Excavation Hazards

An Online Continuing Education Course for Engineers

Course Number: C-2001

Credit: 2 Hours / 2 PDH / 2 CPD

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INTRODUCTION

Excavation and trenching are among the most hazardous construction operations. Cave-ins pose the greatest risk and are much more likely than other excavation-related accidents to result in worker fatalities. The United States Bureau of Labor Statistics (BLS) data show that 271 workers died in trenching or excavation cave-ins from 2000 through 2006. In addition to cave-ins, workers may also be exposed to the risks associated with combustible gases and oxygen deficiencies during trenching operations. Other potential hazards include falls, falling loads, and incidents involving mobile equipment. All of these hazards are recognized and preventable, yet injuries and fatalities related to trench work and excavation continue to occur.

In this course, you will learn how to protect employees against trench cave-ins and other hazardous conditions. You will also learn what you must do to comply with the Occupational Safety and Health Administration (OSHA) Excavation and Trenching standard, *Title 29 of the Code of Federal Regulation (CFR),* Part 1926.650.

DEFINITIONS

Accepted Engineering Practices are procedures compatible with the standards of practice required of a registered professional engineer.

Adjacent Structures Stability refers to the stability of the foundation(s) of adjacent structures whose location may create surcharges, changes in soil conditions, or other disruptions that have the potential to extend into the failure zone of the excavation or trench.

Competent Person is an individual who is capable of identifying existing and predictable hazards or working conditions that are 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 is 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 employee occupancy.

Excavation and **Trench**. An **Excavation** is any man-made cut, cavity, trench, or depression in an earth surface that is formed by earth removal. A **Trench** is a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth of a trench is greater than its width, and the width (measured at the bottom) is not greater than 15 ft (4.6 m). If a form or other structure installed or constructed in an excavation reduces the distance between the form and the side of the excavation to 15 ft (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

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

Ingress and Egress mean "entry" and "exit," respectively. In trenching and excavation operations, they refer to the provision of safe means for employees to enter or exit an excavation or trench.

Protective System refers to a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, and from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

Registered Professional Engineer is a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer who is registered in any state is deemed to be a "registered professional engineer" within the meaning of Subpart P when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

Support System refers to 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.

Subsurface Encumbrances include underground utilities, foundations, streams, water tables, transformer vaults, and geological anomalies.

Surcharge means an excessive vertical load or weight caused by spoil, overburden, vehicles, equipment, or activities that may affect trench stability.

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

Underground Installations include, but are not limited to, utilities (sewer, telephone, fuel, electric, water, and other product lines), tunnels, shafts, vaults, foundations, and other underground fixtures or equipment that may be encountered during excavation or trenching work.

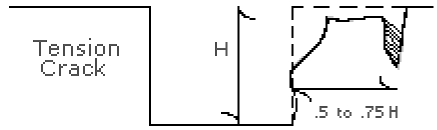
Unconfined Compressive Strength is the load per unit area at which soil will fail in compression. This measure can be determined by laboratory testing, or it can be estimated in the field using a pocket penetrometer, by thumb penetration tests, or by other methods.

OVERVIEW OF SOIL MECHANICS

A number of stresses and deformations can occur in an open cut or trench. For example, increases or decreases in moisture content can adversely affect the stability of a trench or excavation. The following diagrams show some of the more frequently identified causes of trench failure.

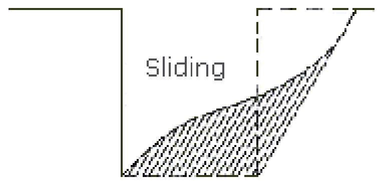
Tension Cracks. Tension cracks usually form at a horizontal distance of 0.5 to 0.75 times the depth of the trench, measured from the top of the vertical face of the trench. See figure 1for additional details.

FIGURE 1. TENSION CRACK.



