



## EXCAVATION AND TRENCHING



OSHA - SUSAN HARWOOD TRAINING GRANT

## WELCOME

- Please sign the attendance sheet
- Take one handout
- Answer the pre-test



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## LOCATION

- Emergency Exits
- Emergency Stairs
- Location of restrooms
- Location of water fountains



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## AGENDA

- Welcome
- Introduction to OSHA
- Worker's rights
- Introduction to Trenching and Excavation Hazards
  - What is trenching?
  - Preventing excavation hazard
- Common Trenching and Excavation Hazards
- Soil Classifications
- Exercises
- Certificates



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# INTRODUCTION TO OSHA

Overview of anti-retaliation provisions, employee rights, employer responsibilities, whistleblower laws, and OSHA's complaint investigation procedures



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## WHY IS OSHA IMPORTANT TO YOU?

- OSHA began because, until 1970, there were no national laws for safety and health hazards.
- 3.6 fatal occupational injury rate in 2021 represents the highest annual rate since 2016.
- 951 Fatal occupational injuries in THE CONSTRUCTION SECTOR

### WORKER FATALITIES

- **5,190** fatal work injuries recorded in the United States in 2021, an 8.9 percent increase from 4,764 in 2020, the U.S.
- Excavation — an average of 79 deaths per year, from a High of 93 deaths in 2020 to a low of 79 deaths in 2021 *(Source: BLS 2021)*



## DISCUSSION QUESTIONS

- When, during your work experience, did you first hear about OSHA?
- What did you think about OSHA then?
- What do you think OSHA's job is?



## HISTORY OF OSHA

- OSHA stands for the Occupational Safety and Health Administration, an agency of the U.S. Department of Labor
- OSHA's responsibility is worker safety and health protection
- On December 29, 1970, President Nixon signed the OSH Act
- This Act created OSHA, the agency, which formally came into being on April 28, 1971



## OSHA'S MISSION

**All workers have the right to:**

- A safe workplace.
- Raise a safety or health concern with your employer or OSHA, or report a work-related injury or illness, without being retaliated against.
- Receive information and training on job hazards, including all hazardous substances in your workplace.
- Request an OSHA inspection of your workplace if you believe there are unsafe or unhealthy conditions. OSHA will keep your name confidential. You have the right to have a representative contact OSHA on your behalf.
- Participate for have your representative participate in an OSHA inspection and speak in private to the inspector.
- File a complaint with OSHA within 30 days, by phone, online or by mail if you have been retaliated against for using your rights.
- See any OSHA citations issued to your employer.
- Request copies of your medical records, tests that measure hazards in the workplace, and the workplace injury and illness log.

**Employers must:**

- Provide employees a workplace free from recognized hazards, to legal to retaliate against an employee for using any of their rights under the law, including raising a health and safety concern with you or with OSHA, or reporting a work-related injury or illness, including a work-related injury or illness.
- Comply with all applicable OSHA standards.
- Report to OSHA all work-related fatalities within 8 hours, and all inpatient hospitalizations, amputations and losses of an eye within 24 hours.
- Provide required training to all workers in a language and vocabulary they can understand.
- Prominently display the poster in the workplace.
- Post OSHA citations at or near the place of the alleged violation.

**FREE ASSISTANCE** to identify and correct hazards is available to small and medium-sized employers, without citation or penalty, through OSHA-supported consultation programs in every state.

**Contact OSHA. We can help.**

1-800-321-OSHA (6742) • TTY 1-877-889-5627 • www.osha.gov

- To save lives
- To prevent injuries
- To protect America's workers



## STRATEGIES TO REDUCE INJURIES AND DEATHS

- Strong, fair, and effective enforcement.
- Outreach, education, and compliance assistance.
- Partnerships and other cooperative programs.



**Outreach Training Program**

Construction | General Industry | Maritime | Disaster Site

**PARTNERSHIP**  
An OSHA Cooperative Program



## HCS PICTOGRAMS AND HAZARDS

Labels for hazardous substances in your workplace

- Labels for a hazardous chemical must contain:**
- Name, Address and Telephone Number
  - Product Identifier
  - Signal Word
  - Hazard Statement(s)
  - Precautionary Statement(s)
  - Pictogram(s)

Health Hazard	Flame	Exclamation Mark
<ul style="list-style-type: none"> <li>• Carcinogen</li> <li>• Mutagenicity</li> <li>• Reproductive Toxicity</li> <li>• Respiratory Sensitizer</li> <li>• Target Organ Toxicity</li> <li>• Aspiration Toxicity</li> </ul>	<ul style="list-style-type: none"> <li>• Flammables</li> <li>• Pyrophorics</li> <li>• Self-Heating</li> <li>• Gases Flammable Gas</li> <li>• Self-Reactives</li> <li>• Organic Peroxides</li> </ul>	<ul style="list-style-type: none"> <li>• Irritant (skin and eye)</li> <li>• Skin Sensitizer</li> <li>• Acute Toxicity (harmful)</li> <li>• Narcotic Effects</li> <li>• Respiratory Tract Irritant</li> <li>• Hazardous to Ozone Layer (Non-Mandatory)</li> </ul>
<ul style="list-style-type: none"> <li>• Gases Under Pressure</li> </ul>	<ul style="list-style-type: none"> <li>• Skin Corrosion/ Burns</li> <li>• Eye Damage</li> <li>• Corrosive to Metals</li> </ul>	<ul style="list-style-type: none"> <li>• Explosives</li> <li>• Self-Reactives</li> <li>• Organic Peroxides</li> </ul>
<ul style="list-style-type: none"> <li>• Oxidizers</li> </ul>	<ul style="list-style-type: none"> <li>• Aquatic Toxicity</li> </ul>	<ul style="list-style-type: none"> <li>• Acute Toxicity (fatal or toxic)</li> </ul>



## OSHA INSPECTIONS

- The OSH Act authorizes OSHA compliance safety and health officers (CSHOs) to conduct workplace inspections at reasonable times.
- OSHA conducts inspections without advance notice, except in rare circumstances (e.g. Imminent Danger)
- In fact, anyone who tells an employer about an OSHA inspection in advance can receive fines and a jail term.

## INSPECTIONS PROCESS

A typical OSHA on-site inspection includes four stages:

1. Presentation of inspector credentials.
2. An opening conference.
3. An inspection walk-around.
4. A closing conference.

## OSHA'S INSPECTION PRIORITIES

Priority	Category of Inspection
1st	Imminent Danger: Reasonable certainty an immediate danger exists
2nd	Fatality/Catastrophe: Reported to OSHA; inspected ASAP
3rd	Complaints/Referrals: Worker or worker representative can file a complaint about a safety or health hazard
4th	Programmed Inspections: Cover industries and employers with high injury and illness rates, specific hazards, or other exposures.

## OSHA'S COMPLAINT INVESTIGATIONS

- OSHA evaluates each complaint to determine how it can be handled best--an off-site investigation or an on-site inspection
- Before beginning an inspection, OSHA staff must be able to determine from the complaint that there are reasonable grounds to believe that a violation of an OSHA standard or a safety or health hazard exists.
- If OSHA has information indicating the employer is aware of the hazard and is correcting it, the agency may not conduct an inspection after obtaining the necessary documentation from the employer.

