Department Of Fire Services

Massachusetts Firefighting Academy

Technical Rescue Programs

TRENCH RESCUE: TECHNICIAN LEVEL

STUDENT GUIDE

5/1/15

Reasons for Failure of Technical Rescue Operations

Acronym: FAILURE

F – Failure to understand or underestimating the environment

A – Additional medical implications not considered

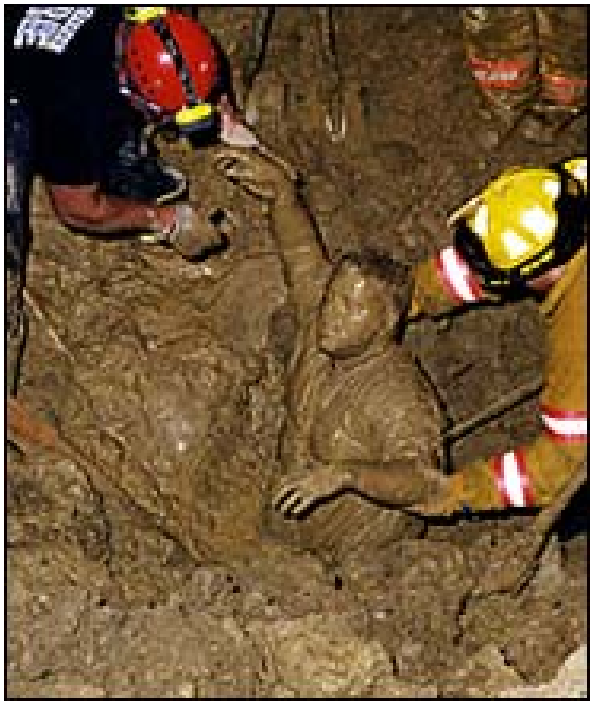
I – Inadequate rescue skills

L – Lack of teamwork and experience

U – Underestimating the logistical needs of the operation

R – Rescue versus recovery mode not being considered

E – Equipment not mastered



New York Times Article by David Barstow, Published: December 21, 2003

A technical rescue incident could happen anywhere at any given moment. Are you and your department Prepared?

Course Outline

Introduction
Definitions
Statistics
Laws and Regulations
OSHA
NFPA
Trench Anatomy and terminology
Soil physics
Conditions and factors that lead to trench collapse
Types of trench collapse
PPE
Tools and equipment
Scene assessment
Hazard control
Trench rescue
Sheeting and shoring
Straight wall trench shoring
Intersecting trench shoring

Course Objectives

To provide emergency responders with the proper tools to safely manage an incident involving a trench, recognize conditions, make appropriate notifications, hazard recognition, and equipment use. To operate at a trench rescue incident safely by properly constructing a protective system for both rescuers and victim(s)

Trenches and excavations have many uses, among them are:

- Underground utilities
- Removal of old utilities
- Underground storage tank removal and installation
- Building foundations

Can you think of more uses?

Scope of the trench and excavation problems:

OSHA has determined that there is a large problem is the United States with trenching.

- Over 10,000 incidents per year are reported
- This is not counting those that go unreported
- These incidents result in over 100 deaths per year
- Averaging approximately 2 per week
- There are thousands of injuries that are reported yearly

A large portion of these injuries are would be rescuers!

- These would be rescuers include:
- Civilians
- Co-workers, contractors
- Law enforcement personnel
- Emergency medical responders
- First due firefighters

ALL THE ABOVE ARE INCLUDED IN THESE STATISTICS

Why do these trench emergencies have to occur?

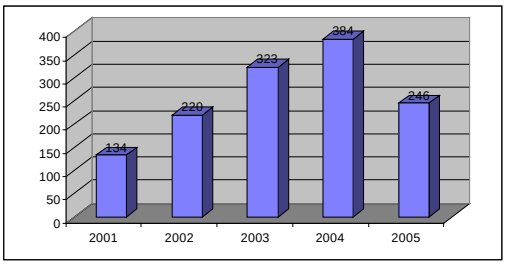
Complacency on the contractors and workers part
Lack of proper training in trench operations
Failure to recognize the unsafe conditions prior to failure
Short cutting the job for profit
Lack of proper safety guidelines
The “it’s not going to happen to me” attitude
This is what we as firefighters are here to prevent.

