King County Technical Rescue Trench Manual

“Above all, Do No Harm”

PURPOSE:

The purpose of this manual is to assist in mitigating a trench collapse as an "Awareness, Operations & Technician level responder", as required by Washington State Law.

OBJECTIVES:

This manual will assist the Trench Rescue Technician to:

- Become familiar with the standards established in NFPA 1006, NFPA 1670, and WAC 296-305-5113
- Develop an understanding of what a trench is, and the hazards associated with a trench during rescue operations
- Determine what is required to mitigate a trench rescue incident
    - Identify the hazards, communicate to all personnel, and develop an incident action plan
    - Utilize tools and equipment to build a safe and effective protection system.

RESOURCES:

King County Zone One Technical Rescue Staff
Pierce County DEM
Spec. Rescue International
Paratech & Air Shores International Equipment Manuals
Personal experiences
FEMA US&R Response System

TRENCH RESCUE INSTRUCTOR

The instructor cadre for King County Technical Rescue classes will consist of individuals who are certified technicians and have met the requirements of NFPA 1041. The instructor will be well prepared for the training sessions so that they can answer questions, provide explanations, and keep material interesting. The instructor will respect their audience and exhibit patience and humility in presenting the sessions. The instructor will participate in meetings, drills, and work groups. This will allow for the development, maintenance, and updates to curriculum to reflect best practices for King County.

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NFPA 1006: STANDARD FOR TECHNICAL RESCUER PROFESSIONAL QUALIFICATION (2017)

Chapter 11: Trench Rescue

11.1 Awareness Level. The job performance requirements defined in 11.1.1 through 11.1.5 shall be met prior to awareness-level qualification in trench rescue.

11.1.1 Identify the need for trench and excavation collapse rescue, given a specific type of collapse incident, so that resource needs are identified and the emergency response system for trench and excavation collapse is initiated.

(A) Requisite Knowledge.
Equipment organization and tracking method, recognition the hazards associated with the weight of soil and its entrapping characteristics, resource capabilities, procedures for activation of emergency response for collapse incidents.

(B) Requisite Skills. Ability to use communication equipment, track resources and communicate needs.

11.1.2* Conduct a size-up of a collapsed trench, given an incident and background information and applicable reference material, so that the size-up is conducted within the scope of the incident management system; the existing and potential conditions are evaluated within the trench and the rescue area; general hazards are identified; a witness or "competent person" is secured; the probability of victim existence, number, condition, and location is determined; potential for rapid, non entry rescues or victim self-rescue is recognized; needed personnel, supply, and equipment resources are evaluated; and utility involvement and location are determined. *(See Annex H.)*

(A) Requisite Knowledge. Methods to distinguish soil types, collapse mechanics, and other contributing factors such as severe environmental conditions and other general hazards; need to immediately secure "competent person" or witness; signs and evidence of victim involvement, number, and location; jurisdictional and community resource lists and agreements; effects and hazards of collapse and rescue efforts on utilities at the incident site; personnel training level and availability; risk/benefit analysis; protocols; incident management system; and all applicable regulations, laws, and standards.

(B) Requisite Skills. The ability to measure dimensions of trench, categorize soil, identify type and degree of collapse, and determine severe environmental conditions with implications for secondary collapse and victim survivability;

demonstrate interview techniques; implement protocols and resource acquisition agreements; implement public works utility notification, response, and location procedures; perform a risk/benefit analysis for determining self-rescue, rescue, or recovery mode; implement an incident management system for span of control; and apply governing regulations, laws, and standards.

11.1.3* Implement a trench emergency action plan, given size-up information and a trench incident, so that initial size-up information is utilized; prebriefing is given to rescuers; documentation is ongoing; the collapse zone is established; a risk/benefit analysis is conducted; rapid, non entry rescues or victim self-rescues are performed; the rescue area and general area are made safe; strategy and tactics are confirmed and initiated for existing and potential conditions; rapid intervention team and operational tasks are assigned; other hazards are mitigated; rescue resources are staged; and a protective system is being utilized.

(A) Requisite Knowledge. Size-up information and documentation; need to brief rescuers; areas that could be affected by collapse; variables to factor risk/benefit analysis; criteria for rapid, non entry rescues; methods to control hazards in the general area; options for strategy and tactical approach by factoring time frame, risk/benefit, approved shoring techniques, and personnel and equipment available; incident management system; rescue personnel and equipment cache staging; and options for victim isolation and/or protective systems.

(B) Requisite Skills. The ability to use and document tactical worksheets; disseminate information; understand mechanics and extent of collapse effects; perform risk/benefit analysis; execute rapid, non entry rescues; mitigate hazards by isolation, removal, or control; reduce imposed loads at or near the lip of the trench; choose strategy and tactics that will enhance successful outcome; use incident management system and resource staging; and apply choice of isolation and/or protective system promptly to surround victim.

11.1.4* Implement support operations at trench emergencies, given an assignment, and equipment and other resources, so that a resource cache is managed, scene lighting is provided for the tasks to be undertaken, environmental concerns are managed, a cut station is established, supplemental power is provided for all equipment, atmospheric monitoring and ventilation are implemented, personnel rehab is facilitated, operations proceed without interruption, extrication methods are in place, and the support operations facilitate rescue operational objectives.

(A) Requisite Knowledge. Equipment organization and tracking methods, lighting resources, dewatering methods, shelter and thermal control options, basic carpentry methods, hand and power tool applications, atmospheric monitoring protocol, rehab criteria, and extrication and removal equipment options.

(B) Requisite Skills. The ability to track equipment inventory, provide power, use lighting, choose and deploy dewatering techniques, acquire or construct structures for shelter and thermal protection, select rehab areas and personnel rotations, operate atmospheric monitoring and ventilation equipment, and perform patient packaging and removal.

11.1.5 Initiate the incident management system given a trench or excavation collapse incident, so that scene management is initiated, initial command structure is identified, resource tracking and accountability is established, and the incident action plan is developed.

(A) Requisite Knowledge. Incident management system structure, implementation procedures, expansion methodology, resource management techniques, tracking methods, incident action plan components, accountability systems, and IMS documentation forms rescuer rehabilitation criteria.

(B) Requisite Skills. Ability to utilize IMS forms and command tools and use communication devices and accountability tracking systems.

11.2 Operations Level. The job performance requirements defined in Section 5.2, Section 11.1, and 11.2.1 through 11.2.5 shall be met prior to operation-level qualification in trench rescue.

11.2.1* Support a non intersecting straight wall trench of 8 ft (2.4 m) or less in depth as a member of a team, given size-up information, an action plan, a trench tool kit, and an assignment, so that strategies to minimize the further movement of soil are implemented effectively; trench walls, lip, and spoil pile are monitored continuously; rescue entry team(s) remains in a safe zone; any slough-in and wall shears are mitigated; emergency procedures and warning systems are established and understood by participating personnel; incident-specific personal protective equipment is utilized; physical hazards are identified and managed; victim and rescuer protection is maximized; victim extrication methods are considered; and a rapid intervention team is staged.

(A) Requisite Knowledge. Shoring and shielding, tabulated data, strategies and tactics, protocols on making the general area safe, criteria for a safe zone within the trench, types of collapses and techniques to stabilize, emergency procedures, selection of personal protective equipment, and consideration of selected stabilization tactics on extrication and victim safety.¶

(B) Requisite Skills. The ability to interpret tabulated data information and tables, place shoring and shielding systems, install supplemental shoring, use protocols, choose methods to stabilize, use personal protective equipment, anticipate extrication logistics, and create systems in trenches 8 ft (2.4 m) deep.

11.2.2* Release a victim from soil entrapment by components of a non intersecting collapsed trench of 8 ft (2.4 m) or less in depth, given personal protective equipment, a trench rescue tool kit, and specialized equipment, so that hazards to rescue personnel and victims are minimized, considerations are given to crush syndrome and other injuries, techniques are used to enhance patient survivability, tasks are accomplished within projected time frames, and techniques do not compromise the integrity of the existing trench shoring system.

(A) Requisite Knowledge. Identification, utilization, and required care of personal equipment; general hazards associated with each type of trench collapse; methods of evaluating shoring systems and trench wall stability; crush syndrome protocols; identification of collapse characteristics; causes and associated effects of trench collapse; potential signs of subsequent collapse; selection and application of rescue tools and resources; risk/benefit assessment techniques for extrication methods; and time restraints.

(B) Requisite Skills. The ability to select, use, and care for personal protective equipment; operate rescue tools and stabilization systems; identify crush syndrome clinical settings; and complete risk/benefit assessments for selected methods of rescue and time restraints.

11.2.3* Remove a victim from a trench, given a disentangled victim, a basic first aid kit, and victim packaging resources, so that basic life functions are supported as required; the victim is evaluated for signs of crush syndrome; methods and packaging devices selected are compatible with intended routes of transfer; universal precautions are employed to protect personnel from bloodborne pathogens; and extraction times meet time constraints for medical management.

(A) Requisite Knowledge. Medical protocols, available medical resources, transfer methods and time needed to execute, universal precautions protocol, rope rescue systems, high-point anchor options, and patient ladder raise removal techniques.

(B) Requisite Skills. The ability to select and use personal protective equipment, provide basic medical care and immobilization techniques, identify the need for advanced life support and crush syndrome management, and use a removal system that matches logistical and medical management time frame concerns.

11.2.4* Disassemble support systems at a trench emergency incident, given personal protective equipment, trench tool kit, and removal of victim(s), so that soil movement is minimized, all rescue equipment is removed from the trench, sheeting and shoring are removed in the reverse order of their placement, emergency protocols and safe zones in the trench are adhered to, rescue personnel are removed from the trench, the last supporting shores are pulled free with ropes, equipment is cleaned and serviced, reports are completed, and a post briefing is performed.

(A) Requisite Knowledge. Selection of personal protective equipment, equipment used and its location, shoring and shielding tactics and order of placement, shoring removal protocols, criteria for a "safe zone" within the trench, personnel accountability, emergency procedures, manufacturer's recommended care and maintenance procedures, and briefing protocols.

(B) Requisite Skills. The ability to use personal protective equipment, remove equipment and protective systems, use trench safety protocols, clean and service equipment, and perform an incident debriefing.

11.2.5* Terminate a technical rescue operation, given an incident scenario, assigned resources, and site safety data, so that rescuer risk and site safety are managed; scene security is maintained, and custody transferred to a responsible party; personnel and resources are returned to a state of readiness; recordkeeping and documentation occur; and post-event analysis
is conducted.

(A) Requisite Knowledge. Incident Command functions and resources, hazard identification and risk management strategies, logistics and resource management, personnel accountability systems, and AHJ-specific procedures or protocols related to personnel rehab.

(B) Requisite Skills. Hazard recognition, risk analysis, use of site control equipment and methods, use of data collection and management systems, and use of asset and personnel tracking systems.

11.3 Technician Level. The job performance requirements defined in Section 11.2 and 11.3.1 through 11.3.6 shall be met prior to technician level qualification in trench rescue.

11.3.1* Support an intersecting trench as a member of a team, given size-up information and an action plan, a trench tool kit, and an assignment, so that strategies to minimize the further movement of soil are implemented effectively; trench walls, lip, and spoil pile are monitored continuously; rescue entry team(s) in the trench remains in a safe zone; any sloughing and wall shears are mitigated; emergency procedures and warning systems are established and understood by participating personnel;

incident-specific personal protective equipment is utilized; physical hazards are identified and managed; victim protection is maximized; victim extrication methods are considered; and a rapid intervention team is staged.

(A) Requisite Knowledge. Shoring and shielding, tabulated data, strategies and tactics, types of intersecting trenches and techniques to stabilize, protocols on making the general area safe, criteria for safe zones in the trench, types of collapses and techniques to stabilize, emergency procedures, selection of personal protective equipment, and consideration of selected stabilization tactics on extrication and victim safety.

(B) Requisite Skills. The ability to interpret tabulated data information and tables, place shoring and shielding systems, identify type of intersecting trench, use trench rescue protocols, select types of collapse and methods to stabilize, identify hazards in a trench, use personal protective equipment, and anticipate extrication logistics.

11.3.2* Install supplemental sheeting and shoring for each 2 ft (0.61 m) of depth dug below an existing approved shoring system, given size-up information, an action plan, and a trench tool kit, so that the movement of soil is minimized effectively, initial trench support strategies are facilitated, rescue entry team safe zones are maintained, excavation of entrapping soil is continued, victim protection is maximized, victim extrication methods are considered, and a rapid intervention team is staged.

(A) Requisite Knowledge. Shoring and shielding, tabulated data, strategies and tactics, methods and techniques to install supplemental sheeting and shoring, protocols on making the general area safe, criteria for safe zones in the trench, types of collapses and techniques to stabilize, emergency procedures, selection of personal protective equipment, and consideration of selected stabilization tactics on extrication and victim safety.

(B) Requisite Skills. The ability to interpret tabulated data information and tables, place shoring and shielding systems, identify supplemental sheeting and shoring, use all trench rescue protocols, identify types of collapse and methods to stabilize, identify exposure to hazards within the trench relative to existing safe zones, select and use personal protective equipment, and anticipate extrication logistics.

11.3.3* Construct load stabilization systems, given an assignment, personal protective equipment, and a trench tool kit, so that the stabilization system will support the load safely, the system is stable, and the assignment is completed.

(A) Requisite Knowledge. Different types of stabilization systems and their construction methods, limitations of the system, load calculations, principles of and applications for stabilization systems, and safety considerations.

(B) Requisite Skills. The ability to select and construct stabilization systems, evaluate structural integrity of the system, determine stability, and calculate loads.

11.3.4* Lift a load, given a trench tool kit, so that the load is lifted the required distance to gain access; settling or dropping of the load is prevented; control and stabilization are maintained before, during, and after the lift; and operational objectives are attained.

(A) Requisite Knowledge. Applications of levers; classes of levers; principles of leverage, gravity, and load balance; resistance force; mechanics and types of load stabilization; mechanics of load lifting; application of pneumatic, hydraulic, mechanical, and manual lifting tools; how to calculate the weight of the load; and safety protocols.

(B) Requisite Skills. The ability to evaluate and estimate the weight of the load, the correct operations of the tools, operation of a lever, and application of load stabilization systems.

11.3.5* Coordinate the use of heavy equipment, given personal protective equipment, means of communication, equipment and operator, and an assignment, so that operator capabilities and limitations for task are evaluated, common communications are maintained, equipment usage supports the operational objectives, and hazards are avoided.

(A) Requisite Knowledge. Types of heavy equipment, capabilities, application and hazards of heavy equipment and rigging, operator training, types of communication, and methods to establish communications.

(B) Requisite Skills. The ability to use hand signals, use radio equipment, recognize hazards, assess operator for skill and calm demeanor, assess heavy equipment for precision of movement and maintenance, monitor rescuer and victim safety, and use personal protective equipment.

11.3.6* Release a victim from entrapment by components of a collapsed trench, given personal protective equipment, a trench rescue tool kit, and specialized equipment, so that hazards to rescue personnel and victims are minimized, considerations are given to crush syndrome and other injuries, techniques are used to enhance patient survivability, tasks are accomplished within projected time frames, and techniques do not compromise the integrity of the existing trench shoring system.

(A) Requisite Knowledge. Identification, utilization, and required care of personal equipment; general hazards associated with each type of trench collapse; methods of evaluating shoring systems and trench wall stability; crush syndrome protocols; identification of collapse characteristics; causes and associated effects of trench collapse; potential signs of subsequent collapse; selection and application of rescue tools and resources; risk/benefit assessment techniques for extrication methods; and time restraints.

(B) Requisite Skills. The ability to select, use, and care for personal protective equipment; operate rescue tools and stabilization systems; identify crush syndrome clinical settings; and complete risk/benefit assessments for selected methods of rescue and time restraints.

NFPA 1670: Standard on Operations and Training for Technical Search and Rescue Incidents

Chapter 11: Trench Search and Rescue

11.1 General Requirements. Organizations operating at trench and excavation search and rescue incidents shall meet the requirements specified in Chapter 4.

11.2 Awareness Level.

11.2.1 Organizations operating at the awareness level at trench and excavation emergencies shall meet the requirements specified in Sections 11.2 and 7.2 (awareness level for confined space search and rescue).

11.2.2 Each member of the organization shall meet the requirements specified in Chapter 4 of NFPA 472 and shall be a competent person as defined in 3.3.21.

11.2.3 Organizations operating at the awareness level at trench and excavation emergencies shall implement procedures for the following:
(1) Recognizing the need for a trench and excavation rescue
(2) * Identifying the resources necessary to conduct safe and effective trench and excavation emergency operations
(3) * Initiating the emergency response system for trenches and excavations
(4) * Initiating site control and scene management
(5) * Recognizing general hazards associated with trench and excavation emergency incidents and the procedures necessary to mitigate these hazards within the general rescue area
(6) * Recognizing typical trench and excavation collapse patterns, the reasons trench and excavations collapse, and the potential for secondary collapse
(7) * Initiating a rapid, nonentry extrication of non-injured or minimally injured victim(s)
(8) * Recognizing the unique hazards associated with the weight of soil and its associated entrapping characteristics
(9) Making the rescue area safe, including the identification, construction, application, limitations, and installation of ground pads around the affected collapse or rescue area.

11.3 Operations Level.

11.3.1 Organizations operating at the operations level at trench and excavation emergencies shall meet the requirements specified in Sections 11.2 and 11.3, as well as the following sections:
(1) Section 5.3 (operations level for rope rescue)
(2) Section 7.3 (operations level for confined space search and rescue)
(3) Section 8.3 (operations level for vehicle and machinery search and rescue)

11.3.2* Members shall be capable of recognizing the hazards of using equipment and operating at trench and excavation emergencies that include the collapse or failure of individual, non intersecting trenches with an initial depth of 8 ft (2.4 m) or less under the following conditions:
(1) No severe environmental conditions exist.
(2) Digging operations do not involve supplemental sheeting and shoring.
(3) Only traditional sheeting and shoring are used.

11.3.3 Organizations operating at the operations level at trench and excavation emergencies shall develop and implement procedures for the following:
(1) * Sizing up existing and potential conditions at trench and excavation emergencies
(2) Initiating entry into a trench or excavation rescue area
(3) * Recognizing unstable areas associated with trench and excavation emergencies and adjacent structures
(4) * Identifying probable victim locations and survivability
(5) * Making the rescue area safe, including the identification, construction, application, limitations, and removal of traditional sheeting and shoring using tabulated data and approved engineering practices
(6) * Initiating a one-call utility location service
(7) * Identifying soil types using accepted visual or manual tests
(8) Ventilating the trench or excavation space
(9) Identifying and recognizing a bell-bottom pier hole excavation and its associated unique hazards
(10) Placing ground pads and protecting the “lip” of a trench or excavation
(11) * Providing entry and egress paths for entry personnel
(12) * Conducting a pre-entry briefing
(13) * Initiating record keeping and documentation during entry operations
(14) Selecting, utilizing, and applying shield systems

(15) ***** Selecting, utilizing, and applying sloping and benching systems
(16) Identifying the duties of panel teams, entry teams, and shoring teams
(17) Assessing the mechanism of entrapment and the method of victim removal
(18) ***** Performing extrication

11.4 Technician Level.

11.4.1 Organizations operating at the technician level at trench and excavation emergencies shall meet the requirements specified in this chapter and the following sections:
(1) Section 7.4 (technician level for confined space search and rescue)
(2) Section 8.4 (technician level for vehicle and machinery search and rescue)

11.4.2* Members shall be capable of recognizing hazards, using equipment, and operating at trench and excavation emergencies that include the collapse or failure of individual or intersecting trenches with an initial depth of more than 8 ft (2.4 m) or where severe environmental conditions exist, digging operations involve supplemental sheeting and shoring, or manufactured trench boxes or isolation devices would be used.