## CONT.

- Employee may file a complaint with **OSHA under Section 11(c)** if your employer retaliates against you by taking unfavorable personnel action because you engaged in protected activity relating to workplace safety and health.
- OSHA requires that complaints must be filed within 30 days after the alleged retaliation.

## RIGHTS AS A WHISTLEBLOWER

- Your employer may be found to have retaliated against you if your protected activity was a contributing or motivating factor in its decision to take unfavorable personnel action against you. Such actions may include:
  - ❖ Firing or laying off
  - ❖ Blacklisting
  - ❖ Denying overtime or promotion
  - ❖ Disciplining
  - ❖ Denying benefits
  - ❖ Failing to hire or rehire
  - ❖ Intimidation
  - ❖ Reassignment affecting promotion prospects
  - ❖ Reducing pay or hour

# QUESTIONS ABOUT OSHA?

## EXCAVATION AND TRENCHING

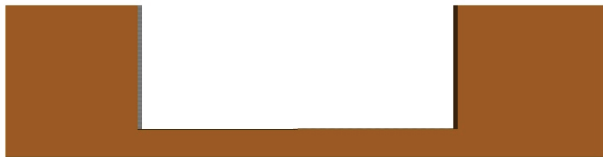


## DEFINITIONS

### Excavation

OSHA defines an excavation as any man-made cut, cavity, trench, or depression in the Earth's surface formed by earth removal. **For rescue purposes an excavation is wider than it is deep.**

Excavation

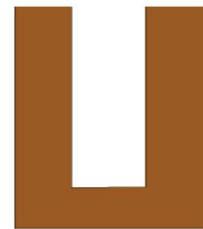


## DEFINITIONS

### Trench

A narrow excavation which is deeper than it is wide, with a maximum width of fifteen (15) feet measured at the floor (bottom).

Trench



## EXCAVATIONS OVERVIEW / MAIN POINTS

- Excavation laws, regulations, standards
- Soil classification
- Soil testing
- Competent person responsibilities
- Hazards associated with trenches
- Protective systems

## TRAGIC FACTS

Excavating is recognized as one of the most hazardous construction operations

- Average of 79 death per year, from a High of 93 deaths in 2020 to a low of 79 deaths in 2021
- Cave-ins are more likely than other excavation-related accidents to result in worker fatalities. deaths

(Source: BLS 2018, [www.osha.gov](http://www.osha.gov))

## TRAGIC FACTS

- 60% of related deaths are rescuers
  - Civilians
  - Fire dept personnel
  - Co-workers
- Cave-ins can happen without warning
- All of the fatalities and injuries could have been prevented

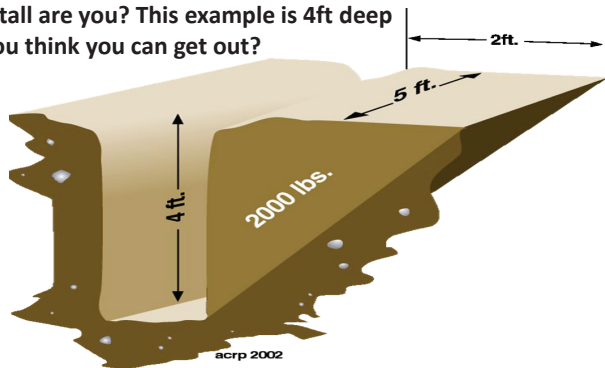
## COLLAPSE FORCES

- 24 inches of soil on a person's chest weighs 750-1000 lb.
- 18 inches of soil covering a body weighs 1800-3000 lb.

## SOIL WEIGHT EXAMPLE

20 cubic feet = 2,000 lbs.

How tall are you? This example is 4ft deep  
Do you think you can get out?



## COLLAPSE FORCE

- Shear wall collapse speed is 45 mph
- 1 cubic foot of soil can weigh from 100 to 125 lb.

## SPEED OF COLLAPSING DIRT

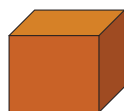
- Imagine this coming down on top of you....

Weight of a Toyota Corolla



2,785 Pounds

Weight of one cubic yard of soil

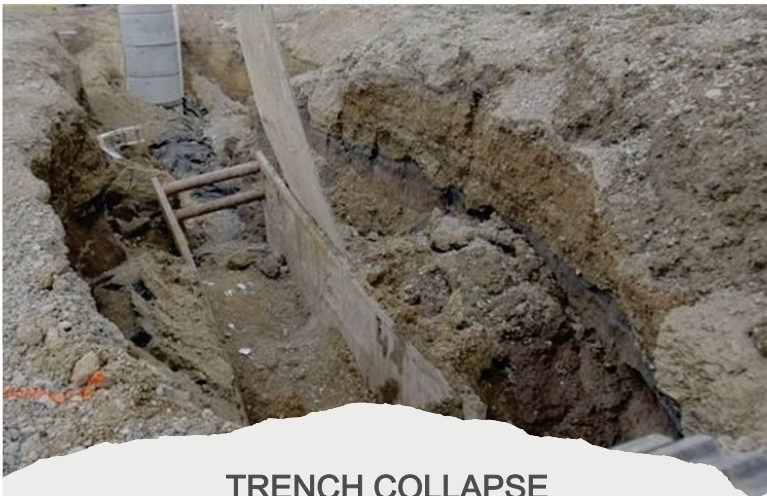


2,700 Pounds



## EFFECTS ON THE BODY

- Respiratory distress
- Crush syndrome
- Total body impact



## TRENCH COLLAPSE

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## THE SEVEN TRENCHING HAZARDS

1. Cave-ins
2. Electric Line Contact
  - Overhead
  - Buried
3. Falls into Excavations
4. Equipment Falling into Excavations
5. Explosion / Fire / Electrocutation
6. Hazardous Atmosphere
7. Drowning



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## UNSAFE ATTITUDES

- “I Know what I’m doing.”
- “It can’t happen to me.”
- “I’ve been doing it that way for years.”
- “I’d sleep in that hole!”
- “Don’t worry, we’ll watch the walls and tell you if you need to get out.”

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## MOST COMMON CAUSES OF CAVE-INS:

- Poor Planning
- Misjudgment of soil type.
- Inadequate, or incorrect installation of protective devices.
- Defective protective devices.
- Failure to adjust for changing conditions



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## LEGAL ASPECTS

- OSHA [29 CFR 1926.650 - 652]

Excavation standard applies to all open excavations made in the earth’s surfaces including trenches, all surface encumbrances that would create a hazard, and protective systems



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## WHAT’S IN THE STANDARD?

- Scope, application and definitions
- Job Site Hazard Listing
- Requirements for Protective Systems
- Appendixes that detail:
  - Soil Classification
  - Sloping and Benching
  - Timber and Aluminum Hydraulic Shoring
  - Protective System Selection Decision Tree



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## GENERAL REQUIREMENTS

1926.651

- (a) Surface encumbrances
- (b) Underground installations
- (c) Access & egress
- (d) Exposure to vehicle traffic
- (e) Exposure to falling loads
- (f) Warning systems for mobile equipment



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## GENERAL REQUIREMENTS (CONT.)

