Aides | **OSHA Susan Harwood Grant** | **Notes**

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Maryland Fire and Rescue Institute
Compliance training over 35 years
Consulting Services
Six (6) MFRI sites throughout Maryland
Training at clients sites
Hands – on instruction
Registration process

Pre - Test

1. Cave-ins can happen with out warning?

A. **True**
B. False

2. A hazardous atmosphere can be found in a trench.

A. **True**
B. False

3. A protective system is a method of protecting employees from cave-ins.

A**. True**
B. False

4. A ladder can be used for access and egress in trenches over ____ feet in depth

A. 10
B. 25
C. **4**
D. 16

5. A competent person must be aware of.

A. Access and egress
B. Water accumulating
C. Hazardous atmospheres
D. **All the above**

6. Soils classifications are

A. **A, B, C, Stable rock**
B. 1, 2, 3, 4
C. Rocky or Smooth
D. Hard or Soft

7. The testing of soil consists of a _____ and_____ test.

A. Day, night
B. Summer, winter
C. **Visual, manual**
D. Hot, cold

8. If water is added to soil it brings_____.

A. Lunch
B. **Additional weight**
C. Strength

9. What effects on the body can a cave-in cause?

A. Respiratory distress
B. Crush syndrome
C. Total body impact
D. **All the above**

10. Soil can weigh about _____ lbs a cubic foot

A. **125**
B. 400
C. 600
D. 50

11. Factors that influence cave-ins are _____.

A. Intersecting trenches
B. Previously disturbed soil
C. Vibration
D. **All the above**

12. The excavation standard applies to trenches also.

A. **True**
B. False

13. Benching is a method of protecting employees from cave-in.

A. **True**
B. False

14. A trench box should be used to protect employees.

A. **True**
B. False

15. No employee shall be permitted underneath loads handled by lifting or digging equipment.

A. **True**
B. False

Aides **Notes**

Enabling Objectives
Identify the laws, regulations, and standards as they apply to excavation
Describe soil classification and the testing used to determine type
Describe the protective systems used in excavations
Discuss the hazards found in trenches
Describe the roll of the competent person

Overview / Main Points
Excavation laws, regulations, and standards
Soil classification
Soil testing
Competent person responsibilities
Hazards associated with excavations
Protective systems

Worker in trench trapped to waist, 3 hrs to remove, crush syndrome in both legs

Worker trapped from slide, fracture to leg

Aides **Notes**

Worker buried in trench, backhoe operator tried to use bucket to free victim

Worker trapped from flowing water and mud, no lockout/tagout

Tragic Facts
Excavating is recognized as one of the most
Hazardous construction operations

541 workers were killed on excavating/trenching
Jobs from 1992-2001
411 (76%) were killed by cave-ins
257 (47%) worked for companies employing
Less than 10 people

Tragic Facts
60% of those killed or injured are would-be rescuers
Fire dept personnel, co-workers, by-standers
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 lbs
18 inches of soil covering a body weighs
1800-3000 lbs

Soil weight examples

Shear wall collapse speed
45 mph

Speed of collapsing dirt

How much pressure does it take to do this?

Aides **Notes**

Effects on the body

Respiratory distress
Crush syndrome
Total body impact

Top Five Trenching Hazards

Cave-ins
Overhead electrical line contact
Falls into excavations
Equipment falling into trenches
Explosion / fire / electrocution

Unsafe attitudes

I know what I'm doing
It can't happen to me
I've been doing it that way for years
I would sleep in that hole
Don't worry we'll watch the walls and tell you
If you need to get out

Most common causes of cave-ins

Poor planning
Misjudgment of soil type
Inadequate or incorrect installation of
Protective systems
Defective protective devices
Failure to adjust for changing conditions

Legal aspects

OSHA 29 CFR 1926 (650-652)
Excavation standard applies to all open
Excavations made in the earth's surfaces including
Trenches, all surfaces encumbrances that would
Create a hazard and protective systems

Aides **Notes**

What's in the standard?

Excavation scope, application and definitions
Job site hazard listing
Requirement for protective systems
Appendixes that detail
- Soil classification
- Sloping and benching
- Timber & aluminum hydraulic shoring
- Protective system selective decision tree

Definitions

Accepted engineering practices – requirements which are compatible with practice of professional registered engineers

Aluminum hydraulic shoring – pre-engineered shoring system comprised of cross braces

Bell-bottom pier hole – excavation which bottom is made larger than cross section to form a belled shape

Benching – a method of excavating the side of an excavation to form one or a series of horizontal levels or steps

Cave-in – separation of a mass of soil or rock material from the side of an excavation

Cross braces – horizontal members of shoring systems installed perpendicular to the sides of the excavation

Excavation – any man made cut, cavity, trench, or depression in an earth surface, formed by earth removal