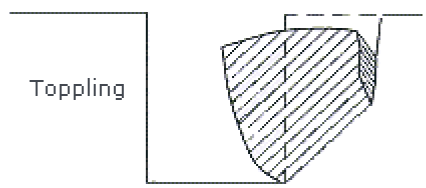
Sliding or sluffing may occur as a result of tension cracks, as illustrated in figure 2.

FIGURE 2. SLIDING.



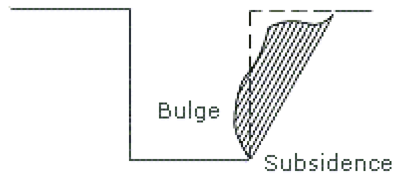
Toppling. In addition to sliding, tension cracks can cause toppling. Toppling occurs when the trench's vertical face shears along the tension crack line and topples into the excavation (see figure 3).

FIGURE 3. TOPPLING.



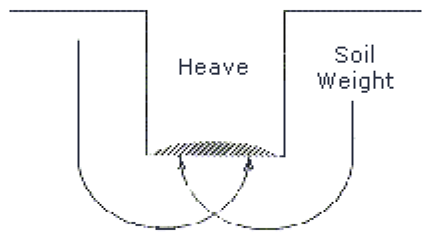
Subsidence and Bulging. An unsupported excavation can create an unbalanced stress in the soil, which, in turn, causes subsidence at the surface and bulging of the vertical face of the trench (see figure 4). If uncorrected, this condition can cause face failure and entrapment of workers in the trench.

FIGURE 4. SUBSIDENCE AND BULGING.



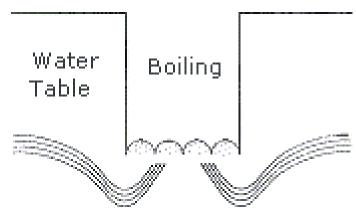
Heaving or Squeezing. Bottom heaving or squeezing is caused by the downward pressure created by the weight of adjoining soil. This pressure causes a bulge in the bottom of the cut, as illustrated in figure 5. Heaving and squeezing can occur even when shoring or shielding has been properly installed.

FIGURE 5. HEAVING OR SQUEEZING.



Boiling is evidenced by an upward water flow into the bottom of the cut. A high water table is one of the causes of boiling (see figure 6). Boiling produces a "quick" condition in the bottom of the cut, and can occur even when shoring or trench boxes are used.

FIGURE 6. BOILING.



Unit Weight of Soils refers to the weight of one unit of a particular soil. The weight of soil varies with type and moisture content. One cubic foot of soil can weigh from 110 pounds to 140 pounds or more, and one cubic meter (35.3 cubic feet) of soil can weigh more than 3,000 pounds.

DETERMINATION OF SOIL TYPE

OSHA categorizes soil and rock deposits as follows:

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

Determining whether a deposit is of this type may be difficult unless it is known whether cracks exist and whether or not the cracks run into or away from the excavation.

Type A Soils are cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (tsf) (144 kPa) or greater. Examples of Type A cohesive soils are often: clay, silty clay, sandy clay, clay loam and, in some cases, 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 part of a sloped, layered system where the layers dip into the excavation on a slope of 4 horizontal to 1 vertical (4H:1V) or greater, or has seeping water.)