1926.651

- (g) Hazardous atmospheres
- (h) Protection from hazards associated with water accumulation
- (i) Stability of adjacent structures
- (j) Protection from loose rock or soil
- (k) Inspections
- (l) Fall protection

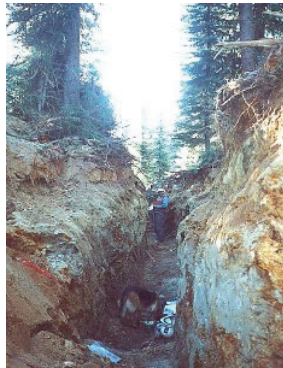


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## SURFACE ENCUMBRANCES

All surfaces encumbrances that are located so as to create a hazard to employees shall be removed or supported as necessary to safeguard employees



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## UNDERGROUND INSTALLATIONS

Utility companies shall be contacted within established local response times



- Advised of proposed work
- Asked to establish location of the utility
- When the request cannot be met, the employer may proceed with caution with detection equipment of an acceptable means to locate utility



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## UNDERGROUND INSTALLATIONS (CONT.)

- While the excavation is open, underground installations shall be protected, supported or removed as necessary to safeguard employees



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## ACCESS & EGRESS

### Structural ramps

- Used by employees shall be designed by a competent person
- When used for equipment shall be designed competent person qualified in structural design
- Stairway, ladder, ramp or other safe means of egress require no more than 25 ft of lateral travel for employees in excavations that are 4 feet or more in depth
- Ladders must be secured and extend a minimum of 36 inches above the landing



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## EXPOSURE TO VEHICLE TRAFFIC

Employees exposed to public vehicle traffic shall be provided with and wear warning vests or other suitable garments

- Marked or made with reflectorized or highly visible material
- Requiring a designated, trained flag person along with signs, signals, and barricades when necessary



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## EXPOSURE TO FALLING LOADS

- No employee shall be permitted underneath loads handled by digging or lifting equipment
- Stand away from vehicle being loaded or unloaded to avoid being struck
- Operators may remain in cabs when vehicles are equipped in accordance with 1926.601



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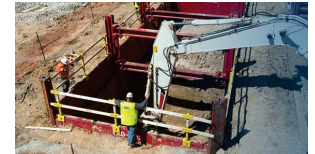
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## WARNING SYSTEMS FOR MOBILE EQUIPMENT

- When operator does not have clear view of edge of excavation
- Warning system shall be utilized
  - Barricades
  - Hand or mechanical signals
  - Stop logs



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# HAZARDOUS ATMOSPHERES

## Testing and controls

- To prevent harmful levels of atmospheric contaminants
- Less than 19.5% or more than 23.5% oxygen
- Atmosphere tested before entry
- Adequate precautions shall be taken
  - ✓ Ventilation
  - ✓ Proper respiratory protection
  - ✓ Testing done often as necessary



## MONITORING



## VENTILATION BLOWERS



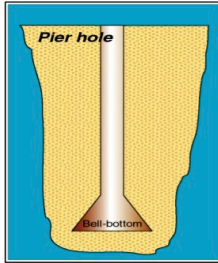
## EMERGENCY RESCUE EQUIPMENT

### Rescue equipment

- Breathing equipment
- Safety harness and line or basket stretcher
- Must be readily available
- Must be attended
- Bell-bottom pier holes, deep and confined footing excavation shall wear a harness with a lifeline securely attached to it

## BELL BOTTOM PIER HOLE

A tubular shaft with a wider bell shaped cross-section at its base for support. Created for foundations and footer construction.



## WATER ACCUMULATION



## WATER ACCUMULATION (CONT.)

Employees shall not work in excavations where there is accumulated water, or where water is accumulating, unless adequate precautions have been taken, to protect employees.

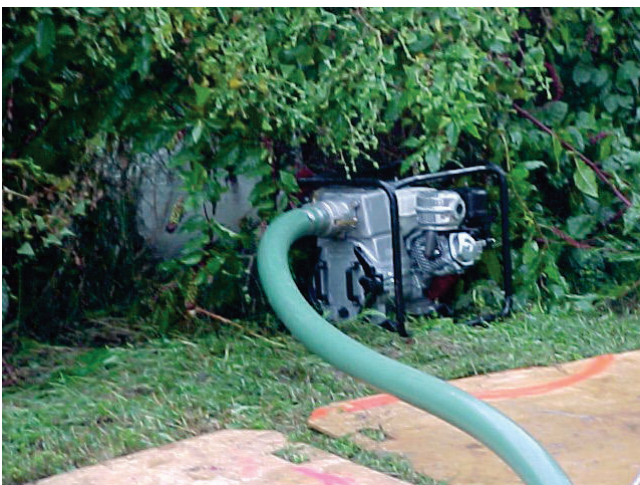
Must take adequate precautions to protect employees

- Accumulating water
- Varies with each situation
- Removal monitored by competent person
- Run off from heavy rains requires inspection by competent person

## WATER REMOVAL FROM TRENCH



## WATER REMOVAL EQUIPMENT



## STABILITY OF ADJACENT STRUCTURES

- Where stability is endangered by excavation operations
- Support systems such as shoring, bracing or underpinning shall be provided
- Sidewalks, pavement and appurtenant structures shall not be undermined unless support systems are used to protect employees



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## PROTECTION FROM LOOSE ROCK AND SOIL

Hazard from falling or rolling from excavation face

- Scaling to remove loose materials
- Installation of protective barricades
- Other means (retaining devices)
- 2 feet from edge of excavation

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## WHAT'S GOOD?



WHAT'S NOT SO GOOD?

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## WHO IS COMPETENT PERSON

- One who is capable of identifying existing or predictable hazards in the surroundings which are unsanitary, hazardous or dangerous to employees & who has authorization to take prompt corrective measures



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## COMPETENT PERSON

- Has specific training in and be knowledgeable about soil analysis, use of protective systems and the requirements of the standard



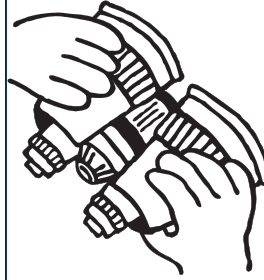
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## COMPETENT PERSON MUST BE AWARE OF:

- Falling loads or equipment
- Hazardous atmospheres
- Weather conditions and forecast
- Stability of adjacent structures.



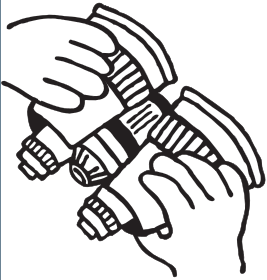
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## THE COMPETENT PERSON MUST BE AWARE OF:

- Surface and overhead encumbrances
- Underground utilities
- Access and egress
- Vehicular traffic
- Continuation of trade activity



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## INSPECTIONS

- Daily and before start of work
- As needed throughout the shift
- After snowstorms, windstorms, thaw, earthquake
- Soil classification
- Any hazard increasing occurrence
- Employees shall be removed until precautions have been taken

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## INSPECTIONS (CONT.)

