Health and Safety

Trenching and Shoring Guidelines

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Trenching and Shoring Guidelines

I. General

Excavating is recognized as one of the most hazardous operations. This standard shall provide guidance for University employees who perform excavations on property owned by the University of Northern Colorado (UNC).

II. Definitions

Aluminum hydraulic shoring: An engineered shoring system comprised of aluminum hydraulic cylinders (cross braces), used in conjunction with vertical rails (uprights) or horizontal rails (walers). Such a system is designed specifically to support the sidewalls of an excavation and prevent cave-ins.

Benching: A method used to protect employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

Cave-in: The separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.

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

Confined Space: A space that by design and/or configuration, has limited openings for entry and exit, unfavorable natural ventilation, may contain or produce hazardous substances and is not intended for continuous occupancy.

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

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

Ingress and Egress: means “Entry” or “Exit”. In trenching and excavation operations, it is referred to the provision of safe means for employees to enter or exit an excavation or trench.

Registered Professional Engineer: An individual who is registered as a professional engineer.

Shield (shield system): A structure that is able to withstand the forces imposed on it by a cave-in and thereby protects employees with the structure. Shields can be permanent structure or can be designed to be portable and moved along as work progresses; also known as a trench box or trench shield.

Shoring (shoring system): A structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation and which is designed to prevent cave-ins.

Sloping (sloping system): A method of protecting employees from cave-ins by excavating to form sides of an excavation that is inclined away from the excavation so as to prevent cave-ins. The angle of incline varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

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

Trench (trench excavation): 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 the trench is not greater than 15 feet. If forms or other structures are installed or constructed in an excavation as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet or less, the excavation is also considered to be a trench.

III. Requirements

Excavations shall be made in accordance to the industrial standards set forth in 29CFR 1926.650, .651, .652.

A competent person shall be placed in charge of all excavations.

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

Training, experience, and knowledge of:

- Soil analysis;
- Use of protective systems

Ability to detect:

- Conditions that could result in cave-ins
- Failures in protective systems
- Hazardous atmospheres
- Other hazards including those associated with confined spaces

Has the authority to take prompt corrective measures to eliminate existing and predictable hazards and to stop work when required.

A. Underground utilities must be located and marked before excavations begin.

B. Spoil piles shall be a minimum of two (2) feet from the edge of the dig area.

C. Employees are not allowed in the excavation while heavy equipment is digging.

D. A competent person shall conduct visual inspections:

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

E. For trenches 4 feet or greater in depth a trench inspection form shall be filled out by a competent person.

IV. Soil Types

Soil and rock deposits are categorized into four types, A through D as follows:

Stable Rock: A natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed. This is usually identified by a rock name such as granite or sandstone.

Type A: Most stable: clay, silty clay, sandy clay, clay loam, silty clay loam and sandy clay loam. No soil is Type A if it is fissured, is subject to vibration of any type, has previously been disturbed, is of a sloped, layered system where the layers dip into the excavation on a slop of 4 horizontal to 1 vertical or greater, or has seeping water.

Type B: Medium stability: angular gravel, silt, silt loam, medium clay, and unstable dry rock; previously disturbed soils unless classified as Type C; soils that meet the requirements of Type A if it is fissured or subject to vibration or dry unstable rock.

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

Layered geological Strata (where soils are configured in layers): the soil may be classified on the basis of the soil classification of the weakest soil layer. Each layer may be classified individually if a more stable layer lies below a less stable layer (ie, where a Type C soil rests on top of stable rock).

V. Test Methods and Evaluating Soil Type

The competent person in charge of the excavation shall be responsible for determining whether the soil is Type A, B, or C. If the competent person wants to classify the soil as Type C, testing is not required. However, tests must be conducted to determine if the soil can be classified as Type A or B. To do this, the competent person shall use a visual test coupled with one or more manual tests.

Visual Test

In addition to checking the items on the trench inspection form, the competent person should perform a visual test to evaluate the conditions around the site. In a visual test, the entire excavation site is observed, including the soil adjacent to the site and the soil being excavated. If the soil remains in clumps, it is cohesive; if it appears to be coarse-granular sand or gravel, it is considered granular. The competent person also checks for any signs of vibration.

