Excavation Safety Guide

IOWA MUNICIPALITIES WORKERS' COMPENSATION ASSOCIATION
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General Requirements

Introduction

This guide will provide information on the Occupational Safety and Health Administration's (OSHA) general safety requirements for excavation work as published in 29 Code of Federal Regulations 1926 Subpart P.

Definitions

- Competent person - One who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees and who has authorization to take prompt corrective measures to eliminate them.
- Excavation - Any man-made cut, cavity, trench, or depression made in the earth's surface formed by earth removal.
- Registered Professional Engineer - Any person who by education and training, having passed the requirements for registration, is registered as a professional engineer in the state in which work is being performed.
- Trench - A narrow excavation made below the surface of the ground. In general the depth is greater than the width, but the width is no greater than 15 feet.
- Trench shield - A structure that is able to withstand the forces imposed on it by a cave-in and thereby protect workers within the structure.
- Shoring - A structure such as a metal hydraulic, mechanical, or timber system that supports the sides of an excavation and is designed to prevent cave-ins.

Specific Requirements

A basic rule for excavation is, "plan your dig, then dig your plan." If you encounter something unplanned for, then stop and replan.

Before you dig, know everything possible about the excavation route. Have the route surveyed and mapped. Although OSHA does not require soil borings, it is good engineering practice to conduct soil borings to determine soil classes along the route. A soil-boring log provides information on the water table and possible soil contamination from leaking under-ground storage tanks.

The following specific requirements for excavation are found in 29 CFR 1926.651.

- Surface encumbrances - includes trees, signs, sidewalks, power poles, parking lots, and walls which must be removed, braced, shored, or otherwise supported to prevent a hazard.
- Underground utilities - such as sewer, water, gas lines, communications, and electric lines must be identified, and physically located. Iowa law requires everyone to locate underground utilities before digging. First, notify Iowa One Call to begin the process, then wait 48 hours (excluding Saturday, Sunday and legal holidays) BEFORE any digging begins. Call or click before you dig. This service is FREE and it's the law. Give them as much lead time as possible. When located, the utility must be physically and cautiously exposed.

  Once the utility is uncovered, it becomes your responsibility to support, protect or have the utility removed as necessary. Locating all buried utilities that cross or parallel your route may be time-consuming, but failure to do so could have serious consequences. The consequences of digging into a petroleum gas line or buried electrical utility could be fatal but preventable.
- Access and egress - Any trench or excavation **four feet** or deeper must have a means of exit. Ladders and/or ramps must be located no more than **25 feet** from any employee while he or she is in the excavation. Another good safety practice is to ensure that ladders extend **three feet** above the surface of the excavation and be tied off if possible.
- Exposure to vehicular traffic - Workers exposed to vehicular traffic must wear "high visibility" vests or clothing.
- Exposure to falling loads - Under no condition should workers be permitted under loads handled by lifting or digging equipment. Workers must stand away from vehicles being loaded or unloaded. Vehicle operators may stay in their vehicles during loading or unloading, provided they are protected by a cab constructed in accordance with 29 CFR 1926.601(b)(6).
- Warning systems - All mobile equipment (front-end loaders, bulldozers and dump trucks) must be equipped with a warning device such as a backup alarm if the operator does not have a clear and direct view of the edge of the excavation. Some other good safety practices are use of hand signals from a flag person, stop logs, barricades or other mechanical signals. An attentive operator and a flag person who knows and uses proper hand signals provide the safest method.
- Hazardous atmospheres - In excavations deeper than **four feet** with the potential for a hazardous atmosphere or oxygen deficiency, conduct air testing before workers enter the excavation and as often as necessary to ensure the atmosphere remains safe. Ventilation or respiratory protection may be needed to protect workers from harmful atmospheres.

- Water accumulation hazards - Workers must not work in excavations where water is accumulating unless adequate precautions are taken to protect these workers from these hazards. This protection involves specific shoring, water removal (to control the level of accumulating water), use of lifelines, harnesses, and careful monitoring by a competent person.
- Stability of adjacent structures - Excavation below the base or footing of a foundation, wall, sidewalk, pavement, or other structure is not permitted unless
  - shoring or bracing is provided to prevent cave-in
  - excavation is in stable rock
  - a registered professional engineer determines the structure is far enough away that the excavation is not affected or that the excavation will not pose a threat to the workers
- Loose rock and soil protection - Excavated earth (spoil), materials, tools, and equipment shall be placed no closer than two feet from the edge of the excavation. Rock and soil should be scaled off the face of the excavation or retained by shoring or other acceptable methods to prevent the material from falling and striking workers.