There were approximately 46 incidents classified as incident type “354” in Massachusetts over a five year period from 2001 through 2005
These only include the incidents that were reported, many go unreported yearly

07-01-03 - Town of Northbridge, MA
A worker was stuck in the mud during construction inside a foundation for a large building. Firefighters on scene attempted to extract the victim for approximately 1-1/2 hrs prior to arrival of a technical rescue team. Upon arrival of the technical rescue team it took them approximately 20 – 25 minutes to extract the worker safely. The used an air knife to achieve these results, by injecting air down around the patient’s legs and pulled him to safety by hand, without the use of machinery.

08-26-04 - Town of Hudson, MA
Hudson - A homeowner was digging a small narrow trench around his home for drainage and was in the trench working when it collapsed on top of him. Firefighters called to the scene did not have the proper equipment or training to extricate the victim. They called a technical rescue team to properly shore the trench and remove the victim safely without injury to any rescuers

Nationally over the same time period there were 1307 trench classified incidents reported.



Averaging approximately 261 per year

These reported incidents accounted for:

9 fire service injuries
11 civilian injuries
0 firefighter deaths
4 civilian deaths

Laws and Regulations:

OSHA 1926 subpart P

This law covers:

- 1926.650 – scope, applications, and definitions
- 1926.651 – specific excavation requirements
- 1926.652 – requirements for protective systems
- Appendix A – Soil Classifications
- Appendix B – Sloping and Benching
- Appendix C – Timer Shoring for Trenches
- Appendix D – Aluminum Hydraulic Shoring for Trenches
- Appendix E – Alternatives for Timer Shoring
- Appendix F – Selection of Protective Systems

OSHA 1910.146 – Confined Space Regulations

- OSHA Confined Space Law
  - By definition, a trench is a confined space
  - Many of the hazards associated with Confined Space are similar to trenches. i.e. Atmospheric Hazards

NFPA 1006 – Technical Rescuer Professional Qualifications

- 2013 edition
  - Chapter 1 – Administration
  - Chapter 3 – Definitions
  - Chapter 4 – Rescue Technician
  - Chapter 5 – Job Performance Requirements
  - Chapter 7 – Confined Space
  - Chapter 8 – Trench Rescue
    - Conduct a size-up of a collapsed trench
    - Implement a trench emergency action plan
    - Implement support operations at trench emergencies
    - Support a nonintersecting straight wall trench 8ft or less
    - Release a victim from soil entrapment
    - Remove a victim from a trench
    - Disassemble a support system
    - Support an intersecting trench
    - Install supplemental sheeting and shoring
    - Construct load stabilization systems
    - Lift a load
    - Coordinate the use of heavy equipment

- Release a victim from entrapment
- Terminate a trench emergency incident

NFPA 1670 – Operations and Training for Technical Search and Rescue Incidents

- 2014 edition
  - Chapter 1 – Administration
  - Chapter 3 – Definitions
  - Chapter 4 – General Requirements
  - Chapter 7 – Confined Space Search and Rescue
  - Chapter 8 – Vehicle Search and Rescue
  - Chapter 11 – Trench and Excavation Search and Rescue

NFPA 1670 speaks to a tiered response of three levels

The AHJ shall establish written standard operating procedures (SOPs) consistent with one of the following operational levels for each of the disciplines defined in this document:

- *Awareness Level*. This level represents the minimum capability of organizations that provide response to technical search and rescue incidents.

- *Operations Level*. This level represents the capability of organizations to respond to technical search and rescue incidnets and to identify hazards, use equipment, and apply limited techniques specified in this standard to support and participate in the in technical search and rescue incidents

- *Technician Level*. This level represents the capability of organizations to respond to technical search and rescue incidents and to identify hazards, use equipment, and apply advanced techniques specified in this standard necessary to coordinate, perform, and supervise technical search and rescue incidents.

