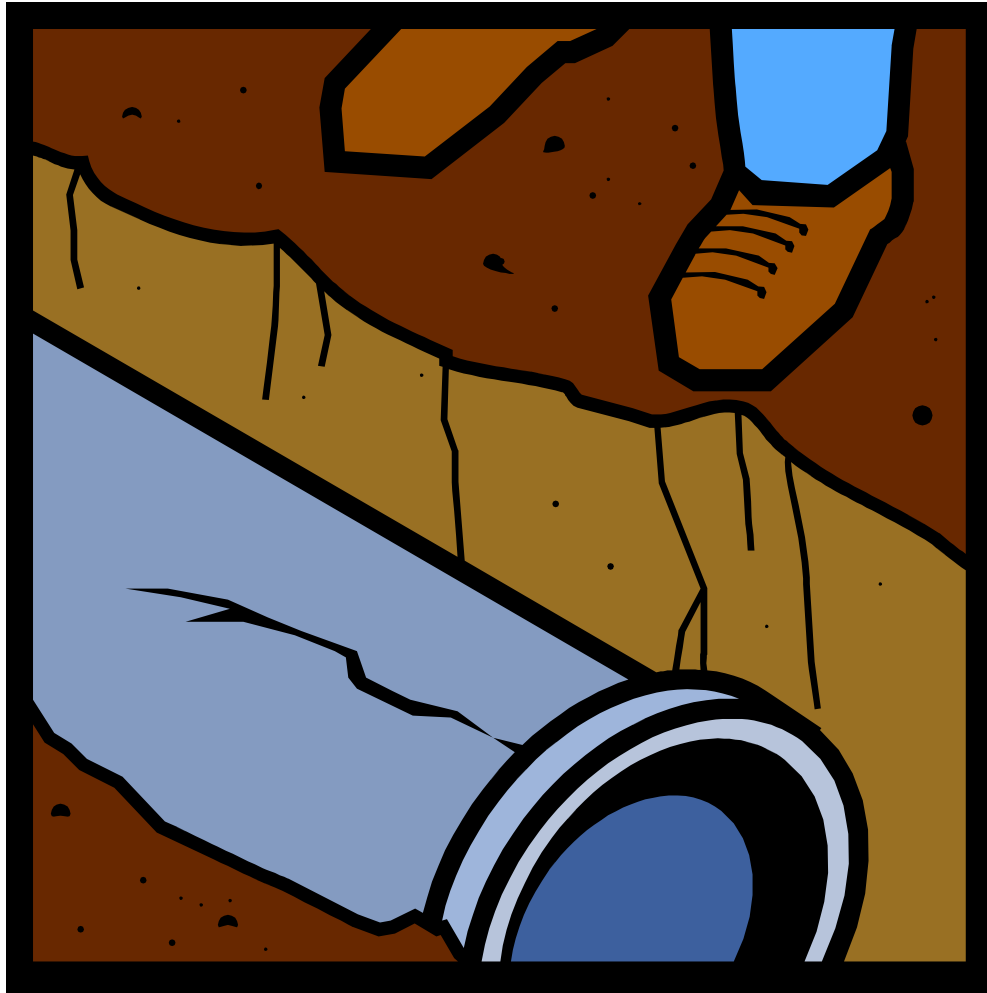


# Trenching



# *Trenching*

- **29 CFR 1926.651 “Excavation Requirements”**

- Controls the trenching and excavation requirements for construction (excluding tunnels)
- Provides requirements for employee entrance, working environment, and egress to/from open surface trenches and excavations



# *Trenching*

## - Pre-excavation requirements

- The estimated location of utility installations such as sewer, telephone, fuel, electric, water lines, or other underground installations that reasonably may be encountered during excavation work shall be determined prior to opening an excavation
- Utility companies or utility locator should be contacted to precisely locate such utilities
- Excavation may proceed with **CAUTION** if
  - >> Utility Company/Locator can not be located or contacted >>
  - Utility Company/Locator can not locate utility

# *Trenching*

- Excavation opening requirements
  - When excavating operations approach the location of underground utilities, the exact location shall be determined by safe and acceptable means
  - While excavation is open, underground installations shall be protected, supported, or removed as necessary to safeguard employees

# *Trenching*

## -Excavation access/egress

- Structural ramps/runways used for access/egress
  - If constructed of two or more members, shall have members connected together
  - if constructed of two or more members, shall have members of uniform thickness
  - Cleats or other connections shall be attached to bottom of runways/ramps
  - Runways/ramps shall be anchored to prevent movement or slipping
- Ladders
  - Shall be of proper design
  - Shall be secured from movement or slippage
  - Shall extend 3' above top of excavation

# *Trenching*

## – Employee protection

- Employees exposed to public vehicular traffic shall be provided with and wear vest or other suitable garments marked with high visibility materials
- No employee shall be permitted underneath loads handled by digging or lifting equipment
- When mobile equipment is operated near excavation; barricades, hand and mechanical signals, or stop logs shall be used to protect employees in excavations



# *Trenching*

## –Hazardous atmospheres

- Excavations of greater than 4' depth that are located in or near hazardous materials, liquids, or gases shall be tested for the presence of hazardous atmospheres prior to employee entry
  - >> An atmosphere shall be considered hazardous if the level of atmospheric contaminants exceeds 20% of the PEL
- Excavation of greater 4' depth shall be regularly tested for oxygen deficiency (less than 19.5% oxygen)
- Ventilation and respiratory protection shall be provided where hazardous atmospheres are encountered



# *Trenching*

## – Emergency rescue equipment

- Where hazardous atmospheres exist or may be expected to occur, the following rescue equipment shall be readily available for use
  - >> Safety Harnesses and lines
  - >> Basket stretcher
  - >> Breathing apparatus equipment
- Employees entering bell-bottomed holes shall wear harness and life line protection
- Employees shall not work in excavations where there is accumulated water unless adequate safety precautions (shoring, ect.) have been taken



# *Trenching*

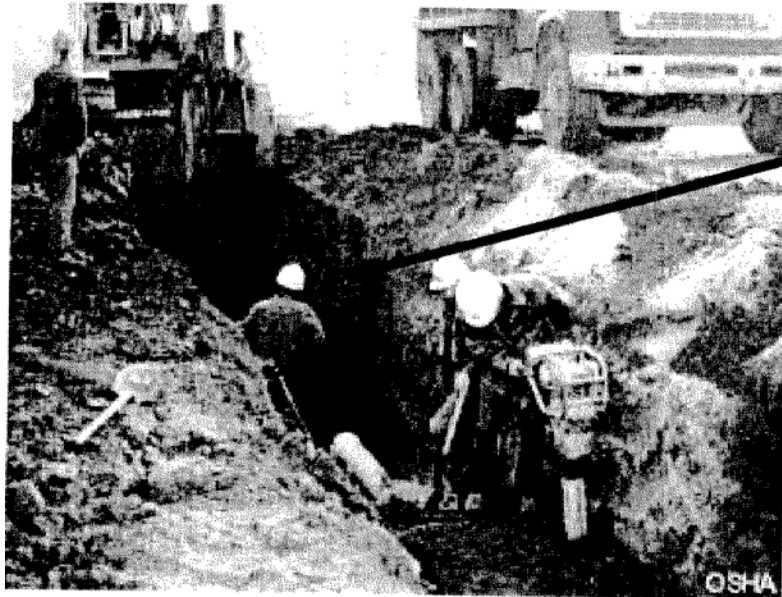
## – Stability of adjacent structures

- Excavations near structures or buildings shall be protected by shoring or other means to assure stability of the affected structure
- Diversion ditches, dikes, or other suitable means shall be provided to prevent surface water intrusion where natural drainage has been interrupted
- Excavations near foundation footings, sidewalks, pavement, or other appurtenant structures shall be protected by underpinning or other suitable means to maintain stability