- When fissures, tension cracks, sloughing undercutting, water seepage, bulging at the bottom
- Change in size, location or placement of the spoil pile
- Indication of movement in adjacent structures



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**TRAINING, KNOWLEDGE AND EXPERIENCE AS DEMONSTRATED THROUGH RESPONSIBLE ACTION MAKES A PERSON "COMPETENT."**

## FALL PROTECTION

If walkway provided

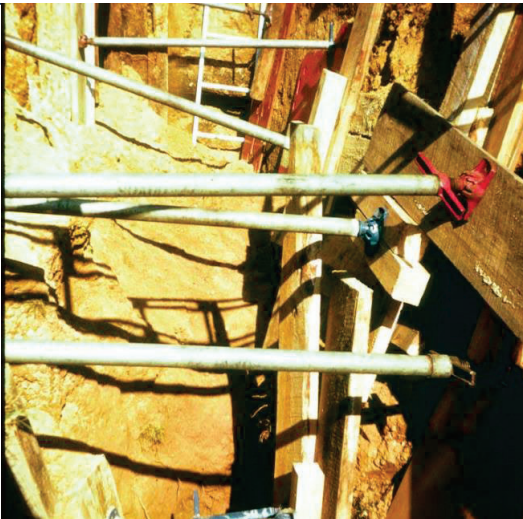
- Where employees permitted to cross, guard rails provided where 6 feet or more above lower levels
- Fall protection standard



## REQUIREMENTS OF PROTECTIVE SYSTEMS

1926.652

- Employees shall be protected from cave-in by an adequate protective system except;
  - Entirely in stable rock
  - Less than 5 feet in depth with no indication of cave-in



## DESIGNS USING MANUFACTURERS DATA

- Deviation will only be allowed after manufacturer issues specific written approval
- Written form at the job site during construction

## MATERIALS AND EQUIPMENT

- Free of damage and defects
- Maintain in manner consistent with manufactures data
- Examined by competent person & evaluated for continued use
- Removed from service until approved by registered professional engineer



## TRENCH BOXES



## INSTALLATION & REMOVAL

- Members securely connected
  - Prevent sliding, falling, kick outs
  - Other predictable failure
- Members shall not subjected to loads exceeding those which were designed
- Members removed from bottom first
- Back fill with removal of support system

## INSTALLATION & REMOVAL (CONT.)

- Excavate to no greater than 2 feet below – only if system is rated at full depth and there are no indications of a loss of soil from behind or below the support system
- Employees are not permitted to work below other employees unless adequately protected from falling, rolling, sliding material
- Employees are not allowed in shields when installed, removed or moved vertically





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### WHAT'S GOOD?



### WHAT'S NOT SO GOOD?

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### SHIELD USED WITH SLOPING

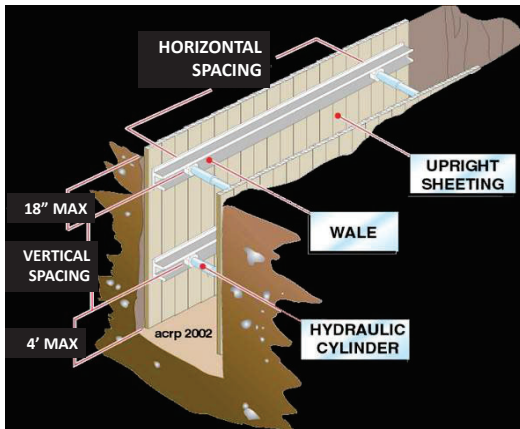


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## HORIZONTAL SHORING DIMENSIONS

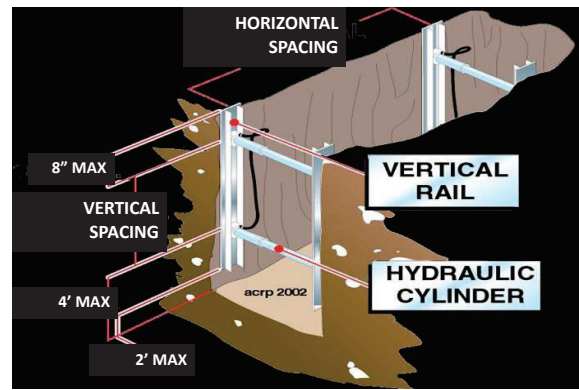


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## VERTICAL SHORING DIMENSIONS

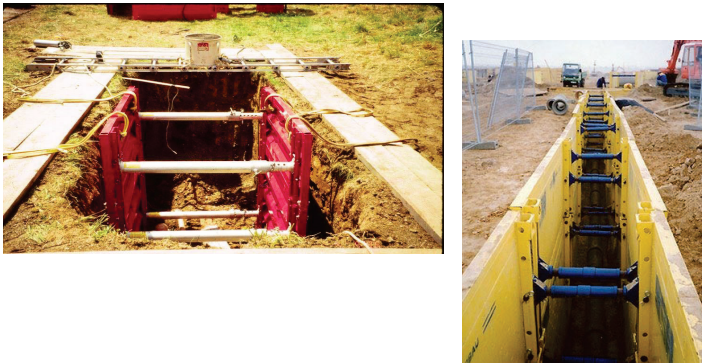


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## PNEUMATIC SYSTEMS



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## SHIELD USAGE AND SAFETY

SHIELDS ARE USED TO PROTECT WORKERS FROM CAVE-INS, NOT TO PROVIDE SUPPORT FOR THE TRENCH.

- Manufacturer's Data must be present at work site.
- Top of the shield must extend to the top of the trench.
- If used with sloping, top of shield must extend 18 inches above vertical trench walls.
- Shields may be stacked, provided the bottom one is rated for the total depth of the trench.
- The trench may be dug 2 feet lower than the shield bottom, but the shield must be rated for that depth.
- Backfill around the box to prevent lateral movement.

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## Remember

To prevent cave-ins:

**SLOPE** or bench trench walls  
**SHORE** trench walls with supports, or  
**SHIELD** trench walls with trench boxes

Employers should also ensure there is a safe way to enter and exit the trench. Keep materials away from the edge of the trench. Look for standing water or atmospheric hazards. Never enter a trench unless it has been properly inspected.



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## SOIL CLASSIFICATION 1926 SUBPART P APP A

- Cemented soil
- Cohesive soil
- Dry soil
- Fissured
- Granular soil
- Layered system
- Moist soil
- Plastic
- Saturated soil
- Soil classification system
- Stable rock
- Submerged soil
- Unconfined compressive strength
- Wet soil

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## SOIL CATEGORY: STABLE ROCK

- Natural solid mineral material that can be excavated with vertical sides and remain intact while exposed. Examples are granite and sandstone.
- Determining whether a deposit is stable rock may be difficult unless it is known whether cracks exist and whether or not the cracks run into or away from the excavation.

## SOIL CLASSIFICATIONS

Stable rock

Type A

- Cohesive soils with an unconfined compressive strength of 1.5 tons per square foot [tsf]
- Examples: Clay, silty clay, sandy clay

## SOIL CLASSIFICATIONS (CONT.)

- No soil is type A if;
  - Fissured
  - Subject to vibration
  - Previously disturbed
  - Seeping water
  - Part of a sloped or layered system of four horizontal to one vertical

## SOIL FISSURING



## TO MUCH WATER?



## WEIGHT AND VIBRATION



## SOIL TYPES

### Type B

- Cohesive soils with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf
- Silt, silt loam, angular gravel
- Soils that are fissured, or subject to vibration

## SOIL CLASSIFICATION

### Type C

Cohesive soils with a unconfined compressive strength of 0.5 tsf or less.

