Training Module: Trenching and Excavation Safety

Objective

The objective of this fact sheet is to provide a refresher and basic synopsis on trenching and excavation safety. The safety hazards that may be encountered during work in trenches and excavations and the preventative measures and engineering controls are discussed.

Trainer’s Note: Work inside an excavation or a trench should be limited. Workers must not enter an unprotected trench or excavation, even for a short task. Workers must exit if they see evidence of problems with the protective system. Do not assume there will be a warning sign before a cave in. Workers will not have enough time to move to safety during a cave in.

Background

U.S. Bureau of Labor Statistics (BLS) data show that 271 workers died in trenching or excavation cave-ins from 2000 through 2006. NIOSH researchers found that trenching and excavation hazards during construction activities resulted in 488 deaths between 1992 and 2000 - an average of 54 fatalities each year. Hazards associated with trench work and excavations are recognized and preventable, yet injuries and fatalities associated with these hazards continue to occur.

Fatalities are mainly caused by cave-ins. Death occurs by suffocation or crushing when a worker is buried by falling soil. Soil can weigh 125 pounds per cubic foot. A worker can be crushed by soil, rock, or an object. A worker can suffocate, even if the worker’s head is not buried, soil prevents chest expansion.

The following are the main causes of lost-time injuries associated with trenching and excavation operations:

- Materials and equipment falling into the trench
- Slips and falls as workers climb on and off equipment
- Handling and placing pipe and other materials
- Being struck by moving equipment
- Falls as workers climb in or out of an excavation
- Falling over equipment or excavated material
- Falling into the trench
- Exposure to toxic, irritating, or flammable gases.

Responsibilities

OSHA requires that a trained and competent supervisor be indentified and on-site to assure the safety
of workers operating in a trench or excavation. The Removal Manager or Site Safety Officer could fill this role based on their level of training and experience.

**Check for underground Utilities**

Underground utilities should be located and marked before excavation begins. This is often accomplished by calling “811” and requesting a utility mark-out. The depth of utility lines varies and most natural gas and electric lines are buried at least 12 inches below the surface. However, these lines, for various reasons, may be encountered closer to the surface.

It may be difficult to identify and mark all utilities that may be present at an emergency response or removal site. Utility Mark-Out Personnel may not have the appropriate level of training to operate at a Site. It may be necessary to review utility plans to determine potential locations as opposed to a physical mark-out.

**Remove Surface Encumbrances**

All equipment, materials, supplies, buildings, roadways, trees, utility vaults, boulders, etc. that could present a hazard to employees working in the excavation must be removed or supported.

The spoil accumulated from digging a trench or excavation must be placed above and away from the side walls of the excavation. Otherwise, the weight of the spoil might create an unsafe condition. OSHA requires that the spoil pile be kept 2 feet or more from the edge of the excavation or prevented from falling or rolling into the excavation by the use of retaining devices.

**Classify the Soil Classification**

It is important to classify the soil at an excavation before choosing the proper protection system. The soil type will dictate the sloping, shoring or trench box specifications. A trained competent person must be the one to classify soil as Type A or B. All previously disturbed soil is automatically considered Type B or C soil.

**Soil may be considered Type C by default and no additional training or tests are required.**

**Type A:** Good cohesive soil with a high compressive strength such as: clay, silty clay, sandy clay, clay loam and cemented soils such as caliche, duricrust and hardpan.

**Type B:** Cohesive soil with a moderate compressive strength such as: silt, silty clay, sandy clay, clay loam, silt loam, sandy loam, angular gravel (similar to crushed rock), any previously disturbed fissured or soil subject to vibration.
**Type C**: Cohesive soil with a low compressive strength such as: granular soils including gravel, sand, and loamy sand or submerged soil or rock that is not stable or soil from which water is freely seeping. This is the least stable soil type.

Any one of the following will cause soil to be classified as Type C.

- Water seepage into excavation.
- Vibration from road traffic or equipment.
- Signs of bulging, boiling, or sloughing.
- Crack lines along failure zone.

**Plan for Protective Systems**

In excavations greater than 4 feet in depth, a method to protect people entering the excavation from cave in must be provided. Acceptable protective methods include sloping, benching, shielding and shoring. Sloping or benching is often the preferred methods of protection; however, shoring or shielding is used when the location or depth makes sloping to the allowable angle impractical.

**All excavations more than 20 feet in depth should be approved or evaluated by a Registered Professional Engineer.**

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

- Type A soil must have walls sloped to a maximum angle of 52 degrees (1: ¾ slope) form horizontal in all directions.
- Type B soil must have walls sloped to a maximum angle of 45-degrees (1:1 slope) from horizontal in all directions.
- Type C soil, must have walls sloped at a maximum angle of 34-degrees (1: 1½ slope) from horizontal in all directions.
**Benching:** In Type A and B soil, the vertical height of the benches must not exceed 4 feet. Benches in increments of 2 feet or less is preferred. The angle developed by the edge of the benches must not exceed the maximum allowable slope for that soil type (Type B soil 45 degrees). Benching is not permitted in Type C soil.

