Cecil V. "Buddy" Martinette, Jr., *and* Ron "Z" Zawlocki

Trench Rescue

Principles and Practice to NFPA 1006 and 1670

THIRD EDITION

Chapter 1

Introduction to Trench Rescue

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Trench Rescue Decision Making

- It is always easier to surmise what you might have done, especially after the results of the decision are known.
- Our objective should be to avoid getting into dangerous or risky situations in the first place.

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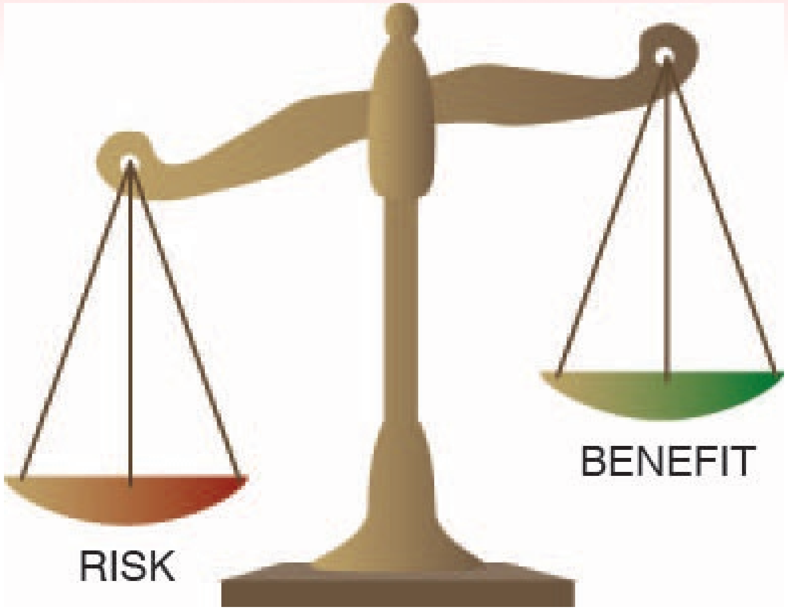
Risk–Benefit Analysis

- Training is key
- Rescue versus recovery
  - A rescue involves a victim who can be saved by your intervention.
  - A recovery involves a dead body and should never be considered an emergency.
  - Evaluate each collapse situation and determine a victim survivability profile.



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Risk–Benefit Analysis

- Risk to the rescuer
  - Does the team stand a fair chance of performing a successful rescue without any member being killed or injured?
- Benefit to the situation
  - There is no benefit to saving a body or property if that action requires risk to your personnel.

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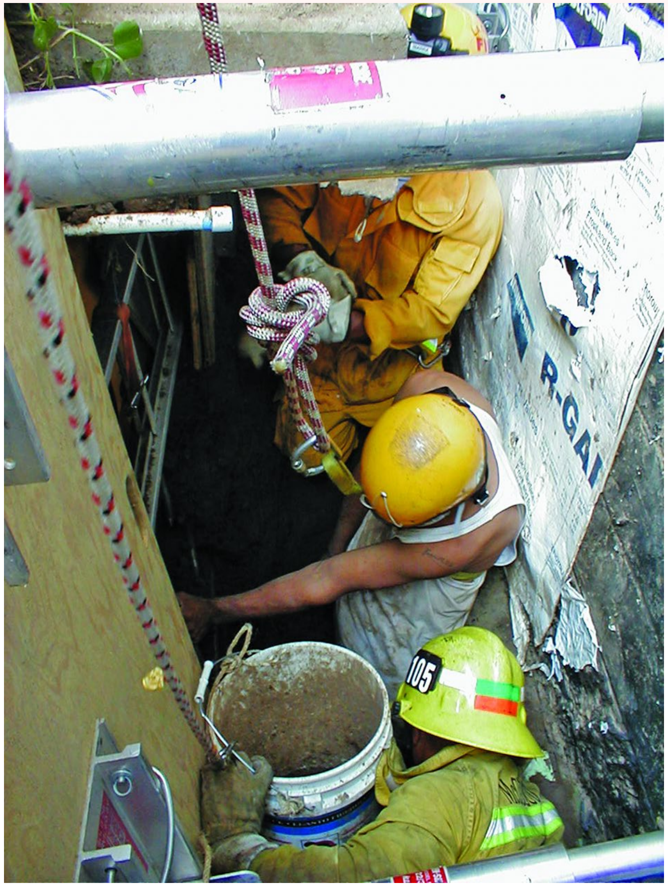
Risk–Benefit Analysis

- Head versus heart decision making
  - Compassion kills
  - Act responsibly regarding your own and others' safety during trench accident mitigation.



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The FAILURE Acronym

- **F**ailure to understand, or underestimating, the environment
- **A**dditional medical implications
- **I**nadequate rescue skills
- **L**ack of teamwork and experience
- **U**nderestimating logistical needs
- **R**escue/recovery mode not considered
- **E**quipment not mastered

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The FAILURE Acronym

- **F**ailure to understand or underestimating the environment
  - Environmental factors:
    - Weight of soil
    - Instability of the trench after the primary collapse
    - Kinetic energy in wall movement
    - Atmospheric conditions
    - Wet or dry conditions

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The FAILURE Acronym

- **A**dditional medical implications
  - There are specific medical needs of a trench collapse victim (crush syndrome).
  - Failure to provide adequate patient care may lead to fatalities.
- **I**nadequate rescue skills
  - Know your limitations.
  - Doing nothing is better than doing something wrong.

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The FAILURE Acronym

- **L**ack of teamwork and experience
  - Team integrity
  - Team processes
  - Team efficiency
  - Are all integral parts of being able to function at the “high performance end and not the dysfunctional end of the team scale”

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The FAILURE Acronym

- **U**nderestimating logistical needs
  - External resources
  - Trained teams
  - Special resources
- **R**escue/recovery mode not considered
  - Do not commit resources to a questionable situation to recover a body.
  - Do not let compassion override good, common sense.

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The FAILURE Acronym

- **E**quipment not mastered
  - Equipment is often specifically designed for trench rescue operations.
  - Rescuers should know the equipment inside and out.

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Causes of Trench Collapse Emergencies

- Noncompliance
  - Contractors must evaluate the cost for a given system.
  - Socioeconomic and demographic issues apply.
- Accidents without a cave-in: many trench emergencies are not collapses.

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Equipment Failure and Load Management

- Backhoe- or excavator-caused problems

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- Rigging

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Atmospheric Concerns

- Recognize that hazardous materials may be buried underground.
- Know that it is impossible to determine what someone may have buried.
- Use extreme caution.

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Rules and Regulations

- Application of standard varies by locality.
- OSHA requires compliance in the following circumstances:
  - An employee–employer relationship exists.
  - Trench operations is part of your job.
  - Rescuers are paid workers and not volunteers.

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Rules and Regulations

- The authority having jurisdiction often determines compliance with other standards such as NFPA consensus standards.

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Rules and Regulations

- Consider the following issues when talking about the liability aspects of trench rescue operations:
  - What is the current "standard of care" for a trench rescue?
  - Which guidelines do similar teams follow?
  - Do you comply with other OSHA or NFPA standards?

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OSHA CFR 1926 Subpart P, Excavations

- Understanding the excavation standard will give you the data and information needed to decide on appropriate protective systems and safety requirements for trenches.
  - Can be universally applied to any given rescue operation by using the toolbox approach

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OSHA CFR 1926 Subpart P, Excavations

- Knowledge of the standard, its requirements, protective systems, and soil classifications will qualify the user as a competent person according to the standard.

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OSHA CFR 1926 Subpart P, Excavations

- The current OSHA standard, OSHA CFR 1926 Subpart P, Excavations, was originally a part of the Contract Work Hours Standard Act.
  - Requirements were very confusing.
    - Led to inadvertent noncompliance and insufficient criteria for protective system design.
  - The current standard retains a lot of information from the original act.
    - It has been clarified to ensure that the requirements can be better understood.

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OSHA CFR 1926 Subpart P, Excavations

- Chief among the changes and additions to the existing standard are the following:
  - All criteria are performance-based standards.
  - A consistent soil classification method is delineated, including the techniques used to test soil samples.
  - Fines and penalties have been increased.

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OSHA CFR 1926 Subpart P, Excavations

- The standard is divided into several key areas:
  - Scope and definitions
  - General requirements
  - Protective systems
  - Appendices

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General Requirements

- All trenches must be protected before entry, *except*
  - Trenches made entirely of stable rock
  - Trenches that are less than 5 feet in depth, have been previously inspected by a competent person, and have no indication of a potential for cave-in

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General Requirements

- Protection: any trench more than 5 feet deep, including the height of the spoil pile, must be protected
- Spoil pile: 2 feet back from the lip
- Egress: means of egress required for every 25 feet (for trenches 4 feet deep or greater)

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General Requirements

- Determination of hazards (testing)
  - Oxygen deficiency or enrichment
  - Hazardous atmosphere
  - Flammable gases

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General Requirements

- Water accumulation: protection from water by dewatering operations
- Fall protection: use a lifeline and harness
- Soil classification
- Inspection by competent person for secondary cave-in potential, protective systems failure, atmospheric monitoring, and other hazardous conditions

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OSHA's View of Trench Rescue Operations

- Time in the trench is limited, usually hours, whereas the OSHA standard regulates systems engineered to last many days.
- Rescuers are entering for a very different reason than utility workers or commercial construction workers.

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OSHA's View of Trench Rescue Operations

- OSHA will get involved in the following circumstances:
  - Civilian or rescuer injury or death as a result of a collapse
  - Death of anyone involved in a construction accident
  - Request by the authority having jurisdiction

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NFPA 1670 and 1006 Rescuer Levels

- Two very important NFPA documents guide rescue operations in the fire service:
  - NFPA 1670, Standard on Operations and Training for Technical Search and Rescue Incidents
  - NFPA 1006, Standard for Technical Rescuer Professional Qualifications
- NFPA 1670 applies to organizations and NFPA 1006 applies to the personnel who work in those organizations.

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NFPA 1670 and 1006 Rescuer Levels

- NFPA 1006 prescribes the job performance requirements (JPRs) for individuals operating at either Level I or Level II.
- While not limited to trench rescue, this document provides a listing of JPRs, divided into levels by knowledge, skills, and abilities (KSAs), for fire service personnel who perform trench rescue operations.

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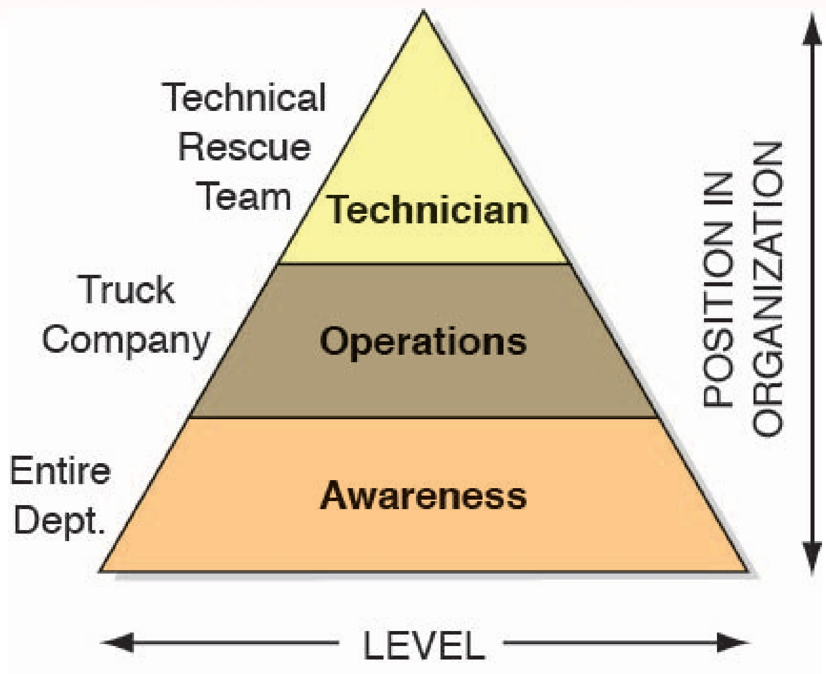
NFPA 1670 and 1006 Rescuer Levels

- NFPA 1670 prescribes various standards for organizations operating at the awareness, operations, or technician levels.



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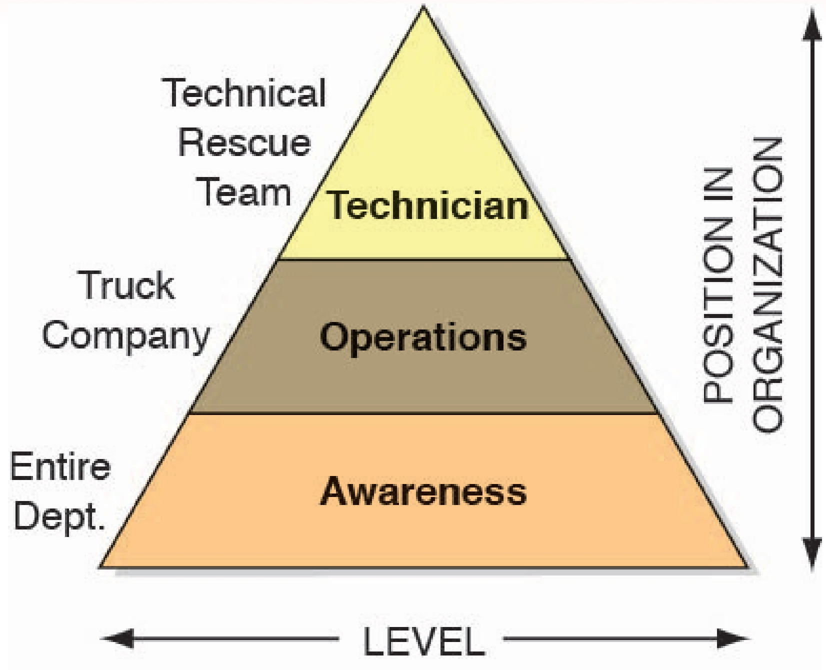
NFPA 1670 and 1006 Rescuer Levels

- Awareness level:
  - This provides information for the first responder to identify the hazards associated with collapse and its dangers.



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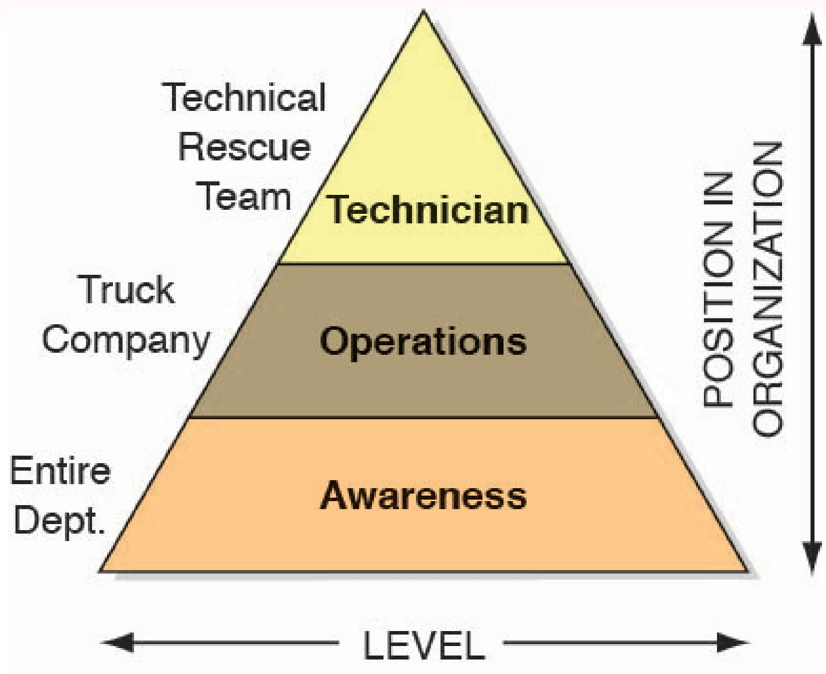
NFPA 1670 and 1006 Rescuer Levels

- Operations level:
  - Operations represents the first level at which personnel learn the necessary techniques to render certain types of collapse environments safe for subsequent rescue operations.



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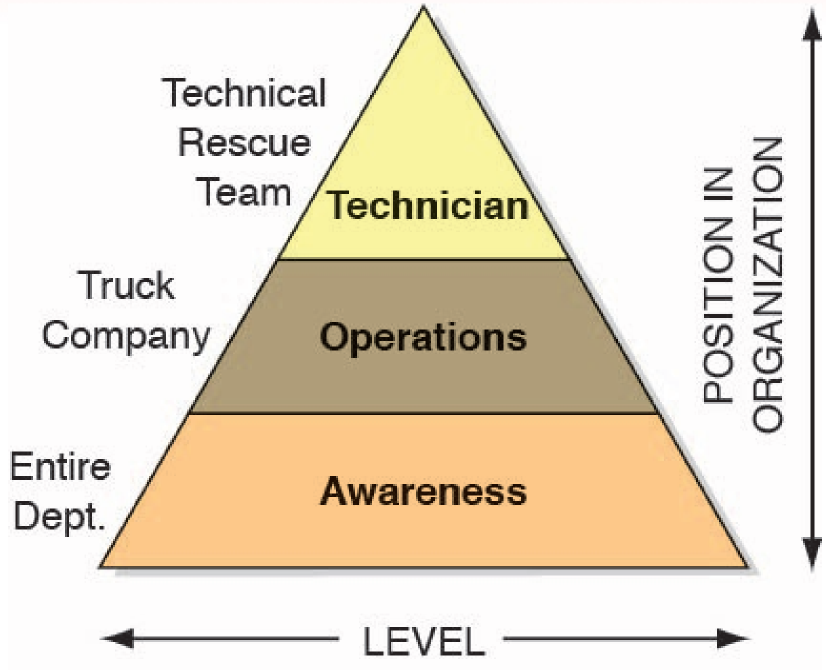
NFPA 1670 and 1006 Rescuer Levels

- Technician level:
  - The technician level involves additional training associated with intersecting and deep-wall trench rescue operations.



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NFPA 1670 and 1006 Rescuer Levels

- NFPA 1670's Chapter 11, "Trench and Excavation Search and Rescue," requires organizations that operate at the awareness, operations, and technician levels to have additional training.

Table 1-1 Additional Training Requirements by Level

Awareness	Operations	Technician
Chapter 4: General Requirements	Operations-level rope rescue	Technician-level confined space rescue
Awareness-level confined space rescue	Operations-level confined space rescue	Technician-level vehicle and machinery rescue
Chapter 4 of NFPA 472, *Standard for Competence of Responders to Hazardous Materials/ Weapons of Mass Destruction Incidents*	Operations-level vehicle and machinery rescue	
Competent person as defined in NFPA 1670 Section 3.3.20		

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Summary

- It is always easier to surmise what you might have done at a rescue incident, especially after the results of the decision are known.
- When dealing with trench rescues, your struggle will be to focus on bringing risk–benefit analysis to the forefront of your strategic decision-making process.

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Summary

- The FAILURE acronym can be used to identify specific aspects of the operation that contributed to it going wrong.
- Common causes of trench collapse emergencies are noncompliance, accidents without a cave-in, equipment failure and load management, and atmospheric problems.

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Summary

- The rules, regulations, and laws that govern our organizations are complex, with some being laws of the land, others being regulations that carry the weight of law, and still others being consensus standards that do not carry the weight of law but are considered best practices.

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Summary

- Understanding OSHA CFR 1926 Subpart P, Excavations, will give you the information needed to decide on appropriate protective systems and safety requirements for trenches.

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Summary

- Generally, OSHA will get involved at an incident if:
  - A death occurs as a result of the collapse.
  - A death occurs as a result of a construction accident.
  - The authority having jurisdiction requests its involvement.

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Summary

- Two very important NFPA documents guide rescue operations in the fire service: NFPA 1670, Standard on Operations and Training for Technical Search and Rescue Incidents, and NFPA 1006, Standard for Technical Rescuer Professional Qualifications.

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Trench Rescue

Principles and Practice to NFPA 1006 and 1670

THIRD EDITION

Chapter 2

Preparing the Rescue System

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The Big Three of Technical Rescue

- Special people
- Special equipment
- Special training

Courtesy of Nigel Letherby

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Special People

- Differ from traditional fire and rescue service providers
- Operate in extremely dangerous, unforgiving, and unpredictable environments with limited resources
- Subject to peer criticism
- Endure intense training to maintain proficiency in situations that do not occur often
- Ultimately, the foundation of success in specialized rescue is rooted in the people who make up the team.