- Gravel, sand, loamy sand, submerged soil, soil from which water is freely seeping

## SOIL STRENGTH MEASURE UNCONFINED COMPRESSIVE STRENGTH (UCS)

- The amount of pressure in tons per square foot (tsf) required to cause the soil to fail in compression.
- OSHA Soil Classification is based on the UCS of the soil.

## BASIS OF CLASSIFICATION

The classification of deposits shall be made based on the results of at least one visual and one manual analysis conducted by a competent person

## ACCEPTABLE VISUAL TEST

- Determine qualitative information on site in general
- Soil adjacent to excavation
- Soil forming the sides of the open excavation
- Soil taken as samples from excavated material
- Estimate range of particle sizes

## ACCEPTABLE VISUAL TEST CONT.

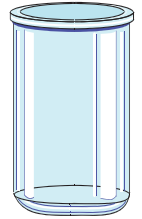
- Observe evidence of surface water
- Water seeping from the sides
- Location of the level of the water table
- Sources of vibration that may affect stability
- Evidence of previously disturbed soil

## ACCEPTABLE MANUAL TEST

- Plasticity
- Ribbon and thread test
- Dry strength test
- Thumb penetration test
- Other strength test
- Pocket penetrometer
- Hand-operated shearvane

## FIELD SEDIMENTATION TEST

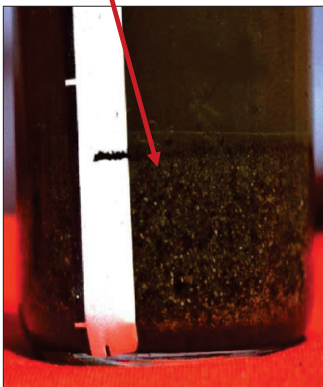
- Flat bottom container - at least 7 inches high (old olive jar)
- One 1/2 to 2 inches of soil
- Place soil in the glass jar
- 5 inches of water on top of soil



## FIELD SEDIMENTATION TEST (CONT.)

After 30 seconds granular sand type material settles at the bottom

After 3 minutes silt type material settles on top of the sand

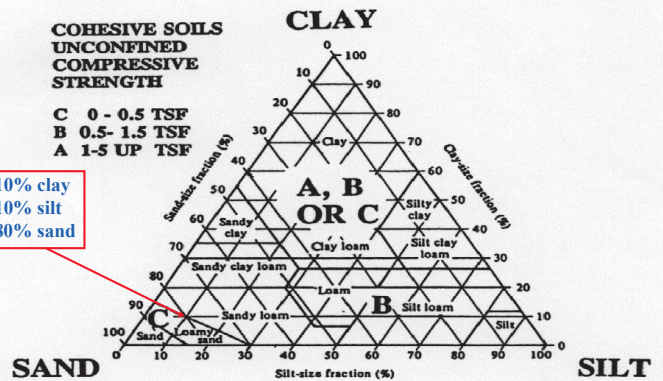


## CLAY, SAND AND SILT

**COHESIVE SOILS  
UNCONFINED  
COMPRESSIVE  
STRENGTH**

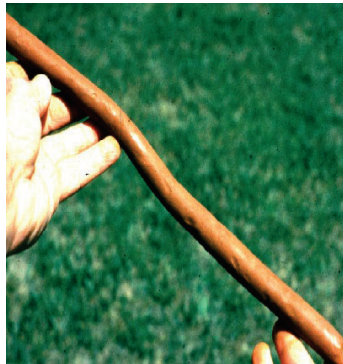
**C 0 - 0.5 TSF  
B 0.5- 1.5 TSF  
A 1-5 UP TSF**

10% clay  
10% silt  
80% sand



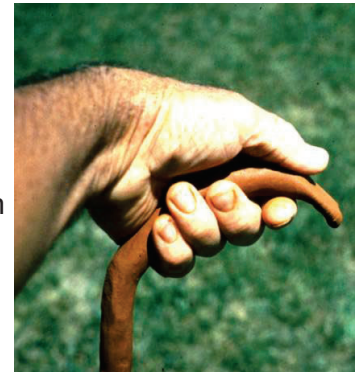
## THE RIBBON TEST STEP 1

- Mix soil + water to make into plastic mass
- Roll mass into cylindrical shape 1/2 to 3/4 inch diameter
- Lay across palm of hand
- Press between thumb and second joint of index finger



## THE RIBBON TESTS STEP 2

- Pass through thumb
- Squeeze until it takes the shape of a 1/8 to 1/4 inch thick strip
- Allow to hang freely from hand



## THE RIBBON TEST (CONT.)

- Clay loam will barely ribbon and break easily
- Clay = relatively long ribbon 6" to 8" or more
- More clay = longer and stronger ribbon
- Silt has tendency to produce short ribbon with broken appearance



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## PENCILING



If a 2 inch or longer thread can be held without breaking, the soil is cohesive.

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## SHEAR VANE / TORVANE



Measures Soil's Shear Strength

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## SHEAR VANE / TORVANE

- Select fresh clod or block of undisturbed soil from spoil pile
- Cut a smooth surface on the clod
- Insert vanes of device into the soil
- Retract vanes to show foot imprint
- Set indicator at zero
- Hold device firmly against soil and twist in clockwise manner until soil fails in shear



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## POCKET PENETROMETER TEST

- Device is designed to work on saturated clay soil
- Measures unconfined compressive strength of soil
- Twice the value of shear strength of same soil
- Note machine ring

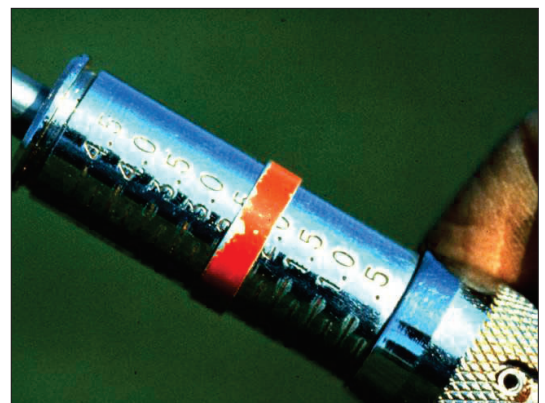


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## POCKET PENETROMETER



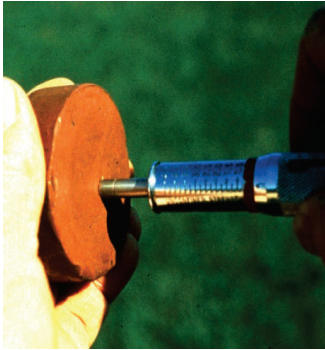
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## POCKET PENETROMETER TEST

- To begin test, remove red protective cap, push ring against body so that low side reads "0"
- Slowly insert piston until engraved mark is level with soil



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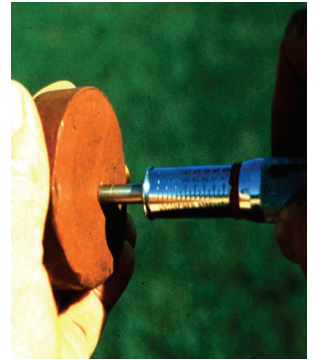
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## POCKET PENETROMETER TEST

(CONT.)

