



# Construction Management

## Trench Excavation

### ABSTRACT

Trenches have long been a source of serious injuries and fatalities, as well as property damage, on a construction project. Even a shallow trench can collapse unexpectedly and cause injury and death (suffocation) to workers. This report outlines some exposures and hazards associated with trenching excavation and suggests remedial measures to better control these exposures, such as worker access/egress warning and protective systems.



### INTRODUCTION

A trench is typically defined as a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, as measured from the bottom to

grade, and the width at the bottom is not greater than 15 ft (4.57 m).

A wide range of operations are associated with trenching. They may include blasting, dewatering, handling and placing heavy materials, moving heavy equipment in and around the trench, and controlling vehicular and pedestrian traffic. This combination of operations creates multiple opportunities for loss. Losses that do occur are often costly, both in lives and material costs.

### SOIL TYPES AND MECHANICS

Soil is a mixture of rock, water, air, and a variety of other materials. It is the proportions of rock, water, and air that, more than anything else, determine cohesiveness or the ability of the soil to stay together. An open, vertical- or near vertical-sided excavation is an unnatural, and therefore unstable, condition. In nature, soil appears in what is called the natural angle of repose; unless created by erosion, this angle will not be vertical. Soil is a very heavy material: a cubic foot weighs between 110-130 pounds (49.90-58.97 kg), which is slightly less than what a cubic foot of concrete weighs - 150 pounds (68.04 kg). A cave-in of only one cubic yard (9 cubic feet) of soil can result in the displacement of over one half of a ton (530.73 kg) of soil.

### HAZARDS AND EXPOSURES

Every year, many workers are killed or severely injured in trench cave-ins. Cave-ins have resulted in extensive property damage when sidewalks, roads, and adjacent structures are damaged by settlement and/or undermining, resulting from trench excavation. Related problems, such as the vibration and shocks associated with heavy construction equipment or blasting, are also concerns. Underground and overhead utilities may be damaged by the excavation equipment, resulting in injury, as well as costly service interruption and repairs. Inadequately protected trenches also become a hazard for pedestrians and vehicles not associated with the construction work in progress.

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In addition to the hazards outlined above, hazardous atmospheres and water accumulation in the trench are important considerations. The work being performed may generate the hazardous atmosphere, i.e., welding or cutting operations or the use of fuel-powered equipment in or near the trench. Hazardous atmospheres may also result from local existing conditions, i.e., adjacent gas lines or gases seeping in from the soil. Water can result from aboveground, such as rain or runoff, or leach-in from the groundwater below. The accumulation of water in a trench weakens the soil, making it more susceptible to cave-in. Conversely, air drying of previously stable soil may render it unstable and should be avoided.

### CONTROLLING THE HAZARDS

Despite the many hazards and exposures, controlling the hazards is possible. Plans must be made at the time of bidding to assure that necessary resources are available. Construction Management Report CM-20-04, Organizing for Loss Control - Prejob Planning, gives an overview of general issues to consider. Listed below are some specific issues of concern.

Study plans, specifications, and test borings to determine the following:

1. The location of the excavation boundaries and right of way.
2. Best routes to move equipment and material to and from the excavation site.
3. Relative location of roads, sidewalks, and structures that may require barricades, shoring, underpinning, prejob surveys, and/or monitoring during the course of construction.
4. Existence of utilities (underground and overhead) and methods of operations and protection procedures to be used (see Construction Management Report CM-55-06, Protection of Underground Utilities During Construction). [4]
5. Soil conditions, including groundwater levels, geology, and seismicity of the area.
6. Requirements and controls for dewatering operations (see Construction Management Report CM-55-05, Dewatering).
7. Requirements and controls for blasting operations.
8. Requirements for signs, barricades, flagmen, and traffic control plans.

### Requirements for Signs, Barricades, Flagmen and Traffic Control Plans

- Identify and analyze material and equipment storage areas for access and security.
- Contact all utility companies, governmental agencies, or other operators of underground facilities to provide notification of intent to excavate (see Construction Management Report CM-55-08, One-Call Systems Directory for the United States). [3]
- Establish procedures and requirements (i.e., operator and/or component person certification) for personnel selection. Determine what personal protective equipment will be needed.
- Inspect and “walk” the right of way to identify additional exposures not indicated in the plans and specifications.



### TRENCHING EXCAVATION HAZARDS

The cave-in is the greatest risk associated with excavations. Each worker in an excavation should be protected from cave-ins through the use of sloping, protective systems, and/or a soil support technique. Daily inspections of excava-

tions, the adjacent areas, and protective systems should be made by the sit supervisor for evidence of possible cave-ins, failure of the protective system, hazardous atmospheres, or other hazardous conditions. Inspections should be made at the start of work and as needed throughout the work day, particularly after heavy rain or other hazard-increasing occurrences. It is extremely important that the supervisor have the authority to stop work and direct workers to safety.

The following are some specific trenching excavation hazards that loss control personnel should be aware of:

#### Site-Preparation Hazards

Digging and site-preparation hazards are those encountered in felling trees and grading the site, accidentally digging into underground electric, gas, or other utilities, contacting overhead powerlines, or undermining existing buildings or structures.