11.4.3 Organizations operating at the technician level at trench and excavation emergencies shall develop and implement procedures for the following:
(1) Evaluating existing and potential conditions at trench and excavation emergencies
(2) * Identifying, constructing, and removing manufactured protective systems consistent with the application and limitations of such systems using tabulated data and approved engineering practices.
(3) * Monitoring continuously or at frequent intervals the atmosphere in all parts of the trench to be entered for oxygen content, flammability (LEL/LFL), and toxicity, in that order
(4) Identifying the construction, application, limitations, and removal of supplemental sheeting and shoring systems designed to create approved protective systems
(5) Adjusting the protective systems based on digging operations and environmental conditions
(6) * Rigging and placement of isolation systems

SAFETY CONSIDERATIONS

According to last known statistics, almost 90% of all fatal trench accidents occurred in trenches less than 20 feet deep. Most of these fatal accidents involved trenches less than 12 feet deep and 6 feet wide. We will be working in a trench that is 20’ long, 8’ deep and 3 $^{1}/_{2}$’ wide. It is very important to practice all the safety tips that will be discussed.

The Washington State Labor and Industries will investigate all trench collapses, and the rescuers actions. We call them to the scene early. The key thing that is looked at is if all the persons involved have followed the basic requirements and rules. What we need to consider is that if we do not follow these rules, lives of the rescuers may be at stake.

“**ABOVE ALL DO NO HARM**!”

Of 64 trench accidents reported to OSHA:

Most occurred in good weather

- 40 of the workers were over the age of 30
- 18 of the workers were over the age of 50

Of 84 trench accidents studied:

- 32 were in clay or mud
- 21 in sand
- 10 in wet dirt
- 8 in sand, gravel and clay
- 7 in rock
- 4 in gravel
- 2 in sand and gravel

BASIC FACTS OF TRENCH ACCIDENTS:

A cubic foot of soil weighs about 100 to 125 pounds

18 inches of soiled removed from on top of a mannequin weighs 2500 to 3000 pounds

The soil concentrated around the chest and back area of the mannequin weighs about 700 to 1000 pounds

Trenches that collapse usually collapse more than once and are 500 times more likely to continue to collapse

The average time to remove two feet from around a worker can easily exceed 30 minutes

The average time to complete a trench rescue is 3 to 4 hours

The use of heavy equipment (backhoes, etc.) during emergency trench rescue operations is very hazardous and has caused severe injury and death to trapped victims

If the worker has been buried above the waist, there is a good chance the worker will die of traumatic asphyxiation if the soil is not quickly cleared away from the chest area

Trench accidents have a 112% higher fatality rate than other construction activities

Trench accidents represent an average of 54 fatalities per year and approximately 1000 to 1500 injuries, of which approximately 150 are permanently disabling

F.A.I.L.U.R.E. ACRONYM

What went wrong!

F: Failure to understand or underestimating the environment
A: Additional medical implications not considered
I: Inadequate rescue skills
L: Lack of teamwork and/or experience
U: Underestimating the logistical needs of the operation
R: Rescue vs. Recovery not determined or communicated
E: Equipment Familiarity

T.E.A.M. ACRONYM

T: Together
E: Everyone
A: Accomplishes
M: More

MEDICAL PROBLEMS
AND CONSIDERATIONS

CRUSH SYNDROME

Crush injury and crush syndrome are common in trapped victims of collapsed structures, collapsed trenches and confined space entrapments. Post-extrication medical deterioration and death occur from potentially treatable mechanisms and so this illness is a primary reason to provide the victim with prompt care within the area of entrapment.

In entrapments that cause crush syndrome, patients can survive for days with this injury, dying shortly after rescue if not treated. Some patients may die days to weeks later. To increase survivability, treatment must be early and aggressive.

DEFINITIONS

Direct Mechanical Crush

- Mechanical disruption of tissue secondary to severe force
- Immediate cellular effect/injury

Crush Injury

- Muscle cell disruption due to compression
- Time/pressure relationship
- Cellular mechanism of injury controversial:
    - Stretch “membranopathy”
    - Cellular Ischemia
    - Reoxygenation injury

Compartment Syndrome

- Crush injury caused by swelling of tissue inside confining fibrous sheath of muscle compartments
- Causes further destruction of intra-compartmental muscle and nerves

Crush syndrome

- The systemic manifestations caused by crushed muscle tissue
- Occurs when crushed muscle is released from compression

<u>Pathophysiology of Crush Injury: (cell function & effects in crush situation)</u>

- Local arterial blood flow interrupted
- Lack of oxygen causes cell to function “anaerobically”, creating lactic acid and other toxins
- Cellular membrane function is disrupted (mechanism is controversial), causing cell death and dissolution
- Intracellular contents, including myoglobin, potassium, purines (later converted to uric acid) and other toxic substances are released into the local tissue area
- Local capillaries are injured and become “leaky”, allowing an increased serum portion of the blood to extrude into the tissue
- The re-introduction of oxygen into the tissue layer may cause additional “reoxygenation” injury by creating other toxins such as free radicals, superoxides and thromboxane

Crush Injury

- All these effects are local only until the tissue is released and reperfused by blood
- That is why patients may remain entrapped for days with a severe crush injury and yet appear systematically stable when reached by rescuers
- Upon release of compression, blood flow is restored to the crushed area and multiple adverse processes begin
- Effects of releasing compressed tissue:
  - Capillary leak = Hypovolemia/hypotension/shock
  - Severe metabolic acidosis = V-Fib
  - High serum potassium level = Cardiac arrhythmia or standstill
  - Myoglobin/Uric acid/other toxins = kidney failure
  - Other toxins = lung, liver, renal injuries

Crush Syndrome: (major causes of death)

- Hypovolemia
- Dysrhythmia
- Renal Failure

Other Causes of Death

- Adult Respiratory Distress Syndrome: severe lung injury
- Sepsis
- Other electrolyte disturbances
- Ischemic organ injury (gangrene)

Crush Injury: Diagnosis

- High index of suspicion
- Identifying potential crush mechanism
- Looking for subtle signs and symptoms
- Urinary myoglobin post-release

Myoglobin

- “Spills” into urine at relatively low serum levels
- Causes reddish-brown urine color in high concentrations
- Lower concentrations detected by positive orthotolidene on urinalysis dip-strip
- May precipitate in kidney tubules, contributing to renal failure

Patient Management

- ABC’s
- Protect airway
- Psychological support
- Assess for crush injury potential
- If crush potential is identified:
    - Establish IV access
    - Fluid replacement prior to lifting compression
    - Consider prealkalinizing with bicarb
    - Cardiac monitor: run baseline strip

Be prepared during extrication to treat

- Hypovolemia
- Acidosis
- Hyperkalemia
- Re-evaluate frequently and outside of the entrapped area prior to transport

THE LAW
&
WHAT IS A TRENCH?

The Washington State Law (WAC 296-305-05113) dictates:

1. Fire departments that engage in trench rescue operations shall adopt and maintain a written response program that addresses training and procedures to follow in emergency life threatening situations.
2. Employees that directly engage in trench rescue operations shall be trained or shall be under the direct supervision of person(s) with adequate training in trench and excavation hazard recognition, equipment use and operational techniques.

Safety is an Attitude!

OSHA trench shoring regulations state:

Trench 4' deep must have ladders every 25'

Spoil pile not less than 1' from lip

Trench greater than 5' deep, spoil pile more than 2' from lip

Trench greater than 4' must have protection for workers

WHAT IS A TRENCH?

WISHA = A trench is defined as an excavation in the ground deeper than it is wide, but not wider than 15' at the base.

WHAT IS AN EXCAVATION?

It is wider than it is deep and more than 15' wide.

WHEN ARE TRENCHES USED?

To place utilities underground
To place or remove underground tanks
To build foundations and or basements

TYPES OF COLLAPSES:

Spoil In or Spoil Pile Collapse:
- This is when the spoil pile slides into the trench because it's to close

Lip In or Rotational Failure
- Caused by the top edge of the trench breaking off

Slough In or Slough Wall Collapse
- Caused by the middle of the trench side collapsing, leaving an overhang

Shear Wall Collapse
- Caused by entire sections of trench wall separating

WHY DO COLLAPSES OCCUR?

Vibrations: These are caused by vehicles; traffic close to the trench, vehicles working around the trench. Therefore, it is so important to immediately complete any lock out tag out when securing the scene. This will help avoid secondary collapses.

Disturbed soil:The soil is disturbed by previous excavations, underground lines, and dump sites. Trenches usually collapse because the newer soil is squeezed by the older soil and the newer soil spills into the trench.

Layered soil: These are similar to disturbed soil but occur naturally.

Too much water: Caused by surface water flowing into the trench from above or from a high water table flowing in from the sides or bottom. The trench collapses because the walls of the trench cannot hold the added weight of the water. The water lubricates the soil to the point where the trench walls will not hold together and support their own weight.

WHY DO COLLAPSES OCCUR CONT.

Too little water: This usually occurs when the trench is left open for long periods of time. The trench collapses because the natural binding properties of soil are reduced to the point where the trench walls will not hold together and support their own weight. Basically, the moisture evaporates from the trench wall.

Intersecting Trenches: The trench usually collapses because the weight of the corner is being pulled in several directions at the same time. Another contributing factor to collapse is that the corners have two wall surfaces exposed, which increases any other contributing effects. This is in the "L", "T", or "cross" trenches.

TYPES OF SOIL

Type A - This type of soil includes: clay, silty clay, clay loam, and sandy clay loam. Cemented soils are also considered Type A. It is also referred to as ***"Compact Soil"***; that is hard, compact and adheres to itself.

Type B - Like Type A soil, but Type B soil is subject to vibration. Also, this soil has been disturbed. Another term used is ***"Running Soil"***, which is soft, loose and free flowing.

Type C - This type of soil deals with granular soils; sand, and sandy loam. They also include submerged soil, soils from which water is freely flowing, or submerged rock that is not stable. Also, this includes sloped or layered systems where the layers dip into the excavation at a slope of 4 horizontal to 1 vertical or steeper. Another term used is ***"Saturated Soil"***, where water can be seen seeping or flowing from it.

All Trench Rescue Incidents will be treated as soil Type C

HOW TO TEST SOIL:

First, Terminology:

Cohesive soil = Soil that is made up of fine-grained material that remains in clumps is said to be cohesive.

Granular soil = Soil that breaks up easily and is primarily composed of coarse-grained sand or gravel is granular.

Fissures = Tension cracks (could suggest a potential collapse).

Visual test - When performing a visual test, begin inspecting the excavated material then the soil that forms the trench wall and also the excavation site in general. This will help you determine the initial cohesiveness of the soil.
The trench particles will tell you a lot about the soil, but the most important area of the visual assessment would be the trench walls and the area surrounding the trench lip.
On the trench walls, look for layered soil and any indication that the soil was previously disturbed. Disturbed soil can be indicated by the presence of utilities. A mixed soil will usually not be cohesive. In general, like particles of soil are the most likely to be attracted to each other and remain attracted.
The hydrostatic forces can also be analyzed by looking for indications of standing, seeping, or running water. Water adds weight, and weight adds more tension to the trench walls. This is true for surface water that has pooled near the trench opening. As a clue to the anticipated hydrostatic forces look for indications that the contractor has “well pointed” the area surrounding the excavation. Well points are used to remove excess water from saturated soil before digging a trench.

Manual test - A manual test is necessary to determine the various characteristics of the soil, and to learn it relative strength when placed under a force. This indicates the ability of the soil to free-stand.

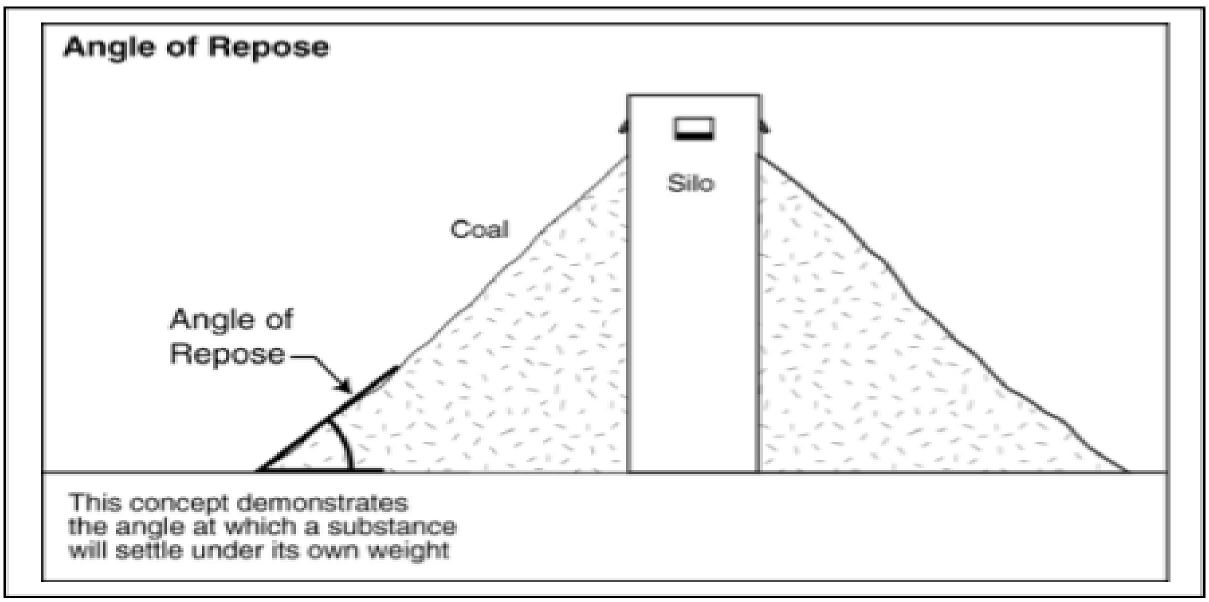
Plasticity test - The plasticity of the soil is the property that allows the soil to be deformed or molded, without appreciable change in total volume. Mold a moist or wet sample into a ball, and then attempting to roll it into threads as thin as 1/8-inch in diameter. A cohesive material can be rolled into threads without crumbling. As a rule, if a two-inch length of 1/8-inch thread can be held on one end without tearing, the soil is said to be cohesive.

Dry strength test - This is done to determine the propensity of the soil to fissure. If the soil is dry and crumbles on its own, or with moderate pressure, into individual grains or fine powder, it is granular. If the soil is dry and falls into clumps that break into smaller clumps, but the smaller clumps can be broken with difficulty, it may be clay in any combination with gravel, sand, or silt. If the dry soil breaks into clumps that do not break into smaller clumps and can only be broken with difficulty, and there is no visual indication the soil is fissured, the soil may be considered unfissured.

Ribbon test - The ribbon test is used to determine how much clay or silt the soil contains. The test is done with saturated fine soil and fine sands that are rolled together between the palms of the hands until a cylinder approximately $^{3}/_{4}$-inch-thick by 6 inches long is formed. The cylinder is then placed across the palm of the hand and squeezed between the thumb and forefinger until it is approximately 1/8 inch thick. The squeezed portion is then allowed to hang over the side of the hand. If the cylinder forms 6 ribbons in length or longer it is said to be clay. If it forms shorter broken ribbons, then the soil contains silt. A clay loam type of soil will barely form a ribbon.

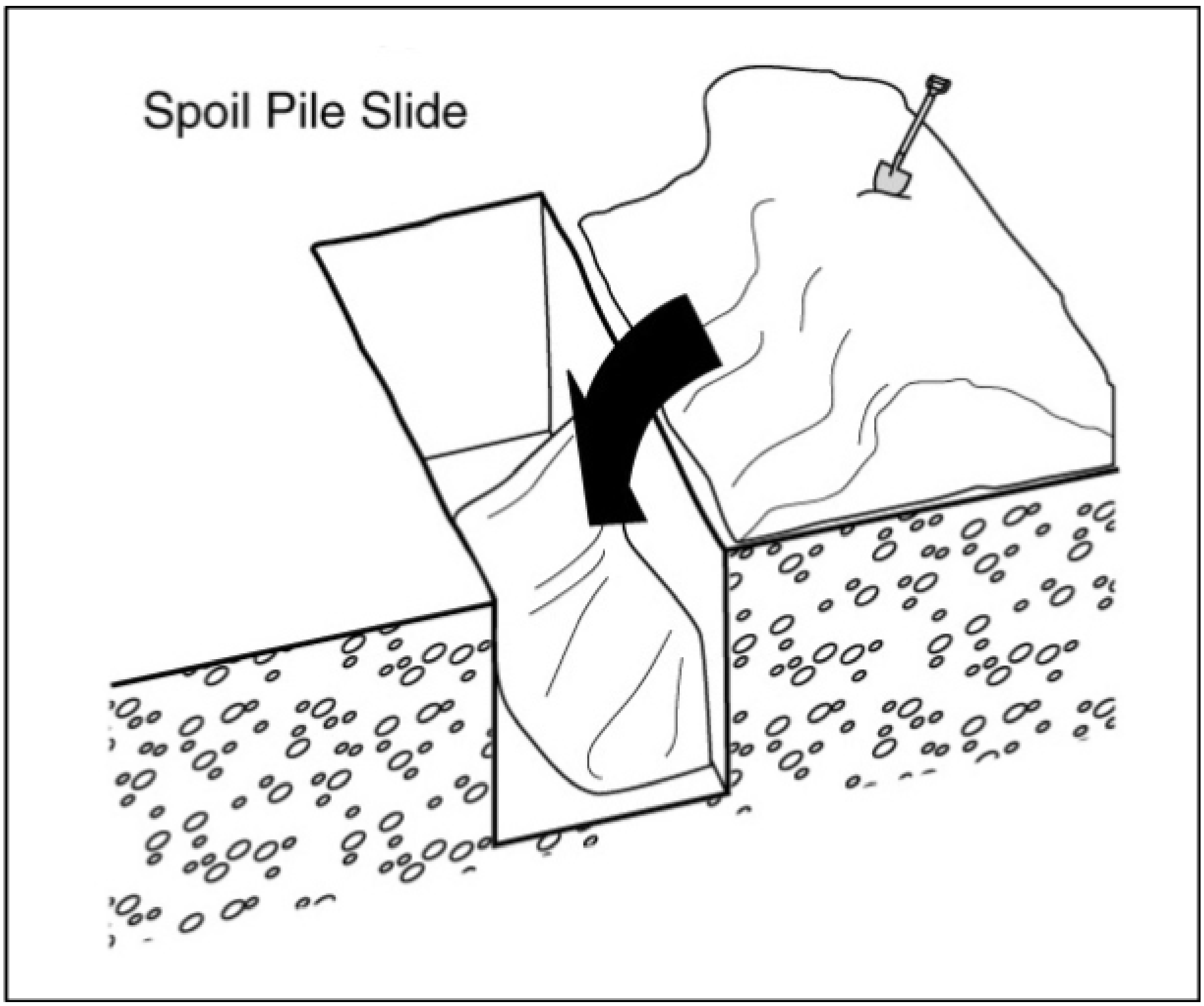
Types of Trench Collapses

Collapses can be somewhat predictable based on soil profile and the, type, size, and conditions under which the trench was excavated. Being able to recognize the types of collapse will help you determine the trench's potential for collapse, and the proper protective system appropriate for making it safe.