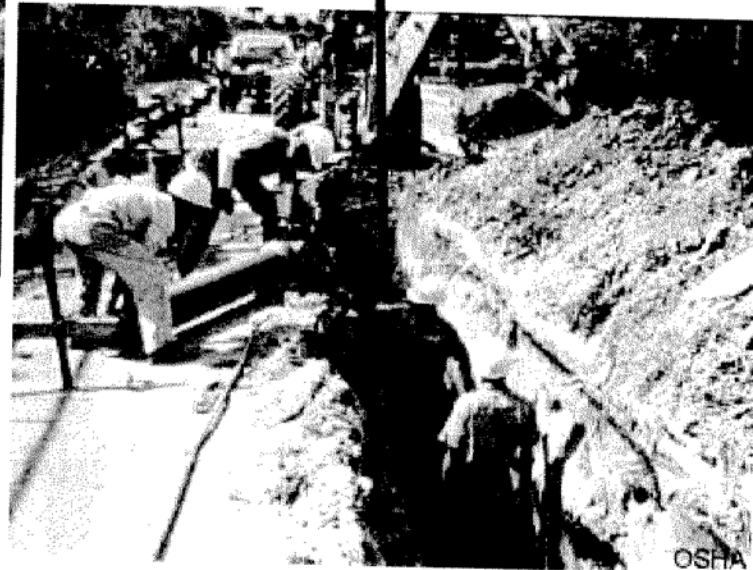
# *Trenching*

- Stability of excavated materials and excavation walls
  - Excavated materials shall be kept a minimum of 2' from the edge of excavations or by the use of retaining devices
    - Excavated materials may require further clearance from excavations in accordance with soil types (see table)
  - Excavation wall slopes or other wall protection shall be used in accordance with soil type, moisture levels, and other criteria as specified in the soil tables (see table)

# *Trenching*



ARE THESE WORKERS SAFE?

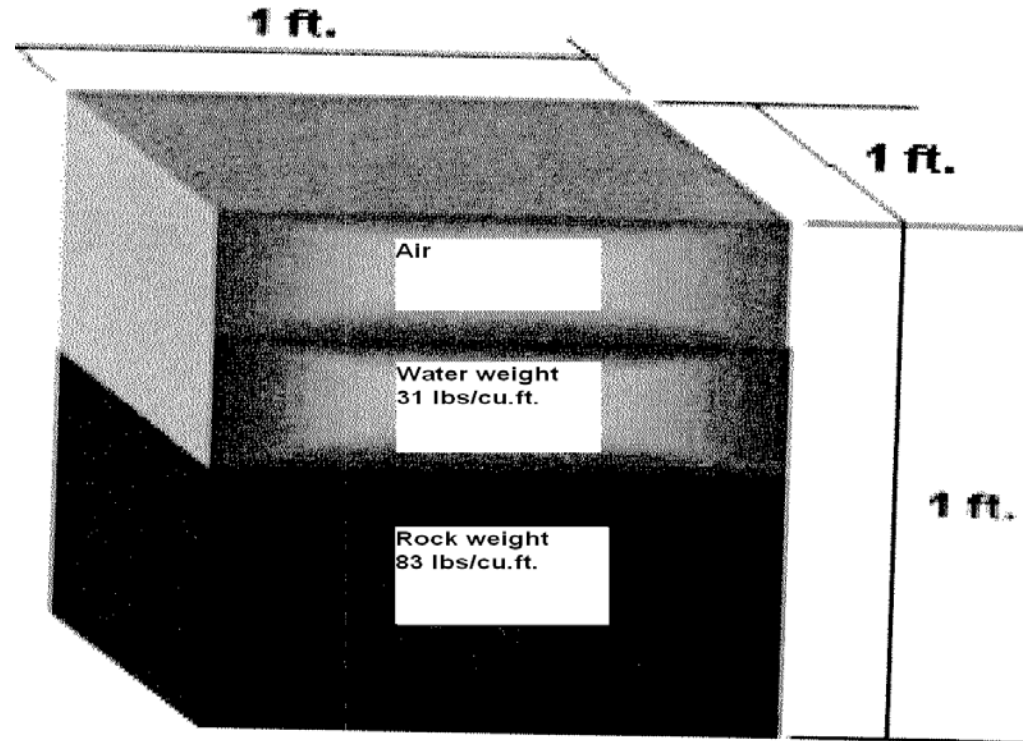


# *Trenching*

- Employee protection in excavations
  - Any excavation or trench >4' depth shall have its walls protected from cave-in or “sluffing”
    - By sloping walls of excavation
    - By shoring excavation
    - By shielding

# *Trenching*

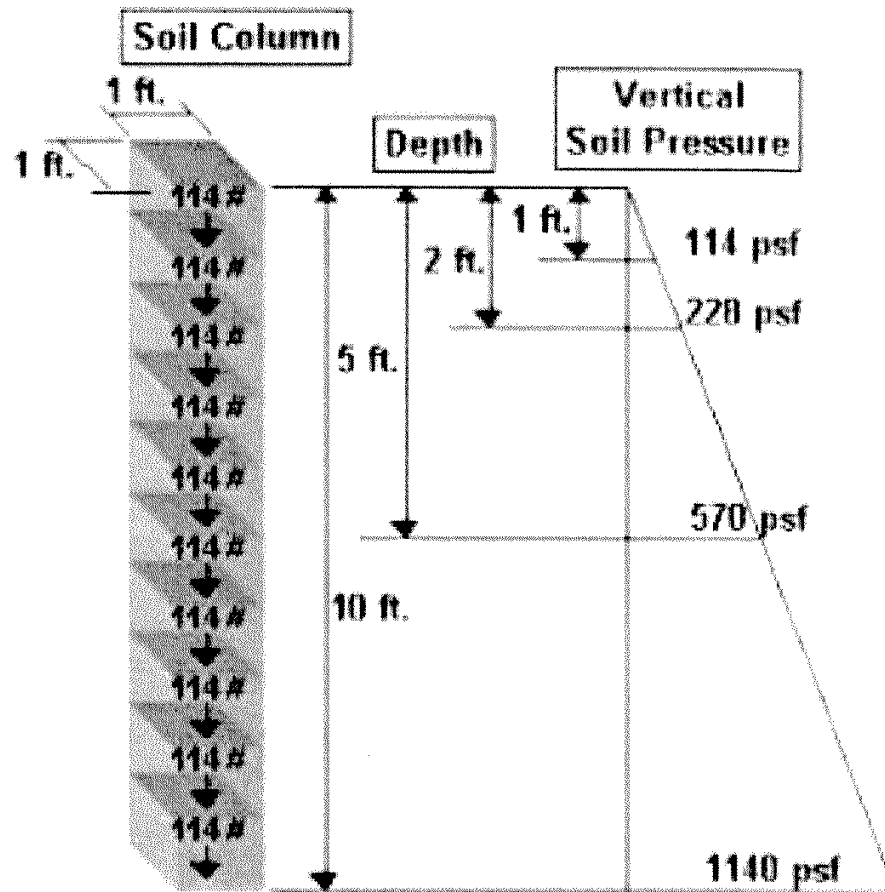
Soil density  
makes it  
Extremely  
Dangerous



Soil weight  
114 lbs/cu.ft.

