AgriLIFE EXTENSION
Texas A&M System

TRENCHING AND EXCAVATION SAFETY

David W. Smith, Extension Safety Program

January 2003. Two Hispanic construction laborers (brothers aged 15 and 16 years), who were employed by a company with 65 employees, died when the trench in which they were working caved in. The laborers were installing conduit in a trench 8 feet deep and 2 feet wide. When work started, the jobsite foreman instructed the crew leader to operate a backhoe to dig the trench and then left the site to check on another job. Approximately 1 hour later, the trench collapsed, burying the two laborers. Coworkers uncovered the two workers and removed them from the trench as the rescue squad arrived. The workers could not be revived. Subsequent investigation indicated an absence of protective equipment or precautions (e.g., no trench box, benching, sloping, or shoring) that could have prevented the collapse of the trench. *Source: FACE Report 2003-07.*

TRENCHING AND EXCAVATION INJURIES

Trenching and excavation is known to be one of most hazardous operations in the construction industry. From 1992 to 2001, the Census of Fatal Occupational Injuries (CFOI) maintained by the Bureau of Labor Statistics identified 542 fatalities associated with trenching and excavation. Jobs most frequently reporting fatalities were those involved in "excavation work", followed by "water, sewer, pipeline, and communications and power-line construction".

Table 1. Number of Excavation and Trenching Fatalities, 1992 - 2001

Industry	No.
Excavation work	141
Water, sewer, pipeline, and communications and power-line construction	131
Plumbing, heating, and air conditioning	59
Heavy construction, not elsewhere classified	27
General contractors, single-family homes	19
Highway and street construction, except elevated highways	16
General construction – nonresidential buildings, other than industrial buildings, warehouses	14
All other industries	135
Total	**542**

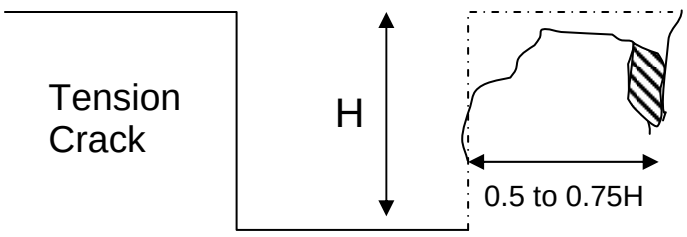
Source: CFOI (excludes New York City).

EXCAVATION FAILURE

There are numerous reasons why the sides of an open, unsupported trench or excavation will fail due to stresses and deformations. High or low soil moisture content, for example, can adversely affect the stability of a trench or excavation. Following are the most frequently cited causes of trench failure.

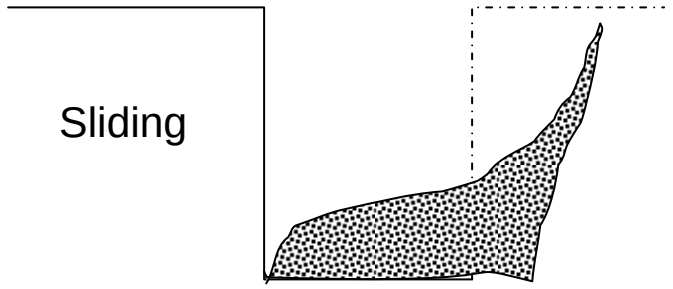
Tension Cracks

Tension cracks usually form at a horizontal distance of 0.5 to 0.75 times the depth of the trench (H), measured from the top of the vertical face of the trench.



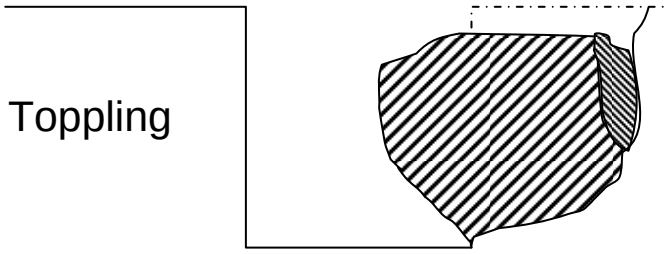
Sliding

Sliding or sluffing may occur as a result of tension cracks.