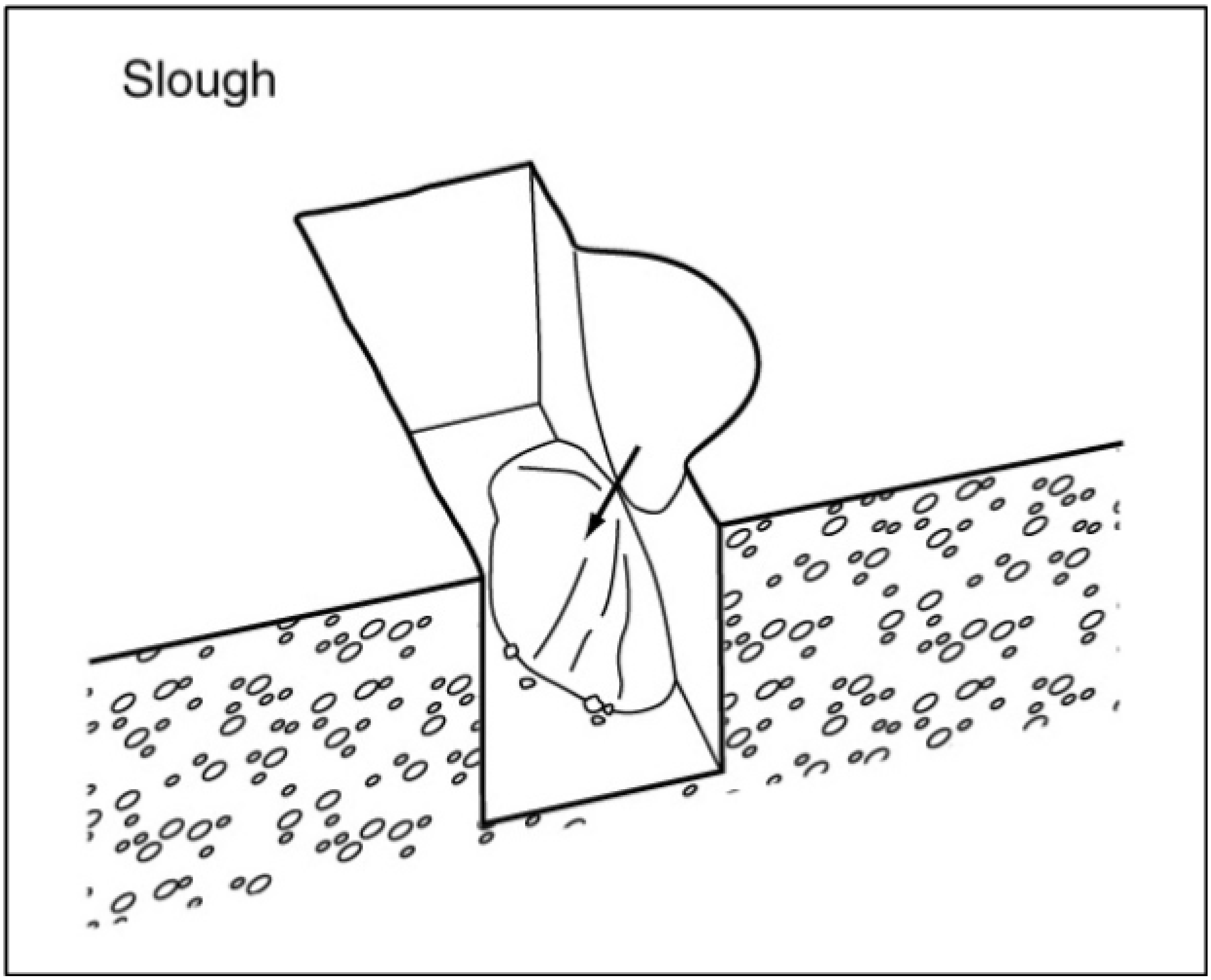


The **spoil pile slide** is the result of the excavated earth placed too close to the lip of the trench. This type of collapse is not as common as you might think, as most contractors recognize the hazard associated with placing the spoil pile too close to the trench lip. A spoil pile slide occurs when the soil's natural angle of response becomes greater than the soil's

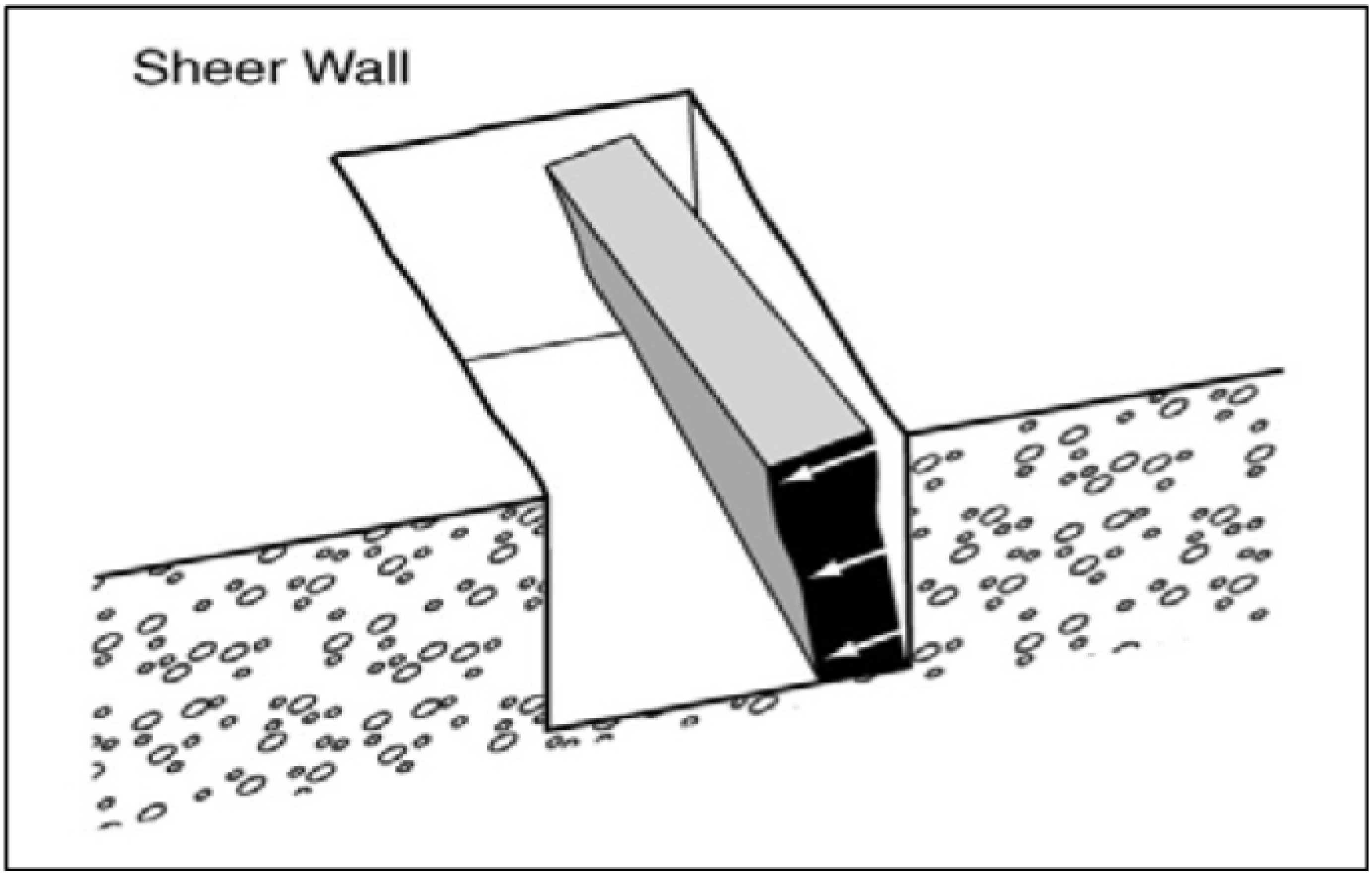
cohesive tendency. When this happens, the spoil pile slides back into the opening. Another factor that creates this situation is that newly excavated dirt may have a certain amount of moisture content that provides some cohesiveness. As the soil dries it becomes less stable. Remember, as we suggested earlier, a hole in the ground wants to naturally fill itself back up.



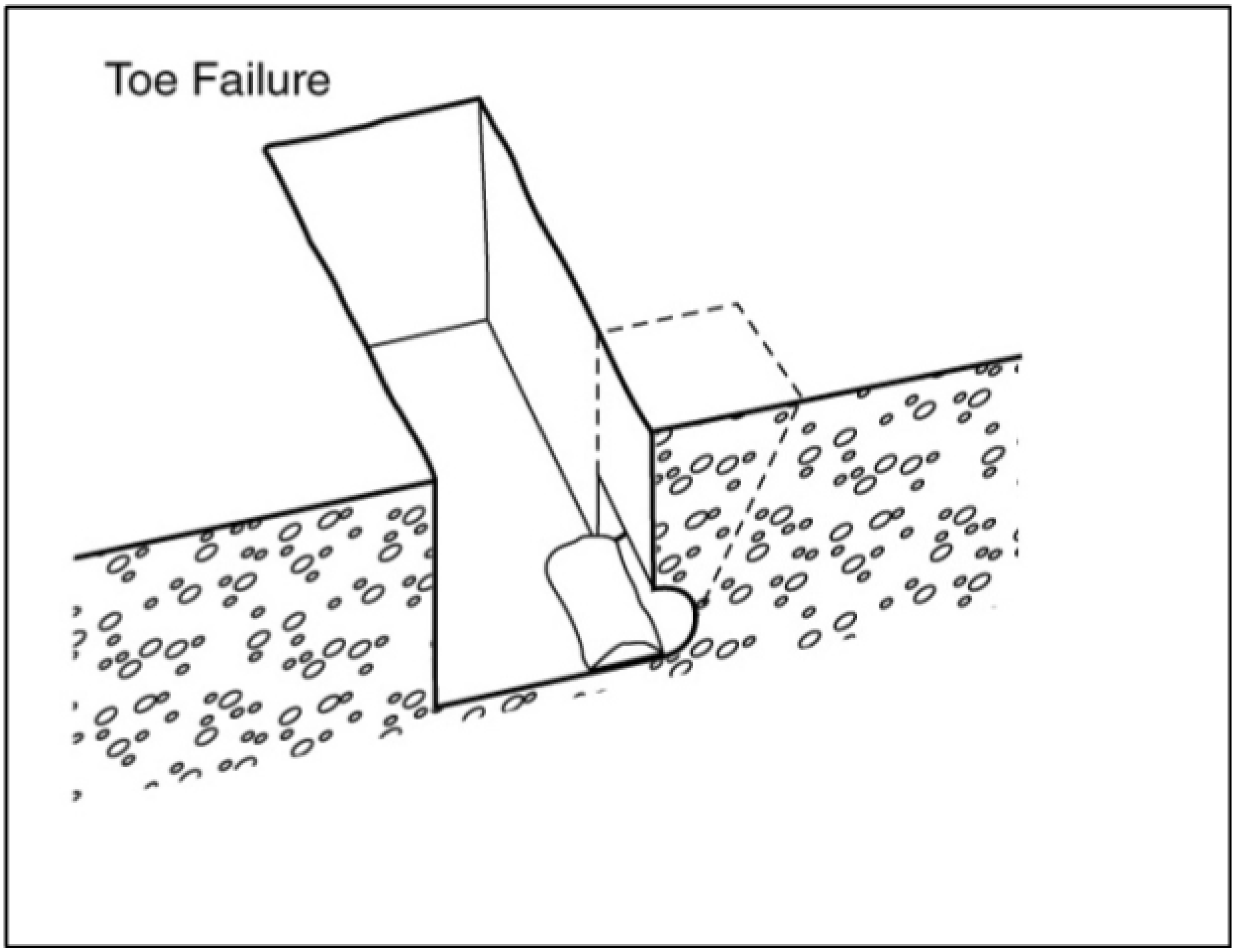
A **slough failure** is the loss of part of the trench wall that can be the result of several conditions. Frequently, the force associated with unconfined hydrostatic pressure becomes greater than the soil's ability to stand. It can also be caused by the spoil pile being placed too close to the trench lip. As the extra weight of the earth is piled up, it is transmitted in a downward force communicated through the trench walls. When this pressure exceeds the soils ability to hold it, a failure will occur. Cracks in and around the excavated surface and multiple soil layers are key indicators that you may have the potential for a slough collapse.



A **shear wall collapse** is indicated by a section of soil losing its ability to stand and collapsing into the trench along a mostly vertical plane. This condition can be caused by cracks in the earth's surface exposed to the weather over time. As the water runs into the opening, it washes out dirt and then dries. Over time, this washing and drying action causes the hole to become deeper and deeper, until it is not supported on two sides and a wall of dirt falls into the trench. Shear wall collapses are normally associated with fairly cohesive soils. That factor makes them look safe. Big problem! As you might imagine, this type of failure can create a big-time collapse situation.

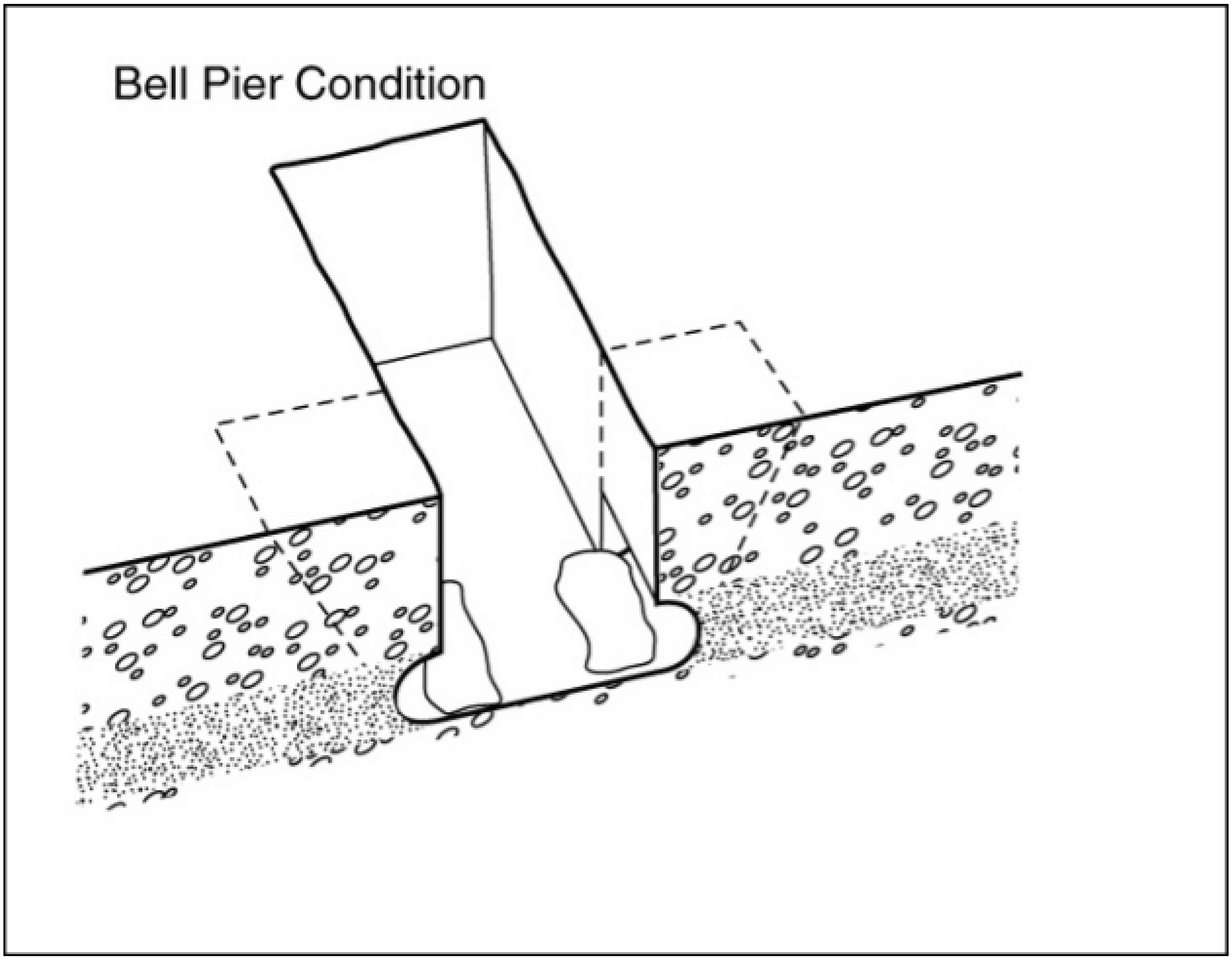


A **toe failure** is a slough that occurs at the bottom of the trench where the floor meets the wall. As the soil falls into the trench it creates an opening at the bottom that is characteristic of a cantilever. It can be caused by a sand pocket, or the effects of water at the bottom of the trench.

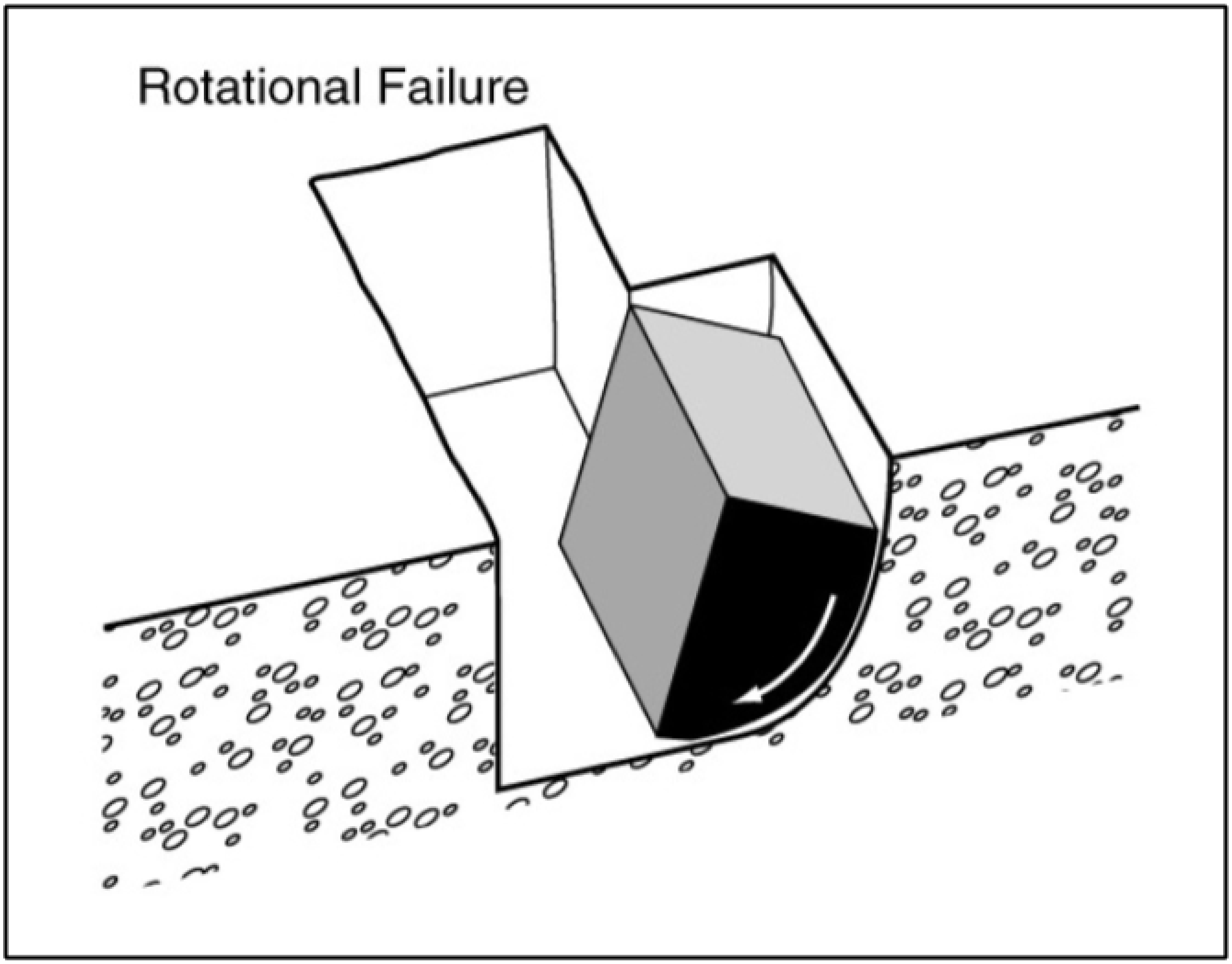


This is a very dangerous type of failure for many different reasons. First, the rescuers might not notice the toe failure until they are standing on top of the cantilevered earth. It then becomes entirely feasible that they will get a close view of the hole by virtue of being in it. Secondly, the situation is hard to fix until after a protective system is in place.