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Special Equipment

- Vital to the rescue effort
- Highly technical
- Expensive and requires frequent training to maintain proficiency

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Special Training

- A training program that is solid, realistic, and practical
- Special equipment will seem foreign without training in its operation
- Practice often and hard

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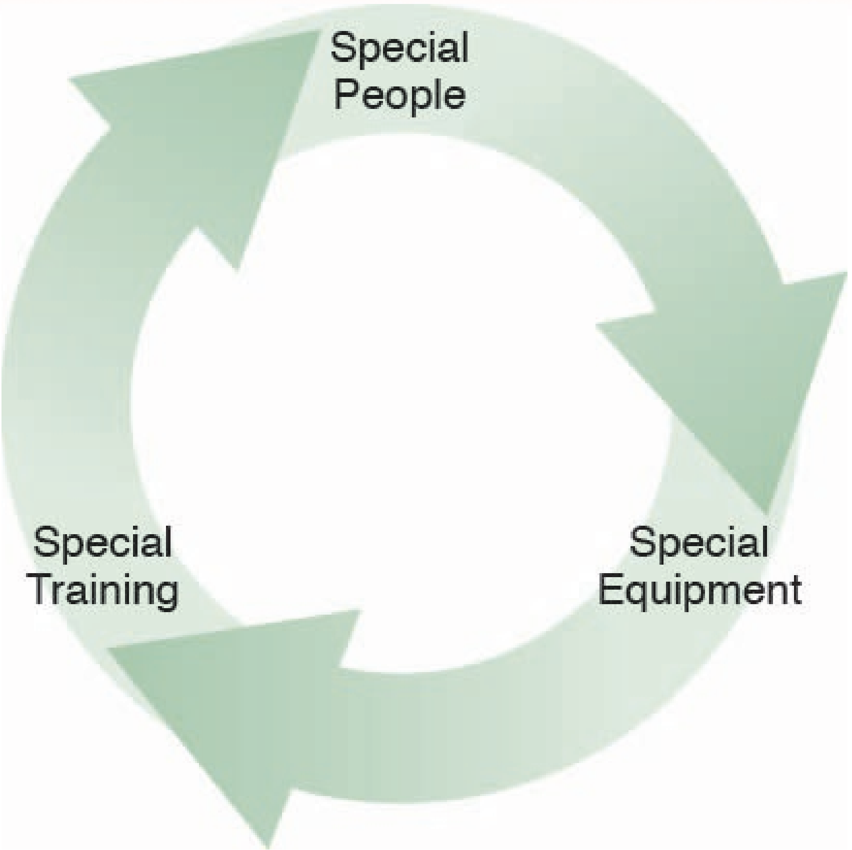
The Specialized Training Cycle

- Constant circle of evaluation
  - Your people
  - Your equipment
  - Your training
- Invest equally in all aspects of the rescue training cycle for a team to maintain proficiency.



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Service Delivery Systems

- Self-sufficient rescue system
  - Requirements
    - Strong commitment to training
    - Specialized equipment
    - Means of transporting equipment to emergency scenes
  - Best method to ensure community preparedness
  - Most expensive, difficult, and time-consuming method

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Service Delivery Systems

- Community-dependent system
  - Requirements
    - Seek out community members with construction and evacuation experience
    - Create a resource call list
    - Determine necessary logistical needs
    - Create a supply list and distribute it to specific vendors
  - Most feasible method because of infrequency of events
  - Personnel must still be adequately trained

Trench Resource List

Name	Item	Contact #
Splinter's Lumber Yard	Panels, bracing	Joe (202) 555-1767
Gopher's Construction	Crane, back hoe, ventilation fan, ladders	Bob (202) 555-3347
Percy's Pumps	Wet/dry pump	Percy (202) 555-2578

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Service Delivery Systems

- Regional approach
  - Requirements
    - Written mutual aid agreements
    - Commitment of all participating organizations to train and keep personnel proficient
  - Most cost-effective method (reduces individual organizational costs)
  - Difficult to organize and maintain

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The Team

- Successful trench rescue operations are more dependent on the team than their tools.

Tips for success:

- Be physically fit
- Be mentally fit
- Be proficient in construction skills
- Include trained medical personnel
- Specialize—place the right person in the right job

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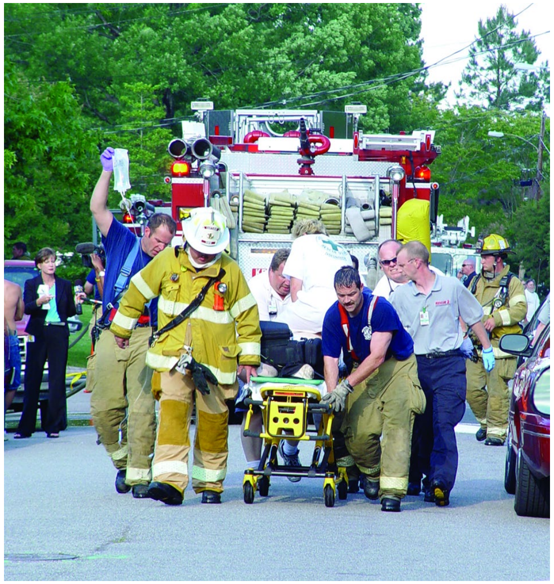

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Team Players

- Work as hard as possible to achieve a successful outcome, regardless of who made the decision or if you agree with the decision.
- Succeed at whichever job you are given.
- Learn from the mistakes of others.
- Ask for help from those with more experience

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Getting Your Equipment to the Scene

- There are many ways to store and carry equipment.
- Rescue rig—does not have to be fancy.
  - Squad truck is not appropriate—too small and narrow

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Getting Your Equipment to the Scene

- Dump truck or flat-bed vehicles are better suited to the task.
  - Big enough
  - Strong enough
  - Self-contained unit
  - Affordable
  - Can sit outside covered with a tarp when not in use

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Getting Your Equipment to the Scene

- Utility trailers (many configurations)
  - Wheelbase and chassis must support the load
  - Large enough to hold the panels (can be open or closed)
  - Disadvantage: may be difficult to maneuver
  - Advantage: low cost and low maintenance

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Getting Your Equipment to the Scene

- Pod system
  - Designed for a specific purpose
  - Truck takes the appropriate pod for the situation

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Getting Your Equipment to the Scene

- Custom and converted vehicles
  - Advantage: splits available storage space
  - Disadvantage: may be quite large

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Getting Your Equipment to the Scene

- Rescue trucks
  - Fire apparatus manufacturers have begun designing and building apparatus specifically for specialized rescue functions.
  - Special apparatus can carry everything from ropes and extrication equipment to shoring panels and concrete cutting saws.

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Summary

- Failure to integrate the Big Three—special people, special equipment, and special training—into an active trench rescue program will result in a weak and potentially flawed system.
- Ultimately, success in specialized rescue is rooted in the people who make up the team.

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Summary

- It is vitally important to the rescue effort that the rescuers be provided with the equipment required to do the job safely and effectively.
- Often, people think that they know their equipment, but when the pressure is on, they struggle with using it correctly and effectively. Sufficient training can prevent this problem.

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Summary

- The development of the Big Three as it applies to teams takes place in a constant circle of evaluation called the specialized training cycle.
- Service delivery systems can be self-sufficient, community dependent, or regional, depending on the needs and resources of the rescue organization.

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Summary

- Trench rescue personnel must be both physically and mentally fit to meet the demands of long-term or otherwise difficult operations.

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Summary

- Once a risk–benefit analysis has been completed and a rescue plan developed, it is the duty of every team player to work as hard as possible to achieve a successful outcome in a given situation, regardless of who made the decision.

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Summary

- Many teams use a dump truck, flat-bed vehicle, or box truck to transport specialized equipment. The back of such a unit is big enough and the chassis strong enough to handle the type of weight represented by shores and panels.

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THIRD EDITION

Chapter 3

Soil Classification and Testing

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Soil Classification

- The system of classifying soils is a hierarchical approach to determine the performance of a soil based on a decreasing order of stability.

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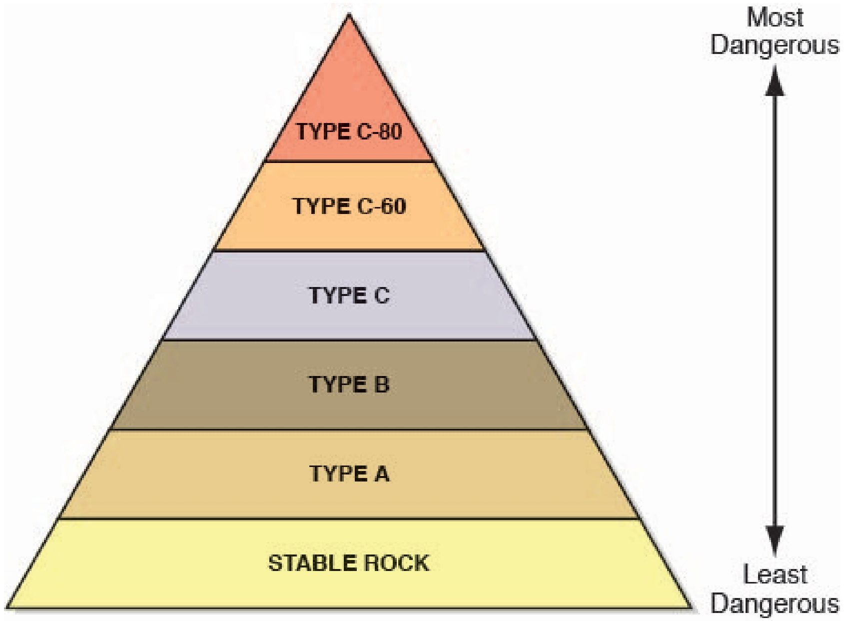
Soil Classification



- The results of a rescue soil assessment are used to identify soil conditions and the level of danger associated with them.

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Soil Classification

- OSHA requires all classifications to be determined based on one visual test and one manual test performed by a competent person.
  - Many of the manual tests recognized by OSHA are not practical for use at rescue incidents.

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Soil Classification

- Rescuers should use visual and manual assessments to help them gauge the risk involved in any potential collapse situation.

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Types of Soil

- Stable rock
  - Least likely to collapse
  - Natural solid material that can remain standing after excavation
  - Dangers generally come from anything except a collapse.

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Type A

Courtesy of Ron Zawlocki

- Cohesive materials with an unconfined compressive strength of 1.5 tons per square foot or greater
- Examples: clay and cemented soils
- Stable and less likely to collapse

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Type A

- Soil is not considered type A if any of the following conditions is present:
  - Fissured soil
  - Soil subject to vibration
  - Previously disturbed soil
  - Soil with a slope greater than 4 feet horizontal to 1 foot vertical
  - Soil subject to other factors that would require them to be classified as less stable materials

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Type B

- Cohesive materials with an unconfined compressive strength of greater than 0.5 tsf but less than 1.5 tsf
- Granular cohesionless materials including angular gravel, silt, silt loam, sandy loam, sandy clay loam
- Previously disturbed soils with the exception of type C soils
- Type A soils that are fissured or subject to vibration
- Materials with a slope steeper than 4 feet horizontal to 1 foot vertical

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Type C

- Cohesive materials with an unconfined compressive strength of 0.5 tsf or less
- Granular soils, sand, and sandy loam
- Submerged soils, soils from which water is freely flowing, submerged rock that is not stable
- Sloped or layered systems with a slope of 4 feet horizontal to 1 foot vertical or steeper

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Types of Soil

Type B soil

Courtesy of Ron Zawlocki

Type C soil

Courtesy of Ron Zawlocki

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Other Soil Classifications

- Other classifications of soil not listed in OSHA standard
- C-60: moist and cohesive or moist and granular that does not fit the type A or B profile
- Also includes C-80 and similar soils
- Tabulated data must be approved by registered professional engineer

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Types of Soil

Table 3-1 Soil Types

Type	Characteristics	Concerns
Type A	• Soil is clay or a mix with mostly clay. Soil plasticity is present. Fissures and other signs of movement are not present. Spoil piles maintain steeper (greater than 56 degrees) angles of repose. • Unconfined compressive strength of 1.5 tons per square foot (tsf) or greater.	• Unusual conditions for a rescue response because the soil is stable and less likely to collapse. • If soil shows signs of movement (fissures, sloughing, raveling, or collapse), or if the trench has been subjected to vibrations, install a shoring system that is strong enough to support C-60 soil.
Type B	• Mixed soil with less clay. Includes granular soil with more than 15% clay. Fissures and other signs of active soil (sloughing or raveling) may be present. Includes previously excavated soils that are not type C soils. Spoil pile angle of repose is 34–55 degrees. • Includes cohesive soil with unconfined compressive strength of 0.5–1.5 tsf.	• The most common type of soil for a rescue response. Soil often looks fairly compact and stable when it is first dug, but becomes active with time. If soil shows signs of movement (fissures, sloughing, raveling, or collapse), or if the trench has been subjected to vibrations, install a shoring system that is strong enough to support C-60 soil.
Type C	• Granular, sand and sandy loam (mix). Can include submerged soil. Spoil pile angle of repose less than 34 degrees. • Includes cohesive soils with unconfined compressive strength less than 0.5 tsf.	• Unstable and heavy soil that is further categorized as either C-60 or C-80. The numbers 60 and 80 represent the lateral pressure (per square foot of exposed wall) times depth.
C-60	• Includes weak/unstable soil types that will stand long enough to install shoring and have a water level at or below the bottom of the excavation.	• In type C soils and in all soils, whenever a cave-in has occurred, rescuers should install shoring systems that are strong enough to support C-60 soil unless the soil has C-80 characteristics.
C-80	• Soil that will not stand up long enough to install shoring. Water level above the bottom (floor) of the trench. Moving soil that looks like wet concrete, mud, or quicksand.	• Conventional trench rescue shoring (panels/struts and wales) is not effective in C-80 soils. Trench boxes, sloping, and sheet piling are commonly used techniques.

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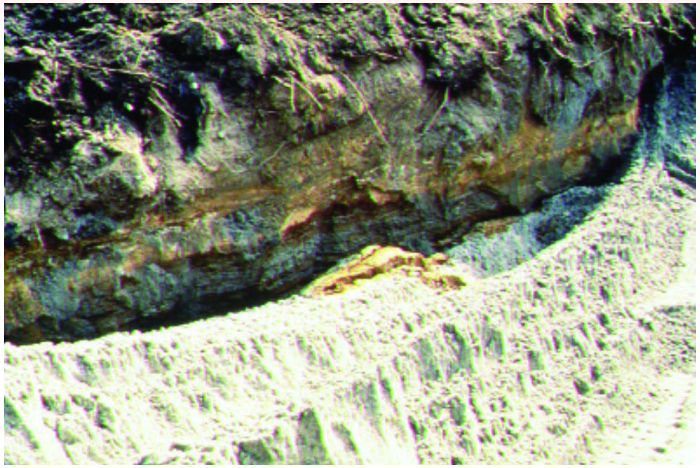
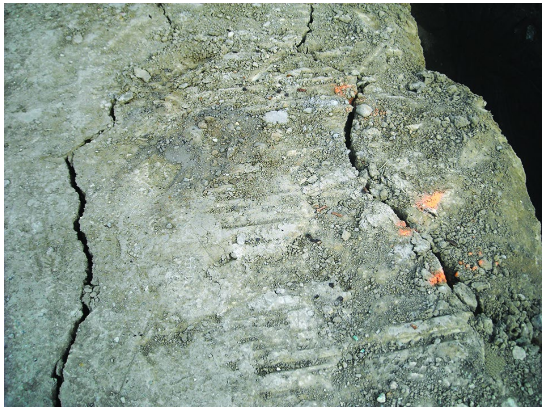
Soil Testing for the Competent Person

- Visual test
  - Walls of trench
  - Excavated material
  - Clumping of excavated soil
  - Fissures and tension cracks



Courtesy of Cecil V. "Buddy" Martinette, Jr.



Courtesy of Ron Zawlocki

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Visual Test

- Water

Courtesy of Cecil V. "Buddy" Martinette, Jr.

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Manual Test

- Plasticity test:
  - Checks the degree to which soil may be deformed or molded without any appreciable change in total volume

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Ribbon Test

- Determines how much clay or silt the soil contains

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Dry-Strength Test

- Determines the propensity of the soil to fissure

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Thumb-Penetration Test

- Estimates the unconfined compressive strength of cohesive soils

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Drying Test

- Determines the difference between cohesive material with fissures, unfissured cohesive material, and granular material

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Penetrometer and Shear Vane

Penetrometer

Courtesy of Cecil V. "Buddy" Martinette, Jr.

Shear vane

Courtesy of Geotest Instrument Corp.

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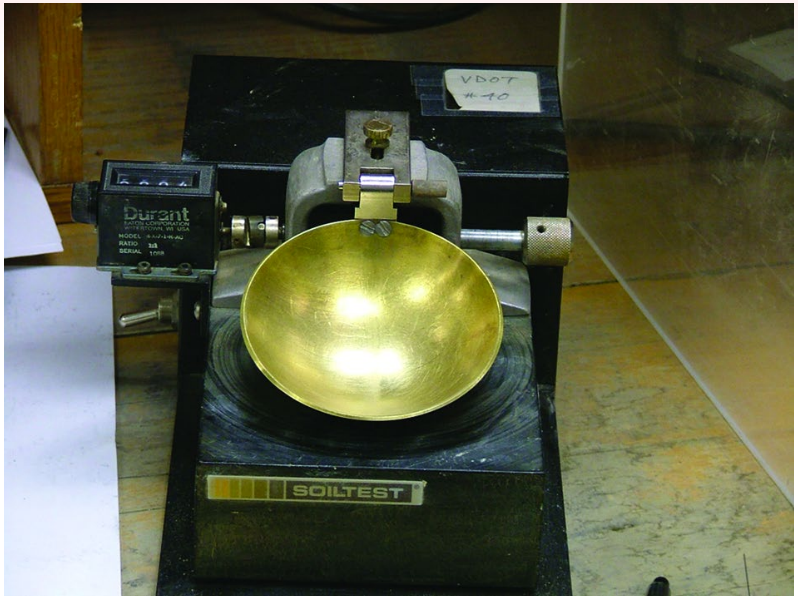
Laboratory Testing

- Atterberg test:
  - Determines liquid limit



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Laboratory Testing

- Triaxle shear test:
  - Determines direct shear strength of soil
- Consolidation test:
  - Determines the settling potential of soil
- Sedimentation test:
  - Determines the profile of the soil

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Laboratory Testing

- Nuclear moisture density gauge:
  - Measures soil density and moisture

Courtesy of DOE and Fluor Fernald

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Rescue Soil Assessment

- In reality, rescue personnel are not expected to analyze soil in the middle of an emergency.
- Every type of protective system that rescuers build should be based on the worst-case scenario
  - Type C soil

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Rescue Soil Assessment

- Focus on recognizing soil characteristics that can be used to determine the level of risk associated with the soil at each rescue incident.
  - Visual assessment:
    - Simple and does not require special equipment
  - Manual assessment:
    - This method is based on two very important aspects of soil strength
      - The breakability of the soil
      - The moldability of the soil

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Visual Assessment

- Look at the trench wall and lip area.
  - Are there signs that the soil is active?
- Indications of unstable soil include
  - Cave-in
  - Fissures
  - Sloughing
  - Raveling
  - Bulging areas

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Visual Assessment

- Look closely at the soil sample from the spoil pile.
- If the individual grains are readily apparent, it is sand or gravel base.
  - Not very cohesive
  - Has the potential to become active or fail
- If it is difficult to make out the individual grains, it is most likely cohesive.


Courtesy of Cecil V. "Buddy" Martinette, Jr.

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Visual Assessment

- Look at the spoil pile itself and the angle at which the standing soil is resting under its own weight.
  - This is the angle of repose.
- If the excavated material is lying at a somewhat steep angle, it is most likely much more cohesive than a soil for which the angle of repose is less steep.

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Visual Assessment

- Do not forget the effects that moisture can have on the spoil pile's angle.
- Free-standing time and the overall effects of drying can take what was once a cohesive and stable soil and turn it into a dangerous and active soil.

Courtesy of Scott Shahan

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Manual Assessment

- To assess moldability:
  - Simply grab a sample of soil and slowly add water.
  - As the water is added, try to mold the sample into a ball.
  - If it is moldable to any degree, it is most likely clay.
  - If you cannot mold the sample, it is mostly sand.

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Manual Assessment

- To assess breakability:
  - Find a dirt clod and stomp on it with your foot.
    - If the clod breaks, it is mostly silt.
    - If your foot breaks, it is mostly clay.
    - If there are no clots, it is sand/gravel.

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Interpreting the Assessment Results

- If all of the results from your rescue soil assessment point toward more stable soil conditions, the trench may not be in imminent danger of collapse. In this case, the standard shoring procedures should be followed.

Table 3-2	Signs of Stable and Unstable Soil
Unstable soils (higher risk)	• Signs of movement (active soil conditions) • Not cohesive (can see individual grains) • Not holding a steep angle of repose (spoil pile) • Cannot be molded (sand/silt) • No clots (sand) or clots that easily break apart (silt)
More stable soils (lower risk)	• No signs of movement (passive soil conditions) • Cohesive (cannot see individual grains) • Holding a steep angle of repose (spoil pile) • Can be molded (clay) • Clots that do not easily break apart (clay)

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Interpreting the Assessment Results

- Standard shoring procedures:
  - Protect the lip area with ground pads.
  - Use panels and shores to create a safe zone around the victim (primary shoring).
  - Expand the safe zone (with panels and shores) to provide a safe working area (usually 12 feet [3.7 m] wide) for rescuers (secondary shoring).

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Interpreting the Assessment Results

- Standard shoring procedures (Cont.):
  - Complete the shoring, making the safe zone at least as wide as it is deep, and adding supplemental shoring as needed. Your rescue shoring should be able to resist at least twice the force of C-60 soil.

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Interpreting the Assessment Results

- If any of the results from your rescue soil assessment point toward more unstable soil conditions, the victim in the trench and rescuers working on the lip may be in imminent danger from collapse.
- The level of danger increases with each assessment result (visual or manual) that indicates unstable soil conditions.

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Interpreting the Assessment Results

- Rescue soil assessment information will help you make decisions:
  - Which type of lip protection to install
  - Whether to implement temporary measures to initially protect the victim
    - Spot shores
    - Skip shores
    - Excavator buckets

Courtesy of Marc Messier

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Summary

- The system that underground construction workers use to classify soils is a hierarchical approach to determine the performance of a soil based on a decreasing order of stability.

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Summary

- Types of soil include the following:
  - Stable rock
  - Type A
  - Type B
  - Type C
  - Type C-60
  - Type C-80

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Summary

- Do not draw conclusions about a trench's safety based on its appearance; instead, rely on your knowledge of testing procedures.