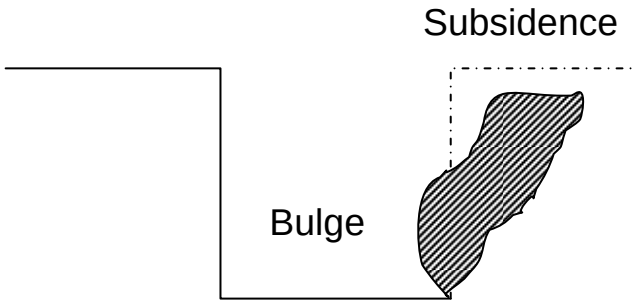
Toppling

In addition to sliding, tension cracks can cause toppling. Toppling occurs when the trench's vertical force shears along the tension crack line and topples into the excavation.



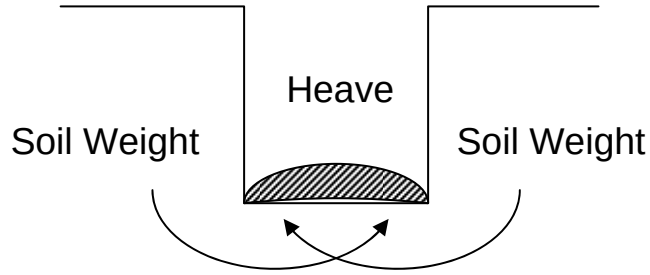
Subsidence and Bulging

An unsupported excavation can create an unbalanced stress in the soil, which, in turn, causes subsidence and bulging of the vertical face of the trench. If uncorrected, this condition can cause face failure and entrapment of workers in the trench.



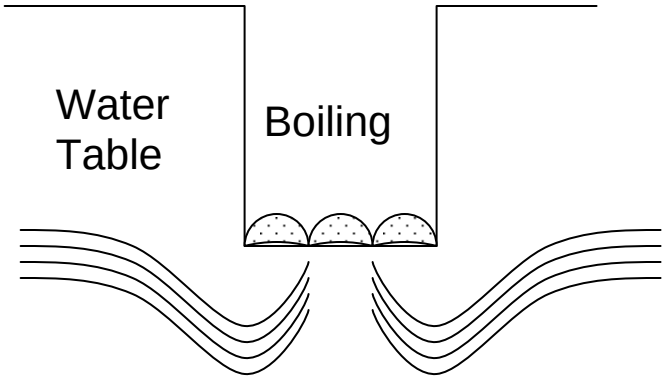
Heaving or Squeezing

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 the drawing above. Heaving and squeezing can occur even when shoring or shielding has been properly installed.



Boiling

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. Boiling produces a "quick" condition in the bottom of the cut, and can occur even when shoring or trench boxes are used.



TYPES OF PROTECTIVE SYSTEMS

Occupational Safety and Health Administration (OSHA) standards 29 CFR 1926.650, 1926.651, and 1926.652 are designed to protect workers from excavation hazards. OSHA standards apply to all businesses that employ 11 or more employees.

According to OSHA standards, employers must protect employees from cave-ins using an adequate protective system unless: 1) excavations are made

entirely in stable rock; or 2) excavations are less than 5 feet in depth and examination of the ground by a competent person provides no indication of a potential cave-in.

Three acceptable protection systems recognized by OSHA include sloping and benching, shield systems, and support systems. Selection and design of appropriate protection depends upon the physical dimension of the excavation or trench, soil type, exposure to physical surface and subsurface obstacles, and the type of work activities within the excavation.