During a visual test, the evaluator should check for crack-line openings along the failure zone that would indicate tension cracks, look for existing utilities that indicate that the

soil has previously been disturbed, and if so, what sort of backfill was used, and observe the open side of the excavation for indications of layered geologic structuring.

The competent person should also look for signs of bulging, boiling, or sloughing, as well as for signs of surface water seeping from the sides of the excavation or from the water table. In addition, the area adjacent to the excavation should be checked for signs of foundations or other intrusions into the failure zone, and the evaluator should check for surcharging and the spoil distance from the edge of the excavation.

Manual Tests

Thumb Penetration Test: Attempt to press the thumb firmly into the soil in question. If the thumb makes an indentation in the soil only with great difficulty, the soil is probably Type A. If the thumb penetrates no further than the length of the thumb nail, it is probably Type B soil, and if the thumb penetrates the full length of the thumb, it is Type C soil. The thumb test is subjective and is therefore the least accurate testing methods.

Dry Strength Test: Take a sample of dry soil. If it crumbles freely or with moderate pressure into individual grains it is considered granular (Type C). Dry soil that falls into clumps that subsequently break into smaller clumps (and the smaller clumps can be broken only with difficulty) is probably clay in combination with gravel, sand, or silt (Type B). If the soil breaks into clumps that do not break into smaller clumps (and the soil can be broken only with difficulty), the soil is considered un-fissured unless there is visual indication of fissuring (Type A).

Plasticity or Wet Thread Test: Take a moist sample of the soil. Mold it into a ball and attempt to roll it into a thin thread approximately 1/8 inch in diameter by two inches in length. If the soil sample does not break or tear when held by one end, it may be considered Type B.

A pocket penetrometer or shearvane (torvane) may also be used to determine the unconfined compression strength of soils.

VI. Ingress and Egress

Access to and exit from the trench require the following conditions:

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

VII. Exposure to Falling Loads

The following steps must be taken to ensure employees are protected from loads or objects falling from lifting or digging equipment:

- All employees on an excavation site must wear hard hats.
- Employees are not allowed to work under raised loads.
- Employees are not allowed to work under loads being lifted or moved by heavy equipment used for digging or lifting.
- Employees are required to stand away from equipment that is being loaded or unloaded to avoid being struck by falling materials or spillage.
- Equipment operators or truck drivers may remain in their equipment during loading and unloading if the equipment is properly equipped with a cab shield or adequate canopy.

VIII. Warning Systems for Mobile Equipment

The following steps should be taken to prevent vehicles or people from accidentally falling into a trench:

- Barricades must be installed where necessary
- Hand or mechanical signals must be used as required
- Trenches left open overnight shall be fenced and barricaded

IX. Hazardous Atmospheres and Confined Spaces

Employees are not permitted to work in hazardous and/or toxic atmospheres. Such atmospheres include the following:

- Less than 19.5% oxygen
- A combustible gas concentration greater than 20% of the lower flammable limit
- Concentrations of hazardous substances that exceed those specified in the Threshold Limit Value (TLV) for airborne contaminants established by the ACGIH

If there is any possibility that the trench or excavation could contain a hazardous atmosphere, atmospheric testing must be conducted prior to entry. Conditions that might warrant atmospheric testing would be if the excavation contains pipelines containing a hazardous material (ie. natural gas).

All operations involving such atmospheres will require the **Confine Space Entry procedures** to be used. Testing will be conducted before employees enter the trench and should be done regularly to ensure that the trench remains safe. The frequency of testing should be increased if equipment is operating in the trench.

X. Standing Water and Water Accumulation

Methods for controlling standing water and water accumulation must be provided and should consist of the following when employees must work in the excavation:

- Use of special support or shield systems approved by a registered professional engineer
- Water removal equipment, such as pumps, used and monitored by a competent person
- Surface water diverted away from the trench
- Employees shall be removed from the trench during a rainstorm
- Trenches carefully inspected by a competent person after each rain and before employees are permitted to re-enter the trench.

XI. Benching, Sloping, Shoring, and Shielding Requirements

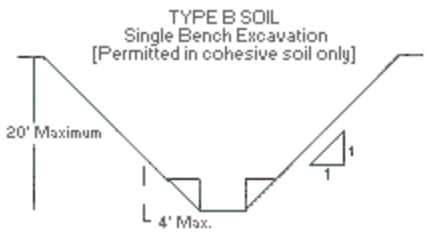
All excavations or trenches 4 feet or greater in depth shall be appropriately benched, shored, or sloped.