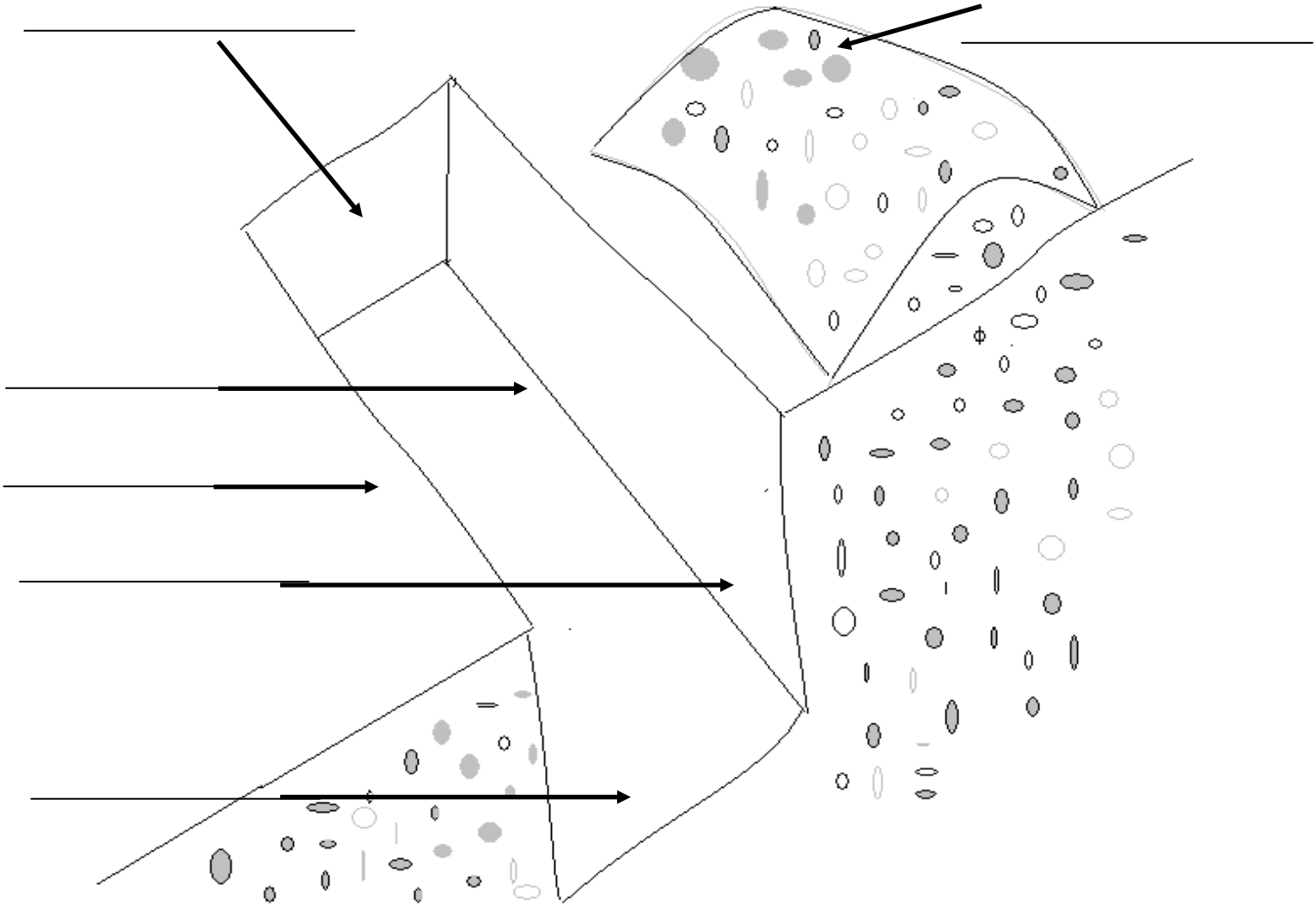
NFPA 1951 – Protective Ensemble for USAR Operations, 2013 ed.