Faces or Sides – vertical or inclined earth surfaces formed as the result of excavation work

Failure – breakage, displacement, or permanent deformation of a structural member

Aides **Notes**

Hazardous Atmosphere – atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness or injury

Kick out – accidental release or failure of a cross brace slides

Protective system – method of protecting employees from cave-ins

Ramp - inclined walking or working surface that is used to gain access to one point from another, constructed from earth materials such as steel or wood

Registered Professional Engineer – person who is registered as a professional engineer in the state the work is to be performed within the meaning of this standard when approving designs for manufactured protective systems or tabulated data to be used in interstate commerce

Sheeting – members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system

Shield – structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure

Shoring – a structure such as a metal, hydraulic, mechanical or timber shoring system that supports the side of an excavation

Sloping – method of protecting employees from cave-ins by excavating to form sides of an excavation that is inclined away from the excavation

Stable rock – natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed

Aides **Notes**

Structural ramp – ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock is not considered structural ramps

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

Tabulated data – tables and charts approved by a professional registered engineer and used to design and construct a protective

Trench – an excavation which is deeper than it is wide, but less than 15 feet wide

Uprights – vertical members of a shoring system placed in contact with the earth

Wales – horizontal members of a shoring system placed parallel to the excavation face whose side bears against the vertical members

General Requirements

Surface Encumbrances
Underground Installations
Access and Egress
Exposure to Vehicle traffic
Exposure to Falling Loads
Warning systems for Mobile Equipment
Hazardous Atmospheres
Water Accumulations
Stability of Adjunct structures
Protection from loose rock and soil
Inspections
Fall Protection

Surface Encumbrances

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

Aides **Notes**

Underground Installations
Utility companies shall be contacted with in established local response times

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

Underground Installations
While the excavation is open, underground
Installations shall be protected, supported
Or removed as necessary to safeguard employees

Access & Egress
Structural ramps
Used by employees shall be designed by a competent person
When used for equipment shall be designed by a competent person qualified in structural design
Stairway, ladder, ramp or other safe means of egress require no more than 25 feet of lateral travel for employees
Ladders must be secured and extend a minimum of 36 in. above the landing

Exposure to vehicle traffic
Employees exposed to public vehicle traffic shall be provided with and wear warning vest or other suitable garment

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

Exposure to falling loads
No employee shall be permitted underneath loads handled by lifting or digging 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

Aides **Notes**

☐ Worker was standing under load being moved

Warning systems for mobile equipment
When operator does not have clear view of edge of excavation
Warning system shall be utilitized
- Barricades
- Hand or mechanical signals
- Stop logs

☐ John Deere got to close to trench and sled in, operator ejected

☐ Concrete truck falls into trench mixing the load

Hazardous Atmospheres
Testing and controls
To prevent harmful levels of atmospheric contaminants
Oxygen deficient <19.5 %
Atmosphere tested before entry
Adequate precautions shall be taken
- Ventilation
- Proper respiratory protection

Testing shall be done often a necessary to ensure safe atmosphere

☐ No ventilation from machinery and pumps

☐ Worker using cut-off saw in trench

☐ Atmospheric monitor with pump to read all levels

☐ Heated propane ventilation system

Aides **Notes**

Emergency Rescue Equipment

Rescue equipment

- Breathing apparatus
- 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

How much water is too much?

Water Accumulation

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

Water Accumulation

Must take adequate precautions to protect employees

- Accumulating water
- Vary with each situation
- Water removal operation shall be monitored by a competent person
- Run off from heavy rains will require inspection by a competent person

Well point system for lowering ground table

Trash pump

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

Aides **Notes**

Is the backhoe supporting the house or vise-versa

Worker buried up to his waist, beneath collapsing brick

Protection from loose rock & soil
That poses a hazard from falling or rolling from
Excavation face
- Scaling to remove
- Installation of protective barricades
- Other means (retaining devices)
- 2 feet from edge of excavation

Were is the protection

Who is protected/ who is not protected

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

<u>Competent Person must be aware of</u>
Falling loads and/or equipment
Hazardous atmospheres
Weather conditions and forecast
Stability of adjacent structures
Surface and overhead encumbrances
Underground utilities
Access and egress
Vehicular traffic
Continuation of trade activity

Aides **Notes**

Inspections
Daily
Star of work
As needed through out the shift
Every rainstorm
Other hazard increasing occurrence
Employees shall be removed until precautions
have been taken
When fissures, tension cracks, sloughing undercutting
water seepage, bulging at the bottom
Change in size, location or placement of spoil pile
Indication of movement of adjacent structure

Who inspected this trench

What 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
Employee protected by adequate protective system
Except: Entirely in stable rock
Less than 5 feet deep with no indication of cave-in