Average soil density

# Trenching

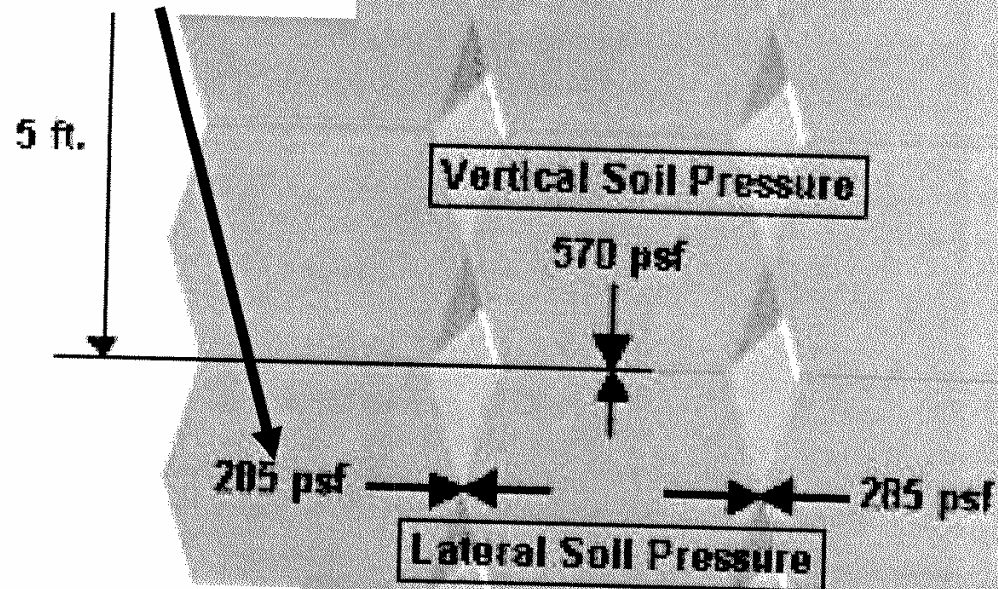


SOIL COLUMN PRESSURE



# Trenching

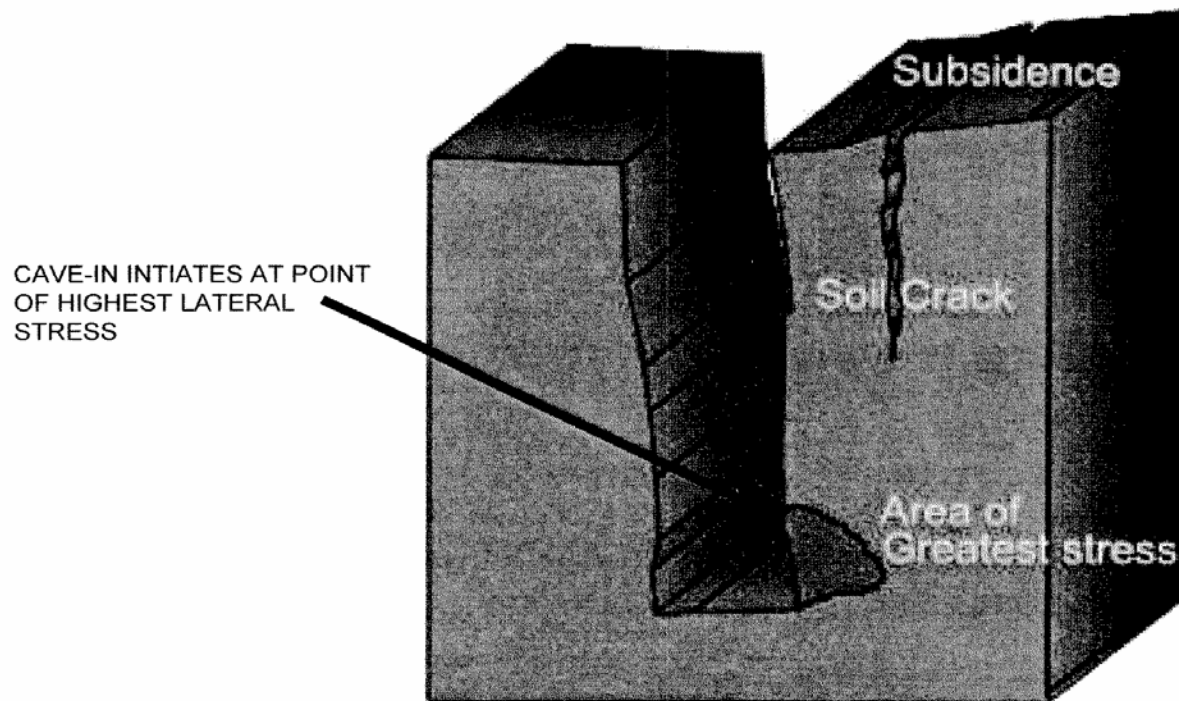
LATERAL PRESSURE ~ =  
50% VERTICAL PRESSURE