- Read strength in tons/sq ft using low side of ring (side closest to the piston end). Record reading and repeat step #1.
- For weak soils, use 1" adaptor foot, multiply by 0.0625



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## THUMB PENETRATION TEST

- The thumb penetration procedure involves an attempt to press the thumb firmly into the soil in question.

## THUMB PENETRATION TEST

(CONT.)

- If the thumb makes an indentation in the soil only with great difficulty, the soil is probably Type A.
- If the thumb penetrates no further than the length of the thumb nail, it is probably Type B soil.
- If the thumb penetrates the full length of the thumb it is Type C soil.
- The thumb test is subjective and is therefore the least accurate of the tests.

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## SOIL CLASSIFICATIONS.

- Layered Geological Strata
  - where soils are configured in layers
  - must be classified on the basis of the weakest soil
- each layer may be classified individually if a more stable layer lies below a less stable layer
- Type C soil rests on top of stable rock

## CLASSIFICATION

- Look for the following conditions
  - Particle size
    - ✓ Primarily fine grained=cohesive material
    - ✓ Primarily coarse-grained sand or gravel
    - ✓ Granular material
  - Cohesion
    - ✓ Remains in clumps=cohesive

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## SOIL STRENGTH IS DEPENDENT UPON:

- Type of Soil.
- Amount of Moisture in the Soil.
- Whether the Soil Has Been Previously Disturbed.

## IF WATER IS ADDED

- It Brings Additional Weight
  - *Hydrostatic Pressure*
- It Erodes the Trench Wall
  - *Water movement typically moves soil*
- It Can Freeze and Thaw
  - *Resulting in cracks & false cohesion*

REMOVAL OF GROUND WATER IS CRITICAL

## SOIL COMPONENTS

- **Clay:**  
Composed of mineral particles less than 0.002 mm in diameter
- **Silt:**  
Individual mineral fragments that range from 0.002 to 0.05 mm in diameter.
- **Sand:**  
Individual rock or mineral fragments that range in diameter from 0.05 to 2.0 mm in diameter.
- **Gravel:**  
Can be either angular or rounded.

## COHESIVE SOIL

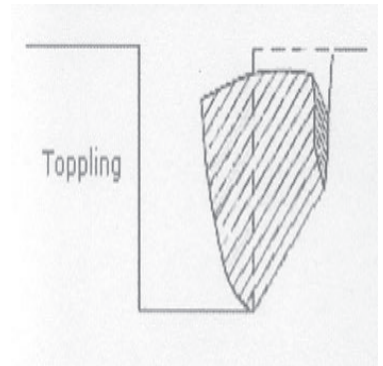
- Soil with a high clay content which has cohesive strength.
- It does not crumble.
- It can be excavated with vertical side slopes.
- It is hard to break up when dry.
- It can be molded.
- It exhibits significant cohesion even when submerged.

## GRANULAR SOIL

- Soils that include gravel, sand, silt.
- Very low clay content.
- It has no cohesive strength.
- Some moist granular soils exhibit apparent cohesion.
- It cannot be molded when moist and crumbles easily when dry.

## SOIL MECHANICS

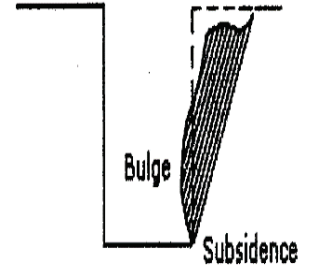
- Toppling occurs when the trench's vertical face shears along the tension crack line and topples into the excavation





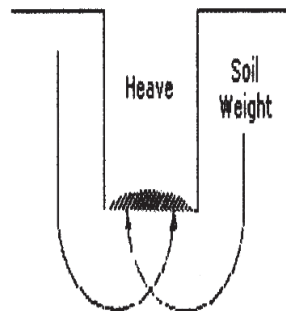
## SUBSIDENCE

- Subsidence and bulging occurs when an unsupported excavation can create an unbalanced stress in the soil which causes subsidence at the surface and bulging of the vertical face

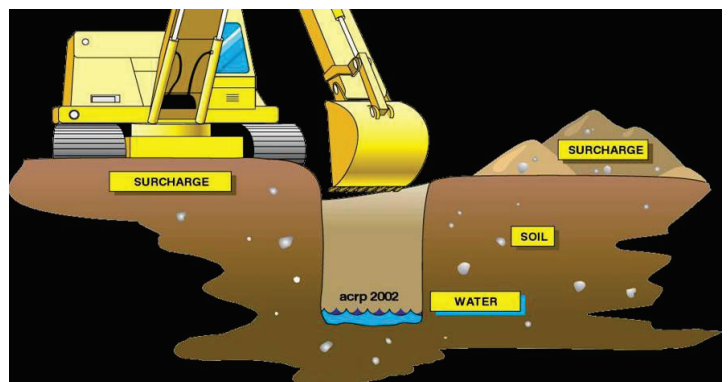


## SOIL MECHANIC

- Heaving or squeezing is caused by the downward pressure created by the weight of adjoining soil or equipment
- Can occur even when shoring or shielding has been properly installed

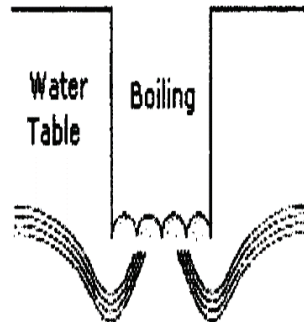


## FORCES ACTING ON A TRENCH



## BOILING

- Boiling is evidenced by an upward water flow into the bottom of the cut
- High water table is one cause
- Boiling produces a quick condition even when trench boxes are used



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## TRENCH BOILING



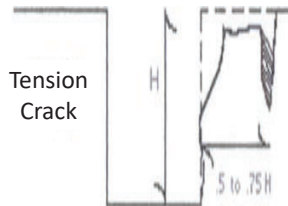
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## TRENCH CRACK

- Tension cracks usually form at a horizontal distance of 0.5 to .75 times the depth of the trench



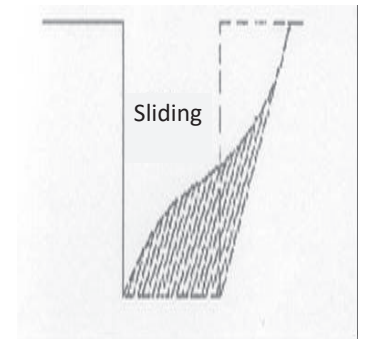
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## SLIDING

- Sliding or sloughing may occur as a result of tension cracks



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## SLOPING AND BENCHING 1926 SUBPART P APP B

- Actual slope
- Distress
- Maximum allowable slope
- Short term exposure
- Stable rock
- Type A soil
- Type B soil
- Type C soil

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## DESIGN OF SLOPING AND BENCHING

### Allowable configurations and slopes

- Not steeper than 1 1/2 horizontal to 1 vertical
- Designs using other tabulated data
- Shall be in written form
- Must identify limits of use of the data
- Identify the registered professional engineer who approved