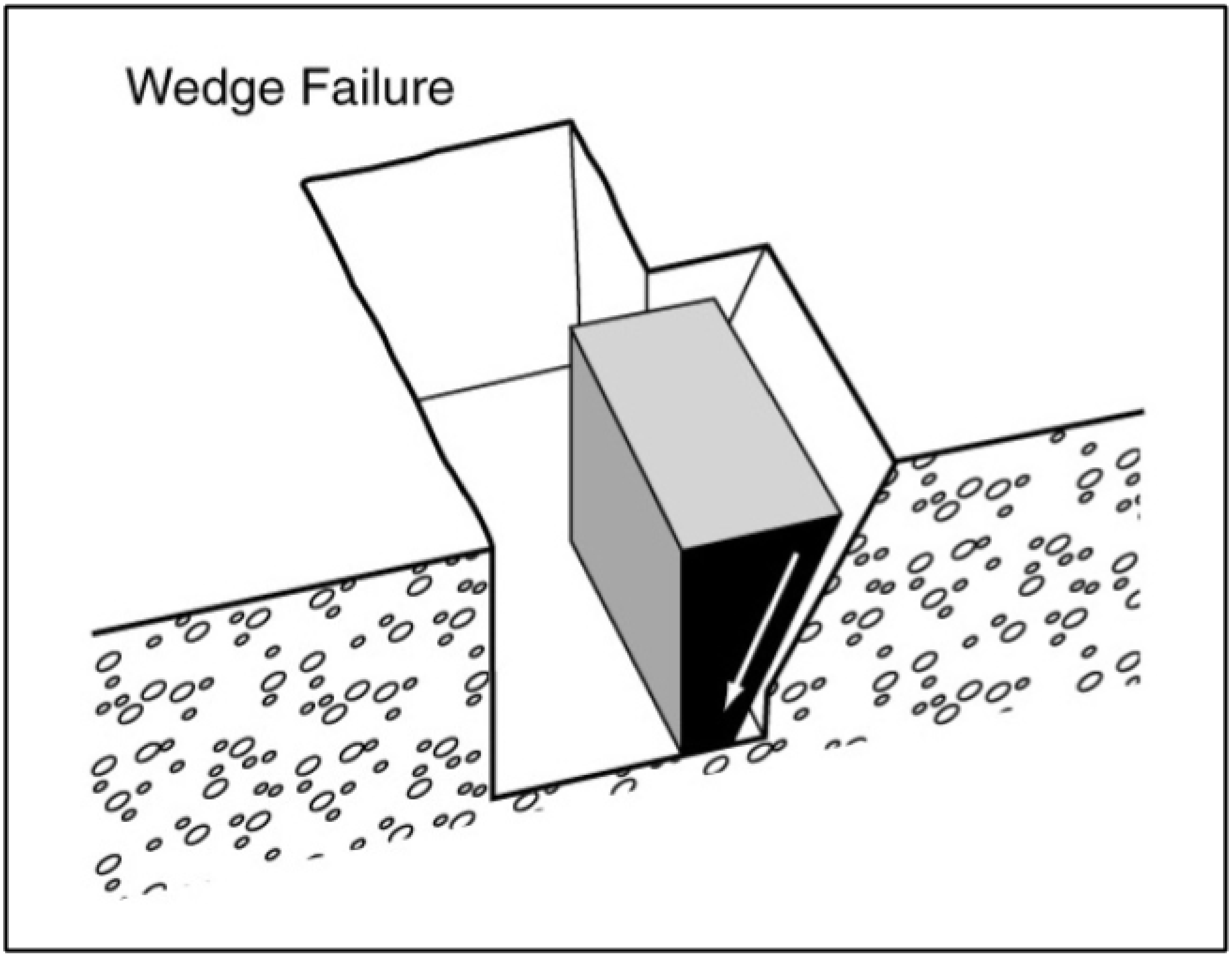
The effects of water accumulation can also cause a **bell pier condition**. This type of situation is not sudden, but more the result of a long-term toe failure on both sides of the trench floor at the toe, due mostly to the effects of water. The bell pier condition is also dangerous for the reasons previously discussed.



A **rotational failure** is characterized by a scoop shaped collapse that starts back from the trench lip and transmits itself to the trench wall in a half moon shape. These types of failures can result in the movement of large sections of soil to the trench floor. What remains is a collapse that looks like someone took a spoon and carved out a chunk of earth. If the rotational failure is large enough, it creates a difficult protective system problem for rescuers, since the void will need to be filled at some point in the operation.



A last type of collapse we will discuss is the **wedge failure**. This type of failure normally occurs with intersecting trenches. It is characterized by an angle section of earth falling from the corner of two intersecting trenches. The wedge failure can be sudden and catastrophic. You will learn how to manage intersecting trenches in the Technician Level of this trench rescue course.



While it may not be difficult to determine what type of collapse has taken place, it is quite another thing to understand why. Keep each of these types of collapse in the back of your head. As we talk about the physical forces associated with collapse, the picture of why it happens will become clearer.

PERSONAL
AND
RESCUE
EQUIPMENT

PERSONAL PROTECTIVE EQUIPMENT

As always, we want to protect ourselves during any incident, whether it’s fires, aid calls or rescues. We are provided with bunkers or turnouts for fires, which may be used for aid calls, especially during the night.

Many may think we can use these turnouts in trench rescue. Unfortunately, many who think this have not had to opportunity to work in a trench during a rescue. Their thoughts come from trying to save money. *Why buy our people another helmet, jump suits, gloves, etc, when they have these items already?*

The key to doing an effective and safe job comes from working in comfort. The helmets, turnouts, and bunker boots we use for fighting fires are too large for trench work, which may cause rescuers to work without them.

To be in a trench the rescuer shall have; a helmet, safety boots, eye protection and gloves.

Specialty Items

Respiratory Protection - As a minimum, you may consider using a dust mask. In any case, if there is any indication that an atmospheric problem could exist you will want to have an SCBA or in-line respirator available.

Skull Caps - Welders wear skull caps to keep their heads cool under their helmet while welding. Rescue personnel have started wearing them for the same reason.

Leather chaps - are good leg protection, and a great idea if you are going to be cutting with a chainsaw.

TRENCH RESCUE EQUIPMENT

GROUND PADS


¶

Ground pads are used to line the area around the trench, the lip. This is a very unstable area. The ground pads assist in distributing the rescuers weight over a large area. These are placed after soil from the spoil pile has been removed, if necessary.

The most common ground pad is 4’x8’ sheet of plywood $^1/_2$” thick. The drawback to this type of ground pad is that it covers a significant portion of the ground around the trench, which makes it difficult to inspect for deteriorating conditions.

In some cases, a 2’x12’ piece of lumber, usually 10’ to 12’ long, can be used as a ground pad. This works well next to spoil pile. This would minimize the amount of spoil pile to be moved.

SHEETING (panels)

Sheeting material can be made up from interconnected steel uprights, sheets of plywood/timber, or Fin Form panels that are used to contact the walls of the trench. They function as a shield system with uprights by holding back running soil and debris.

Most of what you’ll come in contact with is the Finnform, or homemade sheeting panel. The Finnform panel offers the rescuer a viable and safe sheeting panel for efficiently shoring trenches. It is a high strength, relatively lightweight, and non-conductive material that is made entirely of arctic white birch. The exterior of the Finnform panel is made durable by phenolic resins, which are impregnated into the hardwood surface to provide for maximum re-use and ease of cleaning.

The panels must be used with strongbacks. Strongbacks are a 2”x12”x10-12’ upright. The uprights are bolted to the panels using $^{3}/_{4}$”x3 $^{1}/_{2}$” machine bolts and are the main component in the protective system. The strongback transmits the forces across a vertical plane into the trench wall. It is necessary to have the panel(s) tight against the walls of the trench to assure that the strongback can transfer the necessary force from the shore to the trench wall.

SHORES

Shores carry the force from one side of the trench to the other. They can be made up of different materials and forms. As any tool, all shores have their limitations, or as referred to, “their good and bad points”. The only way to overcome any limitation is to know the limitation ahead of time and have alternate tools to overcome the limitation.

Timber Shores - are the most common and oldest type. Timber shores are cut mostly out of 4”x4”, 4”x6”, and 6”x6” Douglas Fir with a bending strength of not less than 1500 psi. In trenches that exceed 20’ in depth, all shores must be commercial, timber shores cannot be used. Remember when using wood shores, the shorter the shore or larger dimension, the stronger it is.

The advantages of wood shores are the low cost compared to other shores on the market and they can be cut to varying size. The size and length of the timber is based on the depth and width of the trench as determined by the type of soil present

Although the benefits may sway one to use or consider using wood shores, keep this in mind; If your trench is greater than 10 feet in depth, and over 4 feet in width with any kind of soil, the minimum timber shore is 4 x 6.

Screw Jacks - are a common shore used in conjunction with timber shores. Also referred to as pipe jacks. This type tool has a boot end that fits over a piece of wood and then tightened by a thread and yoke assembly, or used with a section of pipe, hence, pipe shore. Screw jacks are inexpensive. *The thing to remember is they are not very strong when compared to other types of shoring, and care has to be taken not to over extend the thread.*

Hydraulic Shores “Speed Shores” (manufacturer) - offer a type of protective system that combines the

shore and upright as one unit. This type of shore is operated via a 5-gallon non-flammable and biodegradable fluid. After lowering the shore into the trench and expanded, the fluid is cut off at the cylinder and the hose is taken off the shore. The benefit, the speed shore can be set from outside the trench. The downfall is, they do not work well if the walls of the trench are not vertical or near vertical.

Pneumatic Shores - manufactured by Paratech, Airshore, and ProSpan come in a wide variety of lengths. They are available from 18” to 12’ and come with a multitude of extensions and attachments. They are made from lightweight tubular aluminum.Most pneumatic shores operate under the same principle, they’re extended by using compressed air. After extension, the shore either locks by itself or is manually locked to prevent a collapse under load. These types of shores are quick, strong and dependable. *The main disadvantage to pneumatic shores is the number of shores required to maintain an effective cache and the cost. Most shores are only rated for 400 pounds of lateral force when installed. “Don’t stand on them!”*

Air Bags - a tool most firefighters are comfortable with. The air bag can perform many functions. Lifting is probably one of the most important tasks for us or for the patient. They have been used for lifting pipes, excavators, steel panels, and concrete distribution boxes.They can also be used for filling voids behind the panels. These voids are created by sloughs and other types collapses. As always, we need to be concerned with puncturing the bag and operator error.When using air bags for lifting, always remember, crib as you lift. The bags are not made to support loads, only to lift them.

Cribbing - a couple of key items: First, look at the wood you're using for the crib box, make sure there are no large cracks or splits in it. Splitting in the wood is an indicator of very dry wood. Secondly, always place the load directly over the point of contact, maintaining wood to wood contact from the load to the ground at all times. For various crib boxes, see FOG.

Wedges typically will be used with crib boxes. Wedges will help change the direction of force applied onto the box. They also help fill spaces that are too small for a regular or full piece of wood.

Trench Tools

Entrenching Tool - Is a small collapsible version of the large shovel, which is designed for situations where the working area is limited, and a shovel is too big.

Digging operations to remove trapped victims should begin immediately after the protective system is in place. This means the digging team or person will be working in tight quarters. The entrenching tool is very effective during these times. Small gardening shovels are also very effective.

Hammer - You can never have enough hammers, especially framing hammers. Heavy hammers are the best, time is critical, and you want to drive the nails in with two or three strikes. Obviously, the hammer is a very important tool when working with shores.

Duplex Nails - These nails are the best kind to use, they can be taken out easily. If not familiar with this nail, it has a shoulder or double head. The shoulder allows the claw of the hammer a place to get a bite for removing the nail.

Chainsaw - The saw of choice for rescues involving wood shores - a large emphasis should be placed on safety! Chain saws are used because they're quick and for the most part firefighters have a good working knowledge of them.

Ventilation Equipment – Any electric blower can be used for ventilation. Ventilation is not always necessary. Use only when you have an atmosphere problem. It can be also used to keep our people cool, especially on hot days. When using ventilation, keep hypothermia in mind for rescuers and patients. Also consider the noise level, dust creation and additional soil impacts.

Ladders - Various types of ladders can be used. We use them for both the patient and rescuer. When you first arrive, a ladder into the trench may be all you need to rescue the patient (self-rescue). We use them for entry and exiting. They can also be used as ground pads if nothing else exists or you have the need to span a spoil pile or weak area of the lip. If you use them as ground pad, they have to be assembled with 2 x 12's or plywood to fill the space between the rungs.

Sump Pumps/Dewatering Devices - These devices are very important in trench rescues. Water in the trench deteriorates the trench floor and it make for a very uncomfortable work environment. Always have a backup pump, just in case. Pumps with large diaphragms can be used for mud. Check with your Public Works to see what they have available.

Vacuum Truck – Most Public Works agencies have vacuum trucks and can be called to the scene. They have a great advantage in removing soil, but they create hazards as well. They create vibrations, noise and need to add water to trench to be most effective. It is best to request two trucks to be prepared for the potential failure of one.

EllIS POST SCREW JACKS

Installation of Timber Struts Using Ellis Post Screw Jacks:

1. The rescuer takes the measurement upright to upright and subtracts 10-11 inches from the measurement to allow for the length of the screw jack.

2. Timber strut is cut and inserted into the bucket of the screw jack. Through an existing hole in the bucket, one 16D nail is used to attach the strut to the screw jack.

3. The post screw jack is placed into position between the uprights and the handles on the jack are turned to extend the jack and pressurize the panels against the trench walls. Tighten the jack as much as possible by hand. Then, using a hand tool, such as a framing hammer, turn the handles one more full turn.

4. Proper nailing on both the timber end and the screw jack end of the strut provides positive connections.

ELLIS POST SCREW JACKS Cont.

Post screw jacks consist of a bucket, which accepts the timber strut and an integrated screw mechanism that is used to extend and pressurize the strut. A base or foot is attached to the bottom of the screw. Ellis post screw jacks are rated at 15,000 lbs, stronger than the rated strength of timber. Ellis jacks have a maximum extension or adjustment of 6 inches. **Ellis screw jacks must have timber inside the bucket to maintain its rated strength.** If the post screw jack fits in between the uprights by itself, a piece of lumber must be cut flush with the end of the bucket. This will keep the bucket from collapsing and punching or cutting into the upright or sheeting. **SEE CHART BELOW:**

Max Safe Working Loads

Total distance including Jack	Max load
4’	15,000 lbs
6’	12,000 lbs
8’	7,200 lbs
10’	5,000 lbs
12’	3,000 lbs
14’	2,600 lbs
15’	0 lbs.

Based on Douglas Fir #1 4”x4” (3.5” sq.). Load capacities include a 2.5 to 1 safety factor.

SPEED SHORE

Installations of speed shores

- Connect the hydraulic hose
- Lower the shore into place
- Pressurise the shore using the pump can
- When gauge is in the green the shore is set
- Disconnect the hose utilizing the lowering hook

Tabulated Data for C60 SOIL

TABLE VS-3 TYPE "C-60" SOIL (See 3.3 for definition of C-60 Soil)

Depth of Excavation FEET	HYDRAULIC CYLINDERS					Sheeting (Note 4)
	Maximum Horizontal Spacing *(FEET)*	Maximum Vertical Spacing (Note 6) *FEET*	Width of Excavation *FEET*			
			0 to 8	8 to 12	12 to 15	
0 to 10	6 (Note 5)	4	2" dia	2" dia	2" dia. (Note 1)	(Note 2)
0 to 20	4	4	2" dia	2" dia. (Note 1)	2" dia. (Note 1)	(Note 7)
0 to 25	4	4	2" dia	2" dia. (Note 1)	N/A	(Note 7)

AIRSHORE

The Airshore Rescue Tool is a lightweight, positive locking, aluminum support strut which is activated manually or by air. The tools removable attachments and bases adhere to all shapes, surfaces, and situations. Designed for vertical, horizontal, and angled support and stabilization, the Airshore Rescue Tool will secure your rescue environment.

FEATURES

TROUBLE FREE: The simple design and rugged construction ensures the Airshore Rescue Tool will operate under the worst rescue site conditions. Mud, dirt, sand, or water will not affect the tools operation.

MAINTENANCE FREE: No operation maintenance is required. Periodic cleaning is all that is necessary.

MATERIALS: All aluminum and stainless steel construction for long life and weatherproof operation.

LIGHTWEIGHT: The Rescue Tool weights range from 9 Lbs. (4.1 kg) to 45 Lbs. (20.4 kg).

PNEUMATIC OR MANUAL: Safe, clean - No contaminants.

INSTALLATION: Fast, simple, and fool proof. No special tools required.

PORTABLE: Easy to handle and transport.

ADAPTABLE: Large variety of attachments and bases allows the tool to be used with all types and combinations of materials and configurations.

POSITIVE LOCK: Mechanical lockout. No chance of creep back.

TESTED: Independent tests confirm crush strength of 61,000 lb. (27,700 kg) up to 4 ft (1.2m), 49,000 lb. (22,272 kg) up to 8 ft (2.4m), and 42,000 lb. (19,000 kg) up to 12 ft (3.6m) using two locking pins.

AIRSHORE RESCUE TOOL INSTALLATION

1. Determine the proper size and support configuration that will be required.

2. Select the individual accessory heads and bases. Insert them into the Rescue Tool making sure the hole in the attachment lines up with the quick connect.

3. Make sure pins are out of piston and lock collar.

4. Place the rescue tool in the desired position.

5a. **MANUAL -** Extend the rescue tool until the accessory heads and/or base plates are in contact with the surfaces to be held apart. Place pin in closest piston hole, turn collar up using T-handle until it is snug up against the pin. Tighten T-handles and insert second pin in the next closest hole to the collar. (If required secure accessory heads and bases with nails, screws or bolts.)

5b. **AIR -** Connect the Regulator of your AIR-049R, AIR-050R or AIR051R to the Air Bottle, slowly turn Air Bottle on. Check Regulator to ensure there is adequate pressure in the bottle. Set Regulator to desired pressure (200 psi) for Trench Rescue (100 psi) for Building Collapse. Attach Quick Couplers on the end of each hose to the A.R.T. Struts.

Trench Rescue:
Recommended 200 psi / 14 BAR

Building Collapse and Confined Space:
Recommended 35 psi / 2.45 BAR Set Regulator at 100 psi

Using the Dump Valve or Dual Strut Controller pressurize strut until heads and/or base plates are in contact with surfaces to be held apart. Place the pin in the closest piston hole to collar. Turn collar up using T-handles until it is snug up against the pin and tighten T-handles. **It is not necessary to insert the second pin for Trench Rescue.** Release the pressure and disconnect the air supply hose (secure accessory heads and bases with nails, screws, or bolts.)

6. Check to see that the rescue tool is secure and continue with rescue.

REMOVAL

*** Take down is accomplished by removing the load pressure ***

MANUAL:

Unscrew T-Handles and turn collar downward taking pressure off of the pins; pull pins out of piston, place rescue strut out of your way.

AIR:

Reconnect quick coupler to the ART and re-pressurize. Unscrew T-Handles and turn collar downward. Pull pins out of piston and de-pressurize system; disconnect Quick Coupler and place rescue strut out of your way.

NOTE: Hole Through Collar:

When the pin is put through the collar hole it also goes through the hole in the piston, this prevents the piston and barrel from separating when storing the strut or when carrying to a rescue scene.

SAFETY INFORMATION

- ➢ Only trained and qualified personnel familiar with the equipment and situation should use the Airshore Rescue Tool **(A.R.T.).**

➢ Personnel not directly involved in the operation should keep at a safe distance from the compromised area.

➢ Airshore Rescue Tools are to be operated manually or **with compressed air or CO_2 gas only**. (Under no circumstances should any other gases be used).

➢ Keep hands and feet clear of the Airshore Rescue Tool when stabilizing or supporting with air pressure.