![Benching Diagram](image)

**Shielding:** Trench boxes or trench shields are intended to protect workers from cave-ins and similar incidents. The trench shield is lowered into the excavation and workers may then enter the protected area within the shield. The use is limited to those trenches for which the shield is certified (e.g., maximum depth and material). The manufacturer must approve any modifications to the shields. 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 should be backfilled to prevent lateral movement of the box. Trench boxes 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 be placed two feet above the bottom of an excavation, provided they 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 shielded area in a protected manner, such as by a ladder or ramp. Workers may not remain in the shielded area while it is being moved.

![Shielding Diagram](image)
Shoring: Hydraulic shoring is permitted as workers do not have to enter the trench to install it. It is gauge-regulated and ensures even distribution of pressure along the trench line and can be adapted 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 damaged or defective parts. The top cylinder of hydraulic shoring shall be no more than 18 inches below the top of the excavation. The bottom of the 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.) Three vertical shores, evenly spaced, must be used to form a system. Wales are installed no more than two feet from the top, no more than four feet from the bottom, and no more than four feet apart, vertically.

Provide for Safe Egress

A trench or excavation that is 4 feet or more in depth must have a safe means for workers to get in and out. A means of egress is required to be within 25 feet of lateral travel distance.

The most common method for access is a straight ladder or an extension ladder. If a ladder is used, it must extend a minimum of 3 feet above the landing. The use of step ladders is not permitted.

Locating the method of access/egress outside of the protective system is prohibited.
Provide Protection around the Excavation or Trench

Excavations must be isolated from public access by a substantial physical barrier. Barricades, lighting and posting should be installed as appropriate prior to the start of excavation operations. Guardrails, fences, or barricades should be installed around excavations adjacent to walkways, roads, paths or other traffic areas. Use of barricade tape alone is not considered a sufficient method of isolation when the excavation is unattended. Warning lights or other illumination may necessary for the safety of the public at night. Wells, holes, pits, and similar excavations must be effectively barricaded or covered and posted. Walkways or bridges used by the general public to cross excavations must be equipped with standard guardrails.

Hazardous Atmospheres

Test excavations before an employee enters for:

- Oxygen deficiency
- High combustible gas concentration
- High levels of other hazardous substances such as carbon monoxide

If a hazardous atmosphere/environment cannot be controlled, consider the trench or excavation a permit required confined space and follow all appropriate confined space safety requirements:

- Specialized training for Supervisor, Attendants and Entrants
- Written Permit
- Permit Supervisor
- Attendants
- Engineering controls such as ventilation, dewatering pumps, etc.
- Emergency Retrieval System
- Continuous or periodic atmospheric monitoring
- Emergency Response Team access

Personal Protective Equipment

Personal Protective Equipment (PPE) requirements are determined by a job hazard analysis that takes into account all site hazards, including hazardous substances. At a minimum, personnel working in or around an excavation or trench must wear the following ANSI Approved PPE:

- Steel/Composite Toe and Shank Safety Boots
- Hard Hat
- Eye Protection
- Hi-Vis Vest or Clothing
Emergency Rescue

In the event of any emergency situation requiring rescue from an excavation, site personnel should not attempt to enter an unprotected trench to perform rescue. The person entering to rescue may become another victim or fatality.

Call 911 and request assistance for the Local Fire Department.

Rescue services that can be performed safely from outside the excavation, such as hoisting a harnessed victim, can be undertaken. Other personnel in the excavation shall exit immediately, providing assistance only when not endangering their own safety.

During the site safety planning phase, discuss special situations such as trenches, excavations or confined spaces as well as the chemical and environmental hazards with local emergency responders.

Inspections

Frequent inspection of the excavation and surrounding area by the Competent Person is critical to ensure the safety of the workers involved in work within the excavation. A sample inspection form is included below.

The Competent Person must conduct inspections of the entire excavation site:

- Daily and before the start of each shift.
- As dictated by the work being done in the excavation.
- After every rain storm.
- 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.

Definitions:

**Benching** means a method of protecting 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** means 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** means one who is capable to identify existing and predictable hazards in the surroundings or working conditions that may affect employees and the general public, and who has
authority to take prompt corrective measures to eliminate them.

- The Competent Person(s):
  - Must be trained in and knowledgeable of excavation and trenching standard, and other programs that may apply (Hazard Communication, Confined Space, Respiratory Protection)
  - Must be capable of recognizing hazardous conditions and must have authority to stop work and ensure that hazards are corrected
  - Performs and documents the 'Daily Excavation Inspection', and knows when inspections should be performed
  - Must assure that the location of underground installations or utilities have been properly located.
  - Must identify and ensure the use of adequate protective systems, work methods and personal protective equipment (PPE) on the excavation site.

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

**Registered professional engineer (RPE)** means a person who is registered as a professional engineer.

**Shield (shield system)** means a structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees with the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Also known as trench boxes or trench shields.