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Summary

- Soil testing by a competent person includes the following tests:
  - Visual test
  - Manual test
  - Plasticity test
  - Ribbon test
  - Dry strength test
  - Thumb penetration test
  - Drying test
  - Penetrometer and shear vane tests
  - Laboratory testing

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Summary

- For trench rescue personnel, the focus is not so much knowing the specific soil type as it is recognizing soil characteristics that can be used to determine the level of risk associated with the soil at each rescue incident.

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Cecil V. "Buddy" Martinette, Jr., *and* Ron "Z" Zawlocki

Trench Rescue

Principles and Practice to NFPA 1006 and 1670

THIRD EDITION

Chapter 4

Soil Physics and Trench Collapse

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Soil Physics

- Gravity
  - Force that draws everything to the center of the earth
  - Nature’s way of reaching the lowest energy state

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Soil Physics

- Unconfined compressive strength (USC)
  - The amount of resistance that the soil has to internal pressure
- When the UCS is lower than the soil tension, soil loses its ability to stand.
- A higher UCS suggests a more cohesive soil.

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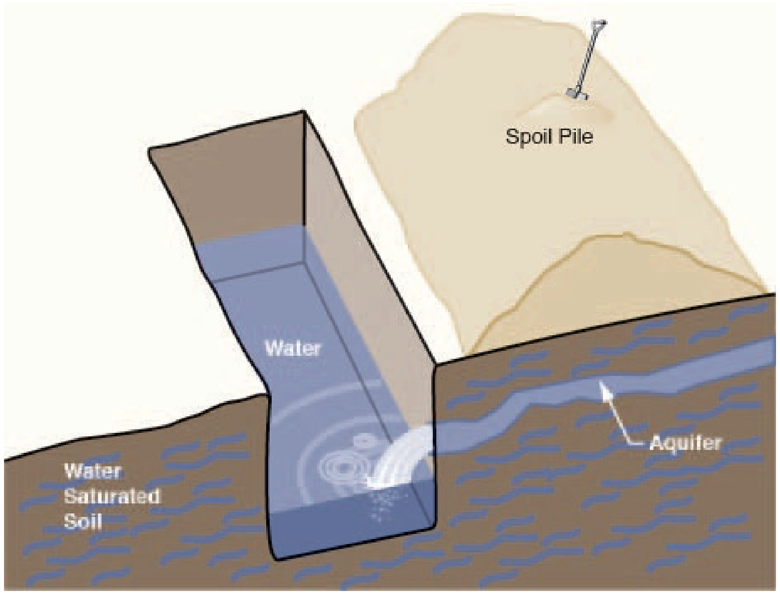
Soil Physics

- Hydrostatic pressure
  - The increased pressure caused by the addition of water to the soil profile
- Dry soil weighs between 80 and 100 pounds per cubic foot.
- Water-saturated soil can weigh as much as 150 pounds per cubic foot.



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Soil Physics

- Active and passive soils
  - Active soil has a tendency to move.
    - Results from the removal or failure of a protective system
    - Inability of the soil to hold its own weight
  - Passive soil has no tendency to move.

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Physical Forces Associated with Collapse

- Weight of soil
  - The weight of 1 cubic foot of most soil is approximately 100 pounds.
  - Dry soil is one-half rock and one-half air (82.68 pounds per cubic foot).
  - Saturated soil is one-half rock and one-half water (113.88 pounds per cubic foot).
  - The specific gravity of rock is 2.65.
  - Water weighs 62.4 pounds per cubic foot.

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Physical Forces Associated with Collapse

- Weight of soil (Cont.)
  - Rock weighs 2.65 x 62.4 = 165.36 pounds per cubic foot
  - Generally dirt weighs between 85 and 150 pounds per cubic foot.
  - On average, dirt weighs 100 pounds per cubic foot.

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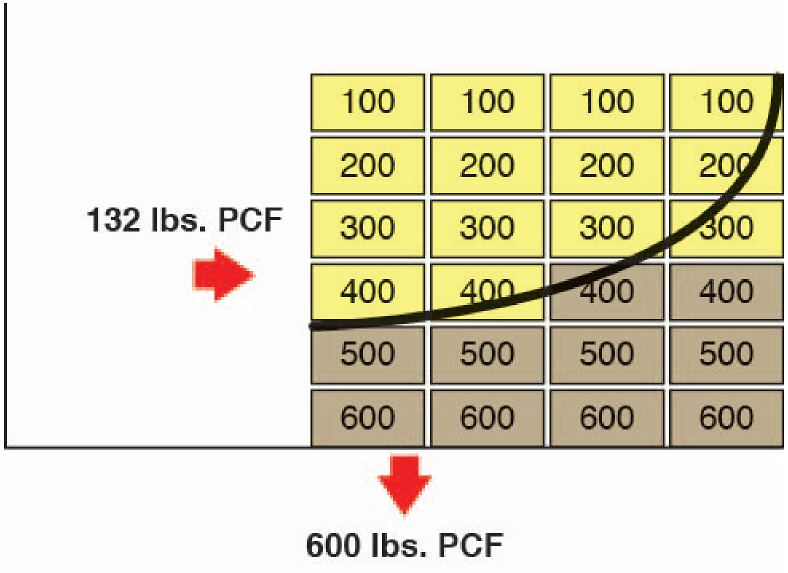
Distribution of Forces

- 100-pound-per-cubic-foot soil: 1 foot × 1 foot × 6 feet column of dirt = 600 psf
- Lateral pressure exerted on the unshored wall = 33% of total force on the bottom of any cubic foot
- In a 6-foot trench, the force at the 4-foot level = 400 psf vertical pressure



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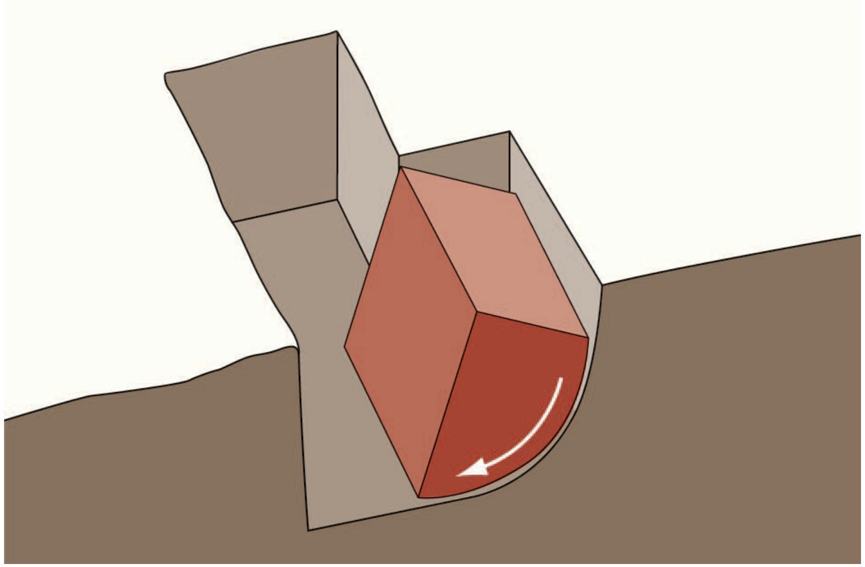
Distribution of Forces

- Rotational failure is the most prevalent type of collapse.



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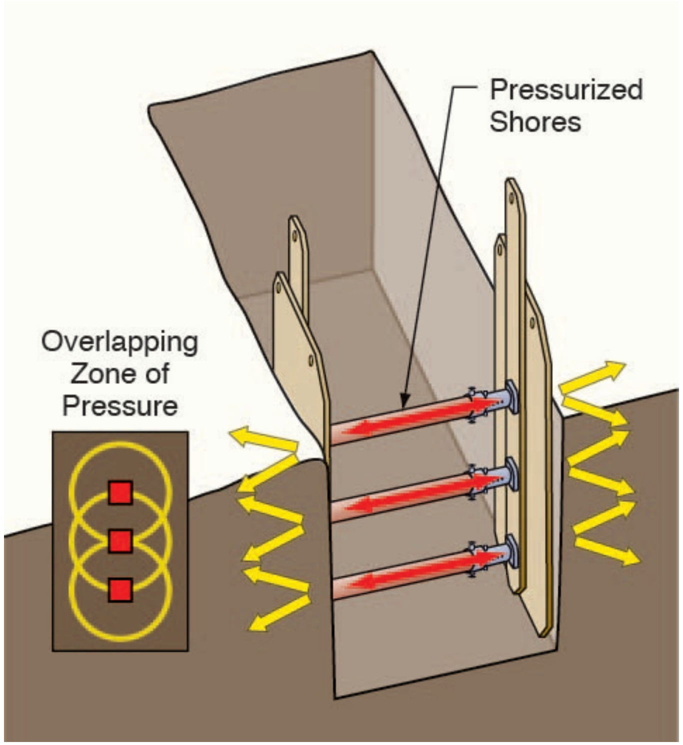
Distribution of Forces

- Properly stabilizing a trench with shoring takes pressure from one side of the trench and transmits it to the earth on the other side of the trench.



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Conditions and Factors That Lead to Collapse

- Collapse may result from one condition or the effects of several conditions:
  - The addition of water
    - Added weight to the total volume of soil
    - Absorption rate determines total weight
    - Effects of water on the soil composition

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Freestanding Time

- An open trench is subjected to environmental factors.
  - Drying, wind, and water
- The longer the trench is open, the closer you are to nature's attempt to fill it back in.

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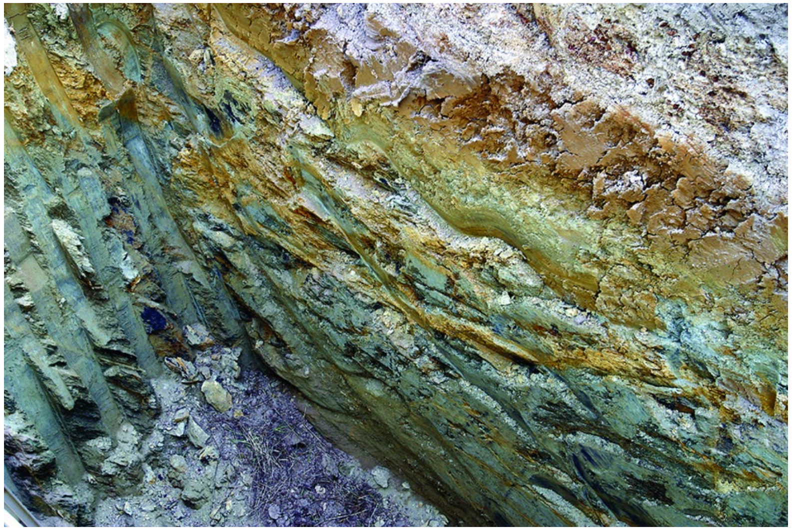
Varying Soil Profiles

- Different materials demonstrate different strengths and friction coefficients.



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Water Table

- A high water table means a heavier, more unpredictable soil.
- Know the types of soils in your response area.

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Disturbed Soils

- Such soils lack the cohesiveness of normal soil.
- Not all previously disturbed soils are dangerous.

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Heavy Equipment

- Do not let your own heavy equipment become part of the problem.

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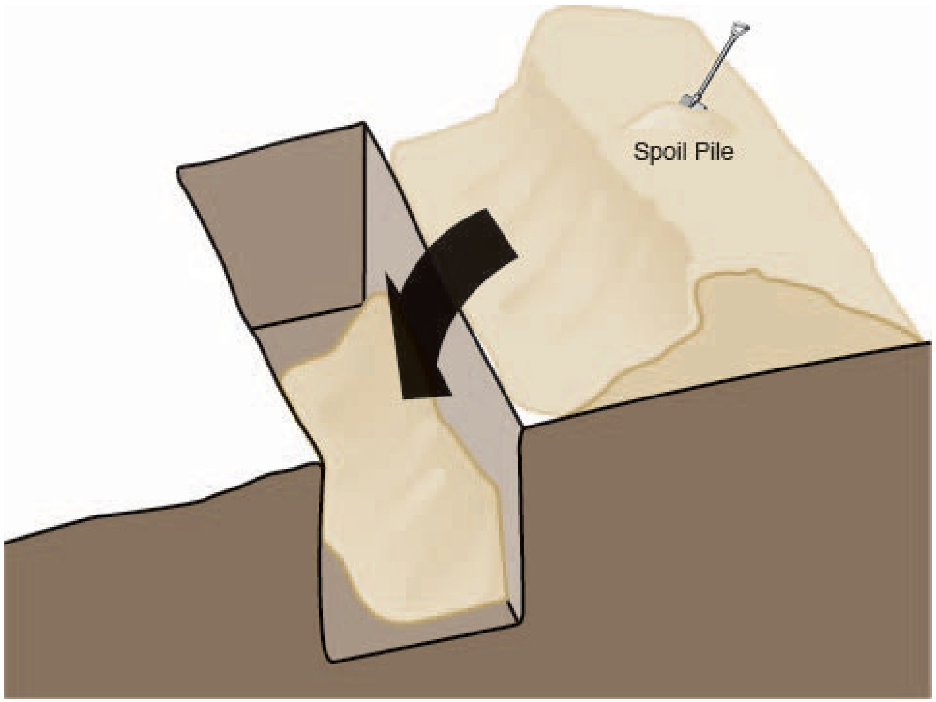
Contractor Work

- Spoil pile location
  - Adds weight to the unsupported trench wall
  - May slide back into the hole
  - Needs to be moved far enough back to alleviate a weight concern



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Vibration

- Road traffic
- Machinery

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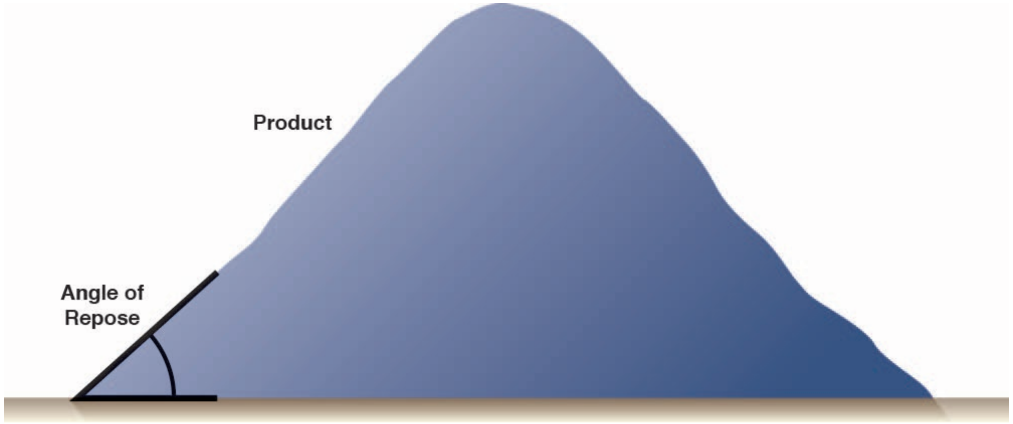
Types of Trench Collapses

- Angle of repose
  - The natural angle at which loose particulate products support their own weight
- At the natural angle of repose, loose particulates can be expected not to flow from a standing position.



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Spoil Pile Slide

- A spoil pile slide occurs when the soil's natural angle of repose is greater than its cohesive tendency.

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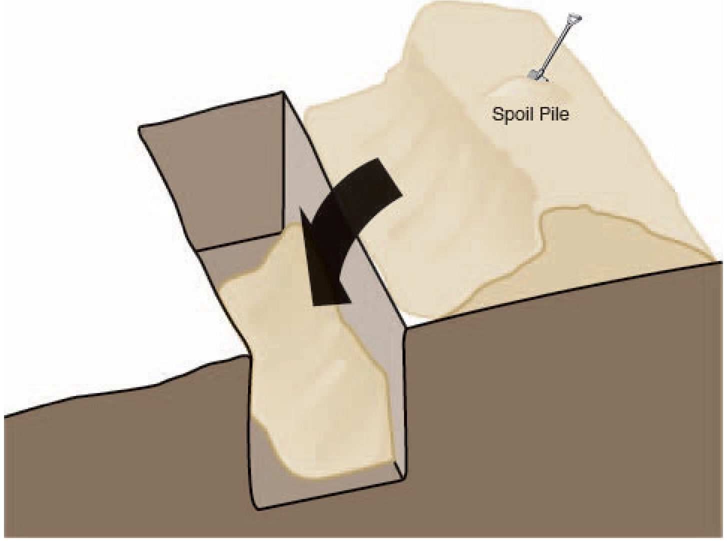
Spoil Pile Slide

- The result when excavated earth is placed too close to the trench lip and subsequently falls in the trench
- Overburden pressure:
  - The effect the weight of the spoil pile places on the trench



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Spoil Pile Slide

- Most contractors are able to recognize and prevent this hazard.
- If a spoil pile maintains any potential to become active, it must be moved.

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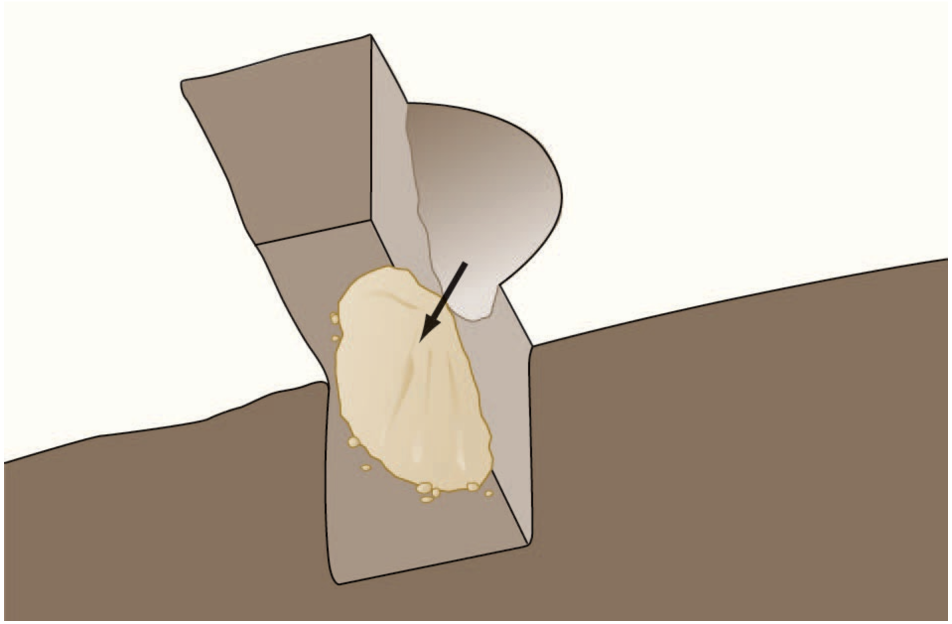
Slough Failure

- The loss of part of the trench wall starting at an area above the trench lip and extending down into the trench wall.
- Causes: unconfined hydrostatic pressure or a spoil pile placed too close to the trench lip



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Slough Failure

- Key indicators for potential slough failure
  - Cracks in and around the excavated surface and multiple soil layers
- Rotational failure
  - Another term for slough failure
  - Used to describe a scoop-shaped collapse that starts back from the trench lip and transmits itself to the trench wall in a half-moon shape that may extend to the trench floor

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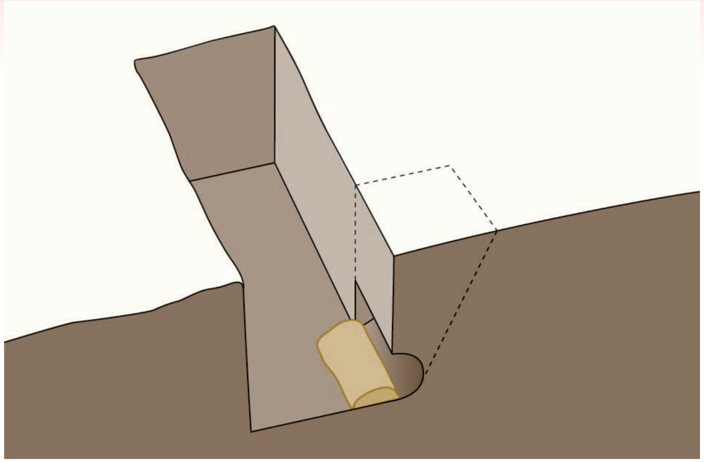
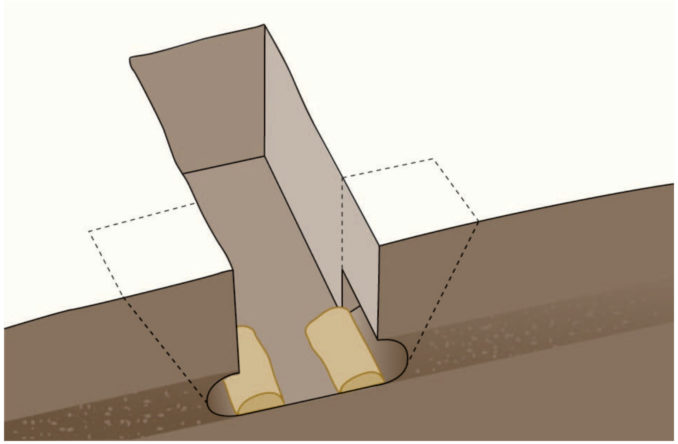
Toe Failure

- A slough that occurs at the bottom of the trench where the floor meets the wall
- A toe failure can be caused by a sand pocket or the effects of water at the bottom of the trench.





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Toe Failure

- Rescuers might not notice the toe failure until they are standing on top of it.
- A toe failure is difficult to correct until a protective system is put in place.
- Bell pier condition
  - Toe failure that occurs on both sides of the trench wall at the toe, most often as the result of a long-term toe failure

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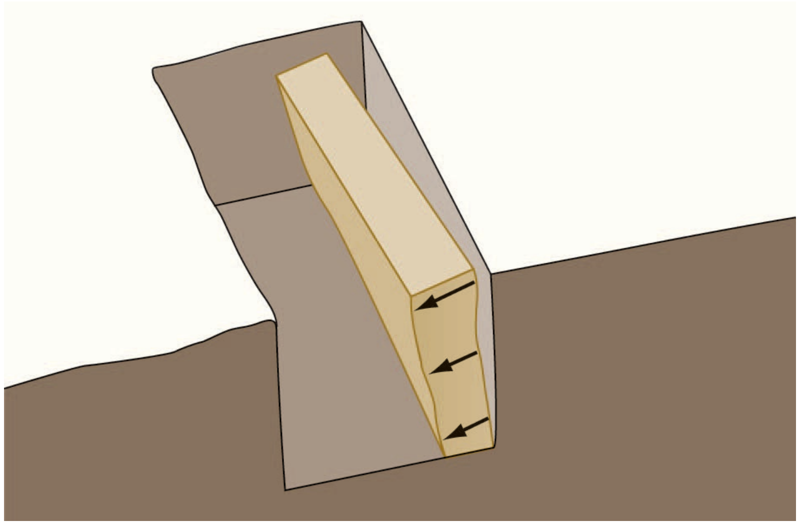
Shear Wall Collapse

- A section of soil loses its ability to stand and collapses into the trench along a mostly vertical plane
  - Often caused by cracks in the earth's surface that become exposed to the weather over time
  - Normally associated with fairly cohesive soils



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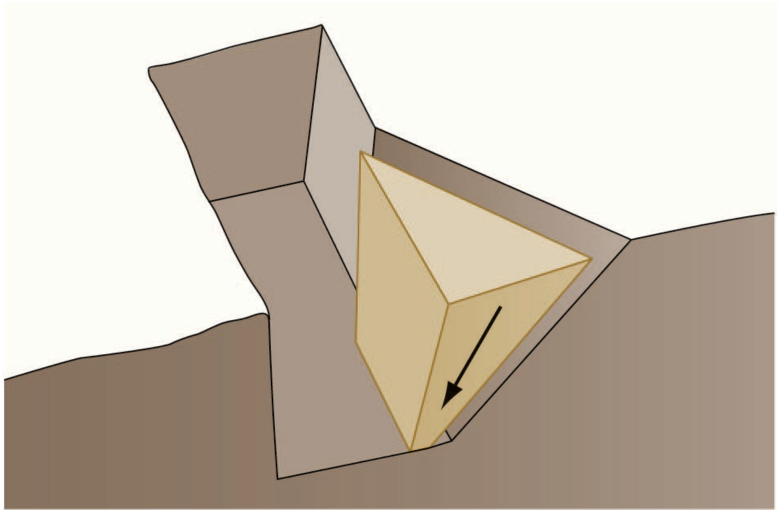
Wedge Failure

- Angled section of earth that falls from the corner of two intersecting trenches
  - Normally occurs with intersecting trenches



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Summary

- One of the keys to success in trench rescue is understanding how the various physical elements interact and contribute to a collapse situation.
- Of all of the physical factors associated with a trench collapse, probably none is as poorly understood as the weight of soil.

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Summary

- There is no definitive way to determine which one condition, or set of multiple conditions, will cause a collapse. Recognizing this complexity is key to successfully evaluating the factors that could lead to trench failure.
- Some soils initially gain strength with the introduction of water, but then at some point get saturated and become weak. Watch out for soils that look solid but are actually wet and unstable.

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Summary

- The longer the trench is open, the closer you are to nature's attempt to fill it back in.
- Because multiple layers of different materials demonstrate different strengths and friction coefficients, it is often difficult to state with any reasonable certainty how they will react in a specific scenario.

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Summary

- A high water table means a heavier, more unpredictable soil.
- Disturbed soils lack cohesiveness because they are broken and/or mixed with other soil types—that is, unless the soil has been compacted back to its original condition or density.

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Summary

- The placement of heavy equipment represents another factor that can lead to a trench collapse. The same equipment that is digging the hole causes pressure to be exerted on the unsupported trench walls. For rescuers, it is important not to let their own heavy equipment become part of the problem.

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Summary

- A contractor can expedite trench work by dropping the spoils right outside the trench to minimize swing time between scoops. The closer the spoil pile is to the trench, the faster it can be used to fill in the trench when the work is complete; however, the spoil pile adds weight to the unsupported trench wall, and part of the spoil pile may slide back into the hole.

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Summary

- Vibration can be caused by road traffic near the collapse site, the machinery digging the trench, or other machinery being operated in the area. When effecting a rescue, it is critical to limit mechanical activity in the area of a trench collapse as much as possible.

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Summary

- Familiarity with the types of collapse will help you determine the trench's potential for collapse and the proper protective system appropriate for making it safe.
- A spoil pile slide is the result of excavated earth placed too close to the lip of the trench.

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Summary

- Slough failure is the loss of part of the trench wall.
- A shear wall collapse occurs when a section of soil loses its ability to stand and collapses into the trench along a mostly vertical plane.

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Summary

- Wedge failure normally occurs with intersecting trenches and is characterized by an angled section of earth falling from the corner of two intersecting trenches.

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Cecil V. "Buddy" Martinette, Jr., *and* Ron "Z" Zawlocki

Trench Rescue

Principles and Practice to NFPA 1006 and 1670

THIRD EDITION

Chapter 5

Incident Management and Support Operations

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Incident Management

- The incident command system (ICS) is used by most fire departments to handle local emergency incidents
  - Developed to provide a coordinated interagency response
- There will always be strategic, tactical, and task levels.
  - Someone will need to be in charge, and other personnel will need to follow directions.

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Incident Management

- Dividing trench scene duties and responsibilities:
  - Allows the incident commander (IC) to implement a systematic method to handle a problem
  - Decreases the organizational span of control and provides a measure of on-scene accountability.

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Incident Management

- The level to which you develop your incident management system will depend on the magnitude of the problem and the number of resources that are present on the scene.

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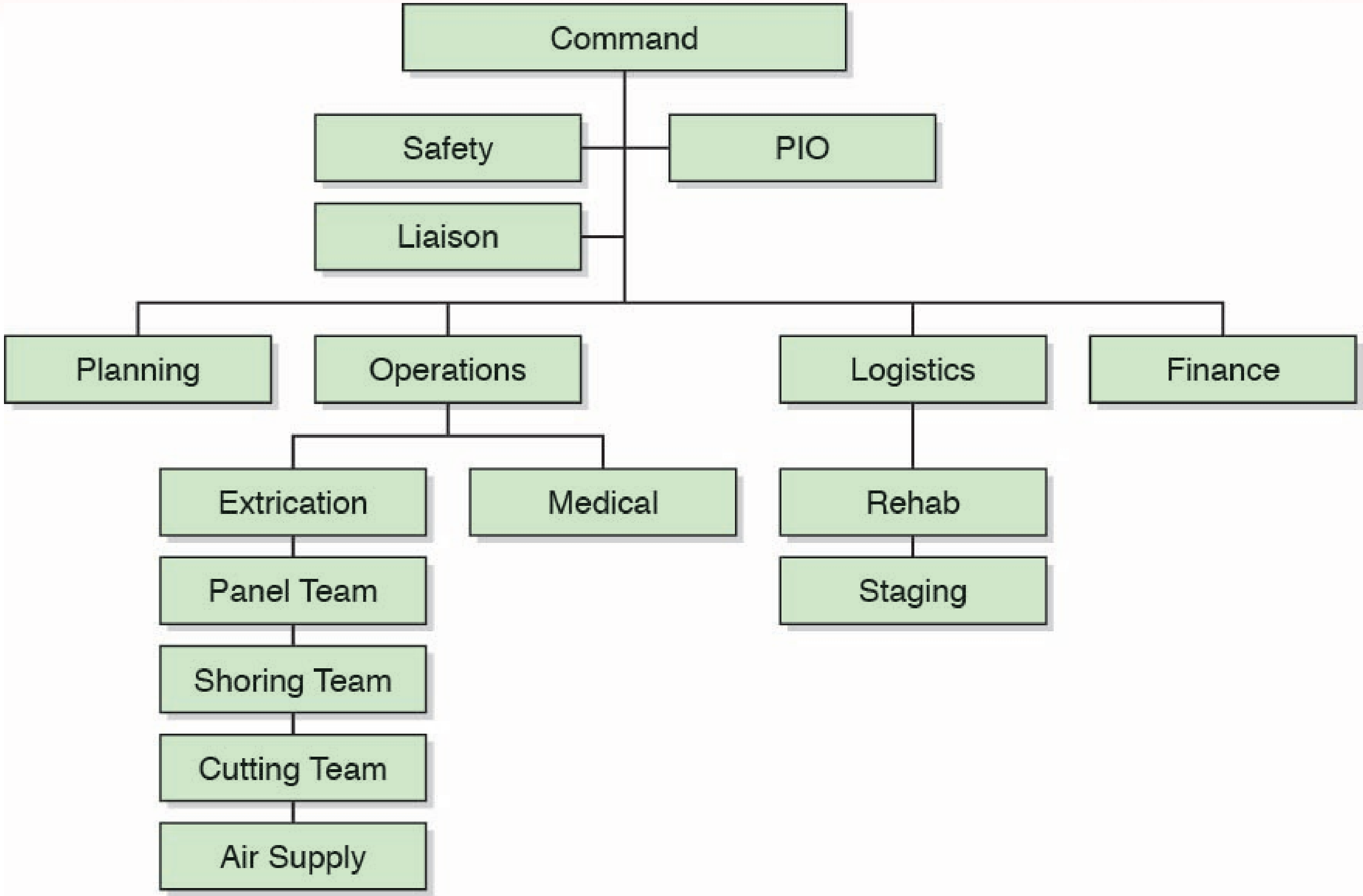
Incident Management



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The Strategic Level

- Incident commander
  - Responsible for determining and arranging the acquisition of all resources necessary to handle the incident
  - Developing the strategic goals for the operation

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Safety Officer

- Cannot simply spot unsafe acts, but rather must also anticipate activities that may lead to an accident
- Must be familiar with the environment and its potential hazards
- Conducts a safety briefing, part of the preoperational briefing

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Liaison Officer

- Conducts multiagency coordination
- Gathers critical interagency information
- Buffers the IC from information that is not critical to the operation

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Public Information Officer

- Provides the media with a direct point of contact for on-scene information
- Frequently issues updates on the progress of the rescue effort
- Educates the media regarding rescue methods and difficulties

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The Tactical Level

- Operations officer
  - Runs the incident response
  - Provides overall coordination of the rescue effort and the implementation of the tactical decisions
- Logistics officer
  - Obtains the appropriate equipment and personnel for deployment

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The Task Level

- Medical officer
  - Establishes medical control area to treat any on-scene rescuer injury and provide patient care
- Extrication officer
  - Responsible for extrication of the victim and all activities required to facilitate the rescue

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Emergency Support Functions

- Air supply operations
  - Necessary if you are considering using pneumatic air shores or air bags

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Cutting Team

- Responsible for cutting and manufacturing systems that contain wood

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Panel Team

- Required to set up, carry, and install all shields or panels

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Shoring Team and Rigging Team

- Shoring team
  - Required to assemble and install all shores and wales
- Rigging team
  - Responsible for establishing the systems by which any person or object will be lifted and/or moved during the incident

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Heavy Equipment Operations

- In some cases, trench and excavation incidents may require a heavy equipment operator.
- Careful consideration should be given to heavy equipment's proximity to the incident, because its sheer weight presents an overburden pressure on the remaining trench or extrication walls.

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Rapid Intervention Crew

- This team should be equipped for and prepared to handle everything from intervention if a secondary collapse occurs to a medical emergency involving a member of the rescue team.

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Logistics Team Manager

- Equipment and logistical support functions entail all areas of equipment storage and dissemination that take place on the scene.
- It is vitally important to keep all equipment not currently in use at a predetermined location.
  - That way, the logistics team can keep track of it and determine its availability at any given time during the emergency.

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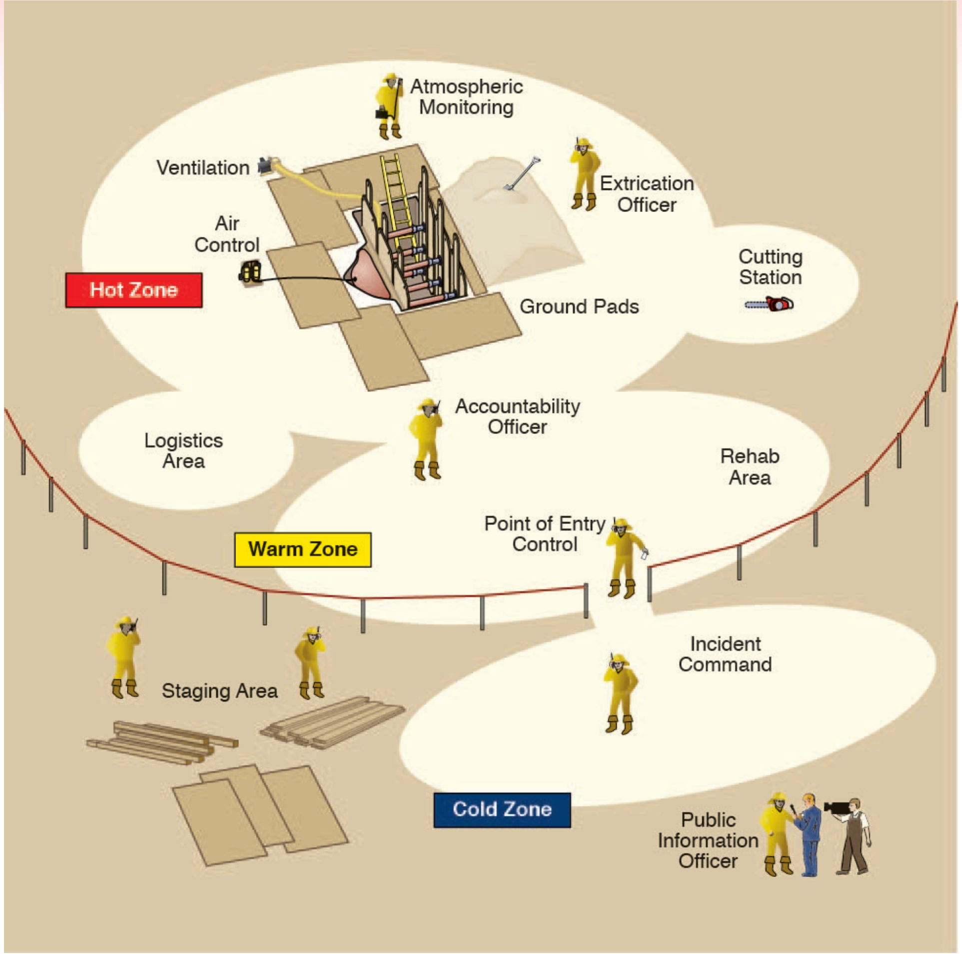
Logistics Team Manager



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Staging Officer and Rehabilitation Officer

- Staging officer
  - Responsible for ordering and maintaining adequate resources
- Rehabilitation officer
  - Provides for rescue personnel rotation to address medical monitoring and fluid replacement

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Termination and Postincident Considerations

- Conduct a modified postincident briefing.
- Recognize that this is a dangerous phase of operation.
  - The adrenaline is gone and personnel are tired.
- Remove equipment in the reverse order in which it was built.
- Personnel should not stand in unprotected areas.

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Termination and Postincident Considerations

- Personnel require frequent breaks.
- Do not rush.
- Clean up the site.
- Critique the response.
- Conduct a critical incident stress debriefing

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Summary

- Having a clearly defined approach to incident scene responsibilities and authority is critical to the safety of both victims and rescuers.

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Summary

- The strategic level of the incident management organization is more about deciding *what* needs to be done and less about determining *how* those actions will be carried out.

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Summary

- The strategic level of the organization generally includes an incident commander, safety officer, liaison officer, and public information officer.

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Summary

- The tactical level of the incident management structure takes the strategic plan developed by the incident commander and implements the tactics necessary to achieve success.

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Summary

- Tactical-level personnel include the operations officer and the logistics officer.
- The task level of the incident management structure consists of the personnel who will implement the tactical objectives.
- Personnel at the task level include the medical officer and the extrication officer.

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Summary

- Emergency support functions at a trench incident include the following:
  - Air supply operations
  - Cutting team
  - Panel team
  - Shoring team
  - Rigging team
  - Heavy equipment operations
  - Rapid intervention crew
  - Logistics team manager
  - Staging officer
  - Rehabilitation officer

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Summary

- No part of termination procedures should begin, nor should you leave the scene, before you conduct a modified postincident briefing.

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Cecil V. "Buddy" Martinette, Jr., *and* Ron "Z" Zawlocki

Trench Rescue

Principles and Practice to NFPA 1006 and 1670

THIRD EDITION

Chapter 6

Equipment

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The Importance of Proper Equipment

- The safety of personnel depends on their level of skill, as developed during both training and real-time incidents.
- All training and experience can be rendered ineffective if personnel do not have the proper personal protective clothing and equipment to give them reasonable protection during the rescue.

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Development of a Safety Culture

- Development of a safety culture is the result of many hours of training and the discipline that comes from everyone on the team being accountable.
- Ultimately, a safety culture is something to be proud of, and it should be emulated by other teams that deliver specialized rescue services.

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Personal Protective Equipment

- PPE can be classified into two main categories:
  - Clothing that the rescuers wear to protect themselves
    - e.g., gloves
  - Equipment provided that would not be considered standard issue items
    - e.g., a breathing apparatus

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Personal Protective Equipment

- PPE is not rocket science; it is more like common sense.
- Rescue personnel's PPE should be appropriate for the type of mission and the hazards present.

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Clothing

- Fire gear
  - Firefighting gear is very bulky and not recommended as standard protection for trench rescue.
  - Turnout gear is certainly appropriate in some circumstances, and if that is all you have, make sure that you have it on.
  - The key is to evaluate the advantages of the warmth the gear provides as compared with the disadvantages of not having as much manual dexterity.

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Clothing

- Jumpsuit
  - The standard fire-resistant jumpsuit is more than adequate skin protection for most trench emergencies.
  - A suit that is too large or too small, or just in the wrong proportions, can cause discomfort and limit ease of movement.

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Clothing

- Long pants and sleeves
  - The minimum level of protective clothing should be long pants and long-sleeve shirts.
  - Short pants or short-sleeve shirts should not be considered.
- Make sure that you wear the proper protection for the environment in which you are working.

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Gloves

- Comfort is the key to success when wearing gloves.
- Standard leather gloves
- Vehicle-extrication gloves
- Nomex flight gloves

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Head Protection

- The most critical piece of protective clothing that you will wear during a trench rescue is the helmet.
- The best helmet to wear at a trench emergency is the heavy-duty construction helmet.
  - Be sure that the helmet selected is American National Standards Institute (ANSI) approved for the the task and has a chinstrap.

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Eye Protection

- The standard pair of safety glasses is more than satisfactory for trench rescue.
- Rescue personnel should never wear reflective sunglasses.

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Foot Protection

- All personnel should wear steel-toed, steel-shanked boots.
- It is a good idea to have a high-top boot.

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Specialty Items

- Respiratory protection
  - Dust mask at a minimum
  - Self-contained breathing apparatus (SCBA)
  - Supplied-air breathing apparatus (SABA)

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Specialty Items

- Hearing protection
  - Choose a level of protection that will shield the rescuer’s ears from high noise frequencies but will not block out all communication.
- Skullcaps
  - Worn to keep rescuers’ heads cool under their helmets
- Leather chaps
  - Good leg protection and a great idea for anyone who will be cutting with a chainsaw

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Equipment for Trench Rescue Operations

- Many different types of tools and equipment may be required on the trench collapse scene.
- Most individuals are already familiar with much of this equipment.

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Lip Protection

- The area around the trench lip is a very unstable area.
- Ground pads or lip bridges are used to line the area around the trench either before or after the removal of the excess dirt from the spoil pile.

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Ground Pads

- Distribute the rescuer's weight over a larger area
- Several different types are available, each with its own pros and cons

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Lip Bridges

- Built with girders, beams, decking, and supports
- Prevent rescuers from riding the wall into the trench in the event of a secondary collapse

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Sheeting

- Sheeting material consists of interconnected steel uprights, sheets of plywood/timber, or manufactured panels that are used to contact the walls of the trench.
- The combination of sheeting and uprights functions as a shield system, holding back running soil and debris.

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Sheeting

- In trench rescue, sheeting will consist of ShorForm, FinnForm, or homemade plywood panels.

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Sheeting

- Cut all of the corners off at 90 degrees to reduce the possibility of splintering.
- Hand holes or holes for ropes can also be drilled to aid with the placement and adjustment of the panels in the trench.

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Shores

- Shores (or struts) are the component in the protective system that transfers the force from one side of the trench to the other.

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Timber Shores

- Timber shores have the advantage of low cost when compared with other shores.
- Timber shores are very time consuming to cut and install and have only limited effectiveness in rescue work.

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Timber Shores

- A screw jack is a tool commonly used in conjunction with timber shoring to form a tight wall-to-wall shore.

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Hydraulic Shores

- This system combines the shore and the upright into a single unit.
- The entire system is lowered in the trench from the top and then expanded by using a reservoir of nonflammable and biodegradable fluid.

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Pneumatic Air Shores

- Come in a wide variety of lengths
- Made from lightweight tubular aluminum
- Quick, strong, and dependable
- Pneumatic shores all operate under the same principle.

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Wales

- Used to span large areas of trench walls (without intermediate struts)
- May be a result of the voids created by the cave-in, the trench shape, or an obstruction at the wall
- Also used to create room for extrication work and victim removal

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Backfill

- Backfill is a generic term given to several common methods used to fill in the soil that has left the trench wall as a result of a collapse.
- Backfilling void areas helps minimize soil movement and distribute the load from the opposite wall.

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Tools and Appliances

Table 6-1 Suggested Hand and Miscellaneous Tools List for Trench Rescue

Shovels	Hammers	Saws
Flat Pointed "D" handled Post hole Entrenching tool	Nailing Large sledge Small sledge	Chain(s) Circular Hand Extra blades Repair kits Saw horses
Tools	**Miscellaneous**	**Cribbing**
Squares Pencils Paper Tool ropes (lots) Tool belts Nail pouches Nails (duplex) Nail bars Tape measures Road cones Barricade tape	Pickets Can of paint Buckets Ventilation fans Fan duct Power cords Generators Pike poles Air monitor Hydraulic rams Screw gun and long screws	2 × 4 inches 4 × 4 inches 4 × 6 inches 6 × 6 inches 8 × 8 inches Wedges, 6 inches and 4 inches

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Tools and Appliances

- Shovels
  - When you are dealing with the movement of dirt, the shovel becomes one of the most important tools employed during a trench rescue.

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Shovels

- An entrenching tool is a small, collapsible version of a larger shovel that is designed to be used in situations where room is limited and a shovel is too big.

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Hammers and Nails

- The hammers that you might find in a discount store are not the appropriate tools.
- You need 20-, 22-, and 24-ounce framing hammers that will drive a 16-penny duplex nail in three hits.

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Hammers and Nails

- The duplex nails used in trench rescue operations to connect wood components are designed to be easily removed.

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Chainsaws

- Stay alert when a chainsaw is in use, regardless of whether you are the one using it.
- Big chainsaws will cut off your leg in half a second.

Courtesy of Cecil V. "Buddy" Martinette, Jr.

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Ventilation Equipment

- The electric-powered ventilation equipment used in trench rescue is normally the tried-and-true fire department smoke ejector.
- Used on the windward side, blowing in the trench, it affords an adequate flow of fresh air into the trench.

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Ladders

- Ladders can be used for a multitude of purposes during a trench collapse.
- Secondary to victim escape is the requirement for ladder egress in trenches more than 4 feet (1.2 m) deep.
- Ladders can be used to span the trench opening and to provide a base for lifting operations over the trench.
- Can be used as wales.

Courtesy of Larry Collins

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Scene Lighting

- It is not unusual for operation periods to extend many hours, and thus rescue events that start in the daylight could be resolved at nighttime.
- Keep in mind that external lighting may need to be powered by an external source.
  - In addition to the lights you will need a power plant to run them.

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Dewatering Devices

- These devices are absolutely necessary for the control of water from both ground seepage and rainwater runoff.
- Excess water in the trench creates an uncomfortable work environment and deteriorates the trench floor and toe if it is allowed to stand.

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Dewatering Devices

- Devices include:
  - Large diaphragm pumps
    - Mud pumps
  - Municipal vacuum truck
  - Rescue Vac system

Courtesy of Bob Schilp

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Setting up a Cutting Station

- When a trench rescue incident requires several pieces of lumber to be cut, you should consider building a cutting station table.
- The table itself is designed with a standard 4 × 8-inch sheet of ¾-inch plywood.
- Once the table is put together, the top can be railed with 2 × 4-inch runners that can be spaced and also marked at designated positions so standard cuts do not need to be measured each time.

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Summary

- In every case, the safety of personnel depends on their level of skill, as developed during both training and real-time incidents.

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Summary

- Instilling a safety mindset into the culture of your team does not happen overnight, but rather is the result of many hours of training and the discipline that comes from everyone on the team being accountable.

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Summary

- PPE can be divided into two main categories: the clothing that rescuers wear to protect themselves and the equipment provided that would not be considered standard issue items.

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Summary

- In all cases, rescuers need to have some level of protection from skin abrasions from contact with on-scene objects. Other PPE includes gloves, head protection, eye protection, foot protection, and specialty items.

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Summary

- Many different types of tools and equipment may be required at the trench collapse scene, most of which will already be familiar to rescuers.
- Equipment specific to trench rescue operations includes lip protection, sheeting, shores, and wales.

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Summary

- Backfilling—filling in voids that have been created from cave-ins—is an essential skill for trench rescue shoring.
- The variations in tools and appliances required to complete a trench rescue successfully are all-encompassing, consisting of any tools you could find at a construction site.

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Cecil V. "Buddy" Martinette, Jr., *and* Ron "Z" Zawlocki

Trench Rescue

Principles and Practice to NFPA 1006 and 1670

THIRD EDITION

Chapter 7

Incident Assessment

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Scene Assessment

- Assessment is the foundation on which you build your decision-making platform.
- When completed, it helps you determine a set of guidelines for action.
- The assessment is nothing more than a tried-and-true situational size-up.

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Scene Assessment

- Assessment can be broken into three time periods:
  - From the time of alarm until you arrive on scene
  - Your arrival on scene
  - Continuously during the operation

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Time of Alarm

- At the time of the alarm, you should begin the process of gathering information.
- The initial information will come from the alarm data that are supplied to the dispatcher at the time the call is received.

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Time of Alarm

- Usually you will get very little detailed information.
- It will then be up to you to question and prompt the dispatcher for additional information while you are en route.

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What Happened?

- Have the dispatcher call back and keep the caller on the line.
- Having the caller available will be critical if you are having trouble finding the accident scene.
- It is helpful for someone to be available if you have additional questions, such as which type of collapse has occurred or how many people might be buried or trapped.

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Why Was the Excavation Work Being Done?

- This type of information will suggest how large the excavation was before it collapsed.
- Consideration may be given to acquiring additional resources when the type of excavation is pinpointed.

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Is/Are the Victim(s) Completely Buried?

- This step in the information process allows you to begin risk assessment.
- If the victim is completely buried, your risk profile should be very limited.
- If the incident involves buried victims, you know that the rescue event is likely to be long and complex.

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Is the Situation a Trench Collapse or Some Other Form of Injury in the Trench?

- If the victim is injured but not buried, you are dealing with a very different type of call than if the victim were buried.

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Will Access Be Difficult for Equipment and Rescue Personnel?

- Lack of access could mean a delay in getting resources to the scene.
- All of the equipment needed may have to be carried to the site if you cannot get your apparatus close to the collapse.

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How Is the Weather, and Is It Expected to Change During the Operation?

- You may need dewatering equipment if it is raining or if a storm is expected.
- If it will be hot during the rescue, you may need more personnel than would normally be necessary.
  - Consider cooling the area using ventilation or even misting fans.

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How Is the Weather, and Is It Expected to Change During the Operation?

- If it is very cold, there can be devastating effects on the victim, but over time rescue personnel may also face the risk of hypothermia.
  - Consider using a warm-air ventilator.
- Consider the need for lighting during overcast conditions or if the situation is likely to extend into the night.

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Arrival at the Scene

- Upon arrival at the scene
  - You will be expected to finish gathering your information and develop a plan for mitigating the incident.
  - Take the basic information that you have gathered, adding to it what you can subsequently glean from witnesses, and assimilating all of those data with what you can actually see with your own eyes.

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Who Is in Charge, and What Has Happened?

- Seek out a competent person in charge on site.
  - This person can give you information as to the original depth and width of the trench and the type of protective system that was or is in place.
- Find out what the victim was doing at the time of collapse and where he or she was last seen.

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Is There a Language Barrier?

- If there is a language barrier, find someone to interpret.

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Based on Equipment Limitations, Is the Collapse Within Your Scope of Operations?

- If the trench is deeper than 20 feet (6 m), cuts through C-80 soil, or is a massive cave-in, commercial techniques for stabilization will be necessary.

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What Are the Injuries? What Is the Victim's Survivability Profile?

- What are the injuries?
  - How serious are the victim's injuries, and is there enough time to provide treatment?
- What is the victim's survivability profile?
  - If your victim is buried and there is no chance he or she jumped in the end of a pipe for protection, you are most likely dealing with a recovery.
    - A recovery is no longer an emergency: Do not get your people hurt.

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Which Type of Protective System Is or Was in Place?

- If the original protective system failed, rescuers face a big problem.
- You may have to remove what was in place and then start over
- You may need to figure out a method to stabilize the existing system.

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Which Type of Protective System Is or Was in Place?

- At this point, if you are dealing with a fatality:
  - Call the Occupational Safety and Health Administration (OSHA) or other professional engineers for help.
  - OSHA is required to investigate such an incident and will be able to do so more easily if the scene is less disturbed.

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Do You Have the Resources to Accomplish This Mission Successfully?

- The success of any rescue operation relies on having trained personnel who have the proper equipment to get the job done.

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Can You Mitigate This Incident with a Rapid Non-entry Technique?

- Non-entry rescue techniques may be appropriate in many situations.
- Rescue entry will not provide any benefit if the victim is deceased.
- In other cases, you may be faced with an uninjured victim who has fallen into the trench and can climb a ladder to safety.
  - A minimally injured victim can do amazing things when faced with a dire situation.

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During the Emergency

- Keep in mind that everything done at a trench collapse scene makes it a new scene.
- Constant evaluation will help you anticipate potential problems and be proactive rather than reactive.

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During the Emergency

- Recognize that good information will lead to a good plan of attack.
- Do not make a move until you have fully assessed the situation or you may find yourself looking at the FAILURE acronym to see where you went wrong.

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What Is in Your Incident Action Plan?

- A trench rescue action plan is the key to communicating expectations to all levels of your team.
- Clearly articulated goals help personnel understand the broader scope of operations.

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What Is in Your Incident Action Plan?

- A clearly identified strategy helps develop tactical objectives.
  - What area will you designate as the rescue area?
  - What area will be designated the general area?
  - How many personnel will you need?
  - What must the scope of their training be for you to be successful?
- Specify the techniques you will employ to rescue the victim in a safe and efficient manner.

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What Is the Operational Period?

- Establish an operational planning period that can serve as a reminder to stop and take note of your progress at achieving the tactical objectives.
  - Trench rescue action plans are dynamic plans because trench rescues are dynamic situations.
  - Constant evaluation will help you anticipate potential problems and be proactive rather than reactive.

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Which Factors Must Be Considered When Looking for Buried Victims?

- The first place you would look for, or expect to find, a victim of a trench collapse is at the end of the pipe string.

Courtesy of Cecil V. "Buddy" Martinette, Jr.

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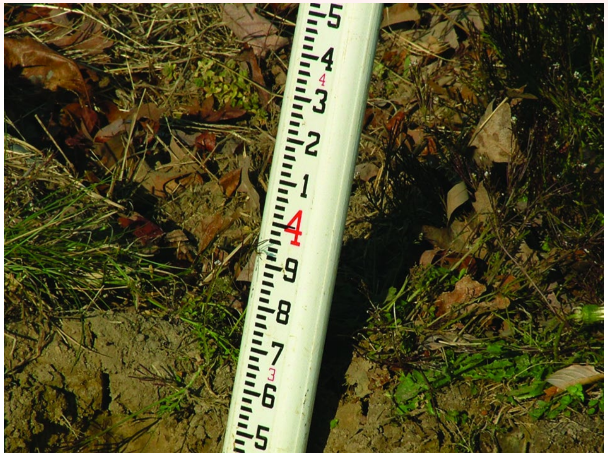
Which Factors Must Be Considered When Looking for Buried Victims?

- The depth of the trench may be determined by looking at the engineer's flagstick.
- You may be able to look at the orientation of laser targets if they have not been moved.



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Courtesy of Cecil V. "Buddy" Martinette, Jr.

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Which Factors Must Be Considered When Looking for Buried Victims?

- More than likely, when you get the call for a collapse, the spot will be noticeable.
- The competent person should have a good idea of the general area in which the victim was last seen.

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Which Factors Must Be Considered When Looking for Buried Victims?

- If the collapse has occurred at the end of a pipe string, listen for sound in the pipes.
- Go back to the point of origination or nearest entry point for the pipe, and listen for sounds from the victim.

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Which Factors Must Be Considered When Looking for Buried Victims?

- More difficult is actually finding a buried victim when his or her location is in question.
  - Use some of the information that you gathered during the assessment.
  - Consider what the victim was doing at the time of the collapse.
  - Paint and grease buckets may have been located on top of the trench within reach of the worker.
  - The same can be said for tools and other equipment.

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Which Factors Must Be Considered When Looking for Buried Victims?

- (cont.)
  - Exposed limbs are obviously a good indication of victim location.
    - Be careful when digging around victims until you are sure of the head and chest location.
  - Almost everyone these days carries a cellular phone that may help locate your victim.
  - Other methods include use of listening devices or seismic indicators.

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Do You Have a Solid Rescue Plan, and Have You Given a Preoperational Briefing to Rescue Personnel?

- Before any operation takes place, all rescue personnel should be informed of at least the big picture elements of the rescue plan.
- Hold a safety briefing.

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Do You Have a Solid Rescue Plan, and Have You Given a Preoperational Briefing to Rescue Personnel?

- Give more detailed information about the method and type of protective system that you will build for those rescue personnel involved in constructing the system.
  - Include all known hazards, command structure, radio frequencies, and tactical objectives.

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Do You Have a Solid Rescue Plan, and Have You Given a Preoperational Briefing to Rescue Personnel?

- Additional components of the plan that should be covered include:
  - Stop work/evacuation notification procedure
  - Personnel accountability system to track the locations and activities of all personnel on the scene.

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Summary

- In trench rescue, assessment is the foundation on which you build your decision-making platform.

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Summary

- At the time of the alarm, you will begin the process of gathering information. Key questions include the following:
  - What happened?
  - Why was the excavation work being done?
  - Is the victim completely buried?

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Summary

- (cont.)
- Is the situation a trench collapse or some other form of injury in the trench?
- Will access be difficult for equipment and rescue personnel?
- How is the weather, and is it expected to change during the operation?

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Summary

- Upon arrival at the scene, you will be expected to finish gathering your information and develop a plan for mitigating the incident. Key questions include the following:
  - Who is in charge, and what has happened?
  - Is there a language barrier?
  - Based on equipment limitations, is the collapse within your scope of operations?

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Summary

– (cont.)
– What are the injuries?
– What is the victim's survivability profile?
– Which type of protective system is/was in place?
– Do you have the resources to accomplish this mission successfully?
– Can you mitigate this incident with a rapid non-entry rescue technique?

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Summary

- Trench rescue situations are so dynamic that constant evaluation for changing conditions is of paramount importance. Key questions include the following:
  - Which factors must be considered when looking for buried victims?
  - Do you have a solid rescue plan, and have you given a preoperational briefing to rescue personnel?

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Cecil V. "Buddy" Martinette, Jr., *and* Ron "Z" Zawlocki

Trench Rescue

Principles and Practice to NFPA 1006 and 1670

THIRD EDITION

Chapter 8

Hazard Control and Atmospheric Monitoring

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Hazard Control

- Hazards can be categorized into one of two types:
  - Hazards that you are able to control
    - Locations of vehicles
    - Trip hazards
    - Spoil pile movement
    - Supporting existing utilities
  - Hazards that you should leave alone
    - Electricity
    - Gas

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Hazard Control

- Hazards can be classified into five categories:
  - Mechanical
  - Chemical
  - Human made
  - Electrical
  - Water

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Mechanical Hazards

- Machines and other entrapping mechanisms could be a danger to rescuers.
- Use lock out/tag out procedures.
- Make sure you bring everything to a zero mechanical state.
  - This means eliminating any possibility that any activation could occur.

Courtesy of Chuck Wehrli

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Chemical Hazards

- Always assume that something hazardous could have been unearthed during digging operations
  - A worker may have carried a chemical in the trench for use during intended work activities.
    - Gasoline for saws, solvents for cleaning, and glue for making pipe connections

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Chemical Hazards

- Never assume anything is safe and always monitor the atmosphere.
- If any concerns about chemical hazards arise, call a hazardous materials team.

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Human-Created Hazards

- Include all of the things that workers do as a part of their normal work but that either do not go according to plan or prove to be hazardous at some point
  - The positioning of the spoil pile and trench equipment relative to the trench opening
  - Inadequate trench protective systems
  - Installation procedures

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Electrical Hazards

- Control of electricity other than shutting off breakers is best left to the people who do it for a living.
- Concerns should be noted in regard to static electricity and its potential impact with exposed natural gas lines.
  - Wrapping a wet towel around the pipe and stretching the towel to contact the ground will ground the pipe and eliminate the static electricity.

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Electrical Hazards

- Be alert when operating around exposed telephone lines.
  - They carry a voltage that can cause injury or even death with contact.

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Electrical Hazards

- Determine the locations of all utilities before digging in a collapsed area.
  - Call the local utility service company or the local utility location service, sometimes called Ms. Utility, One Call, or 811.

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Utility Color Markings

- Red: Electric power lines, cables, conduit, and lighting cables
- Orange: Communications, alarm or signal lines, cables, or conduit
- Yellow: Gas, oil, steam, petroleum, or gaseous material
- Green: Sewers and drain lines
- Blue: Potable water
- Violet: Reclaimed water, irrigation, and slurry lines
- Pink: Temporary survey markings, unknown/unidentified facilities
- White: Proposed excavation limits or route

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Water Hazards

- Water can be a hazard at the scene of a trench collapse, whether in the form of groundwater or rain.
- Water creates extreme forces on trenches that can compromise already poor conditions.

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Water Hazards

- If rain is imminent, start thinking about building a cover for the trench and establishing a method to divert incoming rain.
  - Have dewatering equipment on site.
  - Cover the trench with an inflatable tent and divert the water to an unaffected area.

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Hazard Control Phases

- After identifying all hazards on the scene of the collapse, you will want to turn your attention to addressing them in some sort of logical order.
- Do not blindly address what appears to be the most hazardous element without consideration for those hazards that may not be as readily apparent.

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Hazard Control Phases

- When hazardous materials are involved, you are dealing with “hot,” “warm,” and “cold” zones.
- In vehicle rescue, one learns about the “inner” and “outer” circles.
- Trench rescue incident scene management may use the terms *general area* and *rescue area*.

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Hazard Control Phases

- General area
  - The surrounding area not in the immediate vicinity of the extrication effort
- Rescue area
  - The area located immediately surrounding the rescue site.

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Atmospheric Monitoring for Trench Rescue

- Note of caution:
  - The amount of atmospheric monitoring material covered here is not as comprehensive as it could be.
  - The information presented here is simply intended to make you aware of potential problems and the actions you should take with regard to hazardous atmospheres.

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Confined Space or Trench

- A confined space has the following characteristics:
  - Is large enough and configured so that an employee can bodily enter the space
  - Has limited means of egress for entry or exit
  - Is not designed for continual employee occupancy
  - Has an actual or potential hazardous atmosphere

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Confined Space or Trench

- A confined space may also have any of the following:
  - Material with the potential of engulfing the entrant
  - An internal configuration that could trap or asphyxiate an entrant due to converging walls or sloping and tapered floors
  - Any other recognized serious safety hazard
- Many similarities exist between a trench and a confined space.

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Confined Space or Trench

- Because atmospheric problems are responsible for the overwhelming majority of deaths in confined spaces, it is a good idea to take a look at the subject as it applies to trench rescue.
  - During a rescue effort, someone on your team should be providing periodic monitoring in and around the trench.

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Confined Space or Trench

- (Cont.)
  - Monitoring is used to detect the presence of immediately dangerous to life and health (IDLH) atmospheres, and as a tactical guide to ventilation of the trench.

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Monitoring Considerations

- What is the nature of the hazard I am monitoring?
  - Do you know the upper and lower explosive limits (UEL and LEL) for the particular product?
  - Is the atmosphere oxygen deficient, which might create interference with instrument response?
  - What is the vapor pressure of the product, and what is the outside temperature?

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Monitoring Considerations

- What is the nature of the hazard I am monitoring? (cont.)
  - Is it likely that this combination will create enough vapors to support ignition?
  - Is the vapor a health hazard, and is the material lighter or heavier than air?

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Monitoring Considerations

- Are there sources of electrical interference nearby?
  - Electromagnetic fields, high voltage, static electricity, portable radios, cellular phones, and similar items can interfere with your meter readings.
- What are the environmental site conditions in which you are operating?
  - Conditions such as temperature, humidity, barometric pressure, elevation, particulates, and oxygen concentration must be considered.

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Monitoring Considerations

- Are any gases and vapors interfering with the monitor?
  - The lead in leaded gasoline permanently desensitizes the filament of a combustible gas indicator.
  - Certain acids and corrosives will eat away at the monitor and the sensors.

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Action Guidelines

- In most instances, these guidelines are outlined in OSHA 1910.146, *Permit-Required Confined Spaces*, and should be incorporated into your standard operating procedures.
- Action guidelines indicate which specific action(s) you should take when monitor readings reach certain levels.

Table 8-1 Action Guidelines for Confined-Space and Trench Rescue Operations

Atmosphere	Level	Action	Monitor
Combustible/ flammable gas	10% of the LEL	If outside the space, correct the atmosphere. If inside the space, begin to exit.	Alarms both visually and audibly
Oxygen	Less than 19.5% or greater than 23.5%	If outside the space, determine the problem and correct it. If inside the space, begin to exit.	Alarms both visually and audibly
Toxicity	Carbon monoxide: 35 ppm Hydrogen sulfide: 10 ppm	If outside the space, determine the cause of the problem and correct it. If inside the space, begin to exit.	Alarms both visually and audibly

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General Monitoring Guidelines

- Monitor in order.
  - Oxygen
  - Flammability/combustibility
  - Toxicity

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General Monitoring Guidelines

- Always monitor at multiple levels in the trench.
  - Air has a vapor density of 1.0.
  - Gases and vapors with a vapor density of less than 1.0 will rise.
  - Gases with a vapor density greater than 1.0 will sink.
- Know your monitor's limitations.

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General Monitoring Guidelines

- Understand the relationship between flammability and toxicity.
  - Flammable range is a measurement of the amount of a substance that will ignite when mixed with air.
  - A substance measured in relation to its total volume in the mixture, represented in parts per million (PPM), is the most frequently used method to measure toxicity.

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General Monitoring Guidelines

- A substance (vapor) that comes after you is much more dangerous than one that expects you to come to it.
  - These types of products require great caution because the product or its vapor can spread toward you and potentially cause problems over a greater area.

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General Monitoring Guidelines

- Know your monitor's operational parameters.
  - How long are the sensors in your monitor expected to last?
  - Is the monitor radio frequency shielded?
  - If using a hand aspirator, how many pumps are necessary for each foot of tubing to bring the product into the sensor housing?
  - Do you use a water filter on the end to prevent liquid from being pulled up the tube?

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General Monitoring Guidelines

- Battery-operated monitors will not work if the batteries are dead.
  - Batteries should be checked regularly (each shift).
- Zero and field calibrate (bump check) your instrument in clean air.
  - Ensure it is reading 0 percent for flammability and toxicity and 20.9 percent for oxygen.
  - Follow the manufacturer's recommendations.

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General Monitoring Guidelines

- Sample from upwind.
  - This will allow you to approach the potentially hazardous atmosphere at your own pace.
- Never conduct atmospheric monitoring unless you have been thoroughly trained and are capable of providing that function.

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Specific Monitoring Measurements

- Oxygen
  - Monitors usually measure oxygen concentrations between 0 percent and 25 percent in air.
  - Your monitor should be set up to alarm at 19.5 percent.
  - It should also be set to alarm at levels of oxygen greater than 23.5 percent in air.
    - Above that, the measurement of flammability will not be accurate and will render false readings.

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Flammable and Combustible Readings

- Combustible gas indicators (CGIs) in the air monitoring device determine the presence of flammable vapors of hydrocarbon products within the trench.

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Flammable and Combustible Readings

- You should test for flammability during the following scenarios:
  - Any suspected contaminated trench
  - As part of the process of leak detection
  - If you are investigating an unknown material
- When the level of the product you are testing reaches 10 percent of its lower flammable limit, the CGI monitor will both sound an audible alarm and provide a visual signal.

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Measuring Toxicity

- The air monitor you are using will have either one or two toxicity sensors, most likely set up to measure hydrogen sulfide or carbon monoxide.
- The action limits or alarm settings on such devices are at 35 ppm for carbon monoxide and 10 ppm for hydrogen sulfide.
  - OSHA's time-weighted averages for an 8-hour exposure

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Consistent and Effective Monitoring

- Monitoring should take place before entry and at least every 5 minutes during trench operations.
  - The time frame should be adjusted based on the severity of the atmosphere you are dealing with.

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Consistent and Effective Monitoring

- One person should collect and record monitor readings throughout the entry and rescue/recovery operation. This should be his or her sole assignment.
- All readings should be captured on the trench rescue tactical worksheet.
- Readings should be reported to the extrication officer or the operations officer on a continual basis.

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Consistent and Effective Monitoring

- Any fluctuations or changes in readings should be reported immediately.
- Any alarm levels should be reported immediately and action taken.
- Never leave the monitor unattended. It could get kicked into the trench, stepped on, or ignored.
- Always use a hazardous materials team to your best advantage.

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Hazard Control Using Ventilation

- Ventilation is the hazard control method of choice during rescue operations because it is fast and easily monitored.
- Ventilation is only as good as the technique you employ and is based on the nature of the product.

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Hazard Control Using Ventilation

- When using ventilation as a hazard control method in trench rescue, you must consider the outside temperature and the effect ventilation will have on both victims and rescuers.
- Multiple fans may be needed on intersecting trenches.

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Summary

- The many different hazards that may potentially affect your operation can be categorized into one of two types: the hazards that you are able to control and the hazards that you should leave alone.
- Hazards can be classified into five categories: mechanical, chemical, human made, electrical, and water.

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Summary

- After identifying all hazards on the scene of the collapse, you should next turn your attention to addressing them in some sort of logical order.
- Hazardous materials legislation has created a liability for anyone who has disposed of or is trying to dispose of a hazardous substance. This has generated an entirely new set of problems for rescuers who unknowingly get involved with the improper disposal of materials.

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Summary

- Atmospheric problems are responsible for the overwhelming majority of deaths in confined spaces.
- To use monitored information tactically, you must have established action guidelines.
- Specific monitoring measurements include oxygen, flammability and combustibility, and toxicity.

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Summary

- Monitoring should take place before entry and at least every 5 minutes during trench operations (adjusted based on the severity of the atmospheric problems).
- Ventilation is the hazard control method of choice during rescue operations because it is fast and easily monitored.

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Cecil V. "Buddy" Martinette, Jr., *and* Ron "Z" Zawlocki

Trench Rescue

Principles and Practice to NFPA 1006 and 1670

THIRD EDITION

Chapter 9

Lifting, Moving, and Stabilization

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Lifting, Moving, and Stabilization

- All rescue personnel can benefit from an understanding of the basic concepts of lifting and moving.
- Fundamental information on the physics associated with lifting and moving should be taught in one of the first training classes offered to rescue personnel.

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Basic Physics of Lifting and Moving

- Much of what you do to either rescue or recover a victim involves displacing materials or lifting and lowering objects or people to gain access or move them from one place to another.

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Basic Physics of Lifting and Moving

- The fundamental reason for a trench collapse is the effect of gravity on unconfined and potentially active soil.
- These situations can involve anything from stabilization of current conditions to lifting and moving objects that hinder victim extrication.

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Basic Physics of Lifting and Moving

- To move something, we must first cover the basic physics associated with lifting and moving objects, including gravity and its effects on mass, friction and resistance to force, center of gravity, moment of force considerations, mechanics, and energy and work concepts.

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Calculating the Weight of an Object

- Before lifting or moving an object, some thought should be put into calculating how much the object weighs.
  - This will help you decide the most appropriate lifting method.
- The first thing to consider is the type of material.
  - Will your equipment be sufficient to perform the lift?

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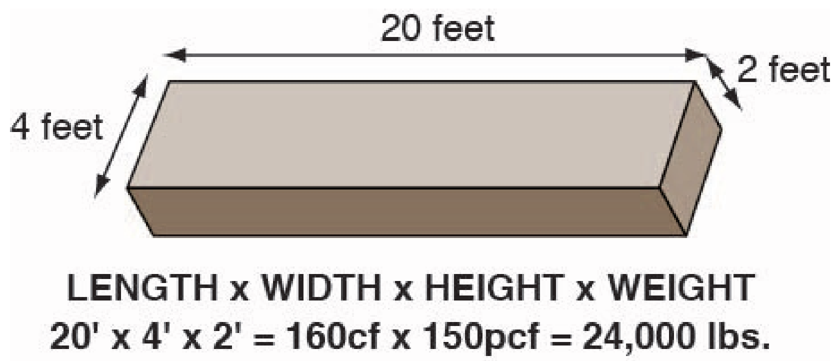
Calculating the Weight of an Object

- Length x Width x Height x Weight
- 20' x 4' x 2' = 160 ft.^{3} x 150 lbs./ft.^{3} = 24,000 lbs.



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Gravity

- Mass influences gravitational pull.
  - Every object has mass, and an object's total mass determines the amount of attraction it has for another object.
  - The more mass it has, the stronger its attraction for other objects.

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Gravity

- Consider the critical aspects of rescue operations and how gravity plays its part:
  - Lifting: The action necessary to raise anything
  - Lowering: Controlling the descent of an object
  - Moving: Exerting enough force on an object to move it
  - Stabilizing: Keeping the object from moving by applying a counterforce

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Friction

- A measure of the amount of force it takes to move an object across the surface of another object.
- The smoother the two surfaces, the easier an object will be to push; the rougher the two surfaces, the more difficult it will be to push the object.

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Friction

- We can reduce the amount of friction between two surfaces by reducing the surface area that connects the two objects.
  - You could put the object on a large piece of smooth cardboard or a piece of cloth and then pull on it.
  - You could place rollers or ball bearings under the object to move it with less effort.
  - Less friction means it takes less force to initiate movement.

Courtesy of Cecil V. "Buddy" Martinette, Jr.

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Center of Gravity

- The center of gravity is the point on a body around which the body’s mass is evenly distributed.
- Determining an object’s center of gravity is critical to any stabilization effort involving vehicle accidents, structural collapse, or trench rescue lifting operations.

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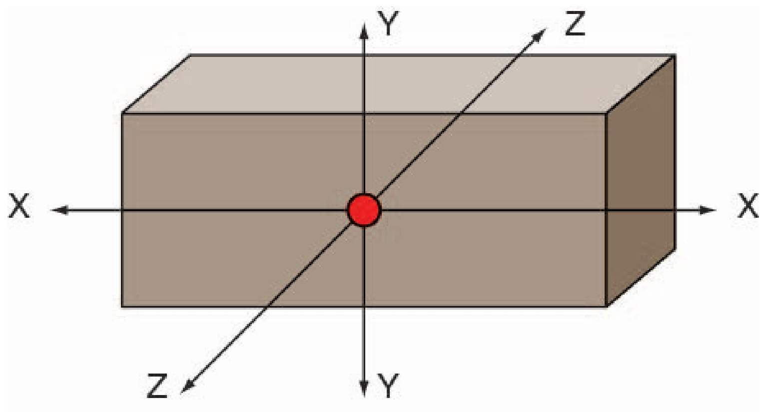
Center of Gravity

- The horizontal, vertical, and diagonal axes of an object will meet at a certain point that represents its absolute center.



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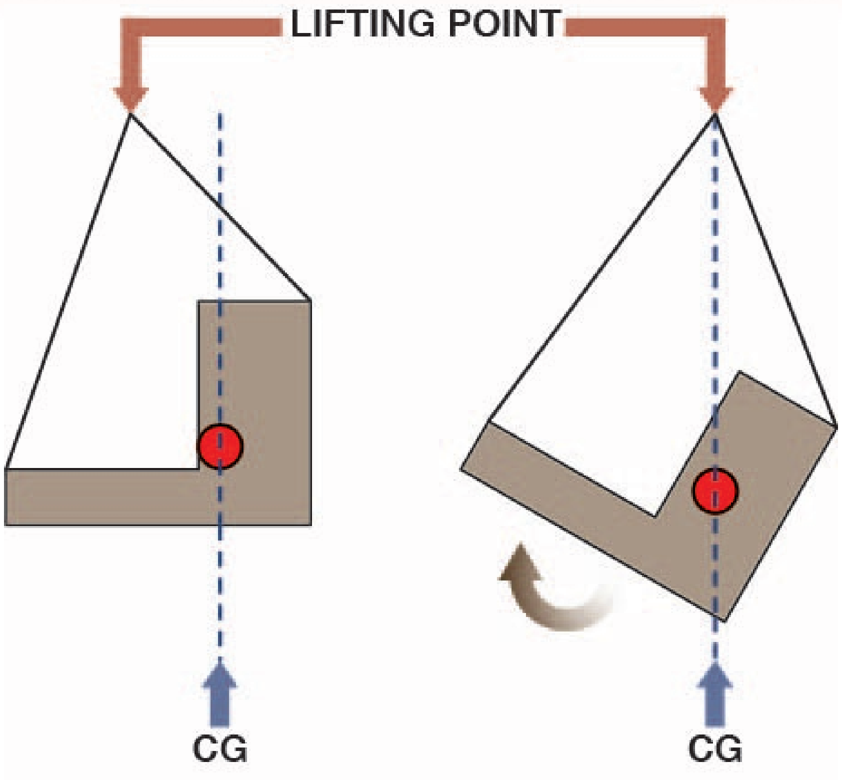
Center of Gravity

- Even irregularly shaped objects have a center of gravity.



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Center of Gravity

- An object on a sloped surface, from a gravity standpoint, is pulled toward the center of the earth.
- The friction coefficient of the two surfaces will determine how fast it arrives at that point.
- The object's center of gravity will be a factor in determining how and in which position the object will come to rest.

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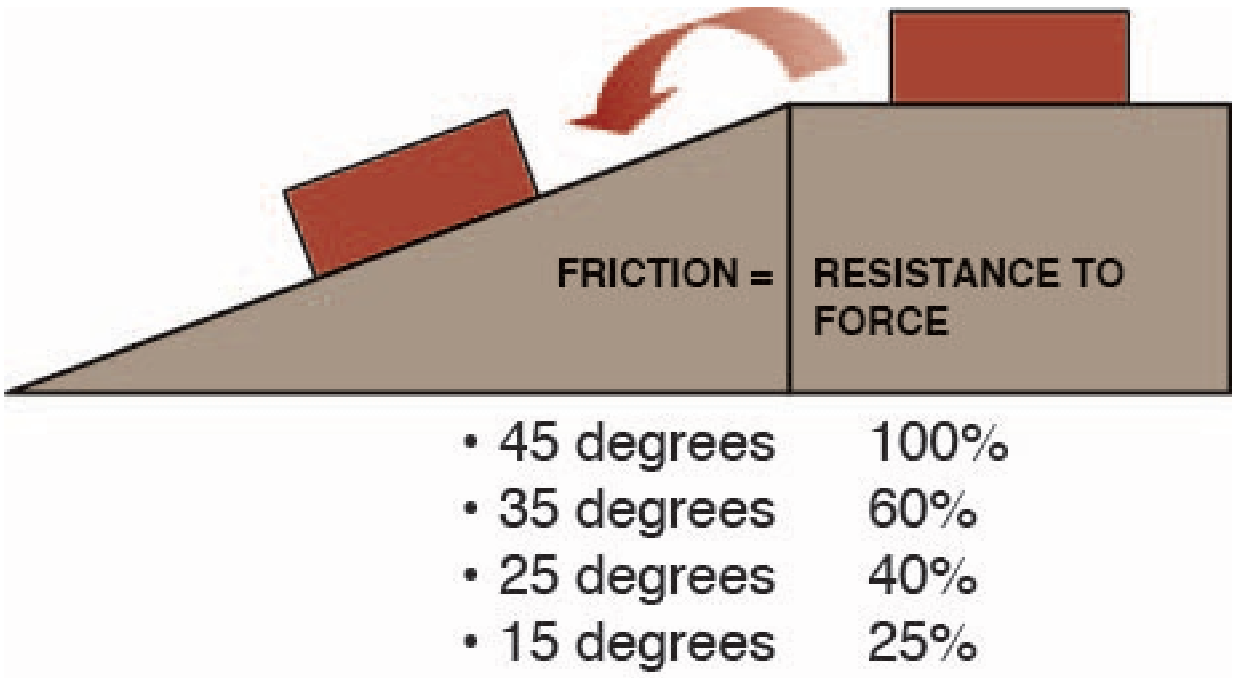
Center of Gravity

- Lower angles mean less weight but greater friction.



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Movement

- Moment of force
  - The mass multiplied by the distance away from the turning point, or fulcrum.
  - Calculated as the amount of force rotating around the fulcrum times the distance from the fulcrum—that is, force times distance is equal to the amount of force.

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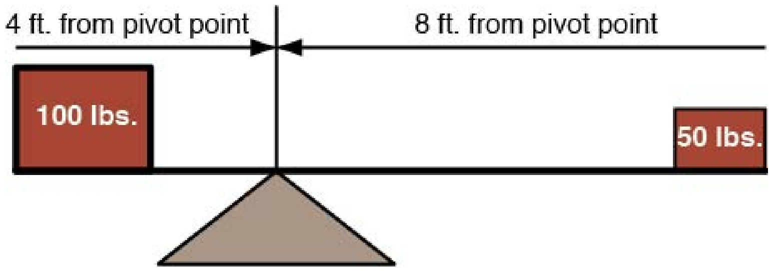
Movement

- Moment of force equals mass times the distance it is away from turning point.



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Mechanics

- The theory of mechanics is subdivided into two areas: energy and work.
- Mechanics deals with energy and forces in relation to bodies.
  - Something that creates a positive output in a given situation is called mechanical advantage.

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Mechanics

- Efficiency, or advantage, is a measurement of the distance traveled compared with the force used to effect the movement.
- Energy is the capacity for doing work and overcoming resistance.
- Work is distance times force, or force as it is applied to set a body in motion.

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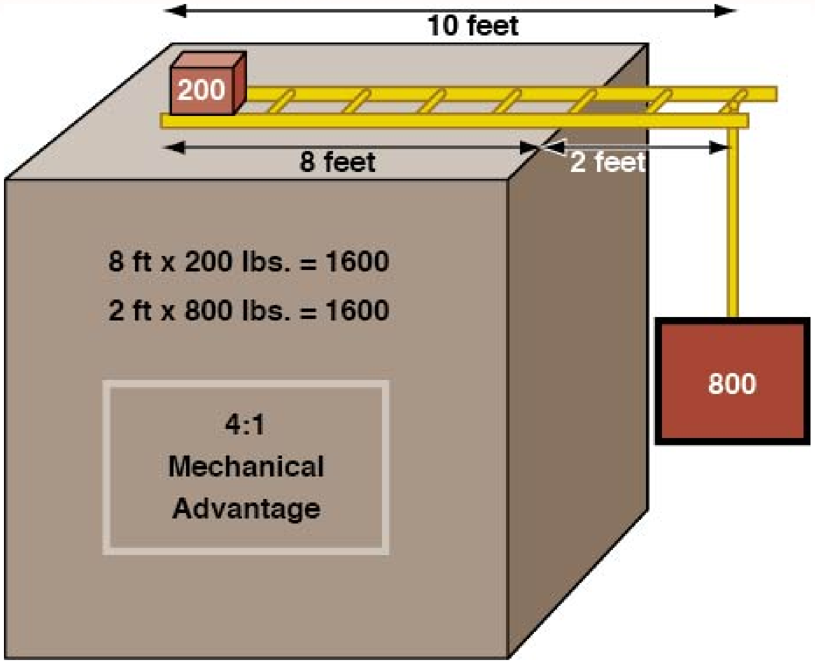
Mechanics

- In this case, the efficiency of the lever is based on the distance that the load is from the fulcrum or turning point.



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Mechanics

- Two kinds of simple machines exist:
  - Those made up of levers
    - Most efficient/least friction
  - Those made up of inclined planes
    - Least efficient/most friction

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Levers

- Levers can be used to move, haul, pull, or raise a load.
- Every lever has a fulcrum, which serves as a pivot point for the lever; force, which provides the power; and a load.
- The position of the fulcrum in relationship to the load determines the classification.

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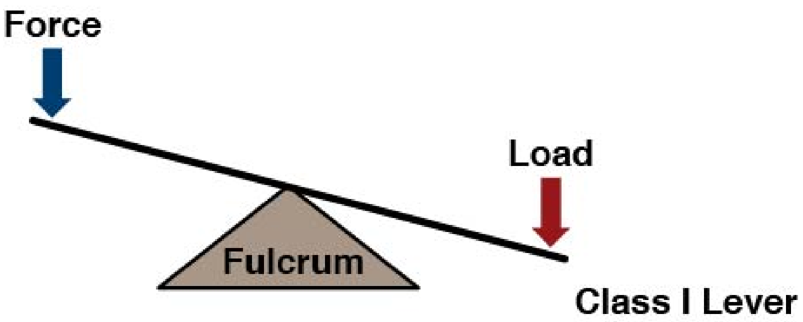
Levers

- Class I lever
  - The best example of this type of lever is a pry bar.



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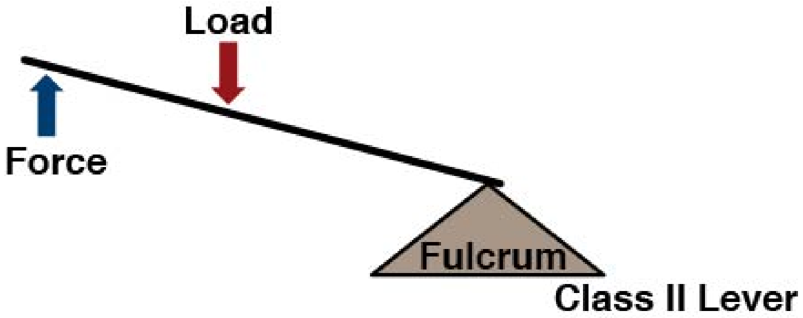
Levers

- Class II lever
  - Best applied for moving objects on a horizontal or near horizontal plane.
  - A good example of this type of lever is the wheelbarrow.



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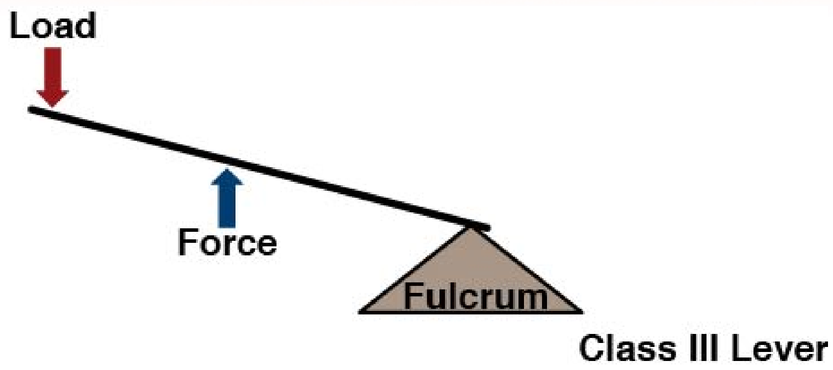
Levers

- Class III lever
  - The primary example is the shovel.
  - This type of lever has the force located between the load and the fulcrum.