Good work practice should dictate that no person will work on the sides of the slope or benched excavation above other workers unless the lower workers are protected from falling materials. If possible and practical, grade the slope away from the excavation. This serves a dual purpose of keeping equipment and vehicles from accidentally rolling into the excavation and directing rain water away from the excavation

OSHA 1926.100(a) requires the use of hard hats where there is a possible danger of head injury from falling objects. Excavation operations expose workers to these hazards in every work zone during excavation.

- Inspections - A competent person must inspect the excavation and its support system for evidence of a situation that could result in possible cave-ins, indications of failure of the protective system, hazardous atmospheres, or other hazardous conditions. The inspections shall be done prior to start of work and as often as needed throughout the shift. Inspections shall be made after every rainstorm or other hazard-increasing occurrence.

When an inspection finds evidence of a situation that could result in a hazard to the worker, exposed workers will be removed from the hazardous area until necessary precautions have been made to ensure their safety.

- Fall protection - Where personnel and/or equipment must cross an excavation, a walkway or bridge shall be engineered to withstand the maximum expected load.

The walkway or bridge shall be provided with standard guardrails that meet OSHA standards outlined in 29 CFR 1926 Subpart M. All excavations in a remote location or unattended should have adequate barriers or physical protection to prevent people from falling into the excavation.

Upon completion, backfill all trenches, wells, pits, or shafts as soon as practical.

Conclusion

Even with the introduction of new equipment and strict enforcement of OSHA standards, many workers die each year and many more are seriously injured in trench accidents.

Being buried alive is just one of the hazards of excavation. This program covers only the general requirements of excavation safety. Following the safety measures listed in this publication and not taking shortcuts will make a dangerous job safer.

Soil Classification

Introduction

This section will provide information on soil mechanics, procedures to reduce the possibilities of cave-ins during excavation, identifying the four Occupational Safety and Health Administration (OSHA) soil classifications, and simple soil identification tests and procedures.

One cubic yard of dirt weighs an average of 2,700 pounds, and a cave-in is like dropping a small car from one foot above your head. To excavate and trench safely, you must know about soil mechanics and how to slope and shore. Horizontal and vertical forces within the earth keep undisturbed soil in place. An excavation disturbs or eliminates these forces. Soil naturally moves downward and inward. A number of factors govern how fast this occurs, such as soil type, moisture, vibration and surface loading.

Soil Mechanics

The type of soil governs the stability of the excavation. OSHA requires that soil classification be made by a competent person and installation of adequate protective equipment be made before workers enter the excavation.

Soil types include:

Type A soil - This is the most stable soil and is composed of clay, silty clay, clay loam and sandy clay. It has an unconfined compressive strength of 1.5 tons per square foot (t/sf) or greater. Type A soil is very cohesive. Unfortunately, people wrongly assume it is stable and will not collapse if not shored.

No soil, no matter the composition or apparent stability, can be classified as Type A soil if the soil is fissured or subject to vibration from traffic, equipment, or other excavation activities.

Soil cannot be classed as Type A soil if layers dip into the excavation on a slope of four feet horizontal to one foot vertical or there are other factors, such as seeping water, that would make the soil less than stable.

Type B soil - This cohesive soil is composed of silt, silty loam, sandy loam, and granular cohesive solids including angular gravel (crushed rock). It has an unconfined strength greater than 0.5 tons per square foot but less than 1.5 tons per square foot.

Type C soil – This is the least stable soil. It is a noncohesive soil composed of granular soils, including sand, gravel, loamy sand, submerged soil or soil from which water is draining, submerged rock, or soil in a sloped layered system where the layers dip into the excavation at a slope of four feet horizontal to one foot vertical or greater. It has an unconfined compressive strength of 0.5 tons per square foot or less.

Stable rock - This natural solid mineral material can be excavated with vertical sides and remains intact while exposed.

Testing

When making a site soil classification, the competent person conducts both visual and manual tests. Factors to examine are:

- Soil particle size - Usually there is a mixture of sizes. The percentage of sand to silt and clay determines the soil type.
- Grain size - If a grain of soil is larger than a #2 pencil lead, it is classified as gravel. If it is smaller, but can be seen by the unaided eye, it is classified as sand. Clay and silt particles cannot be seen without the use of a microscope. A general statement is the larger the grain size the less stable the soil.
- Soil that clumps and holds together when dug out is most likely to be clay or silt.
- Cracks in walls of the excavation, with material spilling off (slabs of soil falling off the sides) indicates Type B or C soil.
- Standing water or water seeping out of the bottom or trench walls automatically classifies the soil as Type C.
- Layered soil adjacent to roadways or buildings, disturbed soil, or soil exposed to a source of vibration, requires a soil classification to be made by a registered professional engineer.