Excavations or trenches 20 feet deep or greater must have a protective system designed by a registered professional engineer.

Benching

There are two basic types of benching, simple and multiple, which can be used in conjunction with sloping.

In Type B soil, the bottom vertical height of the trench must not exceed 4 feet. Benches must be below the maximum allowable slope for that soil type. (For example, a 10-foot deep trench in Type B soil must be benched back 10 feet in each direction, with the maximum of a 45 degree angle.)



Benching is not allowed in Type C soil.

Sloping

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

Soil Type	Height / Depth Ratio	Slope Angle
Type A	¾:1	53 degrees
Type B	1:1	45 degrees
Type C	1½ :1	34 degrees

Shoring

Shoring is the provision of a support system for trench faces used to prevent movement of soil, underground utilities, roadways, and foundations. Shoring or shielding is used when the location or depth of the cut makes sloping back to the maximum allowable slope impractical. There are three basic types of shoring; timber, aluminum hydraulic, and pneumatic.

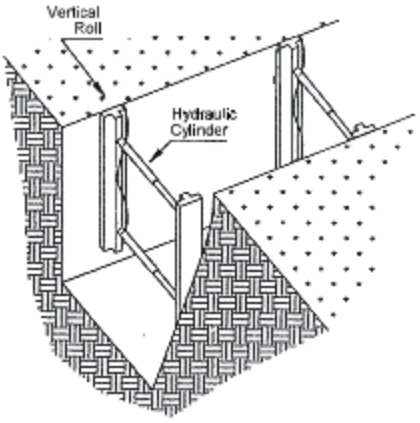
Aluminum Hydraulic shoring provides a critical safety advantage over timber shoring because workers do not have to enter the trench to install them. Hydraulic shoring is also light enough to be installed by one worker. They are gauge-regulated to ensure even distribution of pressure along the trench line and can be adapted easily to various trench depths and widths.

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

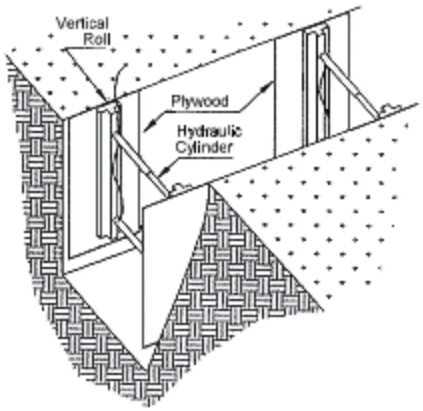
The top cylinder of hydraulic shoring shall be no more than 18 inches below the top of the excavation. The bottom cylinder shall be no higher than four feet from the bottom of the excavation. Two feet of trench wall may be exposed beneath the bottom of the rail or plywood sheeting, if used.

Wales are installed no more than two feet from the top and no more than four feet from the bottom, and no more than four feet apart – vertically.

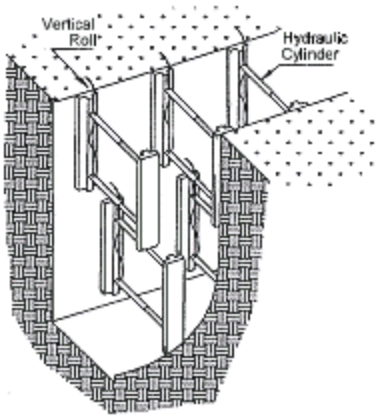
Three vertical shores, evenly spaced, must be used to form a system.



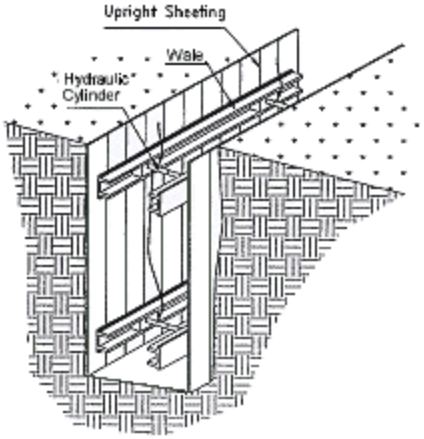
Vertical Aluminum Hydraulic Shoring
(Spot Bracing)



Vertical Aluminum Hydraulic Shoring
(With Plywood)



Vertical Aluminum Hydraulic Shoring
(Stacked)



Aluminum Hydraulic Shoring Waler System
(Typical)

Pneumatic Shoring works in a manner similar to hydraulic shoring. The primary difference is that pneumatic shoring uses air pressure in place of hydraulic pressure. A disadvantage to the use of pneumatic shoring is that an air compressor must be on the excavation site.