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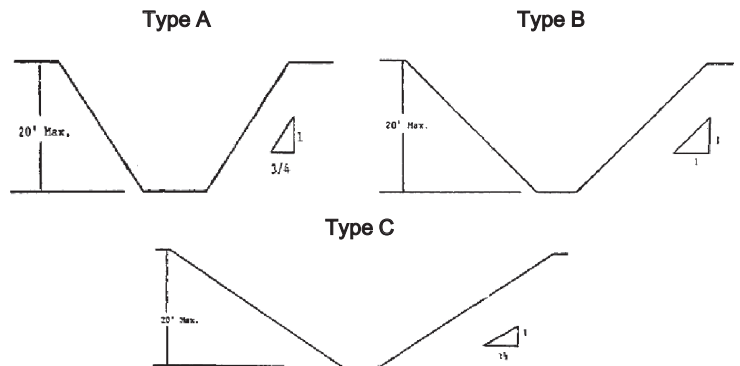
## ALLOWABLE SLOPES

Soil Type	Height/ Depth	Slope angle
Stable Rock	Vertical	90 Degree
Type A	¾ to 1	53 Degree
Type B	1 to 1	45 Degree
Type C	1 ½ to 1	34 Degree

Type A Short term

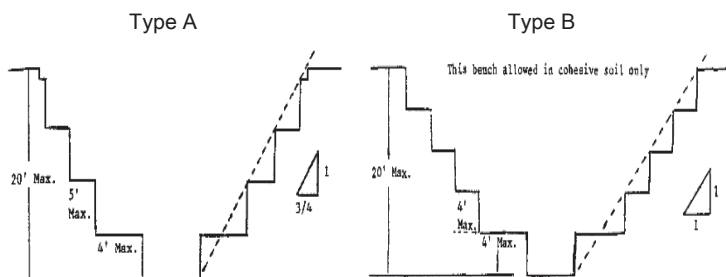
- ½ to 1 height/depth and 63 degree slope
- Max excavation depth 12 ft

## EXAMPLES OF SLOPING FOR DIFFERENT SOILS



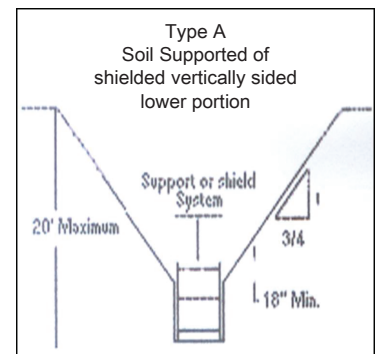
## BENCHING

Only to be used on soil types A and B



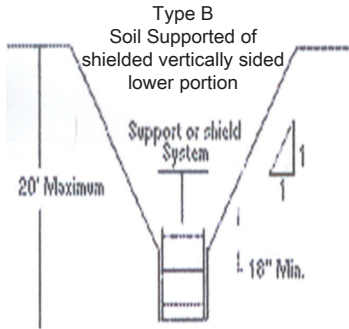
## SOIL TYPE A

- Type A soil
- Supported or shielded vertically sided lower portion
- ¾ to 1
- 20 feet max depth
- Shield 18 inches above to prevent rollover



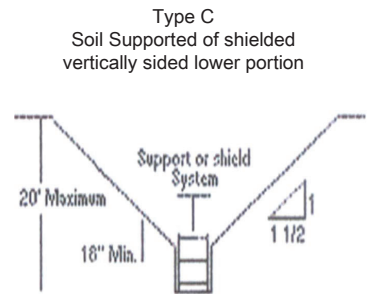
## SOIL TYPE B

- Type B soil
- Supported or shielded vertically sided lower portion
- 1 to 1 sloped
- 18 inches minimum at top of shield to prevent rollover

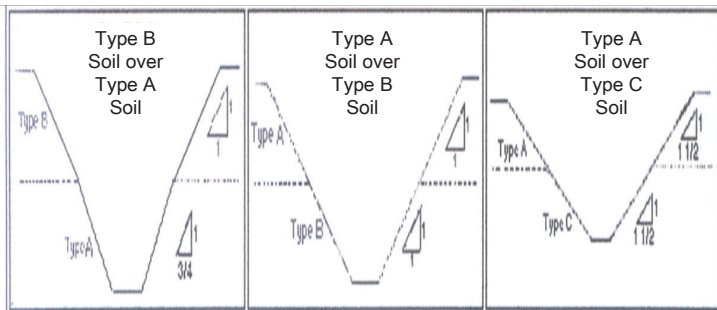


## SOIL TYPE C

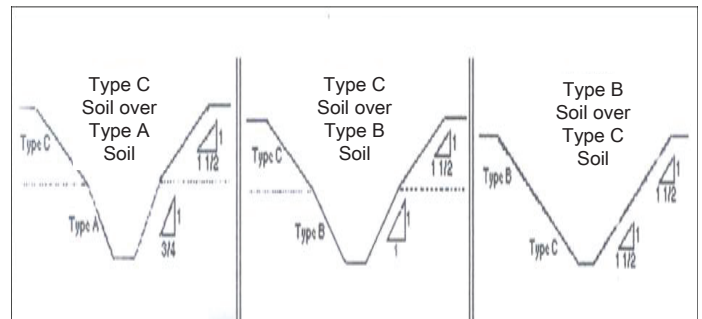
- Type C soil supported or shielded vertically sided lower portion
- 1 1/2 to 1
- 20 feet max depth
- 18 inches above to prevent rollover



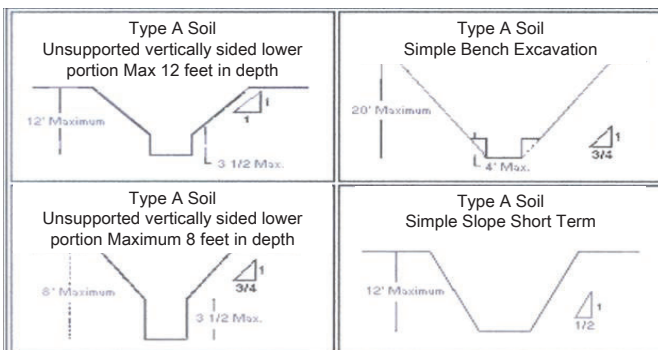
## SLOPE CONFIGURATIONS EXCAVATIONS IN LAYERED SOILS



## SLOPE CONFIGURATIONS EXCAVATIONS IN LAYERED SOILS



## EXCAVATIONS IN TYPE A SOILS



## TIMBER SHORING FOR TRENCHES 1926 SUBPART P APP C

### Basis and limitations of data

- Trenches do not exceed 20 ft in depth
- Each table presents the minimum sizes of timber members to use in a shoring system
- Tables are taken from National Bureau of Standards