Sloping and Benching

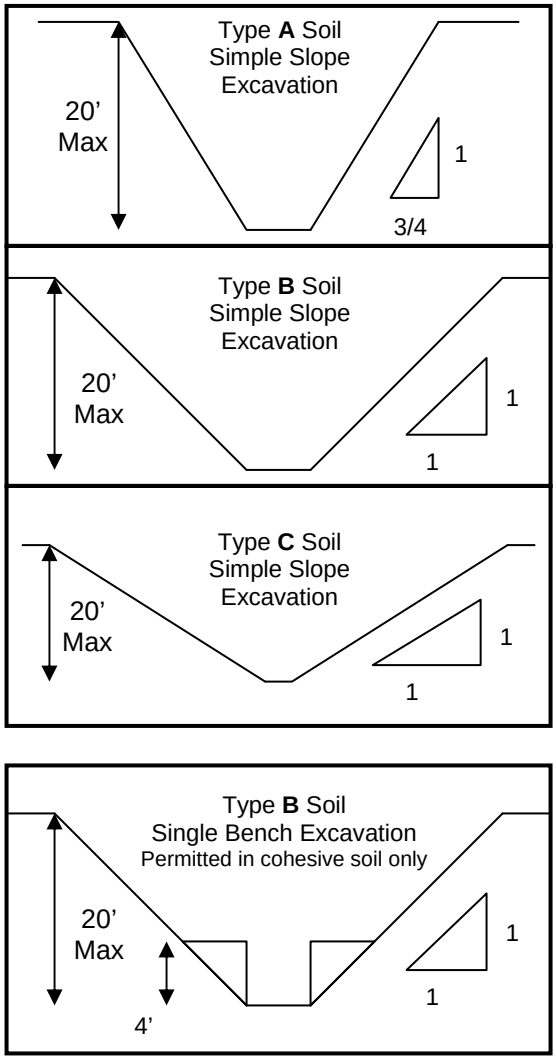
Sloping – A method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent cave-ins varies with differences in such factors as soil type, environmental conditions or exposure, and application of additional loads.

Benching – 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.

Table 2. Allowable Slopes

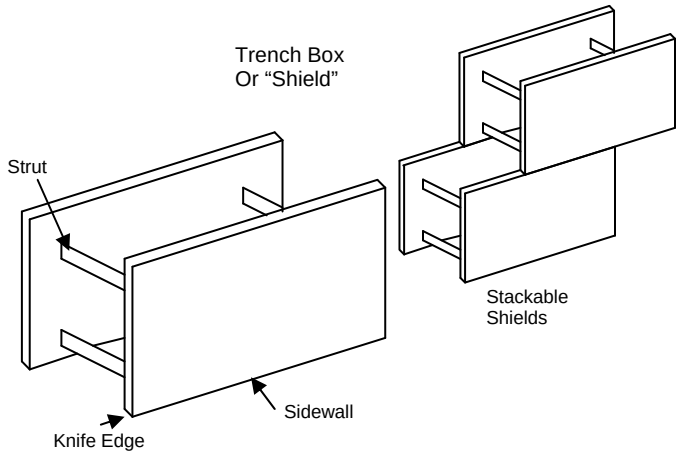
Soil Type	Height/Depth Ratio	Slope Angle
Stable rock	Vertical	90°
Type A	¾:1	53°
Type B	1:1	45°
Type C	11/2:1	34°
Type A[1]	½:1	63°

[1]Short term. For a maximum excavation depth of 12 feet.