Shielding

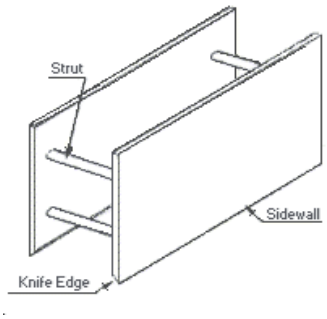
Trench boxes are different shoring because, instead of shoring up or otherwise supporting the trench face, they are intended primarily to protect from cave-ins and similar incidents.

The excavated area between the outside of the trench box and the face of the trench should be as small as possible. The space between the trench box and the excavation side must be backfilled to prevent lateral movement of the box. Shields may not be subjected to loads exceeding those which the system was designed to withstand.

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

Shields may ride two feet above the bottom of the excavation, provided the shields are calculated to support the full depth of the excavation and there is no caving under or behind the shield.

Workers must enter and leave the shield in a protected manner, such as by ladder or ramp. Workers may NOT remain in the shield while it is being moved.



XII. Training and Recordkeeping

It is the responsibility of each department to ensure that their employees receive the required training. Training can be provided by the Environmental Health and Safety department. Training records will be retained by the Environmental Health and Safety office.

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TRENCH INSPECTION AND ENTRY AUTHORIZATION FORM

LOCATION:	**DATE:**
INSPECTED BY:	**TIME OF INSPECTION(S)**
WEATHER CONDITIONS:	**APPROX. TEMP.:**
CREW LEADER:	**WORK ORDER #:**

DIMENSIONS:			
	DEPTH =		
	TOP =	W	L
	BOTTOM =	W	L

SOIL TYPE:	**TESTED:**
❑ Solid rock (most stable)	❑ Yes
❑ Average soil	❑ No
❑ Fill material	
❑ Loose sand	

Yes No	**HAZARDOUS CONDITIONS**
❑ ❑	..... Saturated soil / standing or seeping water
❑ ❑	..... Cracked or fissured wall(s)
❑ ❑	..... Bulging wall(s)
❑ ❑	..... Floor heaving
❑ ❑	..... Frozen soil
❑ ❑	..... Super-imposed loads
❑ ❑	..... Vibration
❑ ❑	..... Depth greater than 10’

PROTECTION METHODS:
(Walls MUST be vertical—NO voids)
SHORING
❑ Timber
❑ Pneumatic
❑ Hydraulic
❑ Screw Jacks
❑ Trench Shield
UNEVEN, IRREGULAR WALLS
❑ Trench Box
Sloping: **q 1:1 (45°)** **q 1 ½:1 (34°)**

PLACEMENT OF SPOILS & EQUIPMENT	
❑ ❑	..... Spoils at least 2 feet from edge of trench
❑ ❑	..... Equipment at least 2 feet from edge
❑ ❑	..... Backhoe at end of trench
❑ ❑	..... Compressor, etc. at remote location
LADDER LOCATION	
❑ ❑	..... Located in protected area
❑ ❑	..... Within 25 feet of safe travel
❑ ❑	..... Secured
❑ ❑	..... Extends 36 inches above the landing
❑ ❑	..... Leads to safe landing

Yes No	**ENVIRONMENTAL CONDITIONS:**	**OTHER:**
❑ ❑	Gas detector used?	❑ ❑ Shoring equip. & matls inspected prior to use?
❑ ❑	Confined space permit issued?	❑ ❑ Is trench SAFE to enter?

COMMENTS:

NOTE All unsafe conditions must be corrected prior to trench entry. If any hazardous conditions are observed, the trench must be immediately evacuated and no one allowed to re-enter until corrective action has been taken.

Turn completed forms into Environmental Health and Safety.