NFPA 472 - Hazardous Material Standard, 2013 ed.

- Standard for Professional Competence of Responders to Hazardous Materials Incidents
  - Chapter 4 - Competencies for the First Responder

Trench Anatomy and Terminology
DEFINITION:

- **Deeper than it is wide**
- **Protective systems for use in excavations more than 20’ in depth must be designed by registered professional engineer**
- **Not more than 15 foot wide at the bottom of the trench, after that it becomes an excavation, not a trench**



- Lips - 2 feet back from the top and side of the trench
- Toe - 2 feet up the wall from the floor of the trench
- Walls (Belly) - Vertical surfaces that run the length of the trench
- Ends - Narrow ends of the trench
- Floor - Bottom of the trench
- Spoil Pile - Excavated soil from the trench

Conditions that may lead to a trench collapse during the construction phase.

- Absorption rate of the water into the soil
- The addition of water,
  - I.e. Rain, broken pipes
- Open trench time
- Type of soil
- Vibration in the area
- Spoil pile location
- Heavy Equipment operation near trench
- Local traffic
- Rescuers on or near the lip
- Hot, dry weather

Types of trench collapse that may occur:

1. Spoil pile collapse
   - Most common type - Why?
   - Gravity exerts pressure downward and towards trench opening
   - Height of spoil pile deepens the trench
   - Patient found on floor or far wall

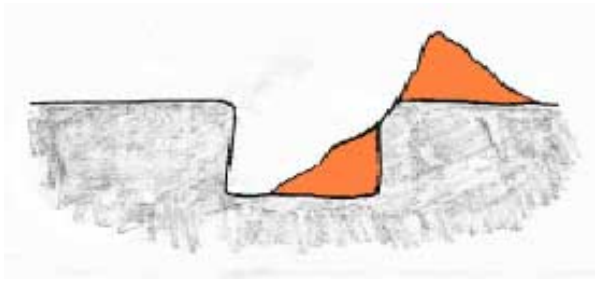
2. Slough-in
   - Part of the wall gives out, leaving overhang
   - Risk of secondary collapse is great
   - Very difficult to shore
   - Patient usually found against far wall or floor

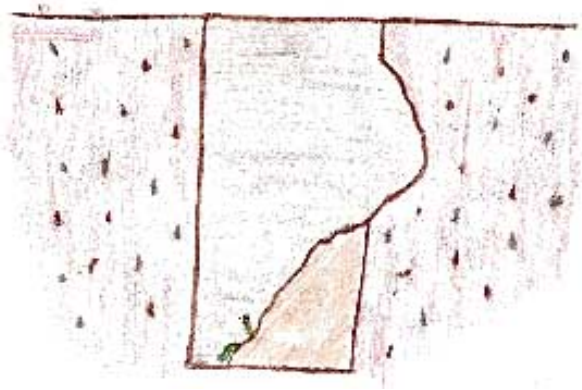
3. Shear wall collapse
   - Loss of the entire wall section
   - Occurs in previously excavated sites
   - Patient found on the floor
   - Travels at approximately 40 miles per hour

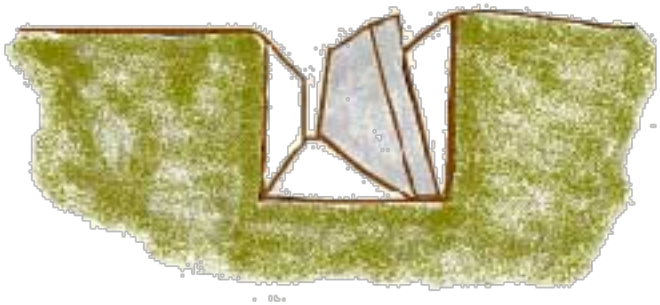
4. Wedge collapse
   - 2 intersecting walls freestanding to create a corner
   - Corner is unsupported and subject to gravitational force
   - Wedge is created by fissure (crack) from one wall extending to the next