➢ Before using, ensure the Airshore Rescue Tool is complete, intact and in good working condition. Do not use the ART if there are signs of any damage.

➢ The Airshore Rescue Tool has been designed and tested for trench rescue, structural collapse, support and stabilization of light and heavy vehicles.

➢ Improvising or adapting the ART for other purposes could cause serious injury.

➢ For specific safety questions or concerns contact Airshore International **1-800-947-9472** or contact your local dealer.

MAINTENANCE INFORMATION

Periodic cleaning and inspection should be standard procedure. This should also be done after every use.

1. Pull piston complete with collar from barrel.

NOTE: Hole in collar:

When separating the piston from the barrel for routine inspection or cleaning, putting the pin through this hole will prevent the collar from separating from the piston.

2. Remove any dirt, sand or water.

3. Inspect for any signs of damage. Be sure to check the following:

   i. Nipple/Safety Limit Ports: Not plugged with debris.

   ii. T-Handle on Collar: Threads are clean and T-handle threads in easily

   iii. Cup Rubber: Check to see that it is secure and round; periodically spray with a non-petroleum based silicone. It's a good idea to "flare" out the rubber cup
   by hand every 2-3 months to help it maintain its shape.

4. Clean strut by wiping, washing or steam cleaning. DO NOT immerse piston cup rubber in solvents or petroleum-based products.

5. Assemble piston and barrel.

6. Pull the piston up and down to ensure free smooth movement.

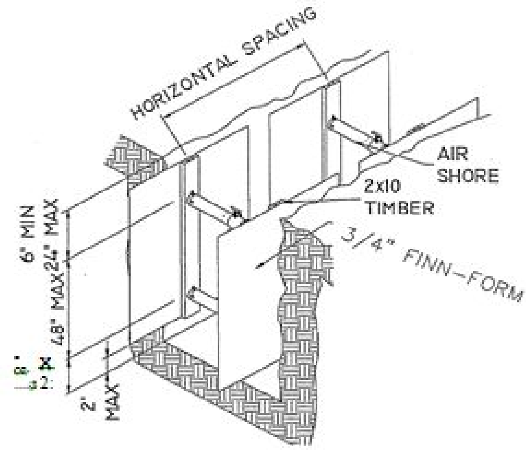
7. Clean and inspect all accessories and bases. Ensure all adjusting screws, bolts, pins and connectors are in place and in good working order.

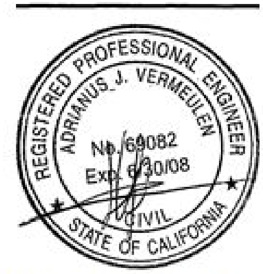
AirShore

Tabulated Data For Use in Excavations with Plywood & Plank

TABLE 1-MAXIMUM ALLOWABLE SPACING

Soil Type	Trench DEPTH (FT)	Trench Width (FT)	Horizontal Spacing (FT)	Vertical Spacing (FT)
A-25	4 to 10	to 6	8	4
		6 to 12	8	4
		12 to 16	5	4
	10 to 15	to 6	8	4
		6 to 12	8	4
		12 to 16	4	4
	15 to 20	to 6	8	4
		6 to 12	6	4
		12 to 16	2	4
B-45	4 to 10	to 6	8	4
		6 to 12	8	4
		12 to 16	4	4
	10 to 15	to 6	7	4
		6 to 12	6	4
		12 to 16	4	4
	15 to 20	to 6	5	4
		6 to 12	5	4
		12 to 16	4	4
C-60	4 to 10	to 6	8	4
		6 to 12	6	4
		12 to 16	4	4
	10 to 15	to 6	5	4
		6 to 12	4	4
		12 to 16	4	4
	15 to 20	to 6	4	4
		6 to 12	4	4
		12 to 16	4	4





Recommended strut pressures (min.)

TYPE A & B		TYPE C	
4 to 20 ft	116 PSI	4 to 20ft	116 PSI

Installation Procedure

1) Soil must first be classified by a competent person in accordance with OSHA appendix A.
2) Tabulated Data allows for a 200 PSF surcharge load. Move surcharge away from excavation or space shores closer together to allow for larger surcharge loads.
3) Inspect equipment to be sure that it is in proper working order.
4) Struts are to be placed and pressurized from outside the trench or from within a shored area. Under no circumstances is a worker allowed to enter an unshared area.
5) Pressurize struts to the minimum recommended pressure.
6) There should be a minimum of three columns of shoring in excavations over 10 ft long and two columns if it is less than 10 ft long. Shoring columns shall be spaced in accordance with the tabulated data.
7) Plywood shall be 3/4" Finn Form, Planks shall be 2" thick timber DF #2 or Better

REMOVAL PROCEDURE

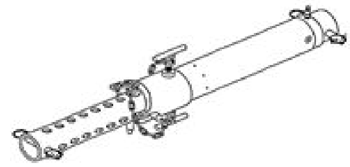
1) Shores are to be removed from the bottom of the trench up. Workers should be outside the trench or inside shored areas when removing shoring.
2) Previously shored trenches are more prone to collapse and should be backfilled or barricaded to prevent workers or equipment from falling into the trench if it collapses.

DATE	REVISED	JOB N0:9853-1
3/11/1998	11/212000	SHT 1 of 1

AirShore Rescue Tool
Tabulated Data For Use in Excavations

AIRSHORE RESCUE TOOL-PNEUMATIC STRUT			
LENGTH (FT)		CAPACITY (LBS) *	
Size (in)	Size (FT)	2 PINS	1 PIN
13-18	1 to 1.5	30,000 LB	19,000 LB
21-28	2	30,000 LB	19,000 LB
26-37	2 to 3	30,000 LB	19,000 LB
33-49	3 to 4	30,000 LB	19,000 LB
45-67	4 to 5.5	25,000 LB	19,000 LB
63-97	5 to 8	25,000 LB	19,000 LB
93-144	8 to 12	20,000 LB	14,000 LB
114-144	10 to 12	20,000 LB	14,000 LB
114-168	12 to 14	10,000 LB	10,000 LB
168-198	14 to 16	5,000 LB	5,000 LB

* Safety Factor is 2:1



NOTES:

1) Soiltype to be determined by competent person.
2) Charts are based on soil types as defined in OSHA, CFR 29, Sub Part P, March 1996.
3) Type C-60 soil is defined as C soil that will stand long enough for shores to be installed. In C-80 soil the shores cannot be installed because the soil will fall in before it is shored.
4) The AirShore Rescue Tool should be used against timber lagging, plywood, or a minimum 6" wide x 18" long spot shore rail.
5) In C-60 Soil 3/4" Finn -Form plywood, or timber lagging shall be used in all cases to prevent sloughing and raveling.
6) In all soils sheeting should be used to prevent sloughing or raveling if it occurs.
7) Spot shore rails may be set horizontal or vertical.
8) All Airshore Rescue tool attachments may be used with this shore at the capacities listed.

TABLE 1-MAXIMUM ALLOWABLE SPACING

Soil Type	Trench Depth (FT)	Trench Width (FT)	Horizontal Spacing (FT) 2 Pins	Horizontal Spacing (FT) 1 Pin	Vertical Spacing (FT)
A-25	4 to 10	to 6	8	8	4
		6 to 12	8	8	4
		12 to 16	5	5	4
	10 to 15	to 6	8	8	4
		6 to 12	8	6	4
		12 to 16	3	3	4
	15 to 20	to 6	8	6	4
		6 to 12	6	5	4
		12 to 16	2	1	4
B-45	4 to 10	to 6	8	8	4
		6 to 12	8	6	4
		12 to 16	3	2	4
	10 to 15	to 6	7	6	4
		6 to 12	6	4	4
		12 to 16	3	2	3
	15 to 20	to 6	5	4	4
		6 to 12	5	3	4
		12 to 16	2	2	3
C-60	4 to 10	to 6	8	6	4
		6 to 12	6	4	4
		12 to 16	3	2	3
	10 to 15	to 6	5	4	4
		6 to 12	4	4	4
		12 to 16	2	2	2
	15 to 20	to 6	4	4	4
		6 to 12	3	3	4

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DATE	REVISED	JOB NO:	SHEET #
9/1/1998	6/17/2005	9853-1	1 OF 2

AirShore Rescue Tool
Tabulated Data For Use in Excavations

hstallation Procedure

1) Soil must first be classified by a competent person in accordance with OSHA appendix A.

2) Tabulated Data allows for a 200 PSF surcharge load. Move surcharge away from excavation or space shores closer together to allow for larger surcharge loads.

3) Inspect equipment to be sure that it is in proper working order.

4) Struts are to be placed and pressurized from outside the trench or from within a shored area. Under no circumstances is a worker allowed to enter an unshared area.

5) Pressurize struts to the minimum recommended pressure.

6) There should be a minimum of three columns of shoring in excavations over 10 ft long and two columns if it is less than 10 ft long. Shoring columns shall be spaced in accordance with the tabulated data.

7) Plywood or lagging is to be used to prevent sloughing and raveling. In all cases where sloughing or raveling occur it must be used. In soiltypes A & B the sheeting may be spaced as needed to stop the sloughing and raveling. In C-60 Soil Plywood sheeting must always be used.

REMOVAL PROCEDURE

1) Shores are to be removed from the bottom of the trench up. Workers should be outside the trench or inside shored areas when removing shoring.

2) Previously shored trenches are more prone to collapse and should be backfilled or barricaded to prevent workers or equipment from falling into the trench if it collapses.

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DATE	REVISED	JOB NO:	SHEET #
9/7/1998		9853-1	2 OF 2

MANAGING A
TRENCH RESCUE
INCIDENT

<u>TACTICAL CONSIDERATIONS</u>

PHASE I – ON SCENE, ESTABLISH COMMAND, SIZE-UP

On Scene

First arriving company officer should establish Command and initiate a size-up of the situation
The first-in company should spot the apparatus at least 100’ from the location of the trench failure. Establish staging at least 300’ from the scene
Complete a risk benefit analysis – RESCUE vs RECOVERY
Call for resources – “Technical Rescue Response”
Complete lock out/tag out, as applicable

Size Up

Secure an RP (responsible party), job foreman, or witness to the accident.
Place a ladder in the trench
Determine exactly what has happened
- Why were they digging
- What time was the collapse
- How many patients
- Last known location

Make patient contact
- Initial evaluation of patient condition
- Protect the patient

Uncover the patient to their waist
Provide them with head and eye protection
Provide them with a tool to dig
Consider oxygen
Determine type of trench and soil
- Survey for cracks and fissures
- Consider possibility/probability of secondary collapse
- Is water a factor?

Determine Risk Analysis, assessing potential hazards
Identify any language barriers that may be present between witness and rescuers. If there are barriers, call for bi-lingual individual to assist with communication with the witness.

Develop Incident Action Plan (IAP)

- *Denotes Trench Technician Position

- Assess on-scene capabilities
- Assess the need for additional resources
  - Consider vacuum truck
  - Public Works representative

Contact Labor & Industries
- Assign a Technical Operations Safety Officer*
- Assign personnel
  - Rescue Group Supervisor*

Shore Team Leader*
Panel Team Leader*
Support Team Leader*

Entry Team Leader*
Rigging Team Leader*
  - Medical Group Supervisor

Consider Entry Medic
Patient Advocate
  - Staging Area Manager

PHASE II – PRE-ENTRY OPERATIONS

Make General Area Safe

Create a Hot, Warm, and Cold Zone
  - Hot Zone – Rescue Operations
  - Warm Zone – Tools/Personnel
  - Cold Zone – Non-Essential Personnel

Control traffic movement
  - Shut down roadways within 300’

Control the crowd
  - Remove all non-essential civilians from the Hot and Warm Zones
  - Remove all non-essential rescue personnel from the Hot Zone
  - Shut down all heavy equipment operating within 300’ of the collapse

Make the Rescue Area Safe

- Protect the patient
  - Consider spot shore
  - Consider panel shelter
- Mark the location of the patient
- Clear trench perimeter and place ground pads – spoil pile minimum 2’ from lip
- Control all hazards in the area. (i.e. confirm lock out/tag out, utilities, gas, electric, water, on-site equipment)
- De-water trench, as necessary
- Monitor atmosphere in the trench
- Ventilate the trench, as necessary
- Assess ladder placement, maximum of 25’ between placement

Do not enter the Trench until Protection Systems are in place

PHASE III – ENTRY OPERATIONS

Stabilize Trench (Making the trench safe)

- Approach the trench from the ends if possible
- Assess current soil conditions (i.e. fissures, unstable spoil pile)
- Assess spoil pile for improper angle of repose and general raveling
- Remove any trip hazards (i.e. shovels, shores, tree roots)
- Entry Team Leader will be responsible for entry operations
- Determine shoring system to be used (i.e. pneumatic, hydraulic, timber)
- Establish equipment cache
- Initiate installation of the protection/shoring system
- Initiate entry
- Make physical contact/assessment of patient
- Initiate treatment
  - ABC's – primary survey
  - C-Spine precautions
  - Secondary survey
  - Consider removing patient from danger prior to providing definitive care

Follow Local Protocols

- Remove the dirt from the collapsed zone. The rescuer(s) shall remain in the "safe zone" while removing dirt from the collapsed zone.
- Secure all unsecured utilities, pipe, or any other obstruction in the trench
- Continue installation of protection systems until all work zones are considered "safe"
- Extricate patient

Patient Removal

Create a safe zone around the patient
Remove objects trapping the patient (i.e. pipes, lumber, machinery)
Continually assess the patient's condition
Begin dirt removal, operating from a safe zone (buckets, small shovels, by hand)

Uncover the patient to below the diaphragm
Completely uncover the patient
Package the patient for extrication
Remove the patient from the trench (vertical haul, horizontal haul)
Transfer the patient to Medical Group

PHASE IV – TERMINATION

Termination Procedures

Personnel accountability and welfare survey
Announce the Termination Action Plan – remind all personnel to maintain situational awareness with a focus on safety
Remove tools and equipment from the trench when approved by L & I
Remove trench shoring system (last in/first out)
Re-stock vehicles
Conduct a debriefing
Secure the scene. This may include covering the trench.

Other Considerations

Rotation of crews.
Environmental effects on the patient and rescuers.
The effects of rain or snow on the hazard profile.
Operational period and logistical need
Time of day. Is there enough lighting for operations extending into the night?
The effect on family, friends, and co-workers; keep them informed.

ATMOSPHERIC MONITORING
FOR
TRENCH RESCUE

The use of air monitoring and sampling equipment is one of the most important aspects of trench rescue operations. During your rescue effort someone on your support team will be providing periodic atmospheric monitoring in and around the trench and will continue to monitor until deemed unnecessary by the Technical Operations Safety Officer. Monitoring is used not only to detect the presence of IDLH atmospheres, but it is also used as a tactical guide to ventilation of the trench.

Here are some basic terms that apply to monitoring and sampling:

Alarm settings:
A preset level within a monitor at which the monitor will display a visual alert and sound an audible alarm. Alarm settings are established by the manufacturer and based on OSHA and NIOSH levels for given product.

Detection Range:
The term used to express the unit of measure that the monitor uses to detect the vapor for which it was intended. Combustible Gas Indicators usually have a display showing percentage (%) of the Lower Explosive Limit (LEL). Toxic sensors such as Carbon Monoxide or Hydrogen Sulfide display in parts per million (PPM).

Explosive Limits:
A reading on the monitor given in percentage indicating a percentage of gas in air mixture. Can be known as Upper Explosive Limit (UEL) or Lower Explosive Limit (LEL).

Flammable Range:
Is the percentage of vapor in air which must be present to sustain combustion should ignition occur?

Flash Point:
The minimum temperature of a liquid that generates enough vapor to form an ignitable mixture in the vapor space above the liquid.

Ignition Temperature:
The minimum temperature to which a liquid must be raised to initiate and sustain combustion..

Immediately Dangerous to Life and Health:
(IDLH) Maximum concentration from which a person could escape (in the event of respiratory failure) without permanent or escape-impairing effects within 30 minutes.

Lower explosive Limit (LEL):
The minimum concentration of vapor in the air which propagation of flame occurs on contact with a source of ignition. Usually expressed as a percentage of gas vapor in air.

Oxygen Sensor:
An electrochemical sealed unit measure the percentage of oxygen in the air. The sensor has two electrodes, an electrolyte solution and a membrane which separates the two. As oxygen passes through the membrane, a reaction with the solution and the electrodes produces and electrical current, which causes the sensor to display the percent of oxygen found.

Permissible Exposure Limit (PEL):
Average concentration that must not be exceeded during an 8-hour work shift or a 40-hour workweek.

Upper Explosive Limit (UEL):
Is the maximum concentration of vapor in air at which propagation of flame occurs when in contact with source of ignition?

Monitoring Considerations

Before monitoring a space, there are some things to consider regarding the atmosphere or potential hazards that exist at a trench rescue operation.

1. What is the nature of the hazard I am monitoring?
    a. What are the upper and lower explosive limits for the particular product?
    b. Is the atmosphere oxygen deficient which might create interference with instrument response?

2. What are the environmental site conditions you are operating in?
    a. Temperature
    b. Humidity
    c. Barometric pressure
    d. Overall weather condition

Action Guidelines

To tactically use the monitor information, you must have action guidelines established.

Atmosphere	Level	Monitor	Action
Combustible/Flammable Gas	10% of LEL	Alarms both visually and audibly	If outside the space correct. If inside the space exit
Oxygen	Less than 19.5% Greater than 23.5%	Alarms both visually and audibly	If outside the space correct. If inside the space exit
Toxicity H2o CO	 10 ppm 35 ppm	Alarms both visually and audibly	If outside the space correct. If inside the space exit

Atmospheric monitoring identifies the hazards and provides a baseline. The first step to handling any hazard is to know it's there!

Ventilation:

Ventilation may be necessary depending on the atmospheric readings and/or known conditions. It is very important to monitor during ventilation, this tells you whether your technique is working or not. If you're still receiving high readings, reconsider the source and ventilation tactics.

Ventilation of a trench may also have negative impacts such as dust, noise, dehydration of the trench wall, hypothermia of the patient and the rescuers. Use of gas-powered blowers should only be considered when electric blowers are not available. A good consideration for trench ventilation is a confined space blower.

ENTRY PERMIT

KING COUNTY TECHNICAL RESCUE CONFINED SPACE RESCUE

NO ONE SHALL ENTER ANY CONFINED SPACE UNTIL A *RISK/BENEFIT* ANALYSIS HAS BEEN DONE!