Manual Testing

Protective system requirements are based on the results of testing. Never enter an unprotected excavation to obtain a soil sample. Take the soil sample from freshly dug material in the spoil pile. The tests should be done as soon as possible to preserve the sample's natural moisture.

Dry Strength

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 unfissured.

Thread test (plasticity)

This determines whether a sample is cohesive. Roll a sample of the soil between the palms of your hands to about one-eighth inch diameter thread at least several inches long.

Place the rolled soil thread on a flat surface and pick up by one end. If the sample holds together for two inches without breaking, it is considered cohesive.

Ribbon Test

This is another test for cohesiveness and is used as a back-up test for the thread test. Roll a representative soil sample into a cylinder about three-fourths inch in diameter and several inches in length. Then squeeze this sample between thumb and fore-finger into a flat unbroken ribbon one-fourth to one-eighth inch thick, which is allowed to fall freely over the fingers. If the ribbon does not break off before several inches are squeezed out, the soil is considered cohesive.

Thumb Penetration Test

The thumb penetration test estimates the unconfined compressive strength of cohesive soils and is based on testing described in the American Society for Testing and Materials (ASTM) standard D2488. Take a soil sample collected from a freshly dug soil clump from the spoil pile. Press your thumb against the sample. If the sample is readily indented by your thumb but penetration can be done only by using great effort, then the soil is classified as Type A. If penetration occurs to the base of the thumb nail and is accomplished with moderate difficulty, then it is Type B. If the sample can be penetrated easily several inches by the thumb, and if it can be molded by light finger pressure, then the soil is Type C. Drying the sample can greatly influence the results of this test. Perform this test immediately after taking the sample.

Mechanical Devices

Mechanical devices for determining soil type include the pocket penetrometer and the hand-operated vane shear penetrometer. Operation of the device and interpretation of the results are found in the manual or literature furnished by the manufacturer of these devices. For a complete discussion of soils and testing, refer to the 29 CFR 1926 Subpart P, Appendix A.

Protective Systems

Introduction

This section will provide information on protective systems used to reduce the possibilities of fatalities and injuries from cave-ins during excavations. Information on sloping and benching techniques for every soil type and methods of using shoring and trench box equipment will also be provided.

Background

Except in stable rock, the Occupational Safety and Health Administration requires workers to be protected against the danger of cave-ins in trenches and/or excavations that are **five feet** or deeper. There are four recognized methods of protection: sloping, benching, shoring and shielding (trench box). The use of any of these methods or combinations of these methods are governed by factors such as space, soil types, depth, speed, and expense.

Requirements

OSHA states, "each employee in an excavation shall be protected from cave-ins by an adequate protective system."
There are only two exceptions when a protective system is not required: (1) excavation made entirely in stable rock; or (2) excavation less than five feet deep which has been examined by a competent person who determined there is no indication for a potential cave-in.

Sloping and Benching

Sloping is a protective measure that cuts the walls of the excavation back at an angle from the floor to produce a stable slope. The slope angle is based on soil type. The flatter the angle of the slope, the greater the protection factor for the employee (see Figure 1).

- Type A Soil: The ratio is 3/4 ft. horizontal for every foot vertical (53° from the horizontal)
- Type B Soil: The ratio is 1 ft. horizontal for every foot vertical (45° from the horizontal)
- Type C Soil: The ratio is 11/2 ft. horizontal for every one foot vertical (34° from the horizontal)

Benching is the process of cutting benches or steps into the excavation (see Figure 2). The angle used for benching is based on a ratio of horizontal to vertical cuts. It should be noted that benching is reserved only for cohesive soils.

It is not permissible to bench Type C soil because of its inability to support a vertical wall. Type C soils always require the use of sloping, shielding, or shoring.

Factors like these make soil less stable:

- Vibration from machinery or traffic;
- Exposure to rain or flooding;
- Periods of low humidity (drying); and
- Soil loading from overburden or equipment.

When these factors are present the excavation, whether benched or sloped, must be re-inspected for signs of distress.