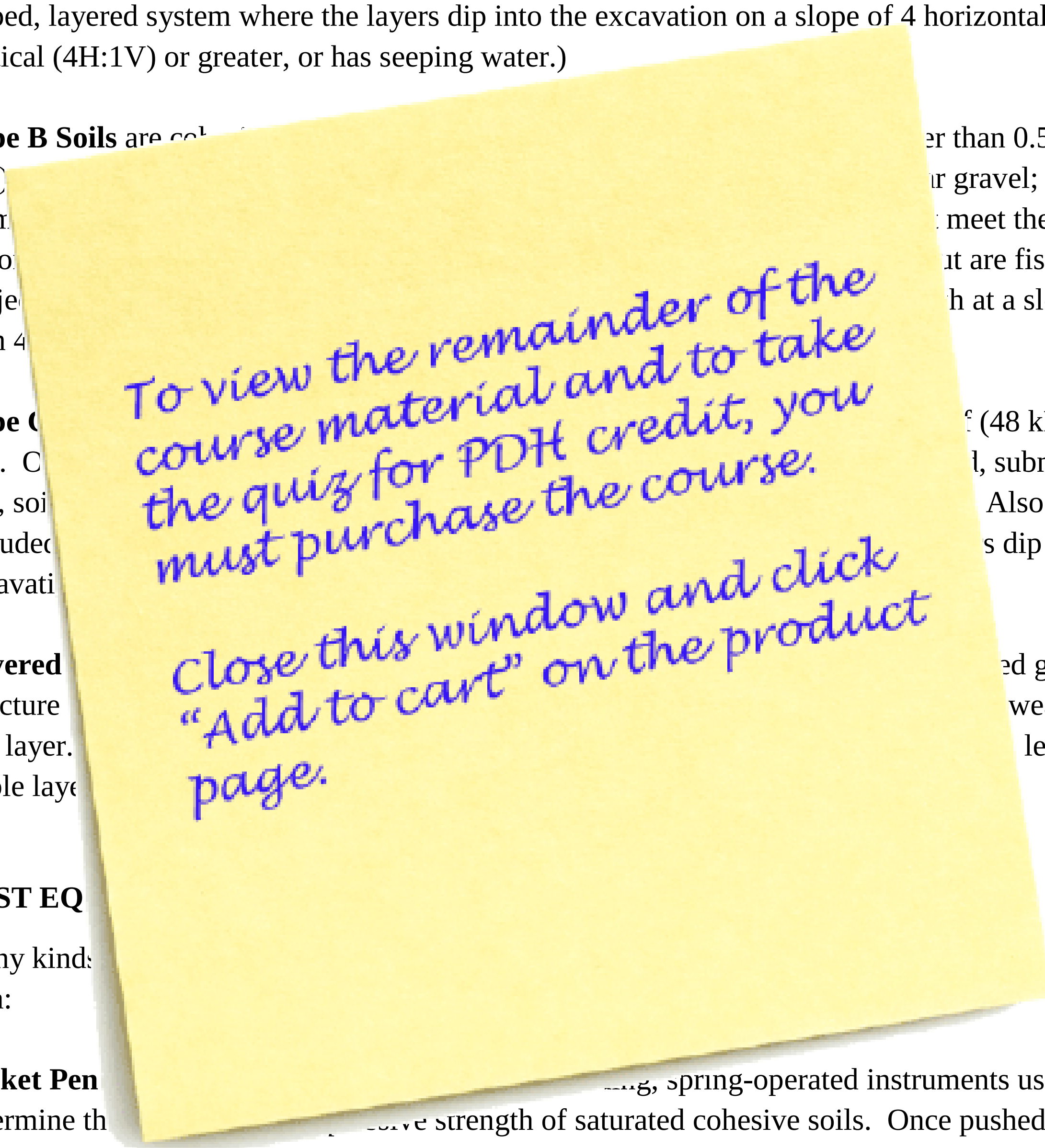
Type B Soils are co… er than 0.5 tsf (48 kPa)… ar gravel; silt; silt loam… meet the unco… ut are fissured or subje… h at a slope less than 4…

Type C… f (48 kPa) or less. C… l, submerged soil, soi… Also included… s dip into the excavati…

Layered… ed geologic structure… weakest soil layer. … less stable laye…

TEST EQ…

Many kinds… n an area:



Pocket Pen… …ng, spring-operated instruments used to determine th… …ssive strength of saturated cohesive soils. Once pushed into the soil, an indicator sleeve displays the reading. The instrument is calibrated in either tons per square foot (tsf) or kilograms per square centimeter (kPa). However, Penetrometers have error rates in the range of ± 20-40%. There are several tests that can be performed with a pocket penetrometer: