Oregon OSHA

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ADSC

The International Association of Foundation Drilling

WEST COAST CHAPTER

Earth Retention Systems And Trenching /Excavation Hazards

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ADSC: The International Association of Foundation Drilling

OSHA's Injury Data

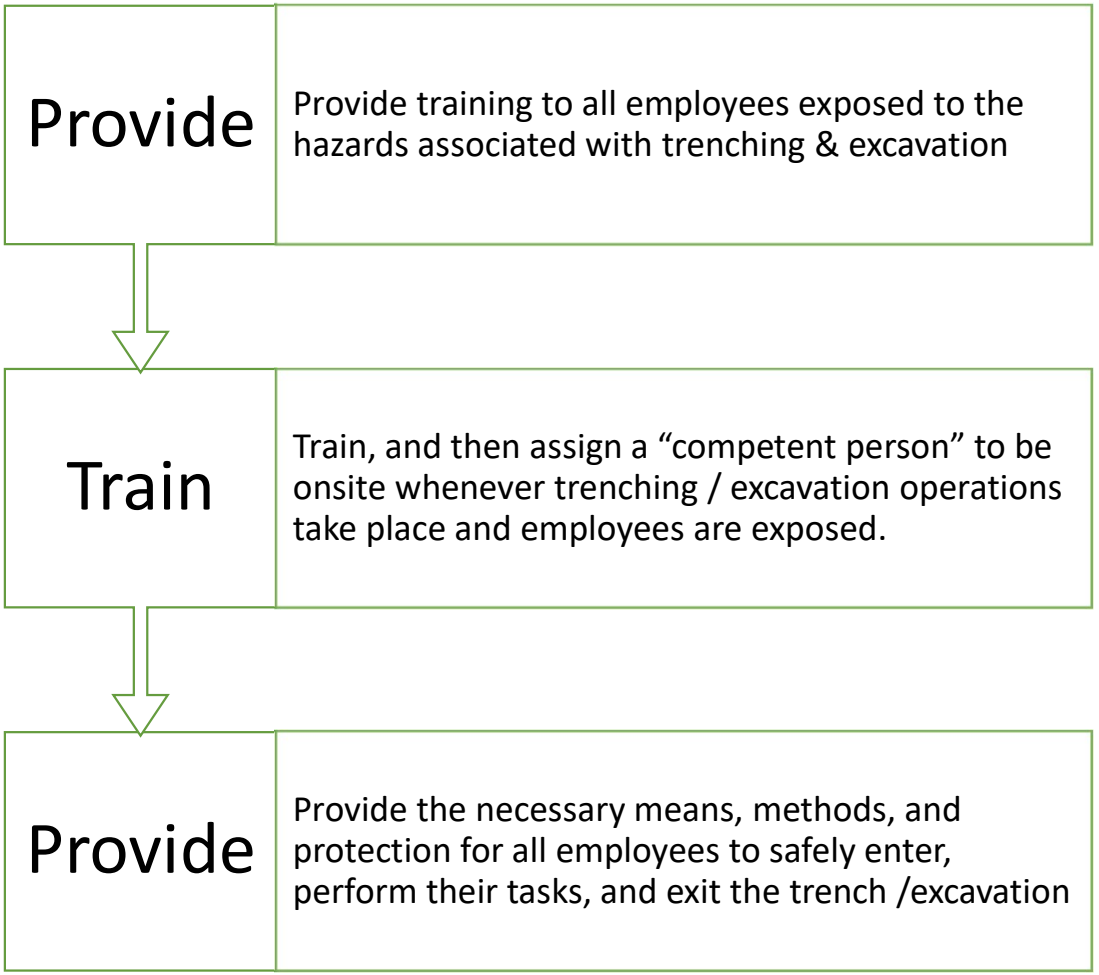
The following hazards are most responsible for excavation related injuries:

- No protective systems
- Failure to inspect the trench before and during work
- Improper spoils pile location
- Access/egress issues

Tragic Facts

- 60% are would be rescuers
  - Civilians
  - Fire/Rescue personnel
  - Co-workers
- Cave-ins can happen without warning
- All of these fatalities and injuries could have been prevented . . .

Employer Responsibilities



Definitions

- Excavation – a man-made cut, cavity, trench, or depression formed by earth removal.
- Trench – a narrow excavation. The depth is greater than the width, but not wider than 15 feet.
- Shield - a structure able to withstand a cave-in and protect employees
- Shoring - a structure that supports the sides of an excavation and protects against cave-ins
- Sloping - a technique that employs a specific angle of incline on the sides of the excavation. The angle varies based on assessment of impacting site factors.

Design of Protective Systems

The employer shall select and construct :

- slopes and configurations of sloping and benching systems
- support systems, shield systems, and other protective systems

- Shield - can be permanent or portable. Also known as trench box or trench shield.
- Sloping - form sides of an excavation that are inclined away from the excavation
- Shoring - such as metal hydraulic, mechanical or timber shoring system that supports the sides

Protection of Employees

Employees shall be protected from cave-in by using an adequately designed protective system

Protective systems must be able to resist all expected loads to the system

Earth Retention Systems

Earth retention systems are used for a variety of construction projects. They may be temporary during an excavation, or more permanent construction, such as basement walls for large buildings.

Earth retention systems may be used to stabilize or support a slope or an existing wall; create highway bridge abutments, wing walls, and approach embankments; or support an adjacent structure prior to performing an excavation.

No matter the application, earth retention systems protect nearby foundations from settlement, stabilizing lateral earth pressures, controlling movement, and draining potential groundwater.

Earth Retention Systems are a form of Engineered Shoring.

Earth Retention Systems

Typical earth retention systems include:

- Sheet Piling
- Soldier Beams and Lagging
- Soil nails / Shotcrete
- External Bracing - soil anchors or tie backs
- Internal Bracing - struts, diagonals, and rakers
- Auger-cast Piles
- Secant Piles
- Diaphragm (Slurry) Walls
- Chemical Soil Stabilization

Driven Sheet Piles

Typically installed using a mobile crane along with a suspended vibratory hammer.

In the last decade or so, dedicted pile drivers equipped with vibratory hammers have become more popular as an alternative equipment to drive and extract sheet piles.

Sheet Piling

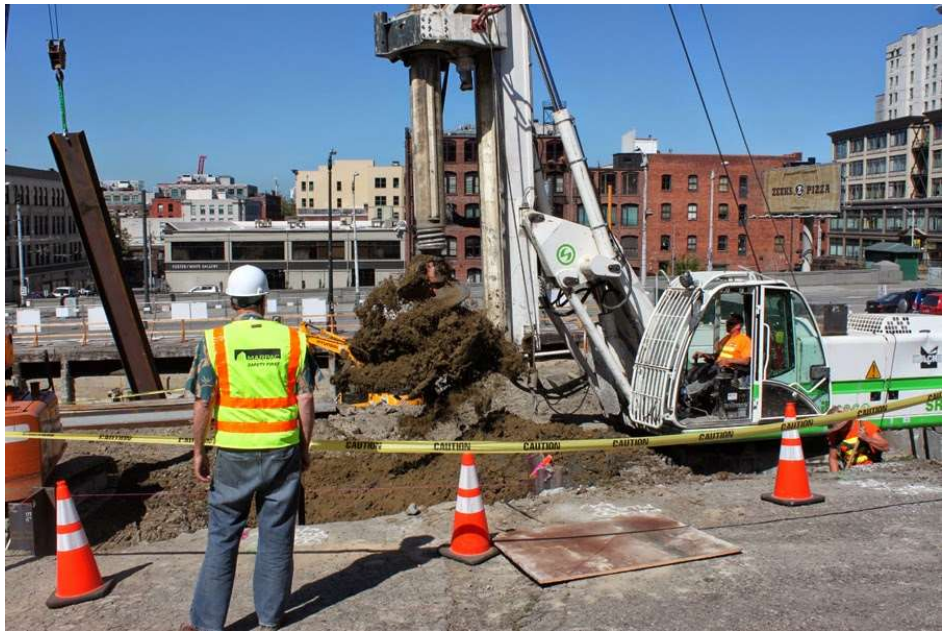
Soldier Beams and Lagging

This wall is designed to be “cantilevered” which is a freestanding structure without lateral support at its top.

This type of wall is cantilevered from the toe of the vertical piles and rise above to retain a higher-level grade on the opposite side.

The wall must resist the lateral pressures generated by loose soils or, in some cases, water pressure.

Drilled-In Soldier Beams (Drilled Shaft)



Drilled-In Soldier Beams (Micropiles)

Driven – In Soldier Beams

Soil Nails and Shotcrete

Shotcrete is pneumatically applied concrete. It is a low slump wet mixture that is blown (sprayed) onto the receiving surface after mixing with compressed air.

The concrete has a relatively low water/cement ratio, high cement content, and typically small aggregate not exceeding pea gravel size. High compressive strengths in excess of 5,000 psi are commonly attained.

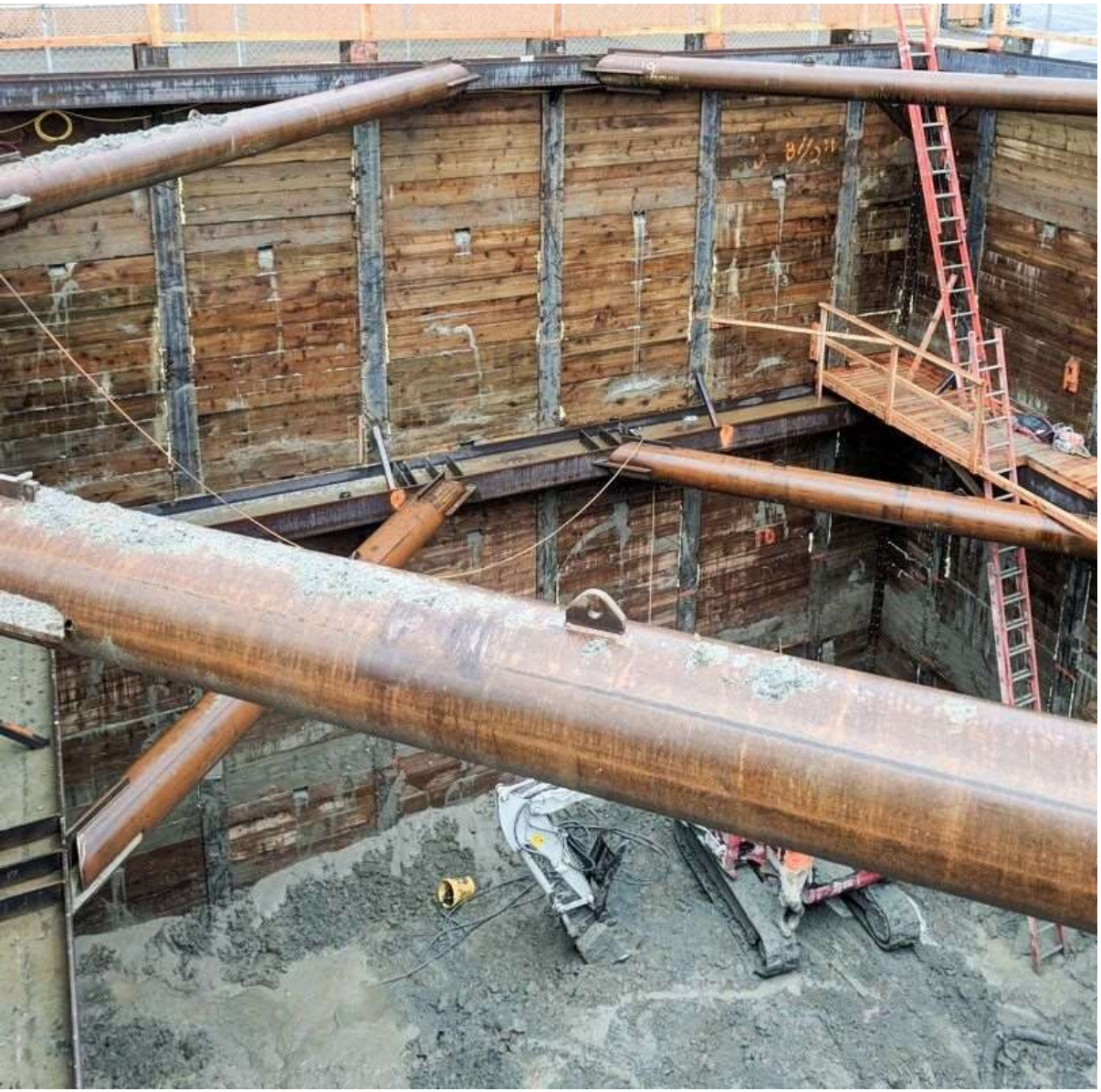
The sticky nature of shotcrete allows it to be placed on vertical and even overhead surfaces without the need for formwork. With good quality control a wall surface can be built out to an 8-inch thickness or more in a single pass.

Tieback Anchors

Tieback anchors are installed behind retaining walls to provide lateral support. A rod, wire, or tendon (cable) is anchored into the ground at one end and to the wall at the other.

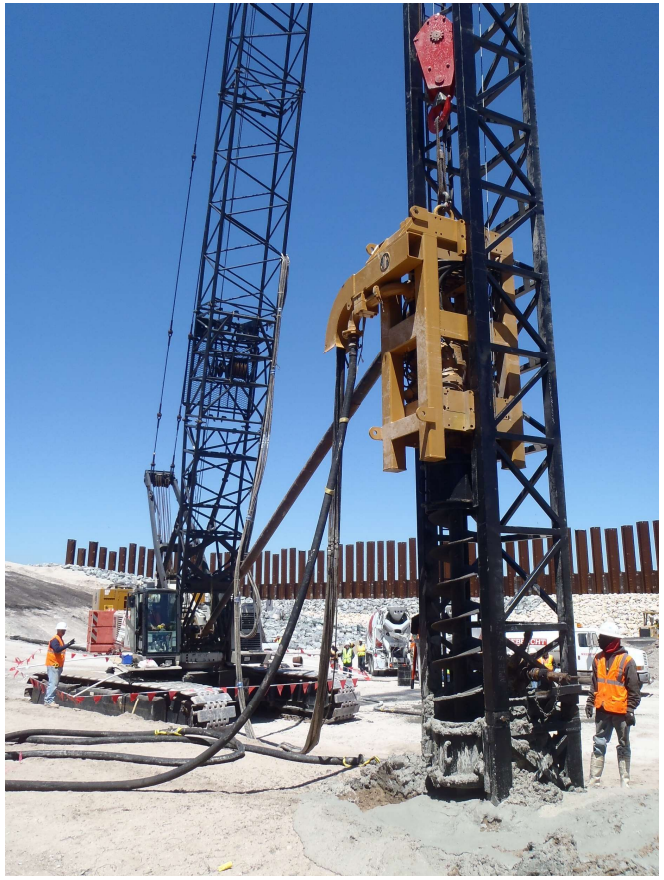
Anchoring in the ground is typically achieved by boring a hole in the soil or rock and encasing a portion of the wire or rod in a grout mixture.

The grout forms a bond with the surrounding soil and the tieback to secure the anchor. The tiebacks are tensioned, which in essence, pulls the wall toward the retained soil.



Soldier Pile and Lagging
Internal bracing - walers and struts

Auger-Cast Piles



Auger-Cast Piles

Secant Pile Wall

Secant Pile Wall

Chemical Grouting

Chemical grouting is a soil stabilization technique that utilizes a polyurethane chemical grout injection process to transform low-fine granular soils into sandstone monolithic masses.

The grouting approach is performed by inserting 1/2″ steel rods into weak soil zones and then injecting a high-density structural polyurethane into the area.

Chemical Grouting

Jet Grouting

Jet grouting is a method of ground reinforcement that uses a high velocity “jet” of grout to breakdown the soil structure and simultaneously mix cement grout with the in-situ soil.

The soil stabilization by jet grouting is occurs due to the hardening of grouted fluid within the soil. These hardened bodies forms like cemented columns which are grouted in numerous numbers as per requirement, thus stabilizing the soil. These columns are called as jet columns or jet grouted columns.

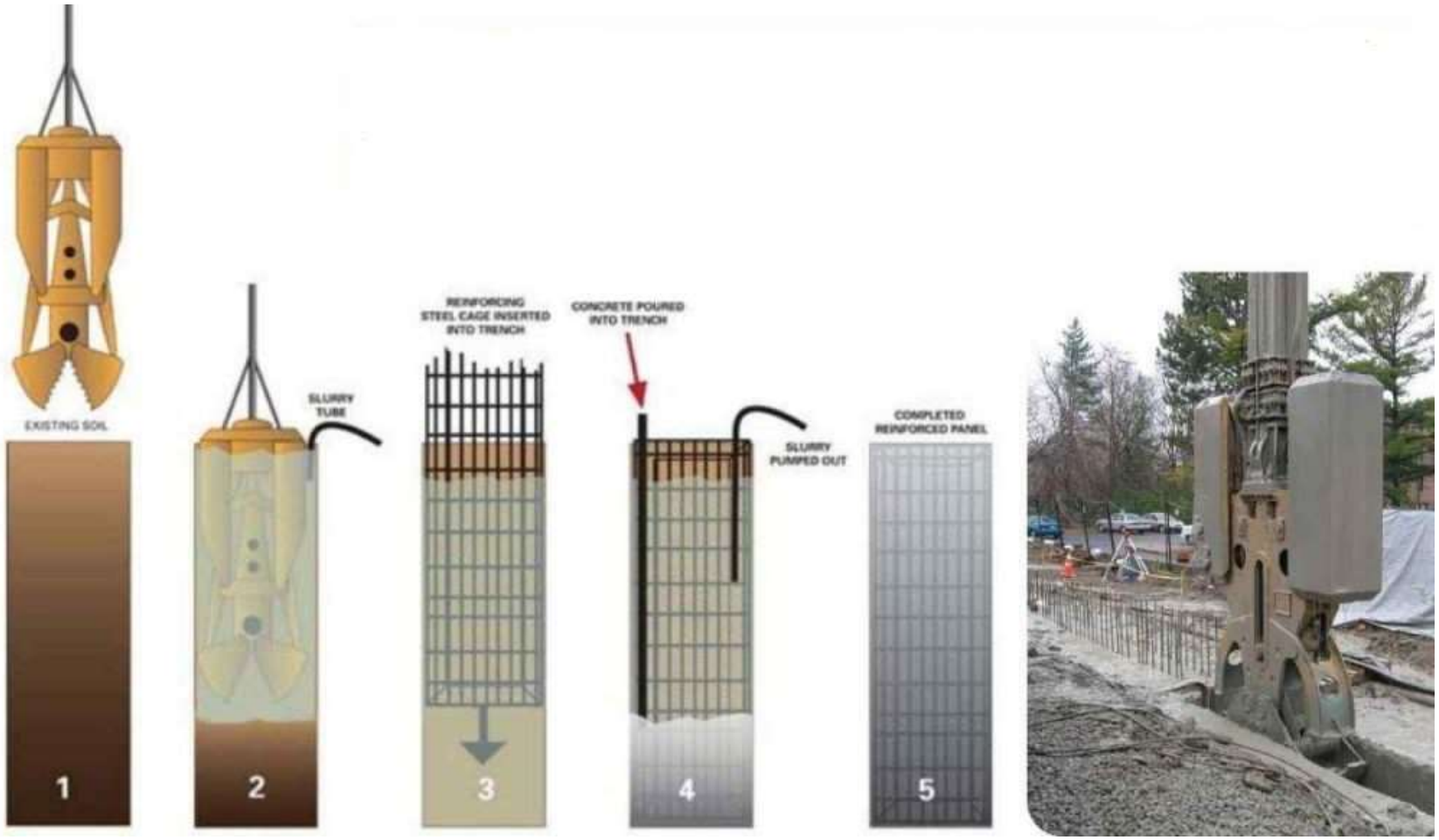
Jet Grouting

Diaphragm (Slurry) Walls

The continuous diaphragm wall (also referred to as slurry wall) is a structure formed and cast in a slurry trench. The trench excavation is initially supported by either bentonite or polymer-based slurries that prevents soil incursions into the excavated trench.

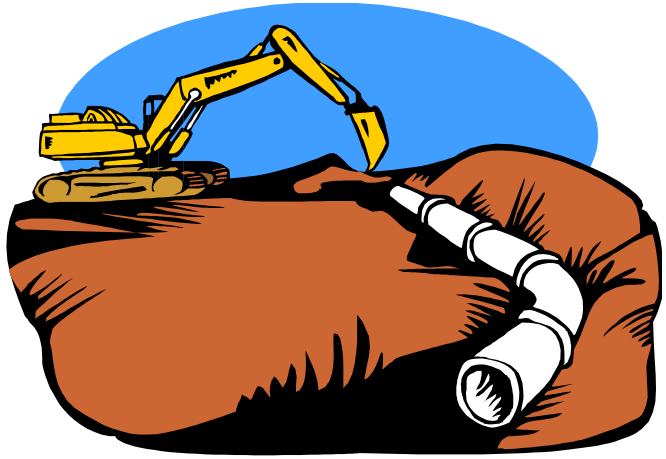
The term "diaphragm walls" refers to the final condition when the slurry is replaced by tremied concrete that acts as a structural system either for temporary excavation support or as part of the permanent structure.

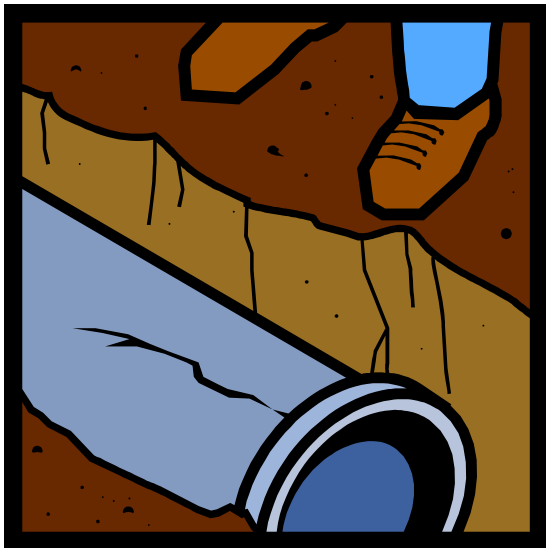
Diaphragm (Slurry) Walls



Even Engineered Shoring Systems can fail

Excavation Hazards





While cave-ins are the greatest risk, other hazards include:

- Asphyxiation due to lack of oxygen
- Inhalation of toxic materials
- Fire
- Moving machinery near the edge of the excavation can cause a collapse
- Accidental severing of underground utility lines

Competent Person

- Soil classification
- The use of protective systems
- The requirements of the standard

Must be capable of identifying hazards, and authorized to immediately eliminate hazards

Inadequate Protective System

Good thing there is a "Competent Person" watching over the work activities.

Inspection of Excavations

A competent person must make *documented daily inspections* of excavations, areas around them and protective systems:

- Before work starts and as needed,
- After rainstorms, high winds or other occurrence which may increase hazards, and
- When you can reasonably anticipate an employee will be exposed to hazards.

DAILY EXCAVATION INSPECTION CHECKLIST

Project Number & Name: _____

Date: _____ Weather Conditions: _____

Competent Person: _____

Surrounding Conditions

Call Before You Dig Notified?
___no ___yes ___n/a

All excavated utilities supported or relocated?
___no ___yes ___n/a

Tension cracking near edge of excavation?
___no ___yes ___n/a

Cracking in sidewalks or pavement?
___no ___yes ___n/a

Settlement of adjacent structures or utilities?
___no ___yes ___n/a

Construction traffic vibration?
___no ___yes ___n/a

Public roadway traffic vibration?
___no ___yes ___n/a

Material stored two feet from edge?
___no ___yes ___n/a

Excavated material two feet from edge?
___no ___yes ___n/a

Construction equipment working at edge?
___no ___yes ___n/a

Water Conditions

Water accumulation at edge of excavation?
___no ___yes ___n/a

Water entering excavation?
___no ___yes ___n/a

Water leaking from utility?
___no ___yes ___n/a

Water seeping through lagging material?
___no ___yes ___n/a

Inspections made after rainstorm?
___no ___yes ___n/a

Water accumulation in excavation?
___no ___yes ___n/a

Earth Retention System

Fall protection system in place?
___no ___yes ___n/a

4” toe board intact?
___no ___yes ___n/a

Soldier piles monitored for movement?
___no ___yes ___n/a

Waler welds intact?
___no ___yes ___n/a

Bracing welds intact?
___no ___yes ___n/a

Tieback anchors intact?
___no ___yes ___n/a

Wood lagging material cracked?
___no ___yes ___n/a

Wood lagging material bowed out
___no ___yes ___n/a

Wood lagging material damaged?
___no ___yes ___n/a

Hazardous Atmosphere

If there is a risk of developing a toxic or flammable atmosphere:

- Test the atmosphere. Ensure workers are receiving no less than 19.5 percent oxygen.

- Test atmosphere as often as necessary to ensure that the air remains safe. Test at multiple levels within the trench.

- Select, use, and maintain equipment for the control of hazardous atmospheres. Some precautions include using respiratory protection or providing adequate ventilation.

- Emergency rescue equipment such as breathing apparatuses, safety harnesses/lines, and basket stretchers should be readily available and there should be workers on hand trained in their use.

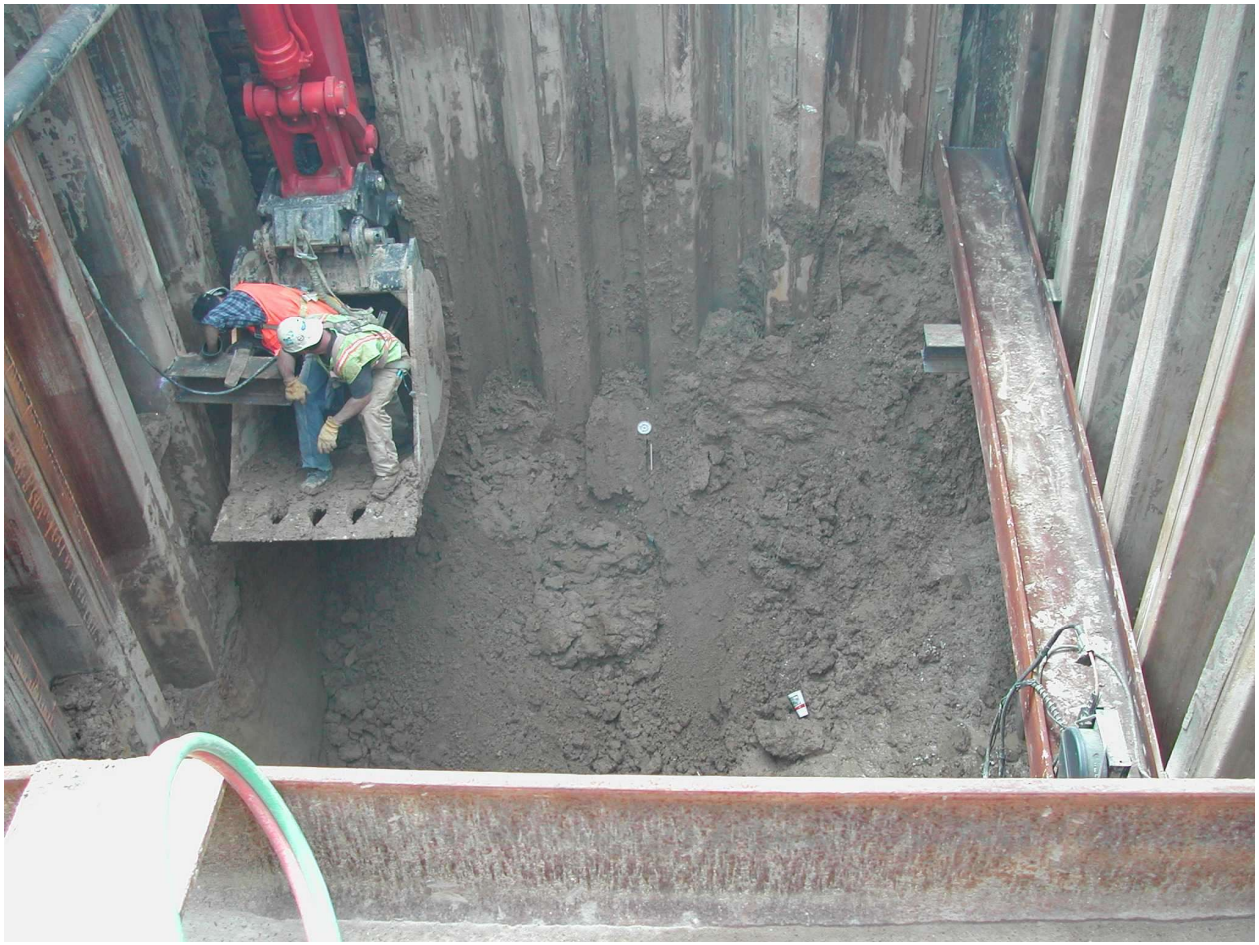
Hazardous Atmosphere

Is it safe to perform “Hot Work” in this excavation?

Access / Egress Requirements

- > 4 ft you must use ladder or ramp to access and/ or egress the trench or excavation
- > 5 ft you must shore, slope, or bench
- Ladder must be within 25’ reach
- Ladder must extend 3’ above lip of trench

Access and Egress



Underground Hazards

Call Before You Drill!

Physically locate utility prior to drilling

Have emergency plan in place – don't wait until after you have a strike

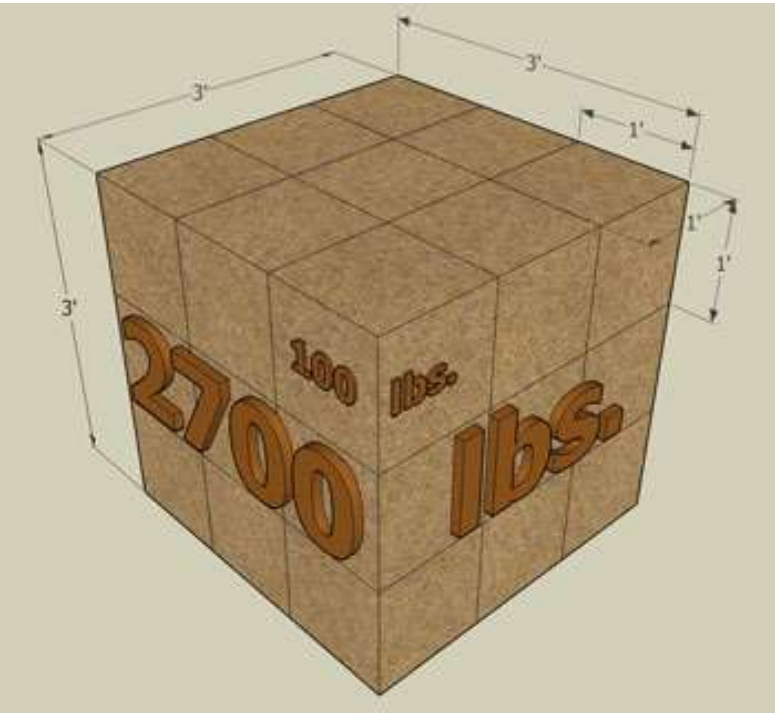
Key Elements to an Underground Utility Damage Prevention Plan

- Proper Planning and Investigation to Determine Actual Utility Locations
- Call Before You Drill
- Pothole Utilities to Determine their Actual Location
- Prepare a Site-Specific Hazard Analysis Regarding Existing Underground Utilities
- Implement the Site-Specific Hazard Analysis During All Drilling Operations
- Prepare an Emergency Safety Action Plan Should Damage to Existing Utilities Occur

Remember -

Underground Utility Damage Prevention is <u>EVERYONE'S Responsibility</u>

Soil Weight



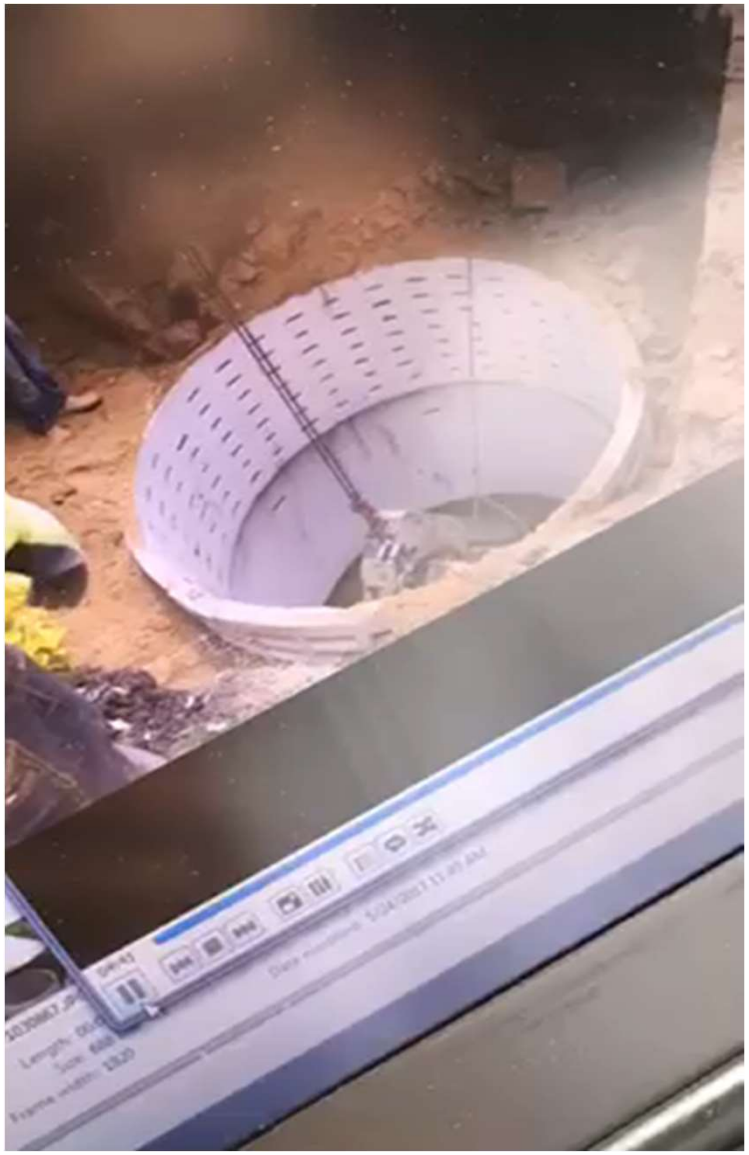
A cube of soil measuring 1 ft. on a side weighs at least 100 lb. (more in many cases).

A cubic yard of soil (3 ft. on a side) contains 27 of these, or 2700 lbs. total. This weighs about as much as a mid-sized automobile.

A trench wall collapse might contain 3 to 5 cubic yards of soil, weighing from 8,000 to 14,000 lbs.

Cave-in Hazard

How long does it take for a cave in to occur?



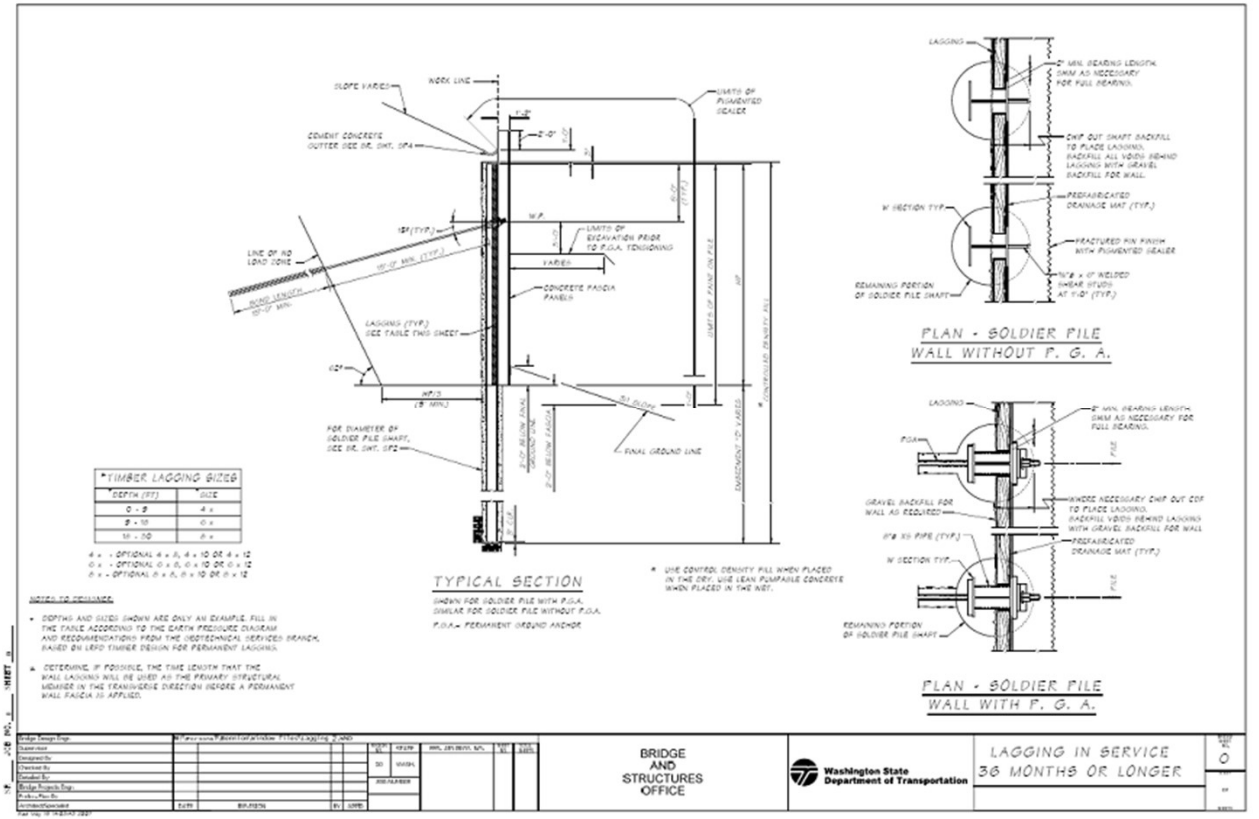
Cave-in Hazard

Cave-In Potential

Engineered Shoring

- General
  - Provides a framework to work in
  - Uses wales, cross braces and uprights
  - Supports excavation walls
- OSHA tables provide shoring data
  - Must know soil type
  - Must know depth and width of excavation
  - Must be familiar with the OSHA Tables

Tabulated Data for Shoring System



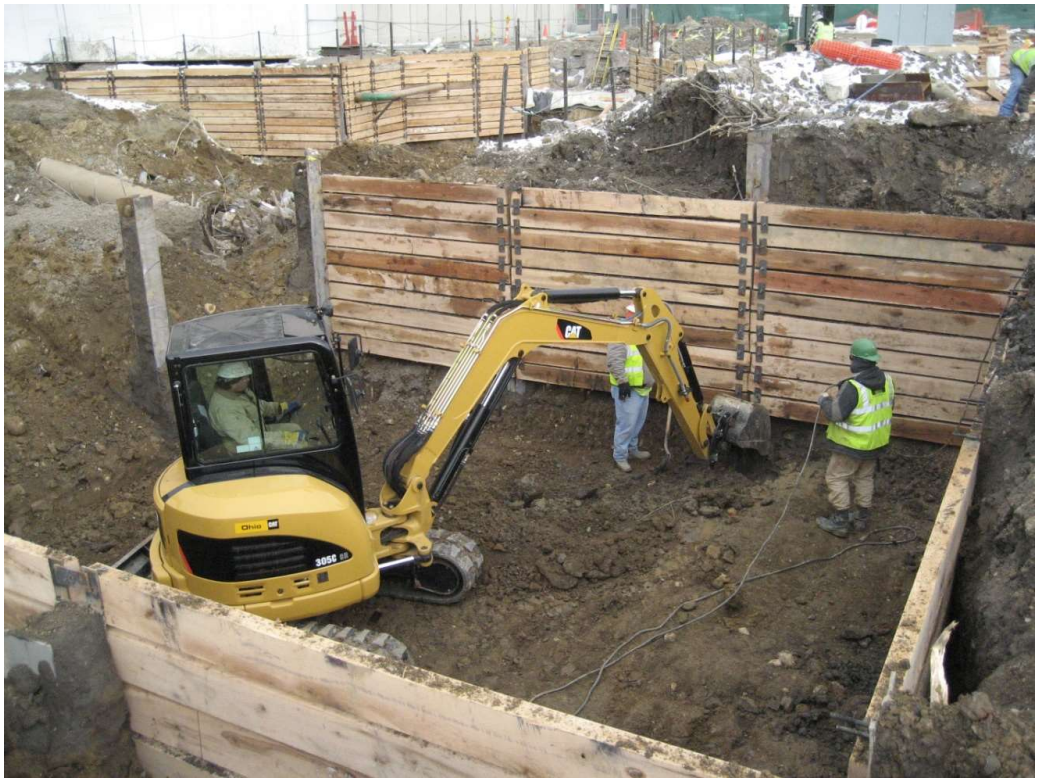
Undermining Existing Structures

- Use extreme caution when excavating or drilling near an existing structure
- OSHA requires a “Competent Person” onsite at all times when excavation operations are active

Engineered Shoring

Limit the depth of the excavation to five-foot lifts.

In some cases, you may only be able to excavate only one board width at a time, due to lose material.



Engineered Shoring

Did we limit the depth of this excavation to a five-foot lift?

Engineered Shoring

Don’t forget to protect/support existing utilities

Backfilling Behind Shoring Walls

Maintain backfilling behind lagging walls to prevent unwanted movement or settlement of adjacent areas or structures

Engineered Shoring

Hand excavated foundation pits – always treat as a confined space

Engineered Shoring

Underpinning Pits

Confined Space Examples

Underpinning Pits – entry for excavating and lagging the pit, inspection, rescue.

Emergency Rescue

Excavation Compliance Requirements

- Falls into the excavation – fall protection at edge of excavation
- Collapse of soil behind lagging – entrapment
- Access / Egress – Scaffold stairs, ramps, ladders
- Confined Space Entry(as necessary)
- Hazardous Atmospheres / Ground or Water Contamination
- Excavation Inspections
- Competent Person onsite
- Equipment Inspections
- Employee Training
- Utility Locate
- SDS Information
- Emergency Rescue Plan
- Use of Whip Checks on pressurized hose (compressed air, grout, water)
- Tabulated Data (Shop Drawings w/Engineer's Stamp
- Retaining Wall designed for loads at top (i.e., material storage, crane operation
- PPE Use – eye, face, hearing, respiratory (as necessary), hand, leg, feet
- Eye Wash Available
- Excavation not to exceed five-foot lifts
- Falling debris from adjacent structures
- Safe Working Platforms for equipment
- Silica Exposures – Monitoring? Historical Data? Engineering controls include wetting down work operations (Water injection, water misting, drilling fluids) or using local exhaust ventilation (dust collectors) to keep silica-containing dust out of the air and out of workers' lungs.
- Fire Extinguishers
- Qualified Rigger & Signal Person(s)

Trenching & Excavations

"*The more people do something without suffering a bad outcome, the harder it becomes for them to remain aware of the risks associated with that behavior.*"

Neil Swidey, author of "Trapped Under the Sea"

Never get comfortable with a trench or excavation!

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