LOCATION:	DATE:
INCIDENT COMMANDER:	RESCUE GROUP SUPERVISOR:
SAFETY OFFICER:	TECHNICAL SAFETY OFFICER:
ENTRY TEAM:	ATTENDANTS:
BACK-UP TEAM:	
TIME PERMIT ISSUED:	TIME PERMIT EXPIRED:
OPERATION MODE: ☐ RESCUE ☐ RECOVERY ☐ DRILL/OTHER	

HAVE THE FOLLOWING PRECAUTIONS BEEN TAKEN?		SAFETY EQUIPMENT USED AT THE SCENE:	
AIR TESTED AT ALL LEVELS	☐ YES ☐ NO ☐ N/A	SABA	☐
VENTILATION PLAN	☐ YES ☐ NO ☐ N/A	SCBA	☐
RETREVAL LINE WORN BY RESCUERS	☐ YES ☐ NO ☐ N/A	AIR MONITORS	☐
RESCUE EQUIPMENT TESTED & READY	☐ YES ☐ NO ☐ N/A	PATIENT PACKAGING	☐
ENTRY TEAM READY	☐ YES ☐ NO ☐ N/A	ROPE SYSTEM	☐
BACK-UP TEAM READY	☐ YES ☐ NO ☐ N/A	VENTILATION FANS	☐
CONTINUOUS AIR MONITORING	☐ YES ☐ NO ☐ N/A	TRIPOD /HIGH POINT	☐
COMM. SYSTEM OPERATIONAL	☐ YES ☐ NO ☐ N/A	PPE FOR SITUATION	☐
SABA/SCBA READY	☐ YES ☐ NO ☐ N/A	COMMUNICATION SYSTEM	☐
ALL SYSTEMS SAFETY CHECKED	☐ YES ☐ NO ☐ N/A	OTHER:	

POSSIBLE HAZARDS:			
ENGULFMENT	☐ YES ☐ NO ☐ N/A	MECHANICAL	☐ YES ☐ NO ☐ N/A
TOXIC ATMOSPHERE	☐ YES ☐ NO ☐ N/A	PNEUMATIC	☐ YES ☐ NO ☐ N/A
FLAMMABLE ATMOSPHERE	☐ YES ☐ NO ☐ N/A	ELECTRICAL	☐ YES ☐ NO ☐ N/A
OXYGEN DEFICIENT OR EXCESS	☐ YES ☐ NO ☐ N/A	COLLAPSE	☐ YES ☐ NO ☐ N/A
LOCK-OUT/TAG-OUT	☐ YES ☐ NO ☐ N/A	HOT WORK CONCERNS	☐ YES ☐ NO ☐ N/A

NOTES:

INITIAL AIR TESTS CONDUCTED: METER SERIAL #					OTHER DETECTORS:		
	TIME	02	LEL	CO	H2S	OPERATOR	
OUTSIDE OPENING							
INSIDE OPENING							Considerations for NON SCBA/SABA ENTRY
4 FEET INSIDE							OXYGEN 20.8%
8 FEET INSIDE							LEL 0%
12 FEET INSIDE							CO < 35 ppm
							H2S 0 ppm
							VENTILATION: Y / N
							RETRIEVAL: Y / N

COMMUNICATIONS SYSTEM: ☐ VOICE ☐ HARDWIRE ☐ RADIO ☐ ROPE ☐ AIR HORN (Abandonment)

SIGNATURES:

SAFETY OFFICER		DATE
OPERATIONS OFFICER/RGS		DATE
INCIDENT COMMANDER		DATE

TECHNIQUES FOR
BUILDING PROTECTION
SYSTEMS

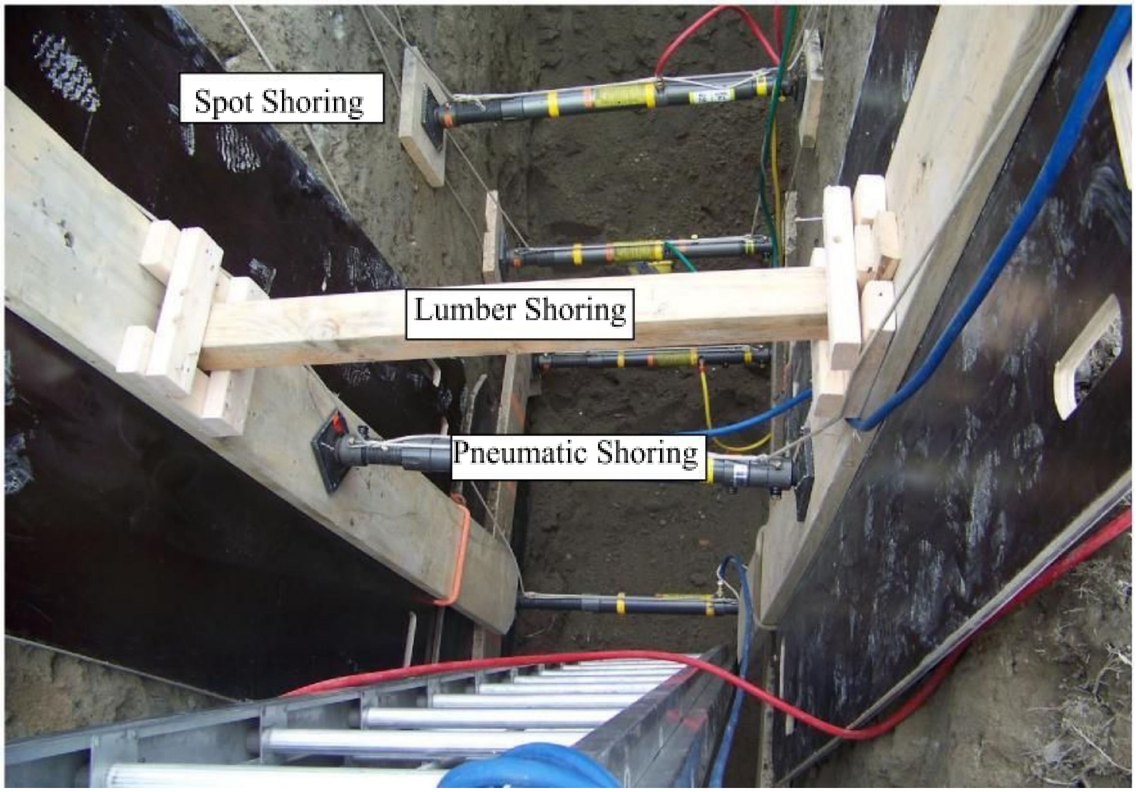
Shoring Basics:
We will identify three types of shoring. We can expect to utilize all three types in one trench collapse incident.

Pneumatic Shoring:
In this course we will use Paratech and Airshore. By standard any pressure below 200 psi is considered "soft." Soft shooting, typically between 75 to 100 psi, is used to hold a strut that is transitional or on a fragile area such as an outside corner.
Hard shot is a strut that is pressurized to between 200 & 250 psi. Per Paratech, a strut is not "installed" until its pressure is above 200 psi. All struts should be hard shot unless conditions exists that precludes the pressure at that time."Installed" means a strut is hard shot, collard locked, (ACME Thread and Lock Stroke) and the base is nailed to the strong back or wood base using (2) 16d nails driven half way in and bent over.
Commands for pressurizing are: "Up on the (hose color) to desired pressure" or "down on the (hose color)."

Lumber/Wood Shoring:
This type of shoring utilizes dimensional lumber typically 4" X 4" or 6" X 6" hemlock or Douglas fir. Lumber shores are used in the same fashion as pneumatic shoring except it is not pressurized per se. It is tightened using wood wedges. The dimension of lumber selected is conditional upon the span and the load being applied to the member – axial loading (column) vs. lateral (beam).

As general "rule of thumb" we consider 1' of span will equal 1" of dimension in the lumber, i.e. a 4" X 4" will span up to 4'.

In addition to lumber being used as "columns and beams," wood is used to make wedges, cleats, corner blocks, thrust blocks, and walers.



Spot Shoring:

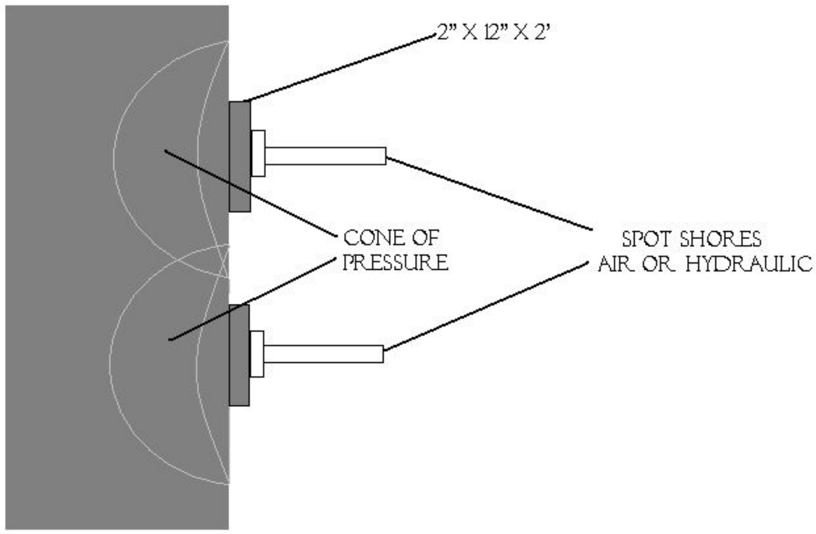
The standard King County for shoring is to use panels in the trench when we can and shooting the struts to the hardbacks (or walers if they are in play). However, there are times when it will be necessary to use a "spot shore" in lieu of that. Examples of spot shoring are:

An initial spot shore over the patient to provide protection until a "system" can be put in place.

To maintain our "two feet from the top and bottom and no more than four feet in between struts". If you find you have removed material from the bottom of the trench to rescue/recover the patient and are now four feet lower than your lowest strut, a spot shore can be used to cover that gap.

There may be other times when the configuration of the trench prohibits putting a panel in place.

A spot shore consists of a strut with an extra-large "foot" attached. There are commercially made bases for this application. Paratech makes one. Another acceptable method is using 2X12 material or Finn Form, cutting it into a 12X12 size and nailing it to the base of the strut.

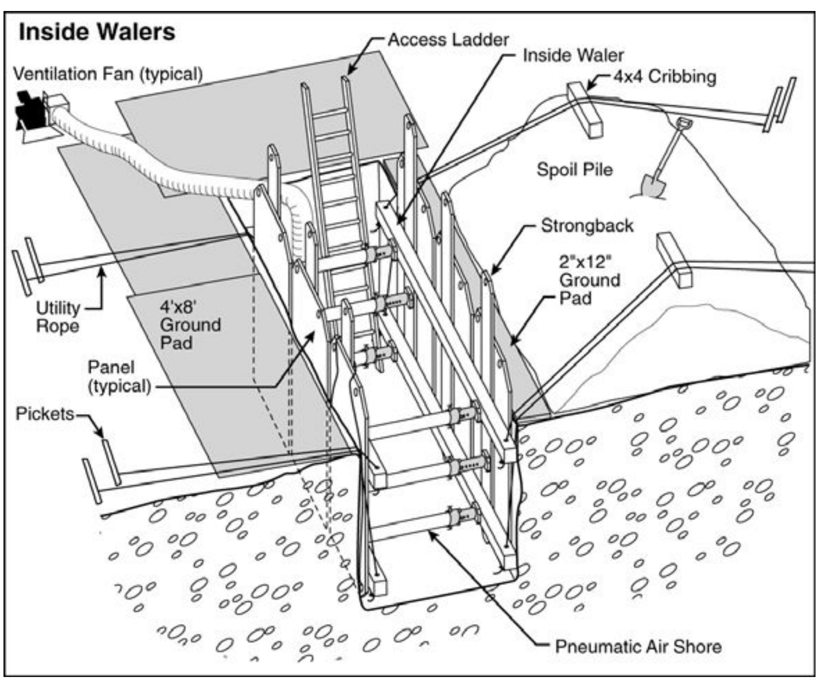

2" X 12" X 2'
CONE OF
PRESSURE
SPOT SHORES
AIR OR HYDRAULIC

INSIDE WALERS

Inside walers are typically 6x6 material and are used in a trench to span a set of panels create an open space. The open space may be required as the result of a piece of equipment in the trench that cannot be moved, to create space for digging and extrication operation, spanning an opening in a trench wall, and/or spanning an intersecting trench. Shoring a "T" or "L" trench would use this type of waler.

An example of how to install an inside waler:

Place all walers in bottom of trench
Place all panels
Raise bottom waler on both sides and tie off to pickets or outside uprights.
Place top waler and tie off to pickets or uprights
Shoot shores between top waler
Shoot shores between bottom waler



STRAIGHT WALL TRENCH

The straight wall trench will usually require the rescuer to set a minimum of three sets of panels. One set directly over the patient and one set on either side of the middle to provide a safe area for rescuers to work. Consideration for the first panel (not set) may be to protect the patient from further injury. Make sure you mark the location of the patient before beginning.

<u>An example of how to set up the protection system:</u>

Consider placing the first set of panels directly over the patient

When placing the shores:

Set the top shore

Next the middle shore

Any other shore required to maintain spacing standards

Last comes the bottom shore

**unless mitigating circumstances prohibit this order. (ie: trench shape)

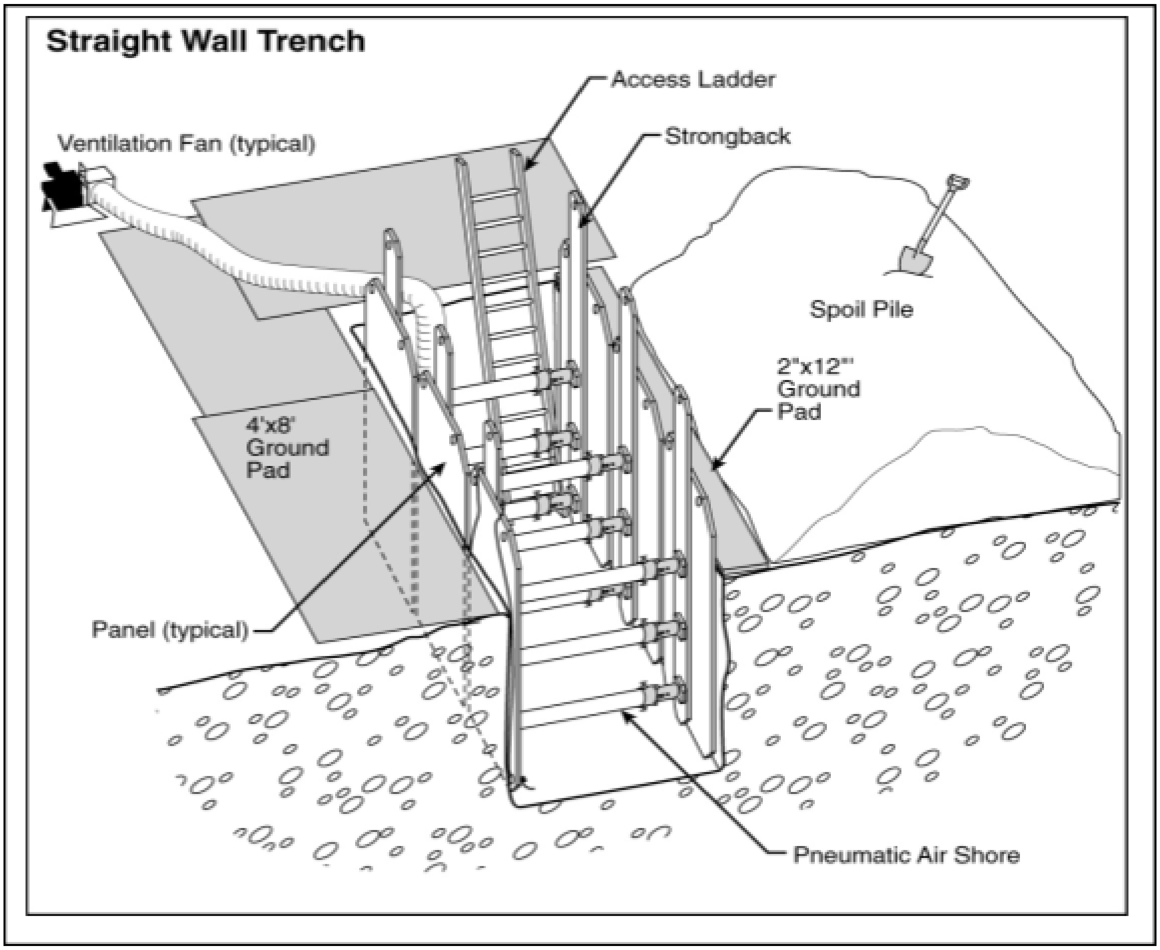
For Hydraulic:

- Set and expand shores between uprights

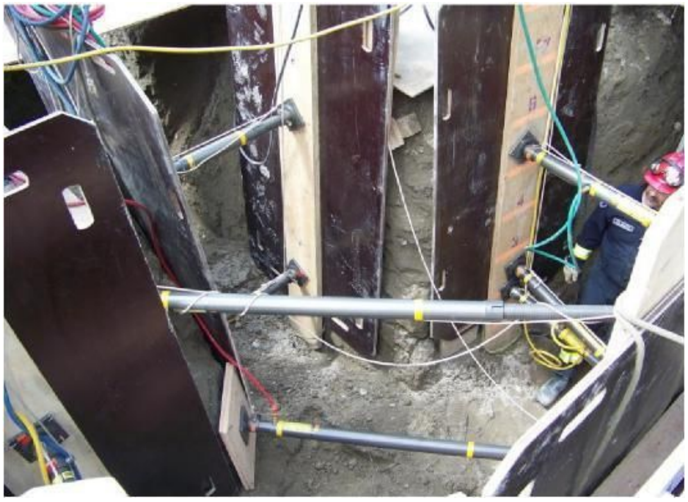
Set the outside panels next using the previous procedures.

The most important keys for setting panels are:

- the uprights are in line with each other
- the panels make full contact to trench wall
- the panels are secure.


Straight Wall Trench
Access Ladder
Ventilation Fan (typical)
Strongback
Spoil Pile
2"x12"'
Ground
Pad
4'x8'
Ground
Pad
Panel (typical)
Pneumatic Air Shore

“T” TRENCH

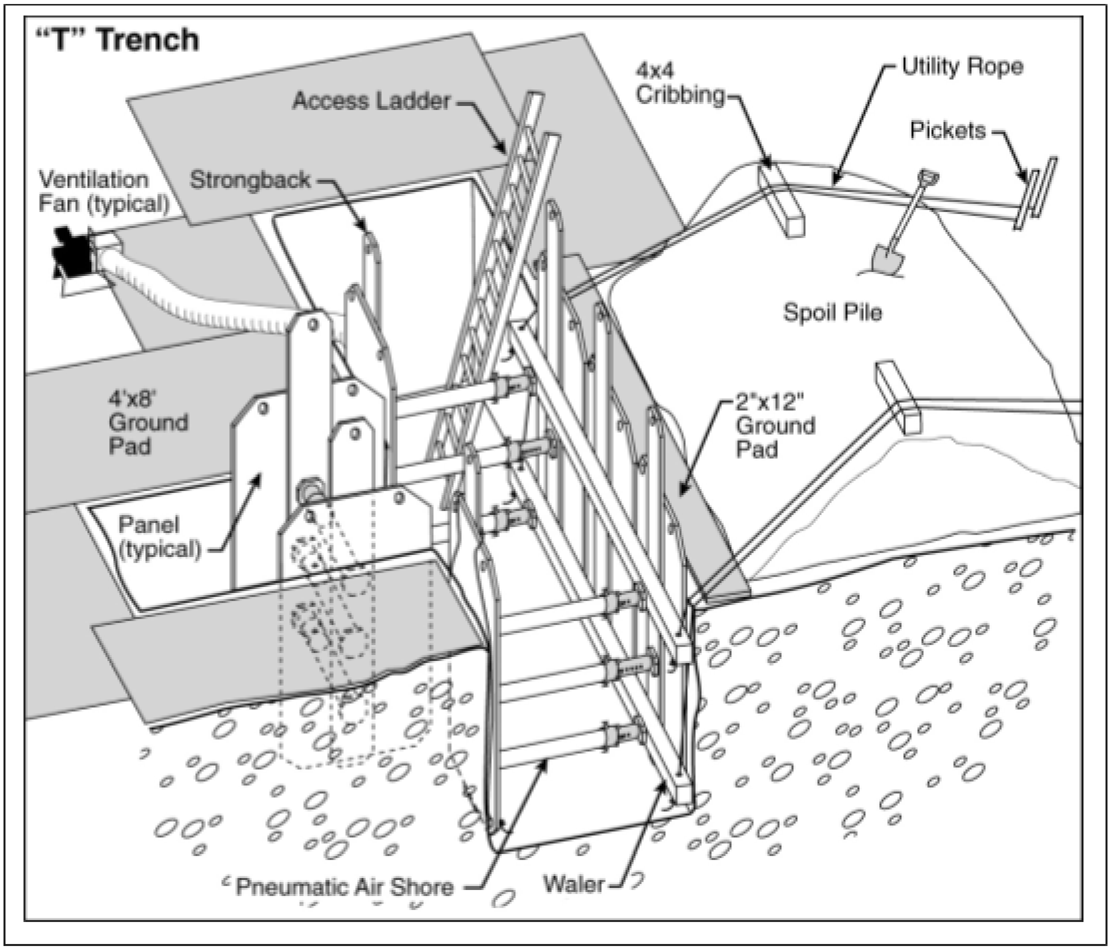


The intersecting “T” trench is a very unstable trench due to the exposed wall and the other wall has been intersected, creating unstable corners. The key is to capture the corners as quickly as possible. Inside walers span the center panel because there is nothing to shore against where the “T” leg intersects with the long wall.