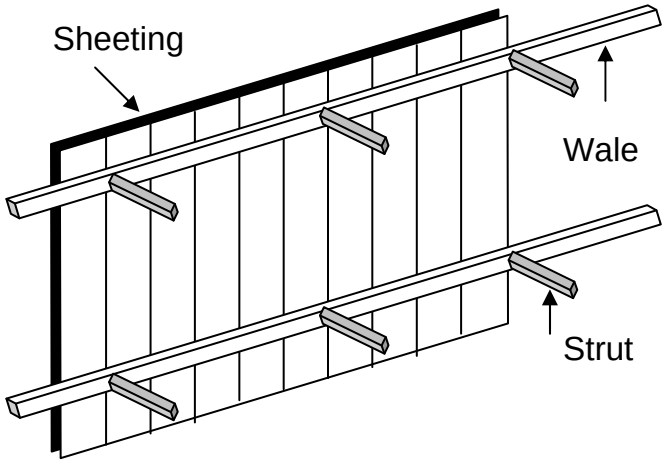
Shield Systems

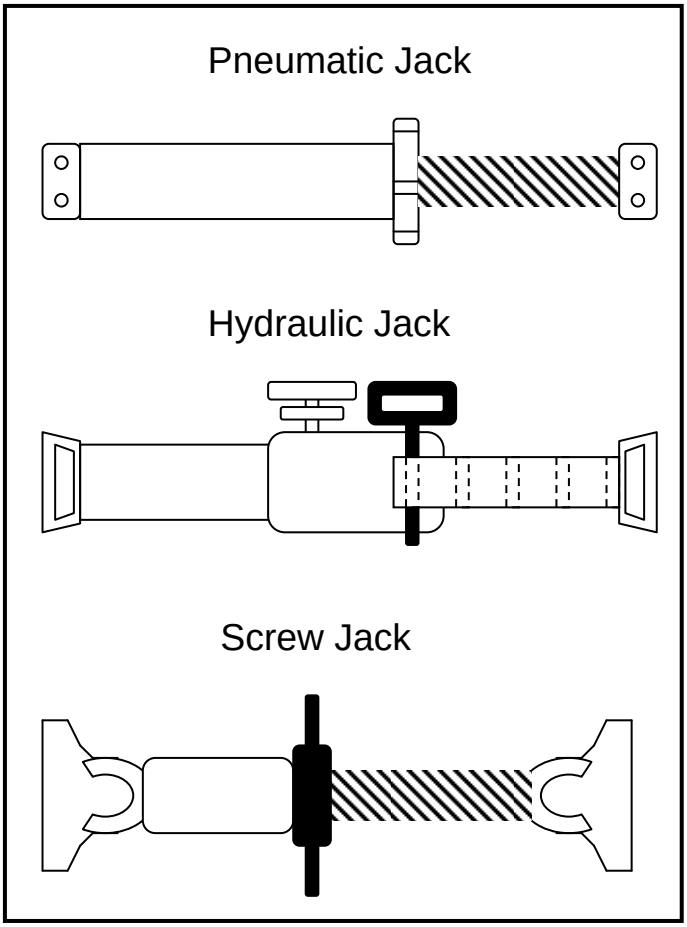
Shield – Any structure that is able to withstand the forces imposed on it by a cave-in and thereby protects employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Shields can be either pre-manufactured or constructed on site. Shields used in trenches are usually referred to as "trench boxes".



Support Systems

Support system – A structure such as underpinning, bracing, or shoring, which provides support to an adjacent structure, underground installation, or sides of an excavation.





OTHER SAFETY PRECAUTIONS

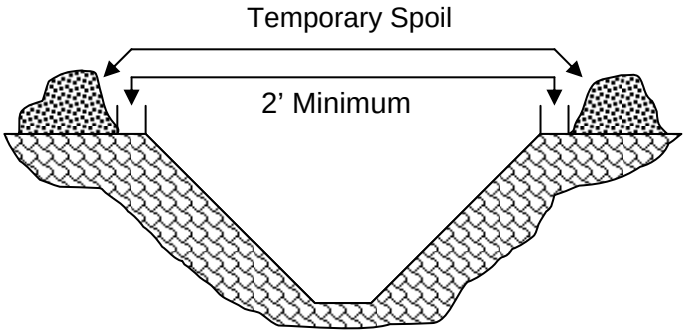
Although cave-ins account for the majority of excavation injuries and deaths, additional hazards exist during excavation work. These include:

- Contact with underground utility installations such as sewer, telephone, fuel, electric, and water lines
- Exposure to vehicular traffic
- Exposure to falling debris from atop the trench
- Hazardous atmospheres (such as oxygen deficient, toxic, or flammable atmospheres)

To protect against these hazards, consider the following safety precautions:

- Contact utility companies within established or customary local response times to locate and mark existing underground lines prior to excavating.
- While the excavation is open, protect, support, or remove underground installations to safeguard employees.

- Place stairways, ladders, ramps or other safe means of egress in trench excavations that are 4 feet or more in depth.
- Provided with and wear warning vests or other suitable garments marked with or made of reflective or highly-visible material to employees exposed to public vehicular traffic.
- Establish barricades, signs, or stop logs to prevent equipment from driving or rolling near the excavation.
- Use monitoring devices to detect hazardous atmospheres where they are reasonably expected to exist, such as in excavations in landfill areas or excavation in areas where hazardous substances are stored nearby.
- Keep emergency rescue equipment nearby during work in an excavation, such as breathing apparatus and safety harness and line.
- Support the stability of nearby buildings, walls, or other structures whose stability may be endangered by excavations operations.
- Keep all excavated materials at least 2 feet from the edge of excavations to protect against falling debris.



- Provide walkways with guardrails for employees or equipment that cross over excavations. OSHA requires guardrails where walkways are 6 feet or more above lower levels.