Distress signs include:

- Cracking excavation walls;
- Cracks in the surface soil 1/2 to 3/4 the distance back from the excavation as the excavation is deep;

- Bulging of the trench wall; and
- Sloughing off of clods or small sections from the trench wall.

All of these indicate an imminent danger of cave-in. If any of these signs are observed, employees shall be directed to evacuate the excavation and the slope shall be cut back further or a mechanical protective system installed.

Shoring and Shield Systems

Shoring and shield systems are protective measures that add support to an excavation.

The safest system is one that can be installed and removed without personnel entering the excavation.

Shoring

This system is designed to prevent excavation failure (cave-ins) by supporting trench walls with a system of vertical uprights and/or sheeting and Cross braces (shores). Shores are structures that cross the trench and put pressure on the vertical uprights and sheeting (see Figure 3). Shoring methods range from timber shoring to aluminum hydraulic devices that bear directly on the wall of the trench and transmit approximately 1500 pounds per square inch (psi) of pressure to pre-load the soil. This pressure preloading produces the so called "arch effect" that stabilizes the trench wall and prevents a cave-in. Information on timber shoring methods can be obtained from 29 CFR 1926, Subpart P, Appendix C. Appendix D has information for aluminum hydraulic shoring.

Some safety requirements for using aluminum hydraulic shoring are as follows:

- Installation and removal of the shoring is done from outside of the excavation.
- Individual shores (elements) are pressurized and depressurized slowly to prevent failure of the remaining shores or collapse of the excavation walls.
- Data provided by the manufacturer is tabulated and designed by a registered professional engineer (PE).

This information and procedures for use must be followed regardless of soil classifications. Any modification must be made by a registered professional engineer and approved in writing and sealed.

Shielding

A trench shield is an engineered metal box that is placed in the excavation. It does not provide structural strength to the excavation, but provides workers a safe worksite that protects them from collapsing material. A registered professional engineer must design the trench shield or trench box system which can be premanufactured or built on site as necessary. Regardless of where they are built, they must be constructed to exact engineering specifications. There are several safety requirements when using a trench box:

- Shields must be installed in a manner that restricts side-to-side movement or any other hazardous movement in the event of sudden lateral movement, i.e., trench failure.
- The shield system shall not be exposed to loads exceeding the design standard.
- Workers shall be protected from the hazards of cave-ins when entering or leaving the area protected by the shield.
- Workers shall not be allowed inside the shield or to ride on the shield, when the shield is being installed, removed or moved vertically.
- Shield structure shall extend a minimum of 18 inches above the lip of the excavation when used in conjunction with a sloped or benched excavation.
- Excavation may be permitted up to a depth of 2 feet below the bottom of the shield provided the shield is designed to resist the forces calculated for the full depth of the trench and there is no indication while the trench is open of a possible collapse of soil from behind or below the bottom of the shield.

Final Safety Requirement

All excavations must be backfilled as soon as possible after removal of the support system. No worker is permitted in an unshored or unprotected excavation or trench no matter how compelling the reason.

Excavation Safety Quiz

Name: _____

Department: _____

Date: _____

Employee or SSN: _____

Circle the letter indicating the correct answer.

1. A stairway, ladder, ramp or other safe means of egress shall be located in trench excavations that are 4 ft. (1.22 m) 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 thumb penetration test is based on _____.
   a. OSHA table Z-1
   b. NFPA
   c. ASTM D2488
   d. not listed

3. In excavations less than five feet deep, no shoring is required if _____.
   a. soil passes the thumb penetration test
   b. soil is classified as type B
   c. there is no standing water in the excavation
   d. examined by a a competent person who determined there is no potential of a cave-in

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. Excavations with vertical walls that remain intact when exposed are in _____.
   a. Type A soil
   b. Type B soil
   c. Type C soil
   d. stable rock

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 aluminum hydraulic shoring is that workers do not have to enter an unprotected trench to install or remove it.
   a. True b. False

9. When excavating under the base of a wall, foundation or sidewalk, the support system must be designed by a registered professional engineer.
   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

Resources

"Excavations." Code of Federal Regulations Title 29, Pt. 1926, Subpt. P, September 1, 2000 ed.