An example of how to set up the protection system:

First, limit any activity at the corners of the intersection
Set pickets for tie backs
Prepare panels and walers, number of walers depends on the depth of the trench
Prepare shores
Set two panels on wall of “T” leg
Soft shoot (low pressure, about 50-75#) top, middle, bottom
Place all walers on trench floor along long wall
Set remaining 5 panels. Two panels on opposite “T” leg corners Three panels on long wall
Place top waler and tie back to pickets
Soft shoot top shore from outside panels to waler
Raise middle waler and tie back
Soft shoot middle shore on outside panels
Raise bottom waler and tie back to pickets
Soft shoot bottom shore from outside panels to waler

Hard shoot shores on “T” leg shooting all shores on the same horizontal plane at the same time



"L" TRENCH

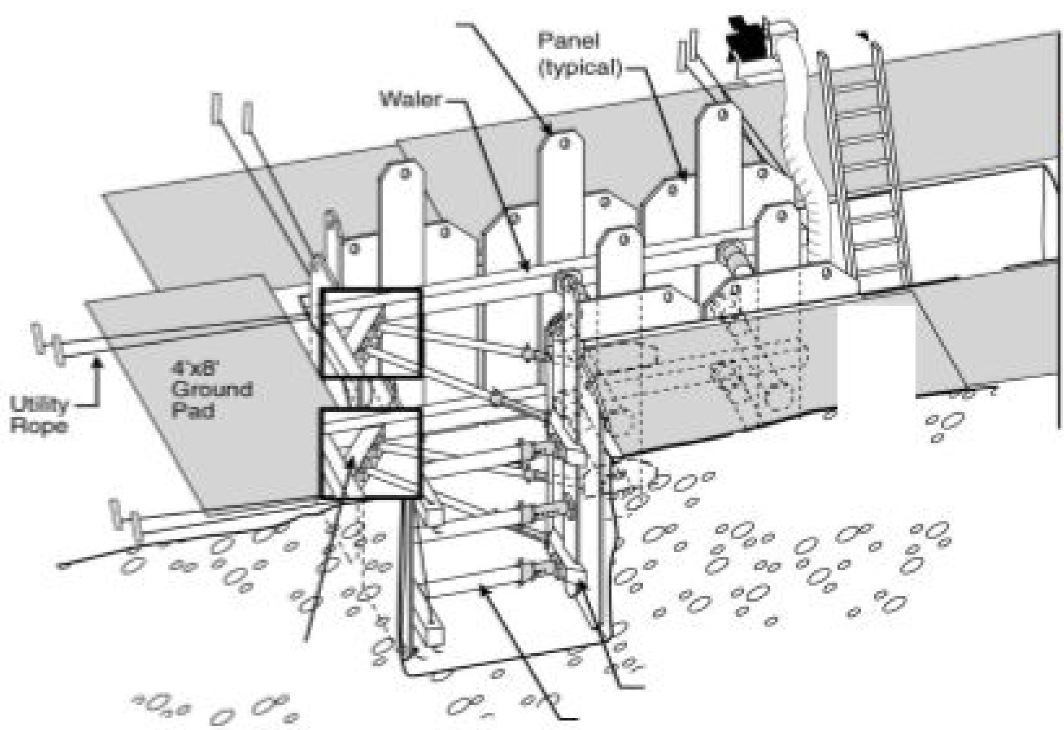
The "L" trench presents a difficult scenario for rescuers because the inside and outside corners of the "L" are difficult to capture with the standard protective equipment.

An example of how to set up the protection system:

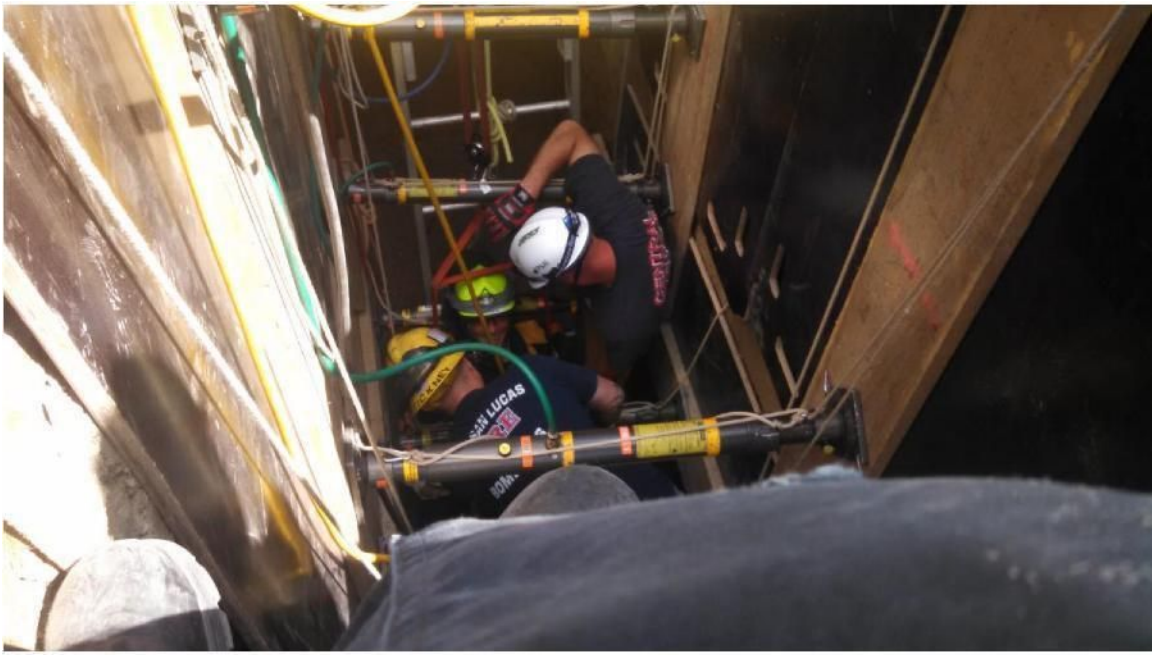
Again, we want to limit activity at the corners of the intersection
Measure depth and width of trench
Set pickets for tie backs
Prepare panels and walers
Prepare shores
Set opposing "inside L" panels, tie to pickets
Place all walers on trench floor, both sides, tie to pickets
Place "thrust blocks" (one per shore) using cleats on inside L panels
Soft shoot center shores to capture corners
Place two outside "L" panels, move them to form a clean corner and skip shore outside perimeter, as necessary
Set walers. Walers should form a clean corner at the outside intersection of the corner panels. Anchor these in place by tying back to pickets
Hard shoot all shores that are now placed.

Place “corner blocks” on whalers using cleats/hangers or toe nails
Slowly pressurize corner/thrust shores from inside “L” panels to corner/thrust blocks simultaneously. Consider keeping these shores at the minimum “installed” pressure.

“L” TRENCH



DEEP WALL TRENCH
15 FOOT TRENCH



Deep trenches are those over 10 feet but not more than 20 feet. If over 20 feet, commercial shoring and techniques are required.

<u>An example of how to set up the protection system:</u>

Measure depth and width of trench
Set pickets for tie backs
Prepare panels
Prepare walers, if needed
Prepare shores
If needed - installing walers

- Set deep wale on bottom floor of trench, picket back.
- Prepare all other walers, as necessary (one set every four feet or per Paratech charts).

Note: You may find that may have to shoot panels to capture the wall before placing walers. You must make this decision based on stability of the soil and your comfort level. If you do this, you will have to maneuver the walers into place between shores.
Lower bottom sets of panels in place, in normal fashion, upright and tie back to pickets

Place top panels at 90 degrees to bottom panels, laying them lengthwise across two panels.

Depending on the trench, one might opt to place the bottom panels horizontally and the top panels vertically.

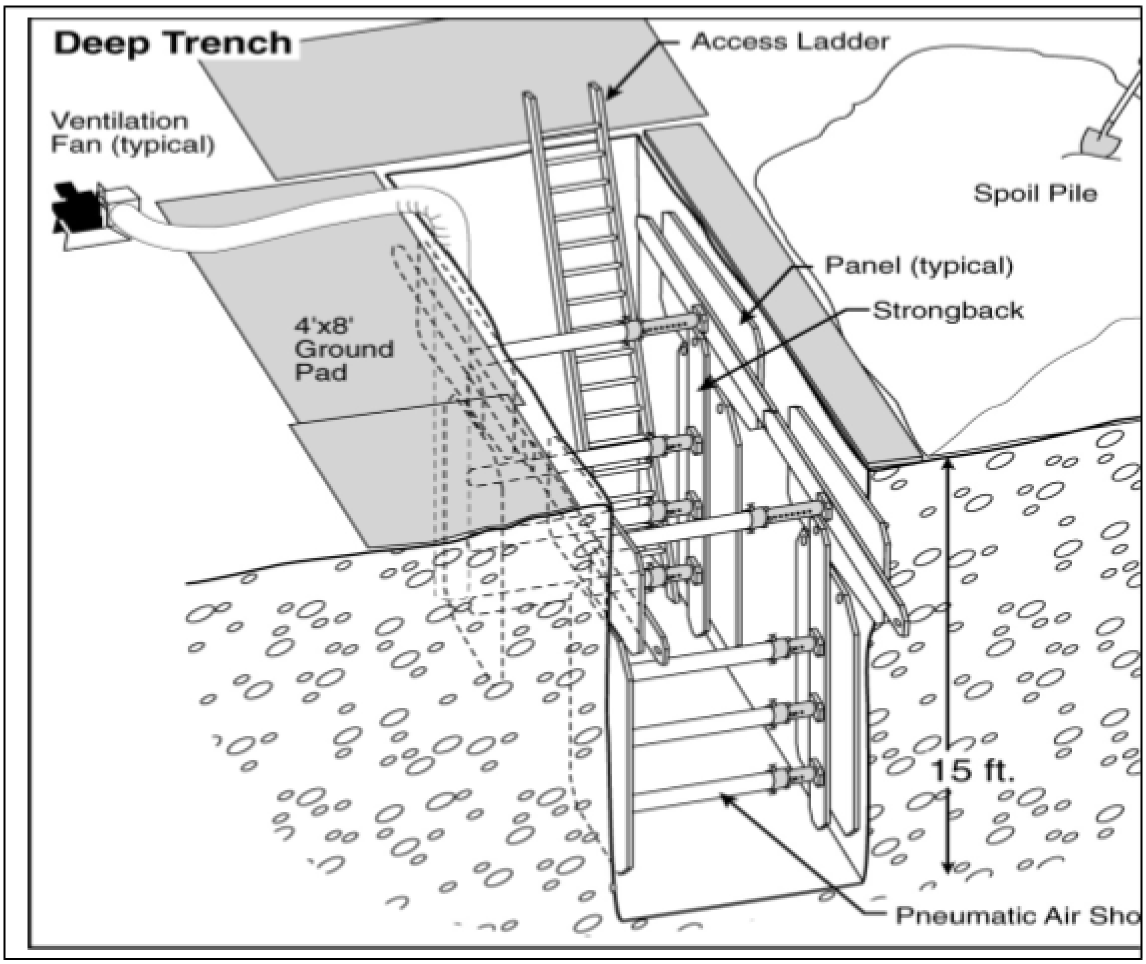
Lower and place remaining sets of walers, not to exceed vertical spacing standards between walers. Tie back to pickets

Shoot top panels using shore system. (No wales) Must be at least two feet from lip

Strive to work from top to bottom

At this depth adding more shores, as necessary, to control the environment. All horizontal and vertical placement shall be per the Paratech chart.

Check and adjust shores



SINGLE WALL SLOUGH – OUTSIDE WHALERS

This type of trench has a collapse of one wall. In this situation the protective system is designed with outside walers to span the opening and provide a backing for protective panels. Outside walers are positioned between the panels and the trench wall and usually consist of 6X6 material.

An example of how to set up the protection system:

Place pickets to tie walers

- Place and tie off bottom waler
- Place middle waler, as needed
- Place and tie off top waler
- Place the first set of panels directly over the patient
- Fill all spaces behind whalers/panels with air bags, back shores* or other material (when expanding bag, do not push out panel).

*This can also be accomplished with a spot shore from the slough trench wall to the outside waler

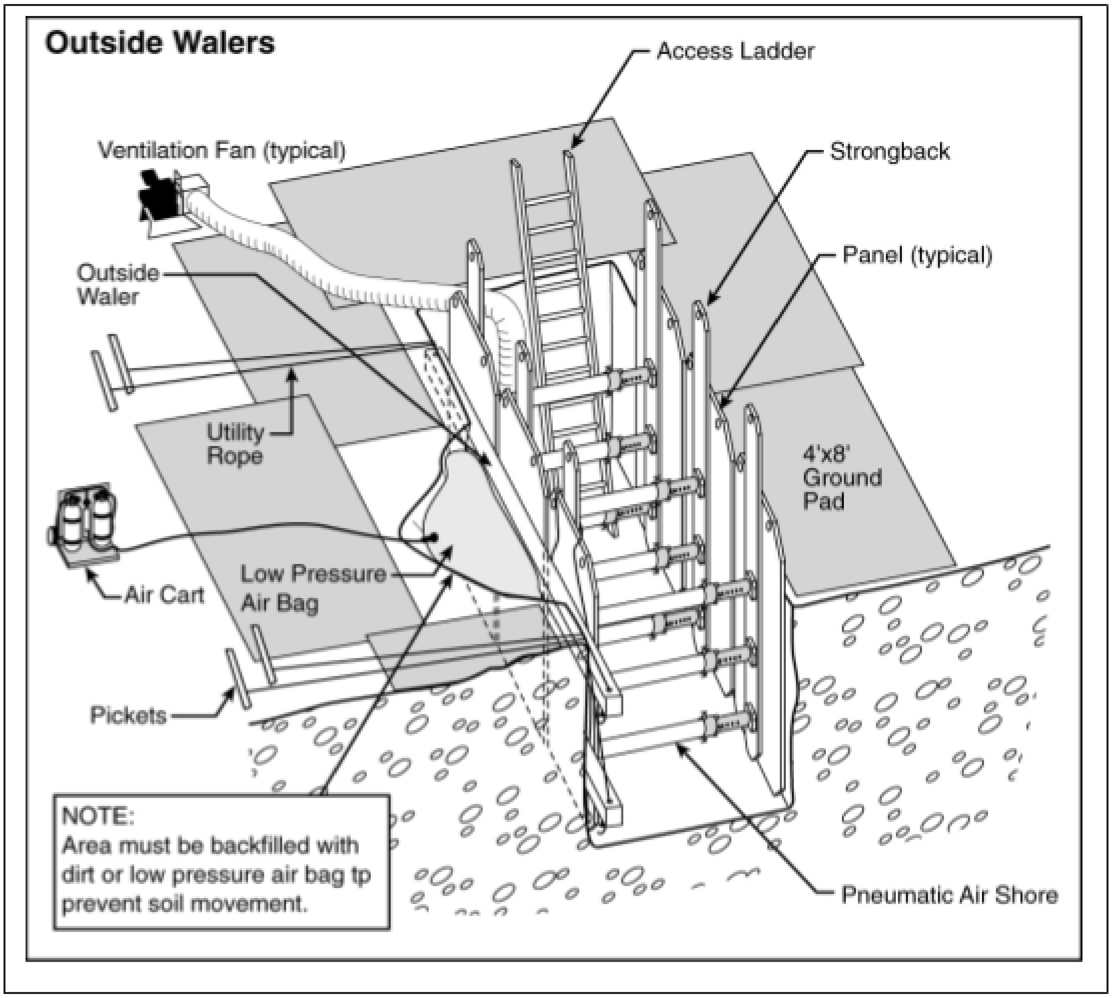
When shooting or placing the shores:

- Set the top shore
- Next the middle shore, as needed
- Last comes the bottom shore

** Unless mitigating circumstances dictate otherwise

Set the outside panels next using the previous procedures.

SINGLE WALL SLOUGH – OUTSIDE WHALERS CONT.



VICTIM ACCESS, PACKAGING, AND EXTRACTION

Once access is made to the victim and a minimal temporary safe zone has been established every attempt should be made to clear an airway and reduce the surface load on the victim's torso if possible. Realize that a safe work zone is defined as two panels in place with properly spaced shores. Until this safe zone is established all work and efforts need to continue to develop this safe zone. If this is not possible due to the condition and configuration of the trench walls then spot shoring should be used to assist in achieving this goal.

All personnel operating in the trench will be wearing class III harnesses. Tag lines will not be used with the exception of use as fall protection while working from ladders at steep angles at a height where an injury could be fatal (greater than 10') or the rope is needed to assist with balance. Disconnect any tag lines once at trench floor.

Victim access will be done by hand. Traditional length tools often will be inadequate to dig in the limited space present. Folding shovels, mini handle shovels and trowels may be more appropriate. Consider metal spoons when digging around a patient's face.

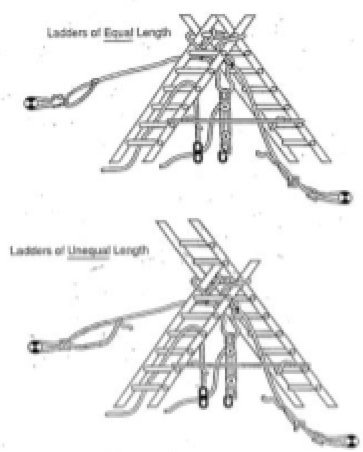
Considerations for the patients rapid cooling should be considered. Halogen lights may be used to warm the area. Disposable space blankets may be used to retain the patient's heat. A Rescue Paramedic should be used to evaluate the patient and determine if ALS intervention should be initiated in the trench. If this can be done without delaying the removal of the patient from the trench then this is appropriate. ALS intervention that will delay patient movement should be discussed with the Rescue Group Leader to determine the risk to the rescuers in the trench due to the type of shoring system in place.

Due to the risk of introducing oxygen into a confined space prior to using medical oxygen the TR Safety and RGL should discuss the possible hazards. If it is determined that this will be a hazard, breathing air may be used from the confined space rescue patient air system. See photos.

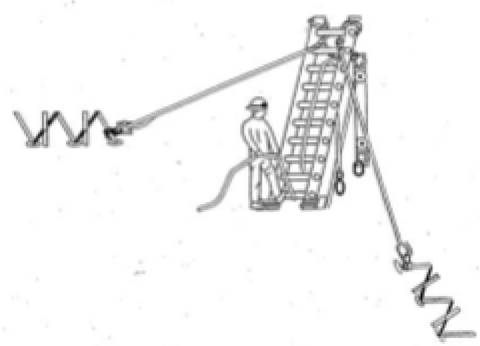
Patient movement is best accomplished with a rapid package/movement device. The Half Sked is good for performing a long axis drag and if they can be slid onto a ladder and pulled out than that may be a quick solution to victim removal. If c spine immobilization is a concern (often) then a device that will give more c spine immobilization such as the Spec Pak or LSP Halfback may be more viable options. If it is not possible to do a ladder slide or moving ladder slide for removal and vertical lift will be needed then a high directional anchor will be of great assistance.

Simple is best for patient extraction. A ladder slide or moving ladder works well if the ladder can be manipulated through the struts. Having that as plan A is always good but you need to be prepared with a plan B. Often in training technicians struggle to attempt to drag a patient over struts and panels. With a 100 lb. dummy this is possible. With a 200 lb. adult this is not. Technicians should practice rigging high directional systems for extraction.