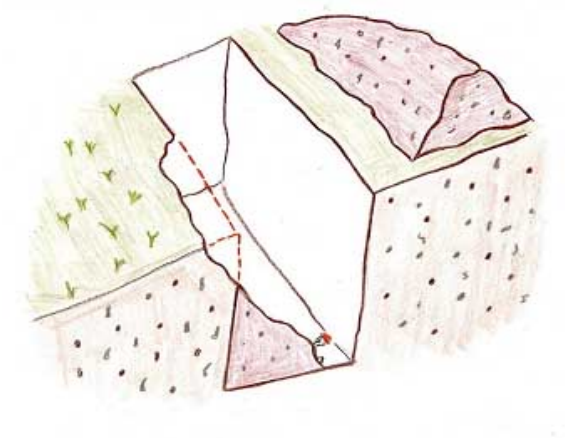
5. Lip in collapse
   - Created by someone standing near the lip of the trench
   - Having the spoil pile too close to the edge of the trench
   - From a slough in undermining the lip and not noticed by rescuers

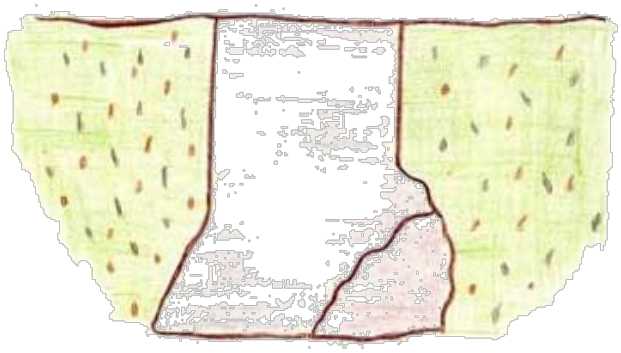
6. Bell Pier collapse
   - “Shaft or footing excavation, the bottom of which is made larger than the cross section above to form a belled shape” A part of the wall closest to the floor which will give way, giving the trench a bell shape.











Secondary Collapse

SECONDARY COLLAPSE COULD HAPPEN AT ANY TIME WITHOUT WARNING

- 50% chance in undisturbed soil
- 75% chance in disturbed soil

All personnel should constantly assess for secondary collapse conditions

Reasons for a Secondary Collapse
1. Unprotected trench
2. Static loads
3. Intersecting trenches
4. Standing Water or water seeping in
5. Vibrations
6. Previously disturbed soil
7. Exterior cracking of trench wall

Other Trench Emergencies
1. Trench worker injuries
2. Dropping tools or machinery falling into trench
3. Boulders dislodged in the trench

1. One cubic foot of dirt weighs? _____
2. One cubic yard of dirt weighs? _____
3. One gallon of dirt weighs? _____
4. One cubic foot of dirt fills? _____ One gallon buckets
5. One cubic yard of dirt fills? _____ One gallon buckets
6. 1 full 5 gallon bucket weighs? _____

Consider these weights in rapid extrication of the victim(s)!

Manual Soil Test – Thread Test

This determines plasticity or cohesiveness of the soil

1. Roll out representative sample to 1/8” diameter
2. If sample stays together in lengths > 2” medium to highly plastic
3. If soil cannot be lumped together in a ball without breaking low plasticity
4. If soil cannot be rolled into a thread at any moisture content non plastic

Manual Soil Test – Ribbon Test

This determines plasticity and compressive strength of samples with some gravel.