**Shoring (shoring system)** means 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) means a method of protecting employees from cave-ins by excavating to form sides of an excavation that are 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 exposure conditions, and application of surcharge loads.

**Soil** - Mixed Types (Layered Geological Strata) - The soil must be classified on the basis of the soil classification of the weakest soil layer. Each layer may be classified individually if a more stable layer lies below a less stable layer, i.e. where a Type C soil rests on top of stable rock.

**Soil Type A** - Most stable: clay, silty clay, and hardpan (resists penetration). No soil is Type A if it is fissured, is subject to vibration of any type, has previously been disturbed, or has seeping water.

**Soil Type B** - Medium stability: silt, sandy loam, medium clay and unstable dry rock; previously disturbed soils unless otherwise classified as Type C.
Soil Type C - Least stable: gravel, loamy sand, soft clay, submerged soil or dense, heavy unstable rock, and soil from which any water is seeping.

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 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.

Test Answers:
1. b, 2. b, 3. b, 4. b, 5. d, 6. b, 7. c, 8. a, 9. b, 10. c
### Training Roster for Heat Stress Site Safety Briefings

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*Note: All completed forms should be retained in site files.*
Trenching and Excavation Safety Module Quiz

Trainer’s Note: This quiz can be taken as a group. If taken as a group, note on this quiz sheet.

Name __________________________

1. A stairway, ladder, ramp or other safe means of egress shall be located in trench excavations that are 4 ft. or more in depth so as to require no more than _____ feet of lateral travel for employees.
   a. 10
   b. 25
   c. 50
   d. None of the above

2. The most common cause of fatalities related to work with excavations is:
   a. Slip or fall into an excavation/trench
   b. Suffocation/crushing due to a cave-in
   c. Exposure to toxic substances
   d. None of the above

3. Protection for workers must be employed when an excavation or trench is _____ or deeper.
   a. 3 feet
   b. 4 feet or more
   c. 6 feet
   d. 12 feet

4. In Type B soil, the sloping ratio is _____.
   a. 3/4 to 1.
   b. 1 to 1.
   c. 1-1/2 to 1.
   d. not permitted

5. When must an inspection of a trench or excavation occur?
a. Change is size or location of spoil pile  
b. Once a day  
c. After a rain event  
d. All of the above

6. OSHA requires a ladder or ramp to exit a trench if the depth of excavation is _____.

a. 3 feet  
b. 4 feet or more  
c. 6 feet  
d. 12 feet

7. The least stable soil type is _____.

a. Type A  
b. Type B  
c. Type C  
d. Stable rock

8. One advantage of hydraulic shoring is that workers do not have to enter an unprotected trench to install or remove it.

a. True  
b. False

9. A worker may be in the excavation or trench as the shielding or shoring is installed?

a. True  
b. False

10. A trench shield (trench box) must be designed by a

a. competent person  
b. machinist  
c. registered professional engineer  
d. certified welder
**Excavation Site Checklist and Daily Field Report**

**Instructions:** Complete the items in the checklist by checking the appropriate response and noting descriptive conditions in the comments column. Sign the form to attest that the indicated items were reviewed during the inspection.

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<th>Competent Person:</th>
<th>Project Location:</th>
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<th>Time:</th>
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<tr>
<th>Description of Inspection Item:</th>
<th>Yes</th>
<th>No</th>
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<tr>
<td>1. Have all utilities marked their locations?</td>
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<td>2. Have all affected parties been notified?</td>
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<td>3. Is proper traffic control in place?</td>
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<td>4. Has the soil been classified?</td>
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<td>All soils are classified as type C soils unless otherwise determined by the competent person</td>
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<td>5. Has a protective system been selected by the competent person?</td>
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<td>6. Has the competent person inspected the excavation/trench prior to start of each work period?</td>
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<td>7. Has the work plan been discussed with all employees?</td>
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<td>8. Are all employees protected from cave-ins when entering and exiting the excavation?</td>
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<td>9. Have hazardous objects around the excavation been removed or supported?</td>
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<td>10. Is all spoil maintained at least 2 feet back from the edge of the excavation?</td>
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<td>11. Are ladders used for access and egress? If so, are they installed correctly?</td>
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<td><strong>12.</strong> Are employees protected from loose materials or tools which could fall into the trench?</td>
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<td><strong>13.</strong> Are employees wearing the proper safety equipment?</td>
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<td><strong>14.</strong> Is the excavation/trench free of standing or seeping water?</td>
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<td><strong>15.</strong> Are there evidences of shrinkage cracks in the face of the trench wall?</td>
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<td><strong>16.</strong> Were there evidences of sloughing of soil from the trench face since the last inspection?</td>
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<td><strong>17.</strong> If a support system has been installed, was it installed in accordance with recommendations?</td>
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<td><strong>18.</strong> Is heavy equipment kept away from the edge of the excavation?</td>
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<td><strong>19.</strong> Are any changed conditions properly noted?</td>
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<td><strong>20.</strong> Additional comments:</td>
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**Competent Person Signature:** ______________________________

**Date:** ______________________________