THAT'S WHY MOST TRENCH  
COLLAPSE INITIATES AT THE  
BOTTOM OF THE TRENCH

SOIL LATERAL COLUMN PRESSURE

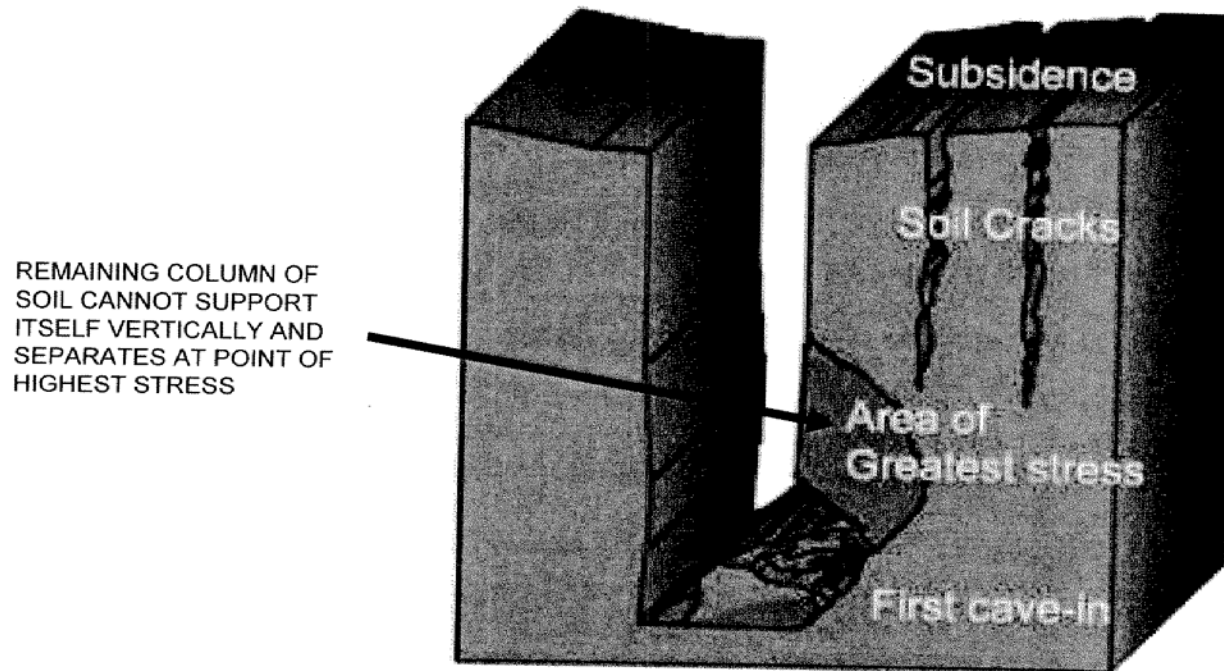
# *Trenching*



ANATOMY OF A CAVEIN - ONSET

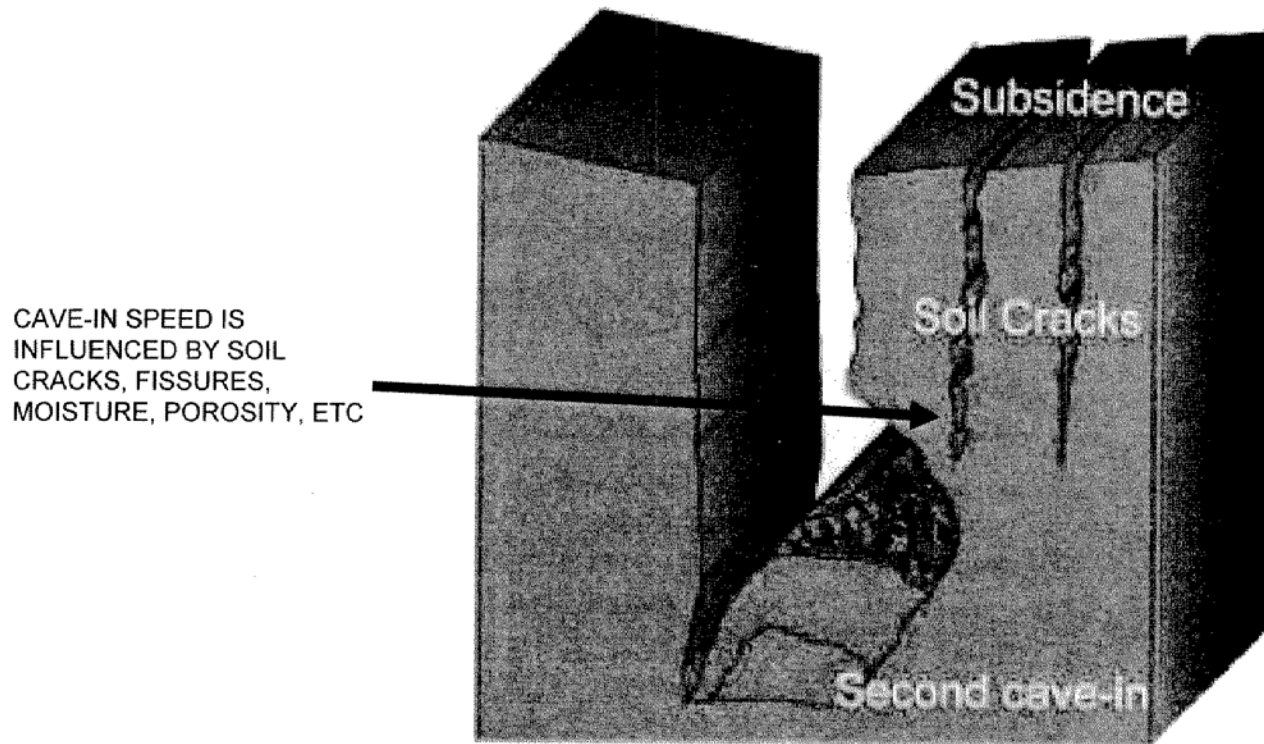


# *Trenching*



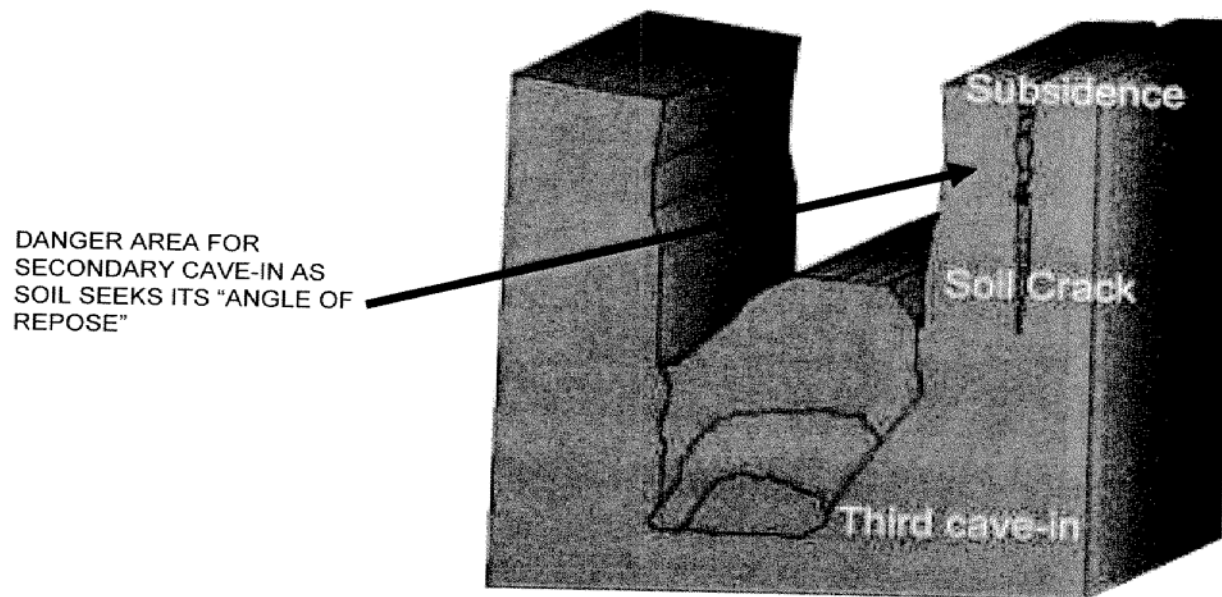
ANATOMY OF A CAVEIN – GROWTH STAGE

# *Trenching*



ANATOMY OF A CAVEIN – FULLY DEVELOPED

# *Trenching*



ANATOMY OF A CAVEIN – COMPLETION

# *Trenching*

- There is a "natural angle of repose" for soil. It means that over time the soil will go to a certain slope (usually its natural angle).



© Pamela Gore, 1998



# *Trenching*






- Excavation protection is a function of soil type

OSHA categorizes soil and rock deposits into four types as follows:

- A. STABLE ROCK is a natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed. Most of the time it is identified by a rock name such as granite or sandstone.
- B. TYPE 'A' SOILS are cohesive soils with an unconfined compressive strength of 1.5 tons per square foot or greater. These types of soils are often clay, silt clay, sandy clay, clay loam and in certain cases, silty clay loam and sandy clay loam.
- C. TYPE 'B' SOILS are cohesive soils with an unconfined compressive strength greater than 0.5, but less than 1.5 tons per square foot. Examples include angular gravel silt, silt loam, and/or previously disturbed soils
- D. TYPE 'C' SOILS are cohesive soils with an unconfined compression strength of 0.5 tons per square foot or less. Granular soils like gravel, sand and loamy sand, submerged soil, soil from which water is freely seeping, and submerged rock that is not stable fall into the Type 'C' soil category.