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Levers

- Various actions of the shovel can represent all three classes of levers, depending on your desired outcome.
  - When the shovel is first pushed into the ground and bent back, it is a class I lever.
  - If you break the shovel forward to gain a better bite, it is a class II lever.
  - The action of throwing the dirt makes it a class III lever.

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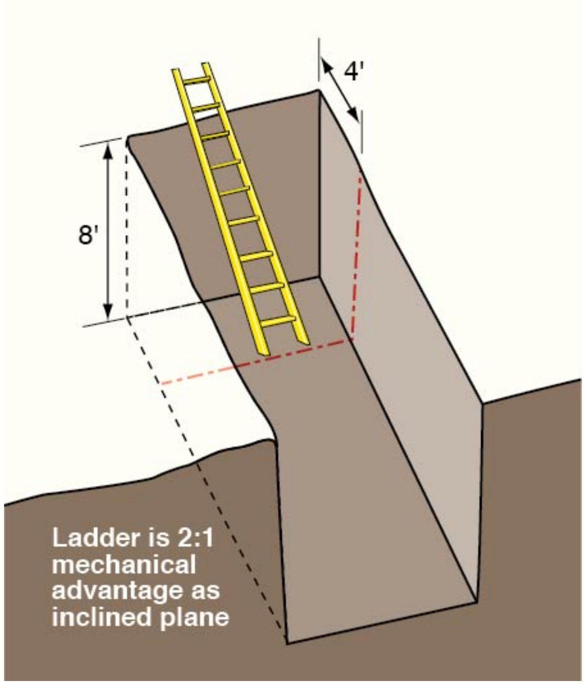
Inclined Planes

- An inclined plane gains efficiency by reducing required force over time.
- The advantage of the trench ladder is figured as distance of the ladder base from the trench wall, divided by the depth of the trench where the wall meets the ladder.



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Rope Raising and Lowering Systems

- The very nature of a trench dictates that you will at some time during the rescue be physically at a point that is higher than the victim you are trying to extricate.
- The preferred rescue method is a non-entry rescue; in many cases this is not possible.
  - Someone will need to enter the environment, physically remove the entrapping mechanism, package the victim, and then remove him or her from the trench.

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Rope Raising and Lowering Systems

- Rope rescue is a discipline that requires many hours of training and is beyond the scope of this text.
- The intent of introducing the topic here is to provide an understanding of the importance of rope rescue raising and lowering systems and how they help effect a trench rescue.

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Rope Raising and Lowering Systems

- If you tie a rope to something to raise or lower it, you need to consider the object’s entire weight. If the object weighs 200 pounds (90.7 kg), the system you create needs to be able to lift 200 pounds (90.7 kg).
- To make the job easier, pulleys can be used.

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Rope Raising and Lowering Systems

- The effect of anchoring one end of the rope and then having the pulley travel with the load divides the work in half, making it a 2:1 mechanical advantage.
- If you take that same system, disconnect the rope from the anchor, add a stationary pulley on the anchor (in addition to the traveling pulley), and then reattach the rope to the load, you will have created a 3:1 mechanical advantage system.

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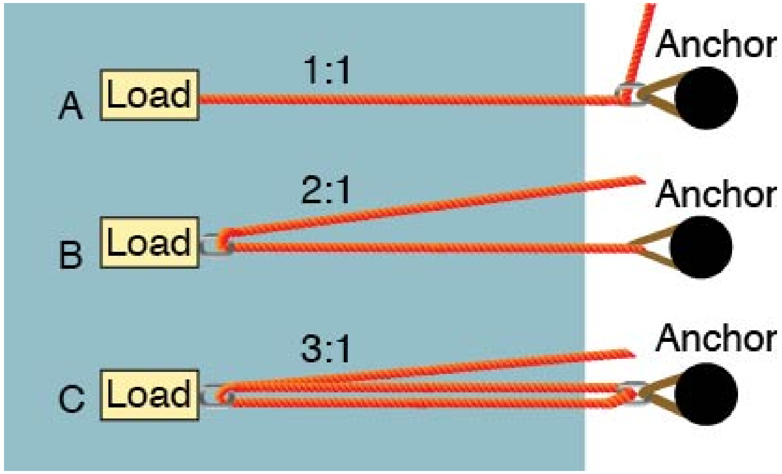
Rope Raising and Lowering Systems

- The number of ropes that are connected to the load pulley are an indicator of the mechanical advantage provided.



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Rope Raising and Lowering Systems

- Only traveling pulleys provide an advantage.
  - Any pulley that does not travel when the load is moved is just a change of direction device and does not provide a mechanical advantage.

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Rope Raising and Lowering Systems

- All systems need to be backed up, and all systems need a method to control the load.
  - It will be necessary to provide a second line to the load that can be anchored and run through a belay device.
  - The belay device could be mechanical or rescue cordage (Prusik) that is of the correct size for the rope being used.

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Air Bags for Trench Rescue

- A pneumatic air bag can perform many functions at a trench rescue.
  - Lifting heavy objects
  - Filling voids created by sloughs and other types of trench collapses

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About Air Bags

- Air bags can be purchased as low-, medium-, or high-pressure systems.
  - The amount of air pressure supplied to perform the lift determines the classification of the bag.
- Low-pressure bags
  - Use 7 pounds per square inch (psi) (0.5 kg/cm)
  - Can lift only limited capacities, as compared with high-pressure bags, but will lift the objects higher

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About Air Bags

- Medium-pressure bags
  - Use 22 psi (1.5 kg/cm)
  - Not as popular as they once were
- High-pressure bags
  - Use 80 to 120 psi (5.6 to 8.4 kg/cm)
  - Will lift a greater weight than low-pressure bags, but will not lift the object nearly as high

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How Air Bags Work

- All air bags are supplied with a volume of air and pressure from a remote air source.
  - Usually consists of a self-contained breathing apparatus bottle
  - Could be an air compressor or even a hand pump
- The effectiveness of air bags is tied to the compressibility of air, as divided over the inside surface of the air bag.

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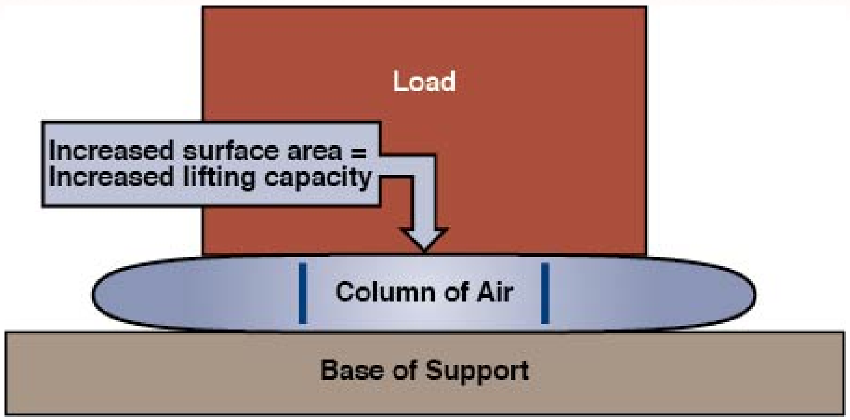
How Air Bags Work

- The lifting capacity of any air bag is limited to the amount of bag surface area that can contact the object, multiplied by the operating pressure supplied to the bag.



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Using Air Bags

- Measure the length and width of one of the bags.
  - Take these measurements and multiply them together, and then multiply the result by the operating pressure as recommended by the manufacturer.
- Compare your figure with the maximum lifting capacity indicated on the bag.
  - Your figure and the manufacturer's rating should be about the same.

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High-Pressure Air Bags

- Consist of rubber or neoprene material reinforced with steel bands or Kevlar, and usually have a coarse surface to increase the friction between the bag and the lifting surface
- Operated with an air system that can supply between 80 and 120 psi (5.6 and 8.4 kg/cm).

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High-Pressure Air Bags

- The drawback to high-pressure bags is that they do not lift objects very high.

Courtesy of Cecil V. "Buddy" Martinette, Jr.

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High-Pressure Air Bags

- To offset this limitation, you can stack them.
  - Stack no more than two and always put the largest-capacity bag on the bottom.
  - The total capacity of your lift is limited to the lowest capacity of the stacked bags.
- High-pressure bags, although very durable, cannot be repaired in the field if they should develop a hole.

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Low-Pressure Air Bags

- Used primarily in trench rescue to fill voids in trench walls
- Can be used to lift some objects
- Operated at 7 to 12 psi (0.5 to 0.8 kg/cm).

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Low-Pressure Air Bags

- Low-pressure bags will lift objects higher than high-pressure air bags will, but they will not lift nearly as much weight.
- Unlike high-pressure bags, if low-pressure bags get a hole in them, the hole can be plugged easily.

Courtesy of Bob Schilp

Courtesy of Bob Schilp

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Cribbing

- During each lift, the object being lifted should never be more than an inch from a substantial cribbing system.
- Cribbing material for trench rescue is usually cut out of 2 × 4-inch and 4 × 4-inch pieces of lumber.

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Cribbing

- It is recommended to cut cribbing from a softer type of wood (e.g., pine) rather than from a harder wood (e.g., oak).
  - Softer woods tend to bend and crack when they are being stressed.
  - Hardwoods in this type of application can and do fail without notice.

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Cribbing

- Generally, cribbing is cut to standard 12-, 18-, or 24-inch (30.5-, 45.7-, or 61-cm) lengths.
  - Over time, the wood will inevitably lose its natural moisture content.
  - It can then become brittle or split under a load.
  - Consider removing wood from response status every 12 to 18 months.

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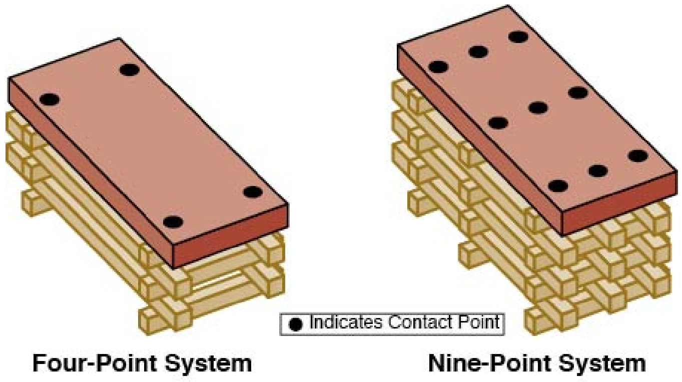
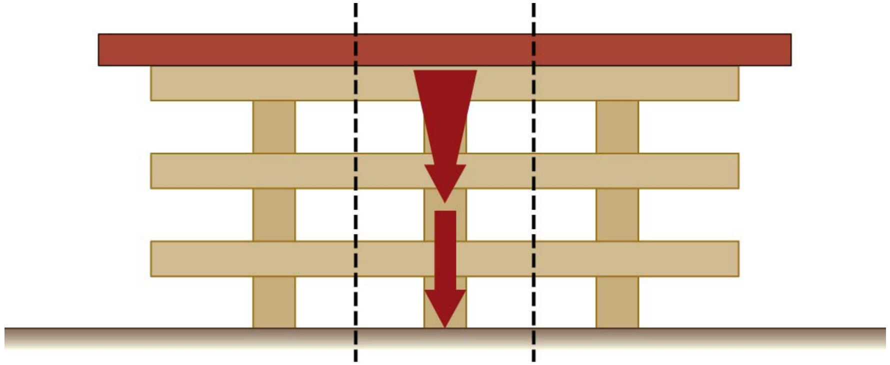
The Box Crib System

- There are three variations of the box crib system:
  - The four-point
  - The nine-point
  - The full-box crib
- Each system is named based on the number of contact points in the cribbing system.





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The Box Crib System

- A four-point box crib system has two timbers for each layer, but a total of four places that each piece of lumber crosses.
- A nine-point box crib has nine contact points and three pieces of cribbing on each layer of the system.
- A full-box crib system would be solid on all layers.

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The Box Crib System

- Each point of contact will support a standard amount of weight, depending on the size of the lumber.
  - A 4 × 4-inch crib will support approximately 6000 pounds (2721.6 kg) per contact point.
  - A 6 × 6-inch crib will support approximately 15,000 pounds (6803.9 kg) per contact point.
  - By adding the number of points together, you can determine the total capacity of the box crib.

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Wedges

- Wedges are cut pieces of lumber that form an inclined plane.
- The plane of the wedge makes it adjustable depending on the space it needs to occupy.
- When used in this fashion, the wedge takes up the space between the object being lifted and the box crib, until a full piece of timber will fit under the object.

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Wedges

- Wedges have a variety of uses at a trench rescue.
  - Functioning as inclined planes, they can be used to tighten objects and take up spaces between wales and uprights.
  - In the timber trench, wedges can be used to tighten the shores to the uprights.

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Wedges

- Wedges being used to fill a void between the wale and the strongback.

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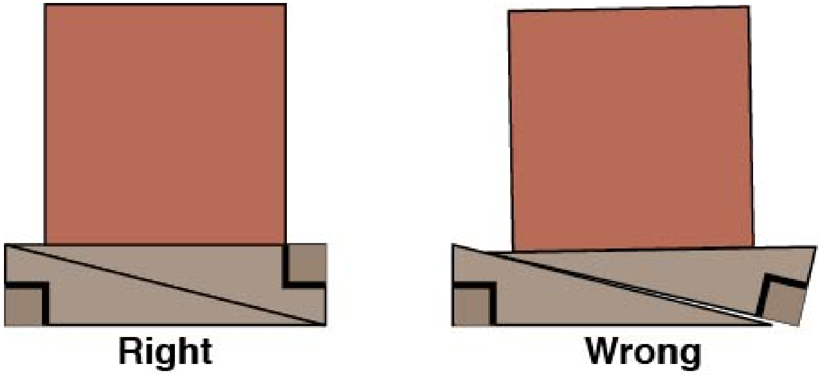
- Cut wedges are married properly when the cut sides are in contact with each other.



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Summary

- All rescue personnel can benefit from an understanding of the basic concepts of lifting and moving.
- Ultimately, when you find yourself on a trench rescue scene, much of what you do to either rescue or recover a victim involves displacing materials or solid objects to gain access.

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Summary

- Before any consideration is given to lifting or moving an object, some effort should be devoted to calculating how much the object weighs.
- The basic physics associated with lifting and moving objects include the concepts of gravity and its effects on mass, friction and resistance to force, center of gravity, moment of force considerations, and mechanics.

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Summary

- The theory of mechanics is divided into two areas called energy and work. The effective use of rescue tools is often determined by a thorough understanding of these concepts and their application in a given situation.
- Levers can be used to move, haul, pull, or raise a load. Every lever has a fulcrum, which serves as a pivot point for the lever; force, which provides the power; and a load.

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Summary

- An inclined plane uses gradual increases in height to gain efficiency by reducing required force over time.
- Air bags can be used to lift heavy objects like pipes, excavators, steel panels, and concrete distribution boxes. Low-pressure and high-pressure bags are most commonly employed in trench incidents.

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Summary

- The lifting capacity of any air bag is limited to the amount of bag surface area that can contact the object, multiplied by the operating pressure supplied to the bag.
- The drawback to high-pressure bags is that they do not lift objects very high.
- Low-pressure bags will lift objects higher than high-pressure air bags will, but they will not lift nearly as much weight.

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Summary

- During each lift, the object being lifted should never be more than an inch from a substantial cribbing system.
- There are three variations of the box crib system—the four-point, the nine-point, and the full-box crib. Each system is named based on the number of contact points in the cribbing system.

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Summary

- Wedges are cut pieces of lumber that form an inclined plane. The plane of the wedge makes it adjustable depending on the space it needs to occupy.

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Cecil V. "Buddy" Martinette, Jr., *and* Ron "Z" Zawlocki

Trench Rescue

Principles and Practice to NFPA 1006 and 1670

THIRD EDITION

Chapter 10

Protective Systems

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Protective System Used for Trench Rescue

- The protective systems used at the majority of trench rescue incidents across the United States consist of panels, struts, wales, and support equipment.
- The method used to install that equipment at a collapsed trench with victims trapped is called trench rescue shoring.

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Protective System Used for Trench Rescue

- Trench rescue shoring is similar to underground construction shoring but has some key differences.
  - Rescue technicians need to know when the incident scene requirements have exceeded their ability to manage the situation safely.
  - They need to understand not only their own techniques and equipment, but also the techniques and equipment that contractors use in less serious but equally dangerous situations (commercial methods).

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Fundamentals of Trench Rescue Shoring

- The sheeting and shoring techniques used by rescuers evolved over time from the underground construction industry.
- While these two shoring disciplines share some similarities, several significant differences exist as well.

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Rescue Shoring Is Not Construction Shoring

- Shoring in the underground construction world differs from shoring of a trench for rescue in several ways:
  - Rescue shoring must focus on the needs of a trapped victim.
  - Sheeting/shoring used for construction purposes is designed to be installed before the soil becomes active.

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Rescue Shoring Is Not Construction Shoring

- A vast variety of methods, techniques, and equipment are used for underground construction shoring, whereas the methods, techniques, and equipment used for rescue shoring are fairly limited.

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Trench Rescue Shoring

- Trench rescue shoring is defined as the use and application of shoring techniques designed to resolve the majority of trench cave-in situations.
  - It is limited to type A, type B, and some type C soil conditions in trenches up to 20 feet (6 m) deep.
- Successful trench rescue teams develop a default rescue shoring method, which they use as their go-to method.

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Trench Rescue Shoring

- When establishing your default method, make sure it meets the following criteria:
  - Can be accomplished with the shoring equipment carried on your trench rescue unit
  - Is built upon best practices with adequate strength to resist the forces of C-60 soil
  - Can be rapidly deployed to protect the victim from additional collapse
  - Can be implemented in phases
    - First to protect the victim, and second to create a safe zone for rescuers to work

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Lip Protection

- At each trench, you will need to decide which kind of lip protection is best suited for the situation.
  - Ground pads
    - Skill Drill 10-1
  - Lip bridges
    - Skill Drill 10-2

Courtesy of Ron Zawlocki

Courtesy of Ron Zawlocki

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Panels

- Of all of the equipment in a trench rescue cache that can be used to make a trench safe, panels (sheeting) along with struts (shores) are used the most often.
  - Panels help to both collect the loads and distribute them.
- The recommended panels at rescue incidents are ¾-inch or 1-inch thick, 4 × 8-foot sheets of Shorform or FinnForm, with a 2 × 12-inch strongback already attached.

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Panels

- Most trench rescue teams rely on default shoring methods that include the use of 4-foot (1.2-m) wide panels with strongbacks positioned in the center.
- Panels should be used whenever possible to shore collapsed walls, because shoring that includes panels provides strength and redundancy to the system.

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Skip Shoring and Spot Shoring

- Skip shoring
  – Shoring done with strongbacks only (no panels).
- Spot shoring
  – Shoring that does not use either traditional strongbacks or panels
  – Uses specially designed rail bases installed directly on the trench walls
- Used when a trench wall is in danger of imminent collapse

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Skip Shoring and Spot Shoring

- The Speed Shore has the strongback portion of the protective system already installed as part of the shore.
- This type of skip shoring is not recommended when soil has collapsed or is active.

Courtesy of Speed Shore Corporation

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Panel Installation

- A same-side panel set is accomplished by lowering a panel into the trench from the same side where it will be positioned.
  - See Skill Drill 10-3
- An opposite-side panel set involves positioning a panel on the wall that is across (opposite) from the side used to lower it.
  - See Skill Drill 10-4

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Panel Installation

- When placing panels for a rescue, the first two panels are set on each side of the victim, and then two more are set on each side.
  - This creates a working area for the rescue team if immediate digging or victim care is needed.
- For nonintersecting trenches up to 8 feet (2.4 m) deep, the recommended number of panels is six.

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Struts

- Struts are the horizontal braces that extend across the trench and transfer the forces from one trench wall, through the strongback/panels, and into the opposite wall.
  - Also known as shores or cross-braces.
- Strut activation forces create pressure on the soil behind the strut and panels.

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Struts

- A best practice for trench rescue shoring is to use struts that meet the following criteria:
  - Can be installed with controllable and measurable strut pressure
  - Can be installed and removed without entering the trench
  - Have full strength with activation forces of between 1000 and 1500 pounds (453.6 and 680.4 kg) of force

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Pneumatic Struts

- Pneumatic struts use air pressure to extend the piston inside the cylinders to create pressure against the strongbacks, panels, and wales positioned on the trench walls.
  - Pneumatic systems allow you to measure (gauge) and control (vary) strut pressure.

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Pneumatic Strut Pressure

- Strut pressure
  - Refers to the amount of air pressure that the air system is sending to the strut
- Activation force
  - Measurement of the total force that the strut exerts
- Total force
  - Pressure (psi or kg/cm) multiplied by the number of square inches of the strut's surface area

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Pneumatic Strut Placement

- The proper strut placement and installation sequence at a rescue incident depends on several factors:
  - How deep the trench is
  - What is likely to collapse next
  - Whether a rescuer has to enter the trench to lock the collar manually

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Pneumatic Struts

- A common practice for primary shoring where the goal is to rapidly protect the area directly above the victim is to install three struts in the first panel set.
  - Middle, bottom, top
- After the first set of panels and struts is in place, rescue personnel can work within the safe area.