Aerial ladders can be used as a high directional as they can be parked 50' from the site and the aerial extended above the victim. A pulley can be suspended from the aerial and a manual haul system built or piggybacked on to the mainline. A pre-rigged 4:1 system can be attached to the tip of the serial. *Due to the hazard of the victim getting caught on a strut only a manual haul system should be used. Don't use the aerial as a crane.* Other options are the use of a ladder gin or ladder A frame. See drawings below of ladder gins and ladder A frames. When an aerial ladder won't reach the rescue site these are good solutions. The Arizona Vortex could be used as well.



How To Construct a Ladder A-Frame



How To Construct A Ladder Gin Open Field

ASSIGNMENTS
&
RESPONSIBILITIES

RESCUE GROUP SUPERVISOR
This position is responsible for the tactical operations of the trench rescue. They determine the action plan and ensures the plan is implemented and adhered too.

TECHNICAL OPERATIONS SAFETY OFFICER
This person is responsible for overall safety. They must identify all scene hazards and potential problems. They shall insure that all personnel working at the site are wearing all necessary protective equipment and following established guidelines.

SUPPORT TEAM LEADER
They manage the support team. Initial tasks include placing ladders into the trench, one at the victim position, then, spaced no more than 25’ apart along the working area of the trench. Other responsibilities may include air monitoring, lock- out/tag-out, equipment cache, lighting, cut shop and/or water removal.

PANEL TEAM LEADER
They manage the panel team. Their first task is placing edge protection, ground pads. Once the edge is secured, the panel team is responsible for preparing and placing the panels.

SHORING TEAM LEADER
Manages the shoring team. The shoring team is responsible for assembling, placing and removing the shoring devices.

RIGGING TEAM LEADER
The rigging team is responsible for all the rope systems used during the rescue. They may need to build; “A” frames, ladder gins, stokes rigging, haul systems and or ladder slides.

ENTRY TEAM LEADER

The entry team enters the trench after all the shoring has been put in its place. They use hand shovels, buckets, and other means of debris removal to free the victim for extrication.

APPENDIX A
TERMINOLOGY

ACCEPTED ENGINEERING PRACTICES: Those requirements that are compatible with standards of practice required by a registered professional engineer.

ACTIVE SOIL: The ability of the soil to contain energy as it relates to movement.

ALUMINUM HYDRAULIC SHORING: A pre-engineered shoring system consisting of aluminum hydraulic shoring cylinders, used with vertical rails (uprights) or horizontal rails (wales or whaler). Such a system is designed specifically to support the sidewalls of an excavation and prevent cave-ins.

ANGLE OF REPOSE: The natural angle at which loose particulate products will support its own weight, and which can be expected not to flow from a standing position.

AHJ: The acronym used to describe the Authority Having Jurisdiction.

BELL PIER: A type of shaft or footing excavation, the bottom of which is larger than the cross section above to form a bell shape.

BENCHING: Excavating the walls of an excavation in such a way to form horizontal steps with vertical faces, placed at predetermined angles and widths to prevent the soil from collapsing or sliding.

C-60 Soil: A class of soil that is a "moist, cohesive, or a moist dense granular soil which does not fit into type A or B classifications and is not flowing or submerged. This material can be cut with near vertical sidewalls and will stand unsupported long enough to allow the shoring to be properly installed

CAVE-IN: The separation of a mass of solid or rock material from the side of an excavation, or loss of the soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.

CEMENTED SOIL: A soil in which a chemical agent similar to calcium carbonate holds together the particles, such as a hand size sample could not be crushed into powder or individual soil particles by finger pressure alone.

COHESIVE SOIL: Clay, or soil with high clay content, which has cohesive strength. Cohesive soil does not crumble, can be excavated with vertical side slopes, and is plastic when moist. Cohesive soil is hard to break up when dry and exhibits significant cohesion when submerged. Cohesive soils include clay silt, sandy clay, silty clay and organic clay.

COMPETENT PERSON: The individual, usually the supervisor or director of rescue operations who meets the OSHA standard to determine soil profiles, safety concerns, protective mechanisms and other requirements.

CONSENSUS STANDARDS: Standards developed by a group of persons who represent a particular industry, or product that is applied to that industry. They are standards that are not legally binding but can be used by Courts to determine negligence.

CROSS BRACES: The horizontal members of a shoring system installed perpendicular to the side of the excavation or trench, the ends of which apply pressure against the either uprights or walers.

DRY SOIL: Soil that does not exhibit visible signs of moisture content.

ENDS: The part of the trench where the walls meet the end.

EXCAVATION: An opening in the earth surfaces that is wider than it is deep.

FACES OR SIDES: The vertical or inclined earth surfaces formed because of excavation work.

FAILURE: The breakage, displacement, or permanent deformation of a structural member or connection that reduces its structural integrity and its supportive capabilities.

FISSURED: A soil material that has the tendency to break along definite planes with little resistance, or a material that exhibits open cracks, such as tension cracks in an exposed surface.

FLOOR: The bottom of the excavation.

GRANULAR SOIL: Gravel, sand, or silt with little clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion, but crumble when dry and cannot be molded.

GRAVITY: The function of nature that determines an object's attraction to another object. It is caused by, and is directly proportional to, the object's mass in relation to mass of another.

HAZARDOUS ATMOSPHERE: An atmosphere that because of being explosive, flammable, poisonous, corrosive, irritating, oxygen deficient, toxic, or otherwise harmful, may cause injury, illness or death.

HYDROSTATIC PRESSURE: The pressure that results from the effects of water contained in soil.

KICK OUT: The accidental release or failure of a cross brace.

LEL: An acronym for Lower Explosive Limit, which represents the minimum concentration of product in air that will support combustion in the presence of a source of ignition.

LAYERED SYSTEM: Two or more distinctly different soil or rock types arranged in layers.

LIP: The area 360 degrees around the opening of the trench or excavation.

LOAM: A soil consisting of a friable mixture of varying proportions of clay, silt, and sand.

MOIST SOIL: A condition in which the soil looks and feels damp.
OSHA: The Occupational Safety and Health Administration that is a federal office and an agency in some states.

PCF: An acronym that describes the term pounds per cubic foot.

PPE: An acronym that describes the term personal protective equipment.

PASSIVE SOIL: A soil with no potential for movement.

PLASTICITY: The property that allows the soil to be deformed or molded, without appreciable change in total volume.

PROTECTIVE SYSTEMS: Pre-engineered systems designed to protect employees from cave-ins, collapse, falling material and other equipment.

RAMP: An inclined walking or working surface used to enter one point from another, and is constructed from each or other structural materials such as steel or wood.

SABA: The acronym used to describe the supplied air breathing apparatus.

SATURATED SOIL: A soil in which the voids are filled with water. Saturation does not require flow. Saturation or near saturation is necessary for the proper use of a pocket pentrometer or sheer vane soil testing devices.

SHEETING: Sheets of timber or Finn Form panels used in contact with the walls of the trench. They function as a shield system.

SHIELD (SHIELD SYSTEM): Permanent or portable structures designed to withstand the forces of a collapse or cave-in, such as trench boxes, rabbit boxes, coffins, etc.

SHORE: Horizontal members installed perpendicular to the wall of a trench, in which the ends press against the uprights, wales, or panels to create pressure zones and support.

SHORING: A system made of timber, metal, hydraulic, or mechanical members that support the walls and prevent cave-ins. Used to support sheeting in conventional rescue operations.

SILT: An earth matter made mostly of sand that is carried by water and deposited as sediment.

SLOPING: Excavating the walls so that they incline away from the trench or excavation at a predetermined angle according to the soil profile to prevent cave in or soil movement.

SPOIL PILE: The dirt taken out of the trench and piled alongside of the trench. The spoil pile must have a two-foot setback from the trench lip if greater than 4’ deep, one -foot, (1’), setback for trenches less than 4’.

STRUCTURAL RAMP: A ramp built of steel or wood, used for vehicles access. Ramps made of soil or rock are not considered structural ramps.

TABULATED DATA: Tables and charts representing information approved by a registered engineer and used to design and construct a protective system. These are found in the shoring tables in the OSHA manual and may be constructed by your own engineer but must show "pre-engineered data".

TSF: The acronym for the term tons per square foot.

TOE: The area where the walls and floor intersect. A 90-degree angle at the bottom of the trench and up the wall two feet.

TRENCH: An opening in the ground that is deeper than it is wide.

TYPE A SOIL: A soil with an unconfined compressive strength of 1.5 tons per square foot or greater.

TYPE B SOIL: A soil with an unconfined compressive strength of greater than 0.5 tons per square foot (tsf), but less than 1.5 tsf.

TYPE C SOIL: A soil with an unconfined compressive strength of less than 0.5 tons per square foot.

UNCONFINED COMPRESSIVE STRENGTH: The force or load per unit area, as calculated with a penetrometer or other device and stated numerically in tons per square foot that determines the point at which a soil will fail in compression.

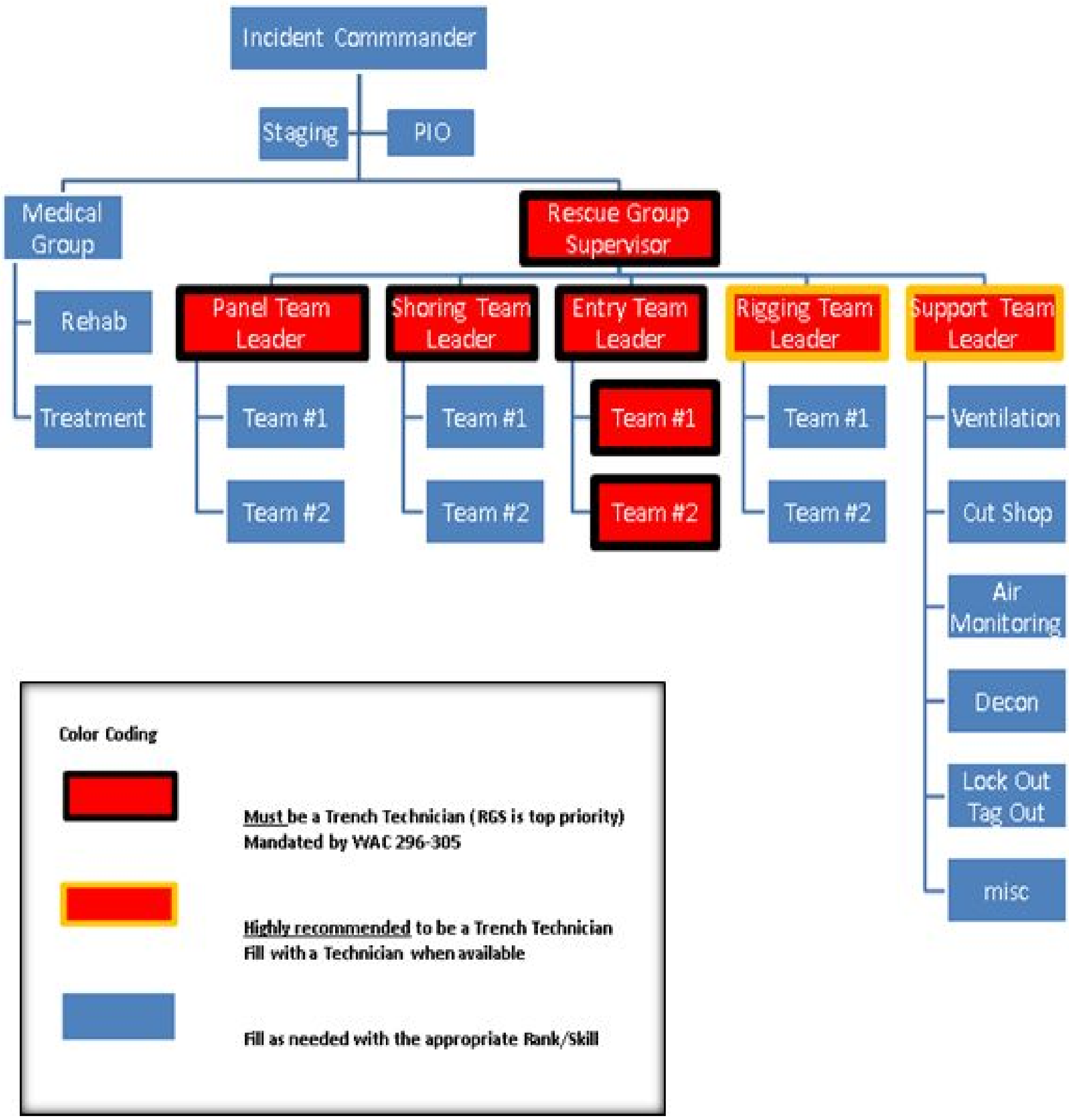
UPRIGHTS: Vertical members placed in contact with the walls, or panels. They may or may not contact each other, and more than one upright may be used on each panel system.

WALERS: Horizontal members of a shoring system placed parallel to the walls whose sides bear against the uprights or the excavation shoring system of face. Walers can be 6x6, 8x8 or 10x10 wood timbers or various steel and aluminum components.

WET SOIL: A soil that contains more moisture than moist soil but is in such a range of values that the cohesive material will slump or begin to flow when vibrated.

Trench Rescue

Organizational Chart



PARATECH TABULATED DATA

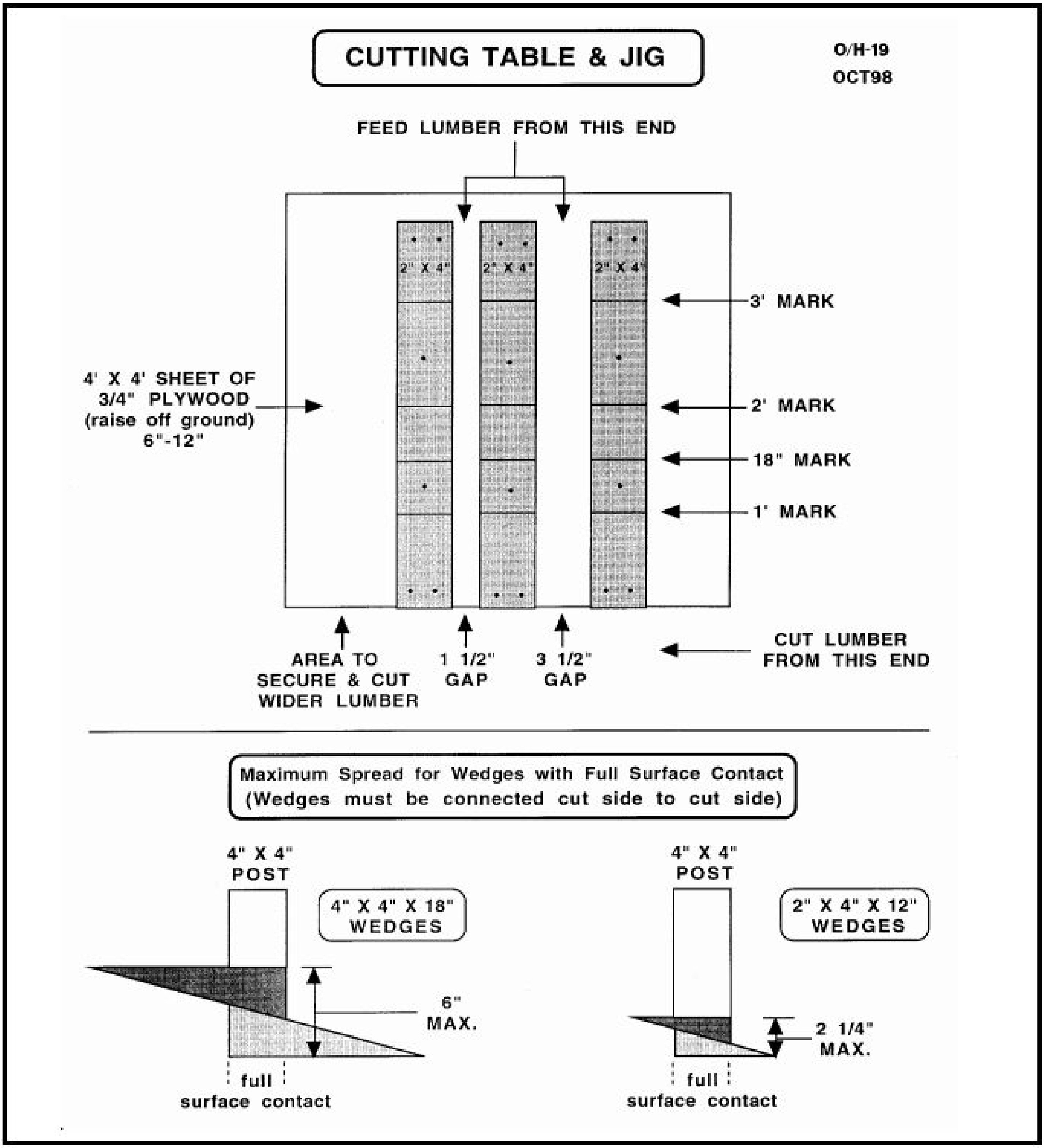
Table 2-6. Trench Work Collapse Spacing Chart
Type C - 60 Soils

AcmeThread and LockStroke Struts Only

Trench Depth (ft)	Trench Width (ft)	Horizontal Spacing (ft)	Vertical Spacing (ft)
4 to 8	Up to 4	6	4
	4 to 8	4	4
	8 to 12	2	2
	12 to 16	2	2
8 to 12	Up to 4	4	4
	4 to 8	3	4
	8 to 12	NA	NA
	12 to 16	NA	NA
12 to 16	Up to 4	3	4
	4 to 8	2	4
	8 to 12	NA	NA
	12 to 16	NA	NA
16 to 20	Up to 4	2	4
	4 to 8	2	2
	8 to 12	NA	NA
	12 to 16	NA	NA

NOTE: A strut must be within 2 ft (0.6 m) of the top and bottom of the trench. Use 150 PSI (10.3 Bar) installation pressure for Table 2-4 (Type A Soils). Use 200 PSI (13.8 Bar) installation pressure for Table 2-5 (Type B Soils). Use 200 PSI (13.8 Bar) installation pressure for Table 2-6 (Type C Soils).

- Soil types are to be determined by a competent person.
- Charts are based on soil types defined in OSHA CFR 29 sub part P March 1996.
- Paratech Rescue Struts should be used with Finn Form panels minimum of 0.75" thick and 14 ply, with 2" x 12" strong back down the center of plywood.
- Note: The Rescue Struts must be within 2ft (0.6m) of the top and bottom of the trench.
- Installation pressure should be 200-250 psi depending on the soil classification.


CUTTING TABLE & JIG
O/H-19
OCT98
FEED LUMBER FROM THIS END
2" X 4"
2" X 4"
2" X 4"
3' MARK
2' MARK
18" MARK
1' MARK
4' X 4' SHEET OF
3/4" PLYWOOD
(raise off ground)
6"-12"
AREA TO
SECURE & CUT
WIDER LUMBER
1 1/2"
GAP
3 1/2"
GAP
CUT LUMBER
FROM THIS END
Maximum Spread for Wedges with Full Surface Contact
(Wedges must be connected cut side to cut side)
4" X 4"
POST
4" X 4" X 18"
WEDGES
6"
MAX.
full
surface contact
4" X 4"
POST
2" X 4" X 12"
WEDGES
2 1/4"
MAX.
full
surface contact

White	PROPOSED EXCAVATION
Fluorescent Pink	TEMPORARY SURVEY MARKINGS
Red	ELECTRIC POWER LINES, CABLES, CONDUIT AND LIGHTING CABLES
Yellow	GAS, OIL, STEAM, PETROLEUM OR GASEOUS MATERIALS
Orange	COMMUNICATION, ALARM OR SIGNAL LINES, CABLES OR CONDUIT
Blue	POTABLE WATER
Purple	RECLAIMED WATER, IRRIGATION AND SLURRY LINES
Green	SEWERS AND DRAIN LINES

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Drake Walters, Paratech (Ret), LN Curtis & Sons
Captain Bill Henderson, Kirkland Fire Department
Firefighter/Engineer Andrew Rockwell, Bellevue Fire Department
Engineer Travis McKenney, South King Fire & Rescue
Captain Matt Lemanu, North Highline Fire Department

TRENCH RESCUE
"ABOVE ALL DO NO HARM"