# *Trenching*

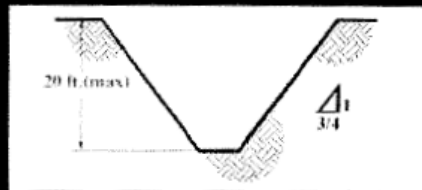
Option		Type A	Type B	Type C
	Simple Slope	Yes	Yes	Yes
	Short-term Slope	Yes	No	No
	Simple Bench	Yes	Yes	No
	Multiple Bench	Yes	Yes/No*	No
	Slope with Shoring/Shielding	Yes	Yes	Yes

\*Multiple bench allowed only in cohesive Type B soil

TRENCH SLOPES VS. SOIL TYPE

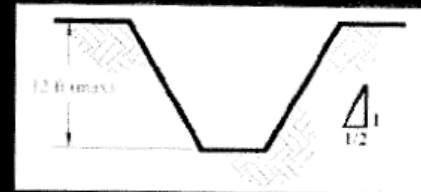
# Trenching

## Slope Configurations



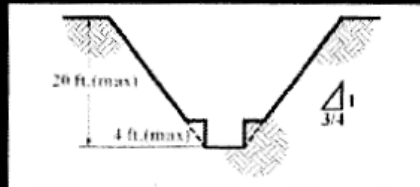
**SIMPLE SLOPE - GENERAL  
TYPE A SOIL**

20 ft. or less in depth  
maximum allowable slope of 3/4:1



**SIMPLE SLOPE - SHORT TERM\*  
TYPE A SOIL**

12 ft. or less in depth  
maximum allowable slope of 1/2:1  
\*open 24 hours or less



**SINGLE BENCH  
TYPE A SOIL**

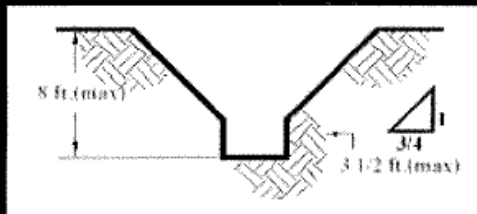
20 ft. or less in depth  
maximum allowable slope of 3/4:1  
maximum bench height 4 ft.



**MULTIPLE BENCH  
TYPE A SOIL**

20 ft. or less in depth  
maximum allowable slope of 3/4:1  
maximum bench heights shown

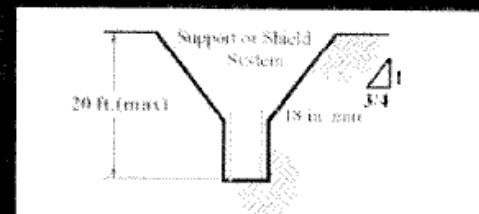
# Trenching



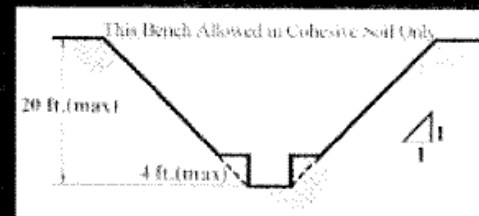
**UNSUPPORTED VERTICALLY  
SIDED LOWER PORTION  
TYPE A SOIL**  
8 ft. or less in depth  
maximum vertical side of 3-1/2 ft



**SIMPLE SLOPE  
TYPE B SOIL**  
20 ft. or less in depth  
maximum allowable slope of 1:1



**SUPPORTED/SHIELDED  
VERTICALLY SIDED LOWER  
PORTION - TYPE A SOIL**  
20 ft. or less in depth  
maximum allowable slope of 3/4:1  
support/shield system must extend at  
least 18 in. above vertical side



**SINGLE BENCH  
TYPE B SOIL**  
20 ft. or less in depth  
maximum allowable slope of 1:1  
maximum bench height 4 ft.

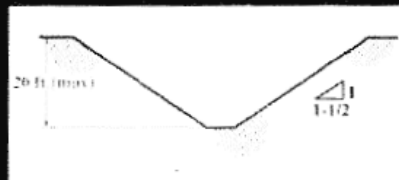


# Trenching



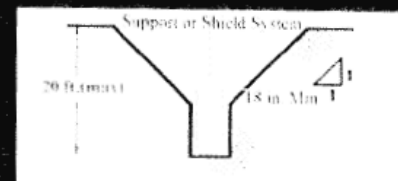
## **MULTIPLE BENCH TYPE B SOIL**

20 ft. or less in depth  
maximum allowable slope of 1:1  
maximum bench heights shown



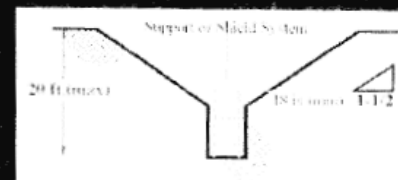
## **SIMPLE SLOPE TYPE C SOIL**

20 ft. or less in depth  
maximum allowable slope of 1-1/2:1



## **SUPPORTED/SHIELDED VERTICALLY SIDED LOWER PORTION - TYPE B SOIL**

20 ft. or less in depth  
maximum allowable slope of 1:1  
support/shield system must extend  
at least 18 in. above vertical side

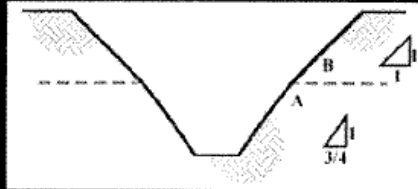


## **SUPPORTED/SHIELDED VERTICALLY SIDED LOWER PORTION - TYPE C SOIL**

20 ft. or less in depth  
maximum allowable slope of 1-1/2:1  
support/shield system must extend  
at least 18 in. above vertical side