Is this the proper use of a protective system

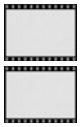
How many laws were broken here

Designs using Manufacturers Data
Deviation will only be allowed after manufacturer issues
Specific written approval
Written form at the job site during construction of system

Aides **Notes**

Materials and Equipment

Free of damage or defects
Maintained in manner consistent with manufacture
Examined by competent person and evaluated for continued use
If damaged shall be removed from service until approved by registered professional engineer



How much abuse can you do to a shield before it fails

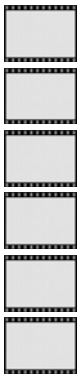
Make sure all cross braces and safety pins are used

Installation and Removal

Members securely connected
- Prevent sliding, falling, kick outs
- Other predictable failure

Members not subject to loads exceeding those which were designed
Members removed from bottom first on removal
Backfill with removal of system
Excavate to no greater than 2 feet below
- Only if system is rated at full depth

Employees not permitted to work above other employees unless adequately protected from falling, rolling, and sliding of material
Employees not allowed in shields when installed, removed or moved vertically



When an inspector is doing this something bad has happen

Not a certified trench box, made be laborers on scene

Safe or not safe

Nice system for shallow trenches

Easily placed in trench

What’s good what’s not so good

Aides **Notes**

Unsupported utilities, no ladder, how much vibration does a freight train make

Horizontal shoring dimensions

Vertical shoring dimensions

Pneumatic systems from airshore

Shield usage and safety
Shields are used to protect workers from cave-ins, not
To provide support for the trench
Manufactures data must be present at work site
Top of the shield must extend to the top of the trench
If used with sloping shield must extend 18 inches, above
trench walls
Shields may be stacked, provided the bottom one is rated
for the total depth
The trench may be dug 2 ft below the bottom of the
Shield, but the shield must be rated for that depth
Backfill around box to prevent lateral movement

Review
Table Top Exercise

Soil Classification
<u>1926 Subpart P App A</u>
Definitions
<u>Cemented soil</u>
Particles held together by a chemical agent
Can not be crushed by finger pressure
<u>Cohesive soil</u>
Soil with high clay content which has
Cohesive strength
Does not crumble, excavated with vertical
Side slopes, and is plastic when moist
<u>Dry soil</u>
Does not exhibit visible signs of moisture
<u>Fissured</u>
Soil material that has tendency to break along
Definite planes of fracture with little resistance

Aides **Notes**

Granular soil
Gravel, sand, or silt with little or no clay content
Exhibits no cohesive strength

Layered system
Two or more distinctly different soil or rock types arranged in layers

Moist soil
A condition in which a soil looks or feels damp
Can easily be shaped into a ball and rolled into small diameter threads before crumbling

Plastic
Property of a soil which allows the soil to be Deformed or molded without cracking

Saturated soil
Soil in which voids are filled with water
Saturation does not require flow

Wet soil
Soil that contains significantly more moisture than moist soil, but in such a range of values that cohesive material will slump or begin to flow when vibrated

Stable rock
Natural solid mineral, excavated with vertical Sides and remain intact while exposed

Submerged soil
Soil which is under water or is free seeping

Unconfined compressive strength
Means the load per unit area at which a soil will fail In compression
Can be determined by laboratory testing

Soil Category – Stable Rock
Natural solid mineral material that can be excavated with Vertical sides and remain intact while exposed.
Examples include granite and sandstone
Determining whether a deposit is stable rock may be Difficult unless it is known if whether cracks exist or Whether or not cracks run into or away from the excavation

Aides **Notes**

Type A soil

Soils with an unconfined compressive strength of 1.5 ton per square foot (tsf) or greater

No soil is type A if;

Soil is fissured

Soil is subject to vibration

Soil has been previously disturbed

Soil is part of a sloped or layered system of four Horizontal to one vertical

How soon will it fail?

What do you have to do to make this trench safe?

How much pressure does it take to make this trench fail?

Type B soil

Soils with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf

Type C soil

Soils with an unconfined compressive strength of 0.5 tsf or less

Soil strength measure

Unconfined compressive strength (UCS)
The amount of pressure in tons per square foot (tsf)
Required to cause the soil to fail
OSHA classification is based on UCS

Basis of classification

Deposits shall be made based on the results of at least one visual and one manual analysis
Conducted by a competent person

Aides **Notes**

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
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)
11/2 to 2 inches of soil
Place soil in glass jar
5 inches of water on top of soil
After 30 seconds granular sand type
Material settles at the bottom
After 3 minutes silt type material
Settles on top of the sand

Graph to determine soil strength

Aides **Notes**

Ribbon test
Mix soil and water to make into
Plastic mass
Roll mass into cylindrical shape
½ to ¾ inch diameter
Lay across palm of hand
Press between thumb and second
Joint of index finger
Pass through thumb
Squeeze until it takes the shape of a
1/8 to1/4 inch thick strip
Allow to hang freely from hand
Clay loam will barely ribbon
And break easily
Clay = relatively long ribbon 6 to 8
Inches or more
More clay = longer and stronger ribbon
Silt has tendency to produce short ribbon
With broken appearance