1. Roll ½” – ¾” diameter soil sample approximately 3 – 5” long
2. Flatten between thumb and forefinger forming a ribbon 1/8” – 1/4” thick
3. If sample holds together 8 – 10” without breaking soil is highly plastic and highly compressive.
4. If sample has difficulty holding together in segments longer than 3 – 5” sample has low plasticity.
5. If sample cannot be ribboned then it is non-plastic

Manual Soil Test – Dry Strength

This determines cohesiveness strength and plasticity

1. Mold a pat of soil ½” thick and approximately 1-1/2” in diameter
2. Allow to dry completely
3. Attempt to break using thumb and forefinger of both hands
4. Very high plastic – sample cannot be broken or powered by use of finger pressure
5. Highly plastic – samples can be broken with great effort, cannot be powered.
6. Medium plasticity – broken or powered with some effort
7. Slightly plastic – can be broken easily and powered readily
8. Non-plastic – sample crumbles with handling
9. Be cautious of breakage along shrinkage cracks

Pocket Penetrometer

Quantitative test using an instrument to measure unconfined compressive strength

1. Choose a representative sample that is as least as large as your fist and has a smooth surface
2. Place the penetrometer perpendicular to the soil
3. Push slowly until the mark (1/4") is penetrated into the soil
4. Read the top of the ring
5. If 0.5 tsf or less Type C or little or no unconfined strength
6. If >0.5 or <1.5 tsf Type B or moderate unconfined compressive strength
7. If 1.5 tsf or greater Type A or high unconfined compressive strength
8. Take numerous samples, throw out high/low and average (inaccuracies)

Thumb Penetration Test

Estimates unconfined compressive strength of soil

1. Choose a representative large clump of undisturbed spoil as soon as practical after excavation to reduce effects of drying
2. 1.5 tsf or greater – soil sample can be readily indented by the thumb with very great effort. "Type A soil"
3. 0.5 tsf or less – soil sample can be easily penetrated several inches by the thumb with light pressure. "Type C soil"

Size Up

Existing and potential conditions

1. Scope, Magnitude, and nature of the incident
   - Do we have enough resources?
   - Do we have enough equipment?
   - Back up rescue teams!
   - Can we handle it?
2. Location, number and condition of victims
   - Location
     - Buried
     - Partially buried
   - Number
     - How many
   - Injuries
     - Crush syndrome
     - Broken bones

3. Risk vs. benefit Analysis
    - Live victims
        - Rescue – risk a lot with safety considerations
- Deceased victims
        - Recovery – risk nothing with safety considerations

Remember technical rescue is a low frequency – high risk operation, special training and special equipment are necessary to perform the rescue safely

4. Traffic and vibrations
    - Shut down traffic and heavy equipment
5. Hazards
    - Disrupted or exposed utilities
    - Standing or flowing water
    - Secondary collapse
    - Mechanical hazards
    - Hazardous materials
    - Explosives
6. Trench dimensions
    - Will our struts reach across?
    - Do we have the lumber to make it?
    - Is it too narrow?
    - Can we fit in?
7. Available resources
    - Local or Regional teams
    - Back-up rescue teams
    - Specialty equipment
    - Local companies
    - Vendors
8. Environmental factors
    - Rain
    - Snow
    - Lightning Storms
    - High Winds

Entry Procedures

- Firefighters should be properly trained
- Firefighters are specially trained
  - Trench Rescue
  - Vehicle Extrication
  - Confined Space
  - Structural Collapse
  - Rope Rescue

Before any entry begins the entire team should be briefed on their roles and responsibilities

- First due firefighters should secure the area as soon as possible
- Establish pre-determined zones for entry teams and support teams

Recognition of Unstable Areas

- Notice any and all cracks or fissures around the trench
  - These should be painted to check for further movement later
- Wet soil – avoid if possible, don't get stuck in the mud near the trench lip
- Loose dirt next to the trench should be shoveled or raked back
- Rocks/boulders should be pulled away from the lip
- NEVER push any debris into the open trench

After a trench collapse emergency is anything really stable?

What is the stability of the adjoining areas?

- Adjoining buildings
- Walls
- Other structures
- Sidewalks
- Roadways
- Shoring, bracing, or underpinning should be provided for safety

Identify probable location of any and all victims!