8 Hour Competent Person Student Manual, Speed Shore Corporation, 1993

OSHA 2226, Excavations, Occupational Safety and Health Administration, 2000 (Reprinted)

Test Answers:

1. b
2. c
3. d
4. b
5. d
6. b
7. c
8. a
9. a
10. c

Excavation Safety Training

The following people have attended training on the excavation safety program on:

Name	Signature	Employee #

Training conducted by_____

Signature _____

Title _____

Exhibits

Figure 1
Simple Slop Excavation

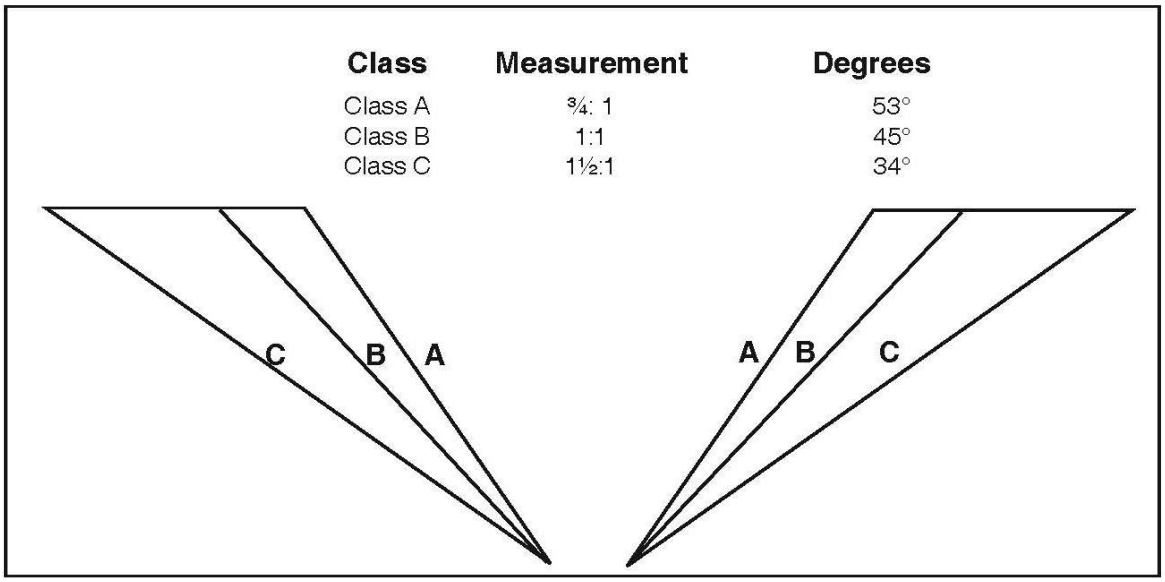

Figure 2
Simple Bench Excavation

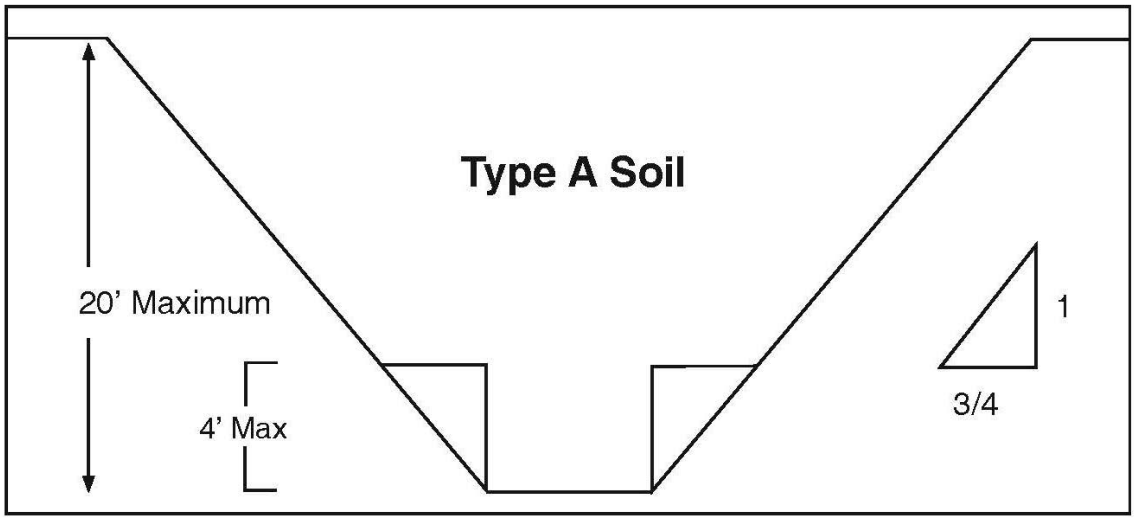

Figure 3
Hydraulic Shoring