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

Shearvane/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 print
Set indicator at zero
Hold device firmly against soil and twist
in clockwise manner until soil fails in shear

Pocket Pentrometer
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

Aides **Notes**

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
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 .0625

Thumb penetration test
The thumb penetration procedure involves
an attempt to press the thumb firmly into
the soil in question

If the thumb makes a penetration in the
soil only with great difficultly, then 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 then it is Type C soil

The thumb test is subjective and is therefore
the least accurate of the test

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 rest on top of stable rock

Aides **Notes**

Look for the following conditions
Particle size
Primarily fine grained= cohesive material
Primarily course grained= sand or gravel
Cohesion- remains in clumps, cohesive

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 and false cohesion

Soil components
<u>Clay</u>
Composed of mineral particles less than 0.002mm in diameter
<u>Silt</u>
Individual mineral fragments that range from 0.002 to 0.05mm in diameter
<u>Sand</u>
Individual rock or mineral fragments that range in diameter from 0.05 to 2.0mm in diameter
<u>Gravel</u>
Can be either angular or rounded

Aides **Notes**

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

Caused by tension cracks
Occurs when the trenches vertical face shears along the tension crack line and topples into the excavation

Shear wall collapse

Subsidence and bulging

Bulging of the vertical face of the trench
Can cause loss of the trench wall

Can the weight of this crane cause a bulge or failure

Where is the crane, are the utilities supported, what shoring
What is the soil doing?

Aides **Notes**

Heaving or squeezing

Caused by downward pressure created by the Weight of adjoining soil or equipment
Can occur even when shoring or shielding is in place

Forces acting on a trench

Boiling

Evidenced by an upward water flow into the bottom of the cut
Caused by a high water table
Can occur even when shoring or trench boxes are used

Trench boiling

Tension Cracks

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

Sliding

Sliding or sloughing may occur as a result of tension cracks

Sloping and benching

1926 Subpart P App B

Definitions

Actual slope

Slope to which an excavation face is excavated

Distress

Soil is in a condition where a cave in is imminent or likely to occur

Maximum allowable slope

Steepest incline of an excavation face that is acceptable for the most favorable site conditions as protection against cave ins

Aides **Notes**

Short term exposure
Period of time less than or equal to 24 hours that an excavation is open
Stable rock
Vertical 90 degrees
Type A soil
¾:1 (53 degrees)
Type B soil
1:1 (45 degrees)
Type C soil
1 ½:1 (34 degrees)

Foot note
Sloping and benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer

Design of Sloping and Benching
Allowable configurations and slopes
Sloped at an angle not steeper than 1 ½ to 1
Type C soil
Designs using other tabulated data
Shall be in written form
Identify limits of use of the data

Identify registered professional engineer who approved
Maintained at the job site

An attempt at sloping

An attempt at benching

Allowable sloping

Examples of sloping for different soils

Benching examples

Allowable slopes

Slope configurations

Aides **Notes**

Slope configurations for A soils

Timber Shoring for Trenches
1926 Subpart P App C
Basis and limitations of data
- Trenches do not exceed 20 feet 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
- Each table contains data only for the particular soil type

Timber shoring examples

Aluminum Hydraulic Shoring for Trenches
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 pounds compressive load at maximum extension
- 3 inch cylinder inside diameter safe working not less than 30000 pounds axial compressive load at extensions as recommended by product manufacturer
- Spacing indicated is measured center to center
- When vertical shores are used must be a minimum of 3 shores spaced equally, horizontally in a group

Aluminum Hydraulic shoring examples

Alternatives to timber shoring

Pneumatic shoring being used in rescue

Aides **Notes**

Selection of Protective Systems

1926 Subpart P App F

A graphic summary of the requirements contained In subpart P for excavations 20 feet or less in depth

Factors influencing cave-ins

Intersecting trenches
Previously disturbed
Vibration
Surcharge load
Inclined layers
Drying/saturation
Free standing time

Collapse forces

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

Soil weight examples

Shear wall collapse speed
45 mph

Speed of collapsing dirt

How much pressure does it take to do this?

Effects on the body

Respiratory distress
Crush syndrome
Total body impact

Aides **Notes**

Fallacies and misconceptions

At what depth/width do most incidents occur?
Between 6-8ft deep and less than 6ft wide
Most incidents occur in bad weather
False

Clay is the least dangerous soil type
False

The typical cave-in

Summary:
Excavation laws, regulations, and standards
Soil classifications
Soil testing
Competent person responsibilities
Hazards associated with excavations
Protective systems

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