TRENCH SLOPES CONFIGURATIONS – PG 3

# Trenching



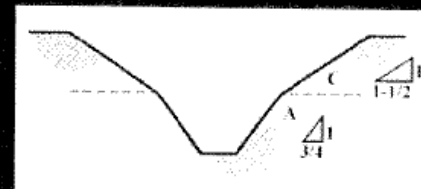
**LAYERED SOILS**  
**B OVER A**

20 ft. or less in depth  
maximum allowable slope for each  
layer  
shown above



**LAYERED SOILS**  
**C OVER B**

20 ft. or less in depth  
maximum allowable slope for each  
layer  
shown above



**LAYERED SOILS**  
**C OVER A**

20 ft. or less in depth  
maximum allowable slope for each  
layer  
shown above



**LAYERED SOILS**  
**A OVER B**

20 ft. or less in depth  
maximum allowable slope for each  
layer  
shown above

TRENCH SLOPES CONFIGURATIONS – PG 4

# Trenching



## LAYERED SOILS A OVER C

20 ft. or less in depth  
maximum allowable slope for each  
layer  
shown above

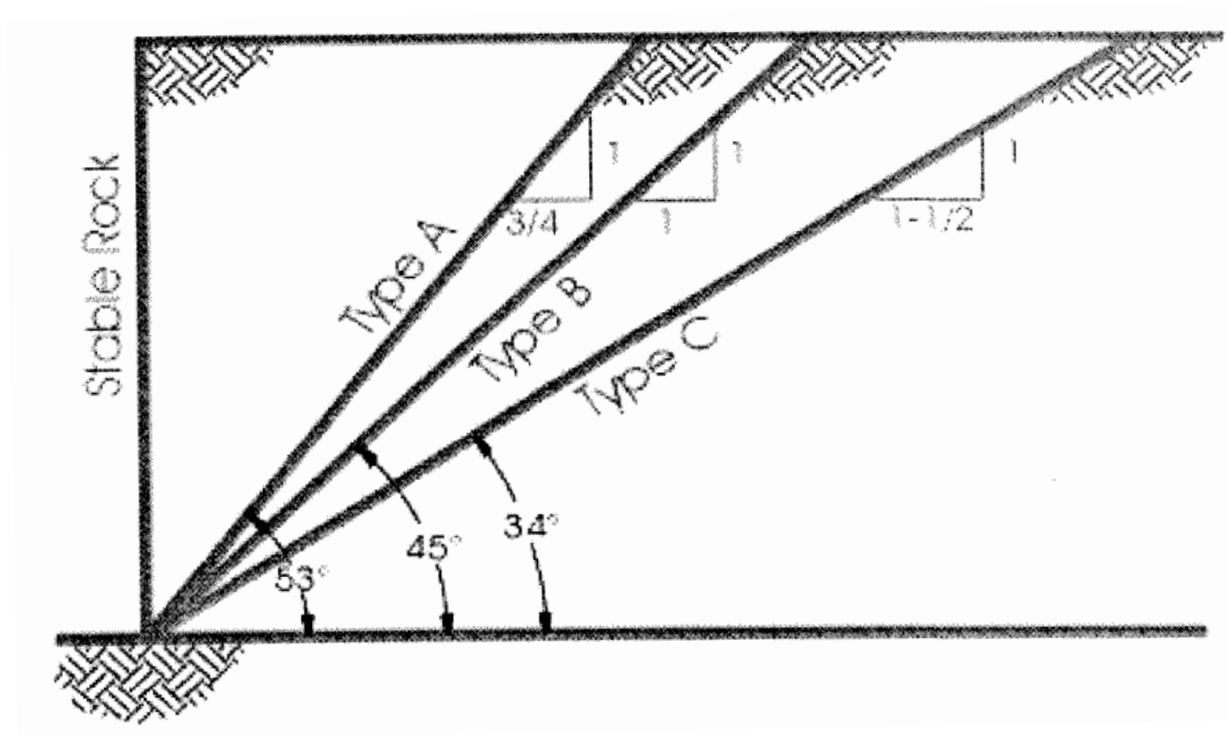


## LAYERED SOILS B OVER C

20 ft. or less in depth  
maximum allowable slope for each  
layer  
shown above

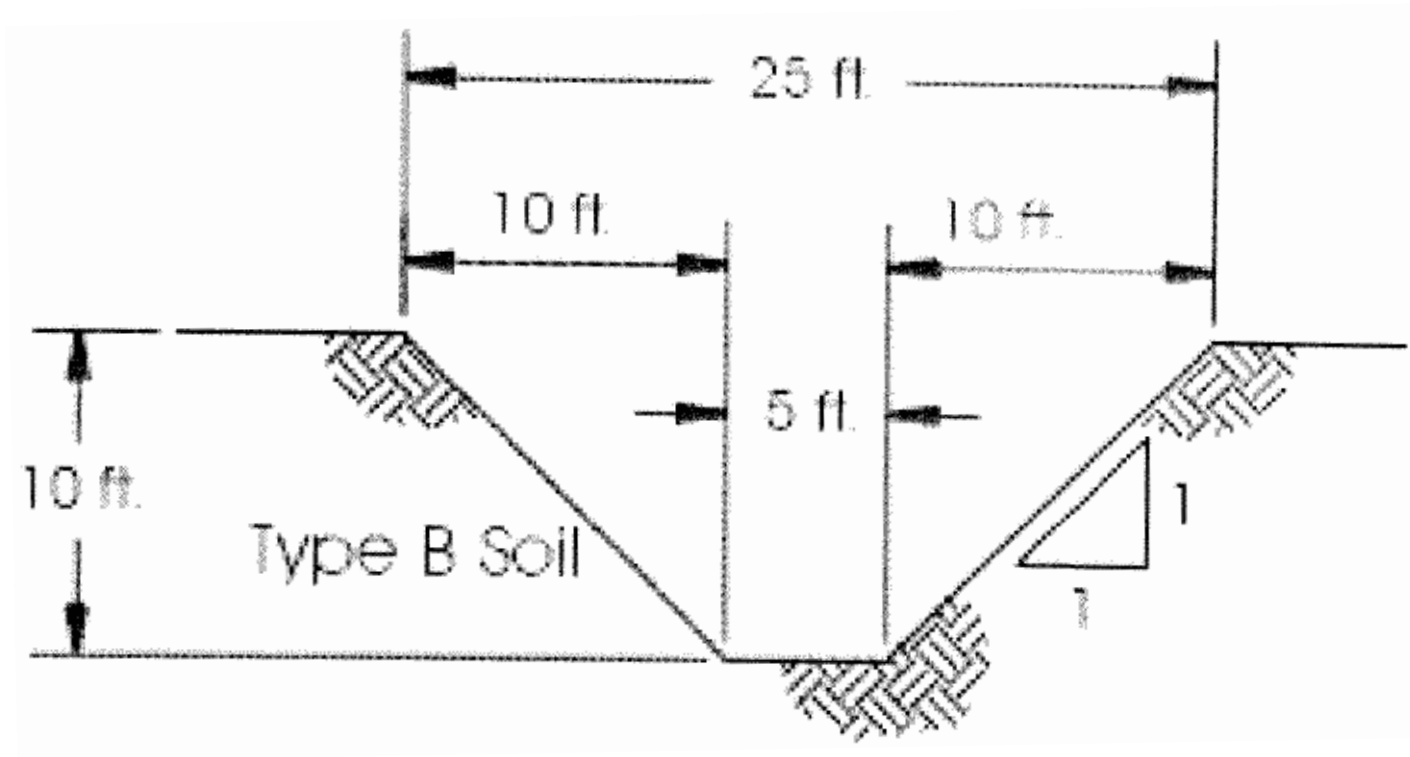
TRENCH SLOPES CONFIGURATIONS –PG 5

# *Trenching*



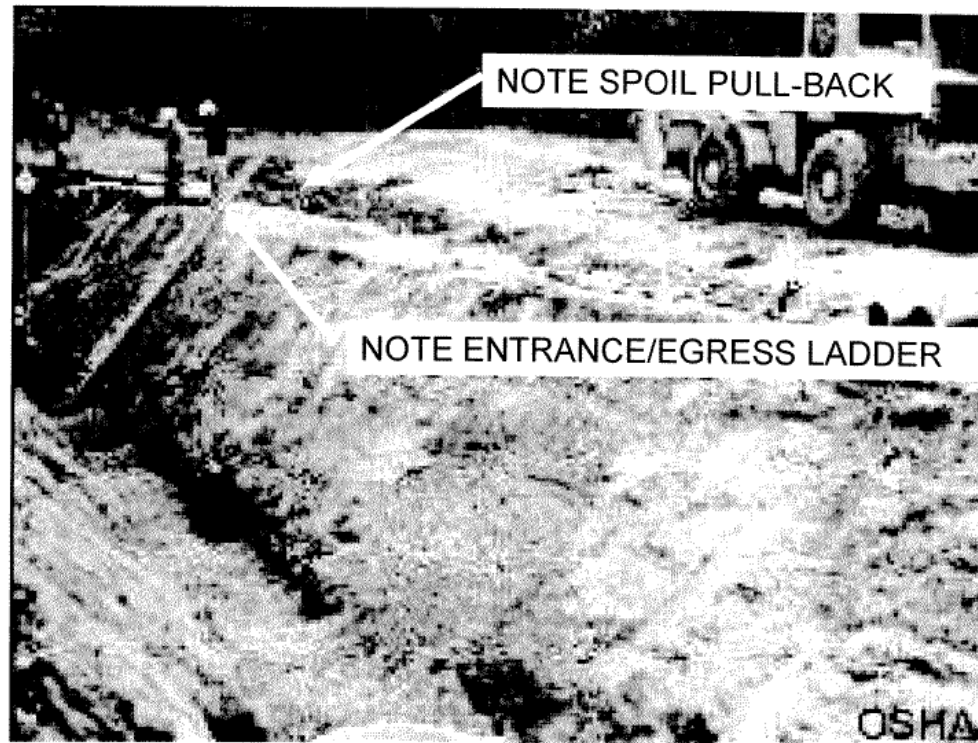
Trench slope angles

# Trenching



## Trench typical dimensions

# *Trenching*

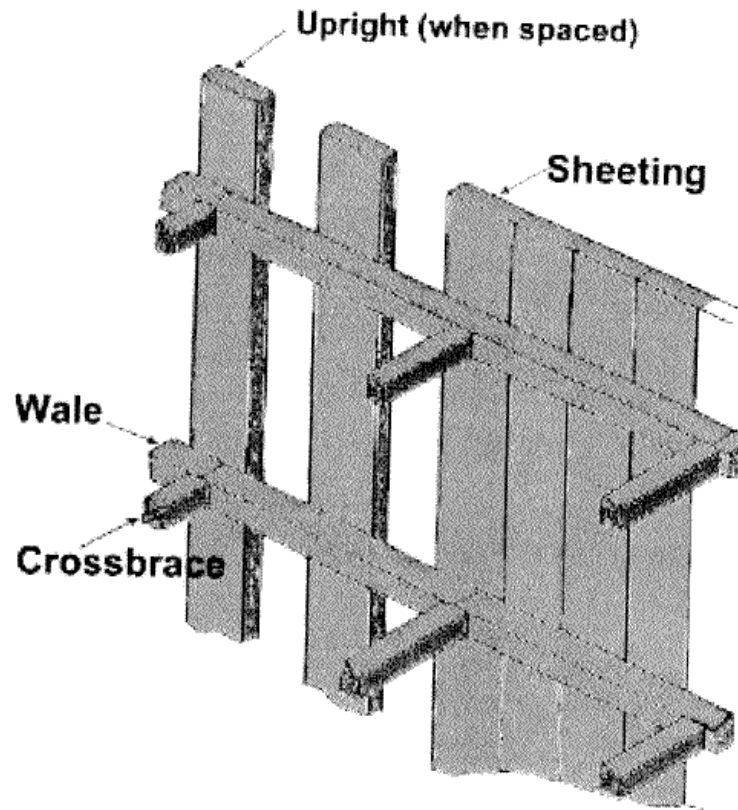


Typical sloped trench

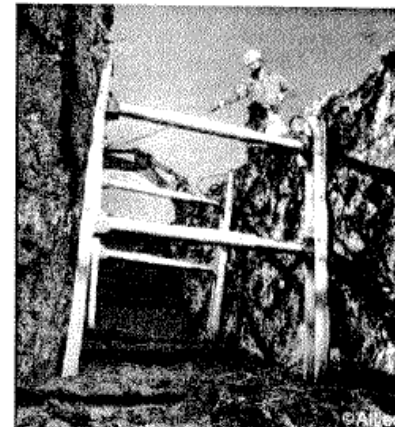
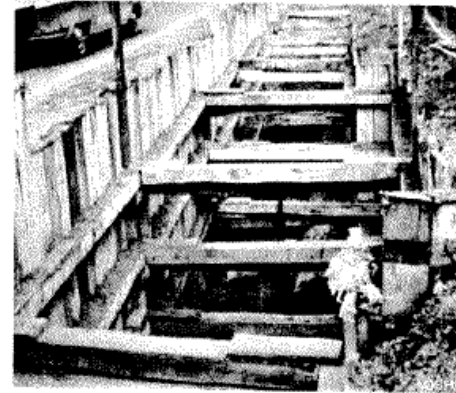


# *Trenching*

## Shoring System Components



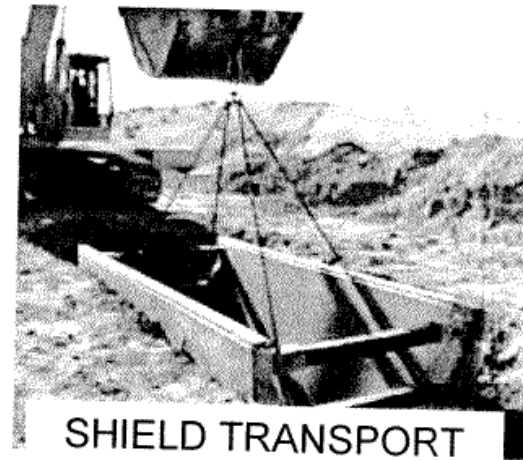
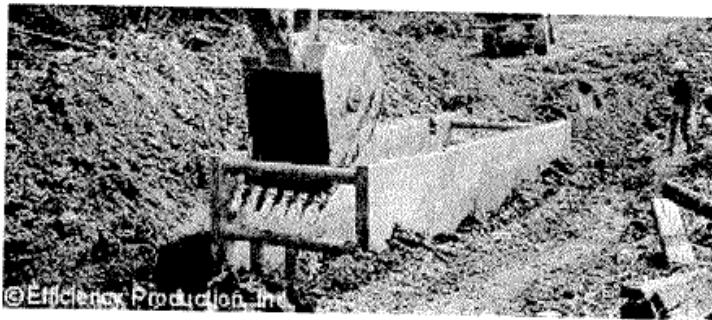
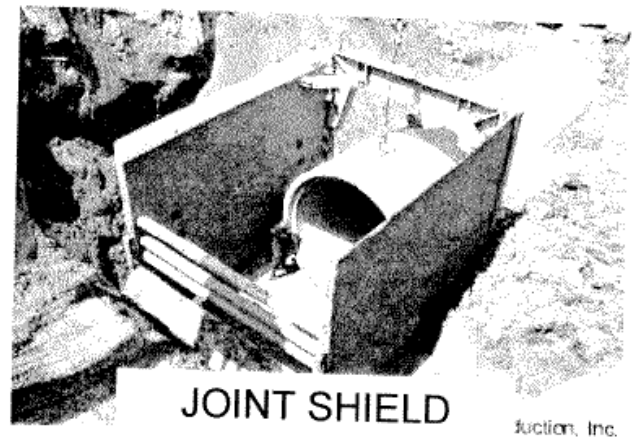
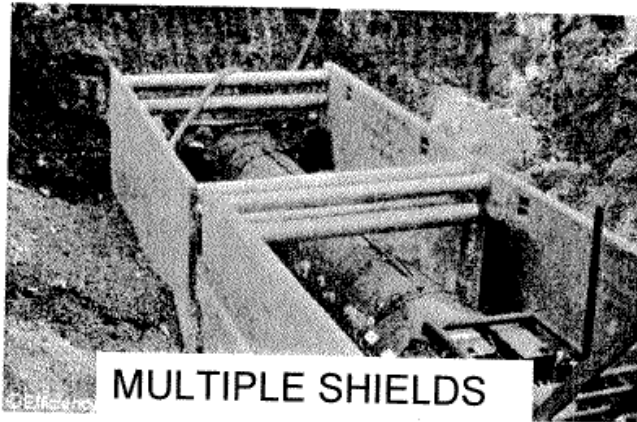
# *Trenching*