#### Materials and Falling Objects

Potential hazards include spoil heaps, large rocks, or soil clumps, stacks of material, and machinery or equipment that has fallen or rolled into the excavation. Any material or equipment that could fall or roll into an excavation should be kept at least 2 ft (0.61 m) from the edge [5], or should be kept from falling in through the use of retaining walls or other devices. The hazard of workers

falling into the excavation is increased if safe means of access/egress, including ladders or ramps, are not provided.

#### Hazardous Atmospheres

Hazardous atmospheres may include oxygen deficiency, carbon monoxide, hydrogen sulfide, explosive gases, or any other hazards that could to exist at each specific project worksite. If hazardous atmospheres exist, emergency rescue equipment should be located nearby, and all site workers properly trained in their use.

#### Mobile Equipment Hazards

Mobile equipment hazards include machine tipover, reckless or out-of-control machine operation, improper digging or placing of items, falls from equipment, and accidental contact with power lines.

#### Workers' Injuries

These include sprained ankles from walking on rough surfaces and ruts, strains from digging and lifting, being struck by objects being swung overhead or dropped, overexertion, being run over by mobile equipment, and during extreme weather, heat, or cold exposure.

#### Collapse of an Excavation

The potential hazard of a cave-in or collapse of an excavation or trench can result from:

- The intrinsic nature of the ground. This refers to the mechanical stability of the soil. Unstable ground results from the soil's lack of strong cohesive properties and weak angles of internal friction. Layered, or nonhomogeneous ground can consist of different layers of soil which may enable cave-ins to be easily set off.
- Overloading at the edge of the excavation or trench. Material or equipment dangerously located too close to an excavation's perimeter edge can cause cave-ins. Existing buildings or fixtures can also be weakened or undermined by an excavation.
- The presence of water. The presence of water will usually result in reduced stability of the excavation or trench walls. Surface water can

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run in, or water can permeate in from the ground. Freezing, thawing, and heavy rains can also have dramatic effects on soil stability. OSHA's excavation standard [5] expressly prohibits employees from working in excavations and trenches where water has accumulated or is accumulating, unless adequate protection has been taken. If water-removal equipment such as trash pumps and siphons is used to control or prevent water from accumulating, the equipment must be monitored continuously to ensure proper operation.

OSHA standards require that diversion ditches, dikes, or other suitable means are used to prevent surface water from entering an excavation.

- The presence of mobile equipment and machinery. The use of earth-moving and lifting equipment can place excess loads along the edges of an excavation. Vehicles traveling near the edge of excavations are all too common on construction sites, usually because there's not enough clearance available between existing buildings, trees, or other obstructions and the excavation. There can lead to difficulty in maneuvering heavy equipment and result in soil instability near the excavation. Other related hazards include noise, exhaust gases, and vibration from the equipment and machinery.

### Stability of Adjacent Structures

The foundations of adjacent structures (buildings, roadways, and sidewalks) can be severely affected by trenching operations. Support systems, such as underpinning or bracing, can be employed. In some cases, this may require the approval of a registered Professional Engineer (PE).

### WORKER ACCESS AND WARNING SYSTEMS [5]

Excavations and trenches that are 4 feet (1.22

m.) or deeper, require a stairway, ladder, ramp, or other safe means of worker access/egress. This means of access/egress must be within 25 ft (7.62 m) of lateral travel of any individual worker inside the excavation. Structural ramps constructed solely for worker entrance and exit should be properly designed, as should ramps designed for equipment access. Any trench excavation over 20 ft (6.10 m) deep requires approval by a professional engineer (PE).

If workers will have to cross a trench, walkways or bridges with standard guardrails should be provided. Workers should not be required to jump over the trench.



An effective warning system should be put into place to alert mobile equipment operators when they're approaching a trench or other excavation, or when they're operating their equipment adjacent or parallel to the perimeter edge. An operator of a miniloader, backhoe, bulldozer, or front-end loader, may not be able to see the edge of the excavation from inside the equipment. Stop-blocks, barricades, hand signals, and similar systems should be utilized and all workers and operators trained in their usage. Sloping the surrounding area adjacent to an excavation away (descending) from the perimeter edge can also be utilized as a means of alerting the operator.

### Work Location

All workers who are not directly involved with the operation should be kept away from digging and lifting equipment. Workers should never be allowed to enter or remain in an excavation when equipment is in use unless communication is provided between the backhoe or excavator operator and some on the ground or in the excavation. Only one worker should provide the signaling, since allowing multiple workers to give

signals may create confusion for the equipment operator. To avoid worker injuries due to operator error or machinery failure, such as from hydraulic leaks, electrical shorts, or other breakdowns, workers in the trench need to move away from the bucket, digger, or other attachment while it is actively running - they should never put themselves or any parts of their bodies in the line of the equipment.

**Protective Systems**

For excavations and utility trenches that are unstable or more than 5 ft (1.52 m) deep, use protective systems such as spoils placement, sloping and benching, scaling, shoring, shields or trench boxes, and water management. Unless a soil analysis has been completed, the earth's slop in an excavation or trench must be at least 1-1/2 units of horizontal run to every unit of vertical rise if no other protective systems are in use.

[5]

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