## EG 1: TIMBER SHORING



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## EG 2 : TIMBER SHORING

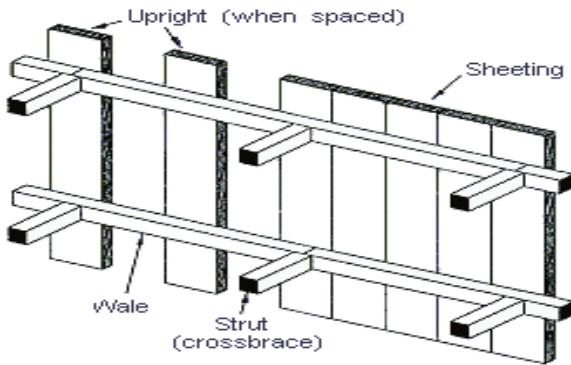


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## TIMBER SHORING



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## ALUMINUM HYDRAULIC SHORING 1926 SUBPART P APP D

Basis and limitations of data

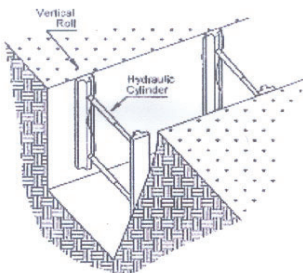
- Vertical shore rails and horizontal wales
- Meet equivalent strength properties
- 2 inch cylinder inside diameter minimum safe working capacity of no less than 18000 lbs compressive load at maximum extension
- 3 inch cylinder inside diameter safe working load not less than 30000 lbs axial compressive load
- Vertical shores used must be minimum of 3 spaced equally

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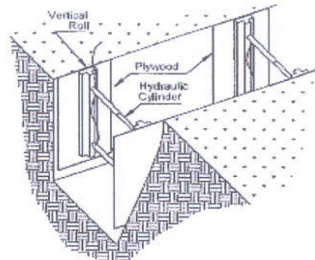
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## ALUMINUM HYDRAULIC



Vertical Aluminum Hydraulic Shoring  
(Spot Bracing)



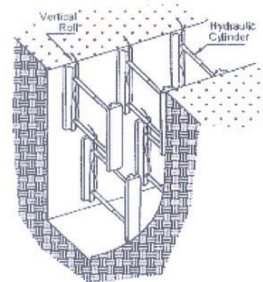
Aluminum Hydraulic Shoring Water System  
(With Plywood)

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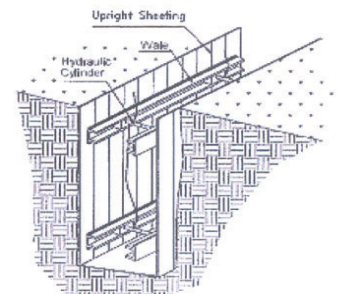
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## STACKED AND TYPICAL HYDRAULIC



Vertical Aluminum Hydraulic Shoring  
(Stacked)



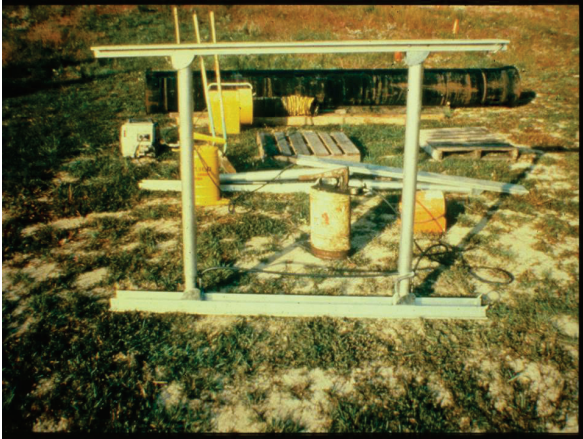
Aluminum Hydraulic Shoring Water System  
(Typical)

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## EG 1: ALUMINUM HYDRAULIC

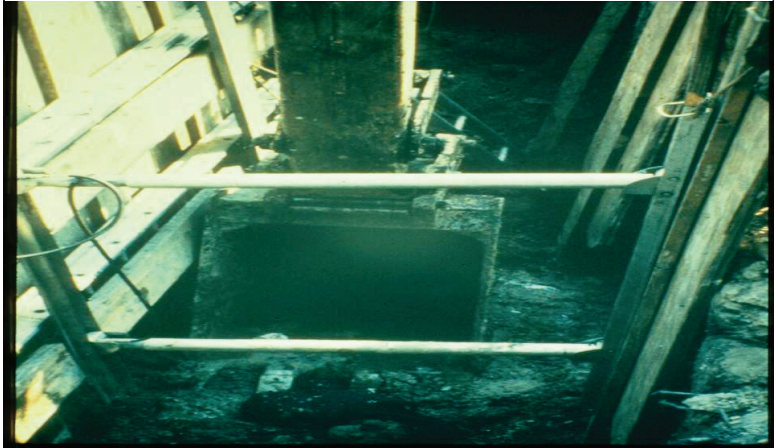


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## EG 2: ALUMINUM HYDRAULIC



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## SPOT-BRACING USAGE



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## HYDRAULIC SHORING USAGE



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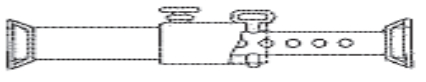
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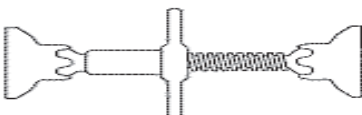
## ALTERNATIVES TO TIMBER SHORING 1926 SUBPART P APP E



Pneumatic & Hydraulic Jacks



Screw Jack

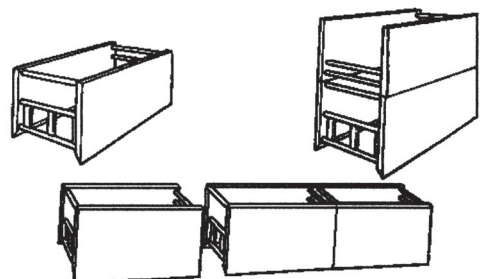


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## ALTERNATIVES TO TIMBER SHORING (CONT.)

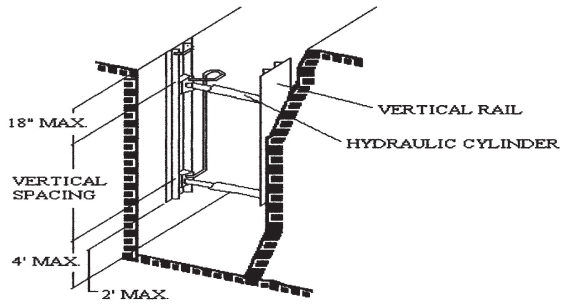


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## HYDRAULIC CYLINDER



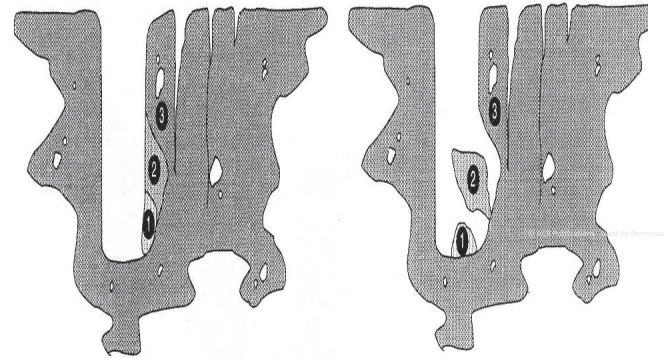
## ALUMINUM HYDRAULIC SHORING



## OTHER FACTORS INFLUENCING CAVE-INS

- Intersecting Trenches
- Previously Disturbed
- Vibration
- Surcharged Load
- Inclined Layers
- Drying / Saturation
- Free standing time

## THE TYPICAL CAVE-IN



## SUMMARY

- Excavation laws, regulations, standards
- Soil classification
- Soil testing
- Competent person responsibilities
- Hazards associated with trenches
- Protective systems

## POST TEST

Please fill-up the Post Test