- Visually see them in the trench
- The presence of drink cups or food containers
- Bystander or witness information
- Any sounds from adjoining pipes
- Grading poles or tools in the trench unattended

Prior to any entry:

Make the area safe

- Place ground pads around the lip area
  - 4 x 8 foot sheets of ½" plywood
  - 2" x 12" planking
- Utilize sheeting and shoring for the trench
- Ventilation
  - Monitor the atmosphere prior to entry
- Dewatering, if there is any standing water in the trench
- Support any exposed or broken utilities
- Get PPE to the victim as soon as it is safe to do so
- Prohibit entry to all but the rescue team
- Shut down all machinery in the hot zone
- Notify Dig Safe – not necessary to wait for them during a rescue operation
- Notify local utilities – DPW, water, sewer, electric, etc.

DPW – might have the availability of a vac truck to remove soil

Identify the soil type

- OSHA identifies 12 different soil classifications in 1926 subpart P appendix A
  - Cemented, cohesive, dry, fissured, granular, layered, moist, plastic, saturated, stable rock, submerged, and wet soil

Rescue teams consider all collapsed soil to be "Type C"

Type “A” soil:

- Type A" means cohesive soils with an unconfined, compressive strength of 1.5 ton per square foot (tsf) (144 kPa) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A

Type “B” soil:

- (i) Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa); or
- (ii) Granular cohesion less soils including: angular gravel (similar to crushed rock), silt, silt loam, sandy loam and, in some cases, silty clay loam and sandy clay loam.
- (iii) Previously disturbed soils except those which would otherwise be classed as Type C soil.
- (iv) Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or
- (v) Dry rock that is not stable; or
- (vi) Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.

Type “C” soil:

- (i) Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less; or
- (ii) Granular soils including gravel, sand, and loamy sand; or
- (iii) Submerged soil or soil from which water is freely seeping; or
- (iv) Submerged rock that is not stable, or
- (v) Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper

Ventilation of an open trench

Follow proper procedures

Positive pressure vs. negative pressure ventilation

- Advantages to both – disadvantages to both
  - It dries out the trench
  - Supplies fresh air to the victim and rescuers if needed
  - Dryness could cause a secondary collapse
  - Air blowing in may make the victim cold
- Use of ventilation tubes allow placement of air where it is needed

- Gases may be heavier or lighter than air, ventilation has to be in the right place
- Hypothermia could become a problem in a prolonged extrication

Ground pad placement

- Distributes the weight of the rescue team over a larger area
- 4’ x 8’ x ½” plywood is most common
  - Anything on site may be used until rescue team arrives

- Start at end of the trench and place one pad at a time leveling the ground as you go without knocking loose soil into the trench.
- If the soil pile is too close have local firefighters and/or contractors move it by and digging, no machinery
- 2” x 12” x 10’ planks can be used when the area is narrow
- Pad placement must be continuous along the entire lip of the trench, where the rescuers will work or stand
- This should be done prior to all other operations beginning.

Entry and Egress paths should be determined as soon as possible

OSHA 1926.651 (c) (2) Means of egress from trench excavations. A stairway, ladder, ramp or other safe means of egress shall be located in trench excavations that are 4 feet (1.22 m) or more in depth so as to require no more than 25 feet (7.62 m) of lateral travel for employees.

Conduct a pre-entry briefing

- Members shall be given their tactical assignments
- When your assignments are complete you should return to staging
- General hazards present and safety instruction shall be detailed
- Communications will be established
- Environmental factors affecting the operation will be discussed
- Operational period will be determined and discussed by the team
- Emergency procedures for:
- Evacuation of the trench
- Secondary collapse
- RIT team operations and designation

Equipment needs for safe operations

- Resources available
- Resources needed
- Specialized equipment called for
  - Debriefing procedures for post incident
  - Documentation
- ICS forms
- To include but not limited to:
  - Time of entry, time of incident, environmental conditions, and locations of victims
- Tactical checklist for the operation
  - Entry / exit times
  - Personal accountability
  - Atmospheric readings
  - Rehab information
  - Injury reports
  - Incident number