TRENCH SHORING EXAMPLES



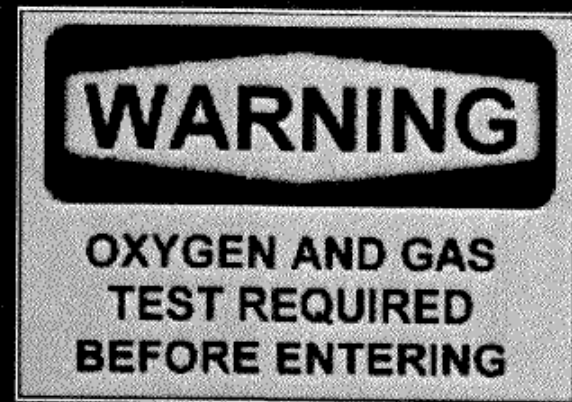
# *Trenching*



# *Trenching*

A hazardous atmosphere is one which is:

- Oxygen deficient
- Toxic
- Explosive
- Flammable
- Corrosive
- Irritating
- Oxidizing
- Poisonous



Trench hazardous atmospheres

# Trenching

Oxygen Content and Worker Level								
Activity	Oxygen Content in the Work Space (%)							
Level	21	20	19	18	17	16	15	14
Resting	A	A	A	A	A	A	A	A
Walking	A	A	A	A	A	A	A	
Moderate Work	A	A	A	A	A			
Heavy Work	A	A	A	A				
	A	Blood Oxygen Content Adequate						
		Blood Oxygen Content Likely Inadequate						

RESPIRATORY PROTECTION REQ'D

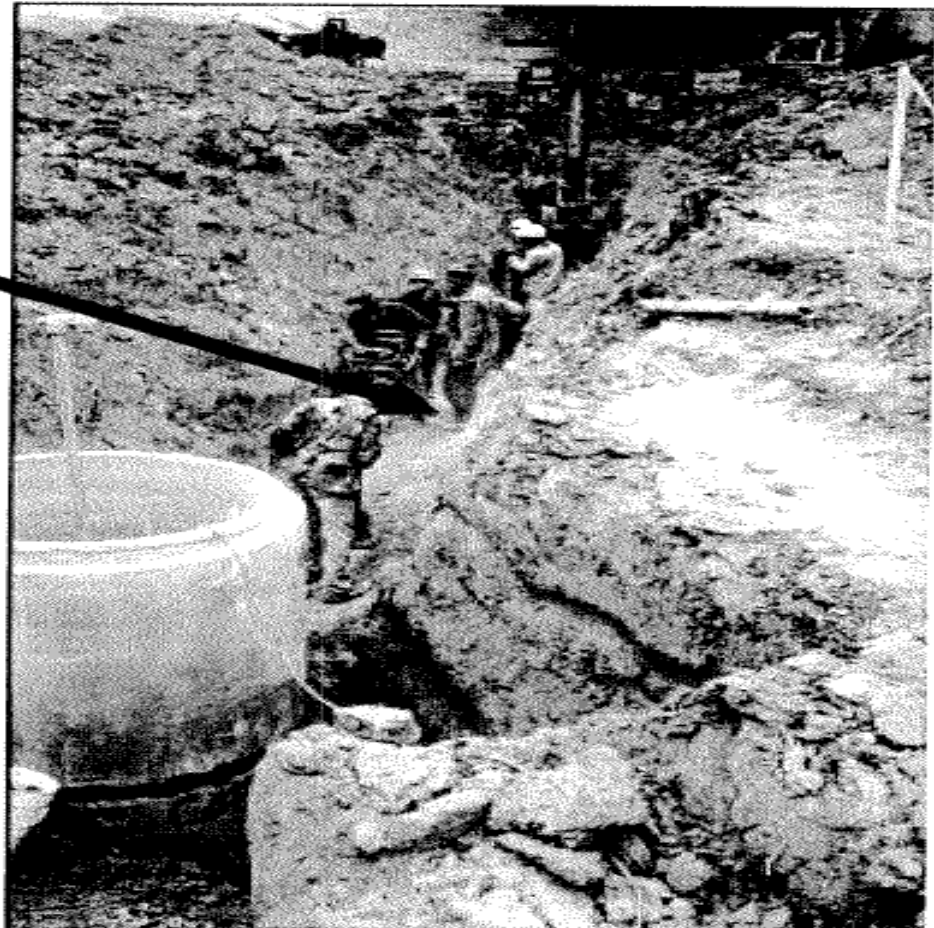
## SAFE WORKING OXYGEN LEVELS IN TRENCHES



# *Trenching*

**BEWARE!**

CO & CO<sub>2</sub> ARE  
HEAVIER THAN AIR  
& WILL COLLECT  
AT BOTTOM OF  
EXCAVATIONS!!!!



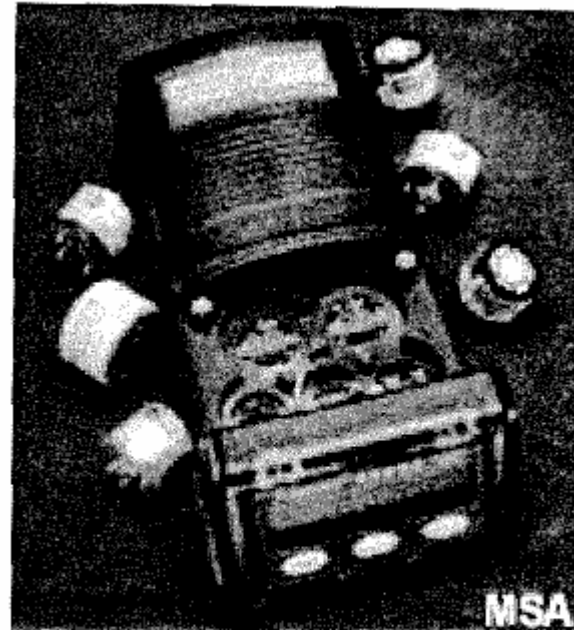
TRENCH MACHINE OPERATIONS



# *Trenching*



ATMOSPHERIC MONITORING PPE



GAS MONITOR WITH GAS SAMPLE  
CANISTERS

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SAFE WORKING OXYGEN LEVELS IN TRENCHES