Shielding systems

_____ May be expandable by width and/or length

_____ Contractor brings it in
He must have one copy of tabulated data on site for a pre-engineered system

_____ Built by contractor
Built by rescue team
Wood
Pneumatic
Hydraulic

Assessing mechanism of entrapment

- Complete or partial coverage
- Entrapment by machinery or other equipment

Performing the extrication

- When ever you are near or may be near a victim hand digging is required
- Lifting can be done using air bags or pneumatics
- Mechanical advantage systems
- Suctioning/vacuuming devices
- Air knives, saws, or other power tools
- Dewatering
- Heavy equipment for digging only
- A frame ladder system
- Ropes, webbing

Types of trenches and shoring

Straight trench

- The easiest to shore
- Requires a minimum of 12 foot of shoring on each side of the trench
- First set of panels always goes over the victim for protection
- Then four feet to either side for rescuer and victim protection
- May require the use of inside or outside wales
- May be shored with wood, pneumatics, or hydraulics

Stepped trenches may be encountered if time and space allows the contractor to do so

“T” Trench

- More difficult to shore
- First set of panels goes over the victim for protection
- Requires shoring of two outside exposed trench corners
- Requires a minimum of 3 sets of panels plus supplemental sheeting and additional panel
- Will require inside wale on one side of the trench
- May require backfilling of voids behind the panels

“X” Trench

- Will require coordination of 4 sets of panels
- Back filling of voids
- There are 4 corners to shore without causing secondary collapse

“L” Trench

- Requires use of multiple struts
- Inside wales on both sides
- Thrust blocks
- May require backfilling of voids
- Multiple panel sets
- Can be done with extra panels or supplemental shoring

Supplemental sheeting and shoring

- Normally 2” x 12” x 12’ foot planks and wedges
- Requires inside wales
- Wedges are pulled and reset as planks are dropped with the digging operations

- After panels are set and shot – back fill behind each one
- Large open voids behind panels can be filled with outside wales
- Areas greater than 18” cannot be filled with soil
- Low pressure air bags work good for this option

Personal Protective Equipment

- Fire gear
  - Not common in trench work because of it’s bulkiness
  - Hard to maneuver in tight spaces with while digging or setting panels
- Jumpsuits
  - More common for rescue teams
  - May be Nomex, PBI, cotton,
- Long pants and long sleeve shirts
  - Most common
  - Keeps body covered
  - Offers protection from hypothermia
- Gloves
  - Required for all technical rescue operations
  - Keep hand covered during hand digging operations around victim
- Eye protection
  - Any rescue technician operating within the hot zone area will have eye protection on
- Rescue helmet
  - Two point attachment on the chin strap
  - Impact shield inside
  - Fire helmet will do but it is big and bulky
  - Rescue helmet works better in tight spaces and small trenches
- Hearing protection
  - Should be available if needed
- Respiratory protection
  - Not common in trench rescue work
  - Should be available if needed

Trench Rescue Tools

- Shoring panels
- Strong backs
- Pneumatic shores
- Rope
- Duplex nails
- Hand tools
- Entrenching tools
- Heating pumps
- Dewatering pumps
- Low pressure air bags
- High pressure air bags
- Regulators
- Small hand tools
- Ventilation equipment
- Atmospheric monitoring equipment
- Medical equipment
- Patient removal devices
- Ground pads
- 2 x 12 planks, etc.

Standard Utility Markings

Mass General Law regulates utility marking colors in Massachusetts.

Positioning of apparatus on arrival

- No less than 250 feet from the trench
- This creates the warm zone for response personnel
- Establish command
- Designate staging
- Create the cold zone
  - 500 foot diameter from trench
- Create the hot zone
  - 100 foot diameter around the trench

Trench Rescue Injuries – some of the most common

- Crush syndrome
- Difficulty breathing
- Hypothermia
- Compromised airway
- Head injuries
- Spinal injuries
- Burns