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Pneumatic Struts

- The middle shore is installed on the first set of panels.
- A single shore may provide enough protection to save a life.

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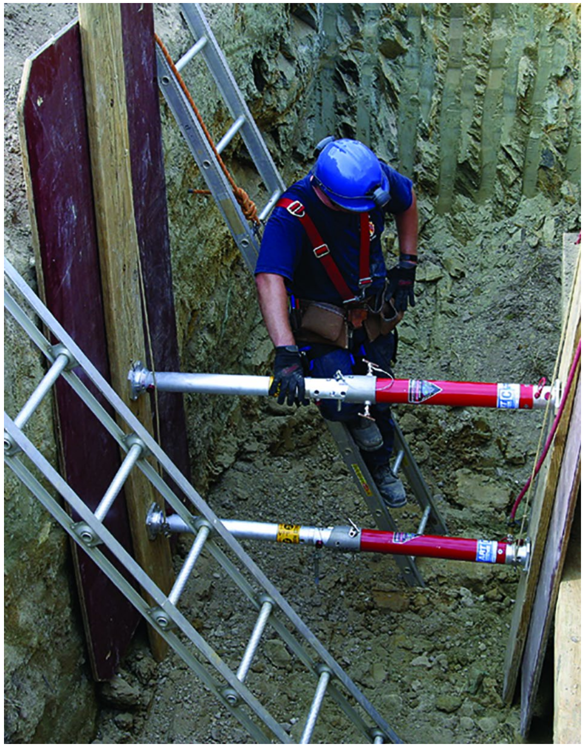
Pneumatic Struts

- The bottom shore being installed



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- The top shore completes the installation of the first set of panels

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Strut Placement Options

- Pneumatic struts that can be installed and locked from outside the trench allow rescuers to place struts where they are needed so as to prevent collapse, while also minimizing the risks to rescuers.

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Strut Placement Options

- A significant disadvantage of struts that require entry for installation is that rescuers entering a trench during the shoring installation process are exposed if a secondary collapse occurs.
  - Shoring from the top down provides the installer with some protection as he or she descends deeper into the trench.

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Strut Placement Options

- When a portion of the wall has collapsed, the sequence and placement of struts may change and should be dictated by the section of wall that is most likely to fall on the victim.
- In the case of a collapse leaving an unsupported overhanging wall, the sequence for shoring with pneumatic struts is top, bottom, middle.

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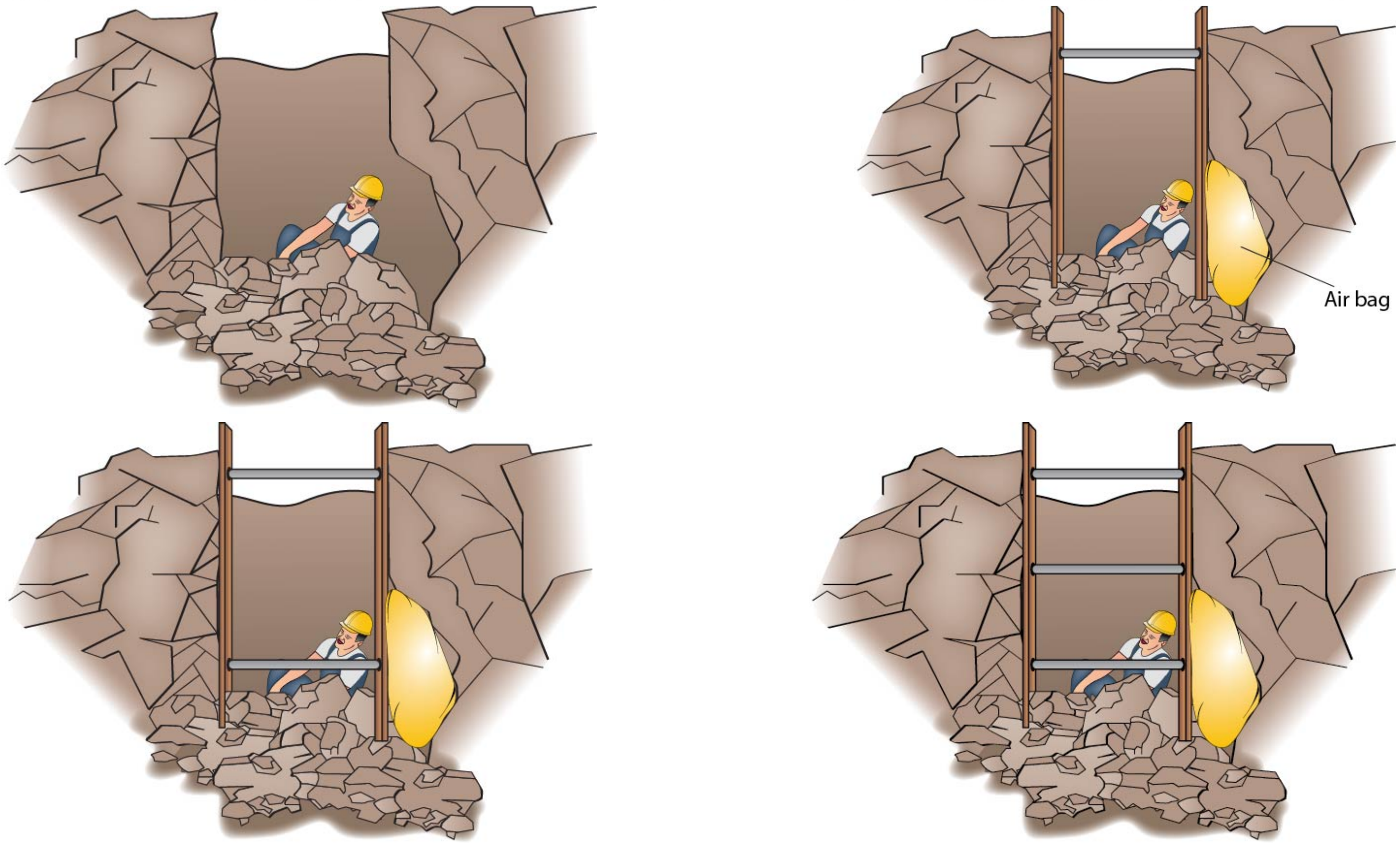
Strut Placement Options



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Pneumatic Strut Spacing

- The 4-foot (1.2-m) rule—no space greater than 4 feet (1.2 m) between any horizontal or vertical shoring point—is a great rule of thumb and the cornerstone of most trench rescue protective systems.
  - Top strut 18 to 24 inches (0.5 to 0.6 m) from the trench lip
  - Bottom strut within 24 inches (0.6 m) of the trench floor

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Pneumatic Strut Spacing

- To install pneumatic shores from outside the trench:
  - Follow the steps in Skill Drill 10-5.
- To install pneumatic shores with rescuer entry:
  - Follow the steps in Skill Drill 10-6.

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Pneumatic Strut Spacing

- Organizations that use struts that must be locked from inside the trench should also use a shoring team consisting of a minimum of four members:
  - Officer
  - Controller (shooter)
  - Strut handler
  - Installer

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Timber Shores

- Timber shores have a long history in both construction and rescue shoring.
  - In either application, they are very time consuming and they expose installers to the trench before it is safe.
- The minimum recommended size of timber shores for active soil is 4 × 6 inches and larger.
- OSHA provides a comprehensive guide for timber shoring.

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Installing Timber Shores

- Timber shores require a somewhat different procedure for their installation than do pneumatic shores.
  - Follow the steps in Skill Drill 10-7.
- Organizations that use timber struts should have a shoring team consisting of a minimum of four members:
  - Officer
  - Two strut handlers
  - Installer

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Installing Timber Shores

- Timber shores are usually tightened by using wedges or timber screw jacks or by oversizing the length of the shore and driving it in with hammers.
- The minimum-sized Douglas fir shore that is approved for type A and type B soil trenches up to 10 feet (3 m) in depth is 4 × 6 inches.

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Installing Timber Shores

- Rails that are 2 × 4 inches can be installed on the strongback prior to setting the panels.
- Known as "railing the strongback"

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Screw Jack Shoring

- Screw jacks are used with pipes or timbers. The screw allows the strut to be tightened against the trench walls.
  - Pressure distribution across the shoring system is difficult and is based on the installer's touch rather than gauges.

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Hydraulic Shoring

- Hydraulic struts have been successfully used to shore trenches for many years.
  - The rescue service borrowed this technique from construction workers.
- Activation pressure is created by pumping hydraulic fluid from a reservoir through hoses and into the strut cylinders.
- Hydraulic struts do not have collars.

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Wales

- Wales are horizontal members that are used to span openings along the trench walls.
- They can be of the inside or outside variety.
- They can be made of timber, laminated beams, metal, or makeshift ladders.
- After installation, it is necessary to backfill the area between the panels and the trench wall.

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Wales

- Inside wales are used to span a trench panel to create a safe area in a "T" trench or to create an open space in the middle of a trench.

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Wales

- Outside wales are placed against the trench wall before the panels are put into position.
- They are used to span an opening that may have been created by a slough of the trench wall.

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Isolation Devices

- The term *isolation device* is specific to rescue operations.
- The use of concrete manhole rings, pre-cast concrete catch basins, steel or concrete pipe, and concrete vaults to provide a measure of protection in a trench is not an OSHA-compliant technique for keeping construction workers safe.
- The use of an isolation device is a temporary or last-resort option.

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Modular Shields

- Modular shields are aluminum trench boxes that are assembled at the scene and are rated for human safety.
- Modular aluminum or steel shoring is available in a variety of shapes and configurations based on the size of the excavation and the type of soil in which they will be installed.
- Some of these units are air or hydraulically adjustable.

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Modular Shields

- Rescuers with access to modular shields are encouraged to train with them and to develop alternative methods for installing them.

Courtesy of Ron Zawlocki

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Engineered Systems

- A pre-engineered rescue shoring system that can resist the forces of extreme soil conditions and can be built with the shoring equipment carried on your rescue apparatus is a great addition to your tactical options.

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Engineered Systems

- A few questions to consider when an engineer creates a design for your organization:
  - How did the engineer calculate the soil forces for this design?
  - Is an accurate soil analysis required to use this design?
  - Does the engineer have field experience with trench rescue teams?
  - How long would it take your trench rescue team to install this system?

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Engineered Systems

- A few questions to consider (cont.):
  - Does this system meet the scope and purposes of the trench rescue operation?
  - Has the system been tested?
  - How many times stronger is the system than the forces that the soil could create?
- To create a protective system that is different from the OSHA standard, the system must be certified and approved by a registered engineer.

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Trench Rescue Shoring Equipment Removal

- Equipment removal needs to be carefully planned and executed to avoid mistakes and injuries.
  - It is best to use fresh crews to perform equipment removal.
- The person in charge of the equipment removal operation must create a plan that includes specific assignments and a clear sequence of events.

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Trench Rescue Shoring Equipment Removal

- Follow these steps to prepare for equipment removal:
  - Examine the lip conditions under each ground pad and/or lip bridge. Look for signs of soil movement.
  - Evaluate the condition of the walls around the sheeting and shoring.
  - If cracks, fissures, sloughing, and other indicators of active soil are present, do not attempt manual removal. Instead, have heavy equipment brought to the scene to remove rescue equipment.

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Trench Rescue Shoring Equipment Removal

- Follow established procedures for:
  - Machine removal of a pneumatic strut shoring system starting from the bottom of the trench and working up
  - Manual removal of a pneumatic strut shoring system starting from the bottom of the trench and working up

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Commercial Shoring Techniques

- Deep trenches and extreme soil conditions (running soils) are beyond the scope of conventional rescue shoring operations.
- In these cases, professional engineers and construction workers should be called to assist with the extrication effort.

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Commercial Shoring Techniques

- Consider using commercial techniques and professional help if any of the following factors is present:
  - Type C-80 soil conditions
  - Soil below the water table
  - A trench deeper than 20 feet (6.1 m)
  - A massive cave-in
  - Workers trapped in running soil, grain, or product
  - Environmental conditions that prohibit the use of rescue shoring

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Commercial Shoring Techniques

- Factors to consider when selecting a protective system:
  - Adjacent structures
  - Existing hazards
  - Soil type
  - Water profile and hydraulic table
  - Depth and width of the trench
  - Purpose of operation (rescue versus utility installations)

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Commercial Shoring Techniques

- Consider the following issues when using commercial shoring techniques:
  - They are usually very time consuming.
  - Application may cause additional collapses
  - Utilities may have to be shut down or removed.
  - Commercial shoring techniques require tabulated data and/or engineered designs.
  - They require a cool, calm, and collected equipment operator working under an experienced rescue officer's direction.

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The Use of Commercial Systems at Rescue Scenes

- Commercial systems require the use of heavy equipment and highly skilled operators.
- To make the trench safe for rescue or recovery operations, rescuers must work hand in hand with heavy equipment operators.

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Sloping and Benching Systems

- Two methods used to protect underground construction workers.
- Both techniques utilize the same principle that removes or minimizes the dangerous vertical sections of the trench walls.
- The walls are angled to a point where the material will support its own weight and will no longer collapse or flow (angle of repose).

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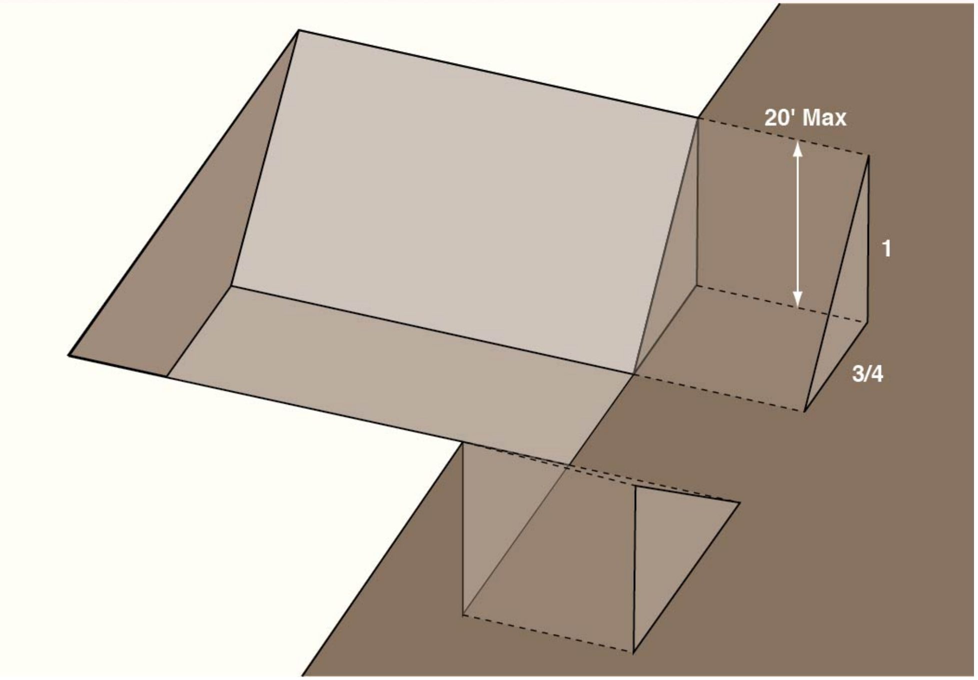
Sloping and Benching Systems

- After the sloping is completed, it reduces the angle of the trench wall to eliminate collapse potential.



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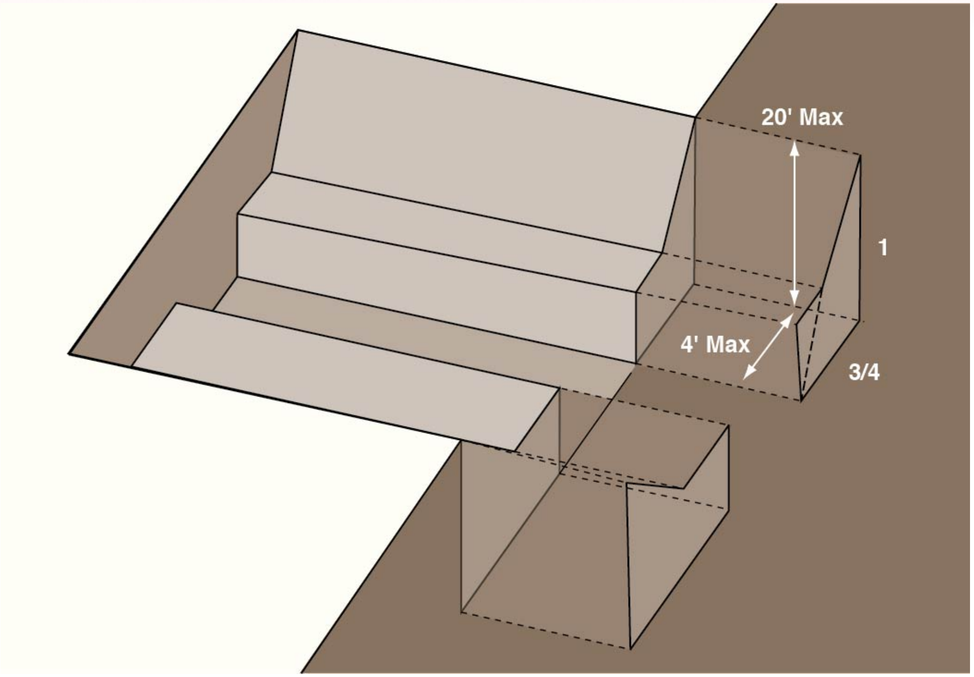
Sloping and Benching Systems

- Benching is another technique that reduces collapse potential.



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Trench Box

- Trench boxes are commonly found at trenching sites.
- Usually contain steel or aluminum side walls and spreaders.
- Come in a variety of lengths, heights, widths, side wall thicknesses, and weights.

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Soldier and Sheet Piling

- Soldier piling and sheet piling are fixed shoring systems that support trench walls.
- Sheet piles can be cantilevered, braced, or tied back to provide ground support.
- Piling is installed by pushing it in with a backhoe; drilling a hole to fit the pile; or using an impact, vibrating, or hydraulic hammer.

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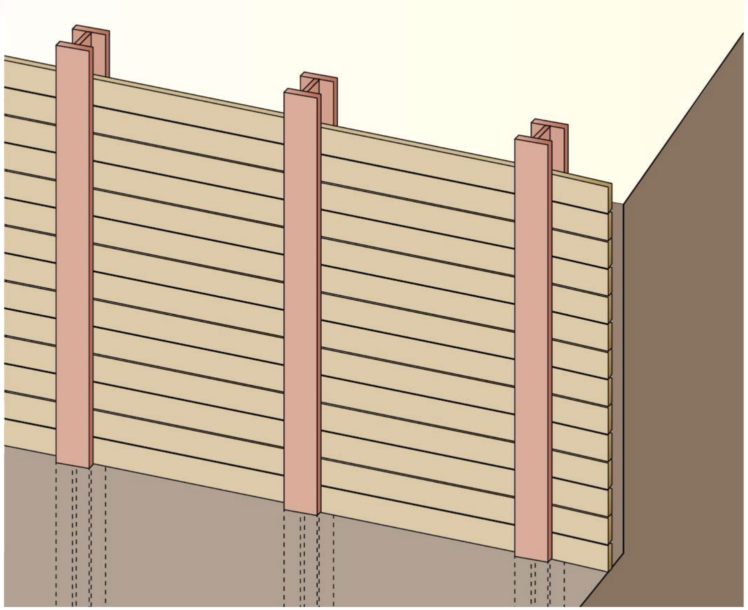
Soldier and Sheet Piling

- Soldier pile shoring consists of a set of horizontally installed wales held in place by a set of vertically installed piles.



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Soldier and Sheet Piling

- Interlocking steel sheet pile shoring is a commercial technique typically used in deep trenches subject to tremendous compressive forces.
- These are seldom used at rescue incidents.

Courtesy of Chuck Wehrli

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Use of Heavy Equipment at Rescue Scenes

- You must be capable of coordinating the use of heavy equipment at a rescue or recovery incident.
- This includes evaluating the capabilities and limitations of the operator and the equipment and establishing and maintaining communication with the equipment operator.

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Capabilities and Limitations

- Backhoe
  - Excavating equipment consisting of a digging bucket on the end of a two-part articulated arm
  - Typically mounted on the back of a tractor or front loader
- Excavator
  - Engineering vehicle consisting of an articulated arm, bucket, and cab mounted on a pivot fastened to tracks or wheels

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Capabilities and Limitations

Backhoe

Courtesy of Ron Zawlocki

Excavator

Courtesy of Ron Zawlocki

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Capabilities and Limitations

- Operational components:
  - Boom: The section of the arm closest to the vehicle
  - Stick: The section of the arm that carries the bucket
  - Bucket: A specialized container attachment with teeth to facilitate digging
  - Lifting eye: The factory-installed rigging point on a bucket
  - Outriggers: Stabilizers
  - Center pin: The center of the rotating platform on an excavator

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Capabilities and Limitations

- Equipment capabilities and limitations are objective and easy to determine based on the size and design of the machine.
- Determining the ability and limitations of the operator is much more subjective.
  - Determine the operator's emotional state and mental sharpness
  - Ask how many years of experience he or she has

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Establish and Maintain Communications

- Operations around a construction site are often noisy and hectic.
- You must either establish radio communications and verify that there is no language barrier, or communicate through well-established hand signals.

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Hand Signals

- Essential hand signals include the following:
  - Boom (up/down)
  - Stick or arm (in/out)
  - Bucket (in/out)
  - Swing (left/right)

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Hand Signals

- To lift and move an object you need to know the following signals:
  - Load (in/out)
  - Load (up/down)
  - Slow
  - Travel (ahead/back)
  - Stop and emergency stop

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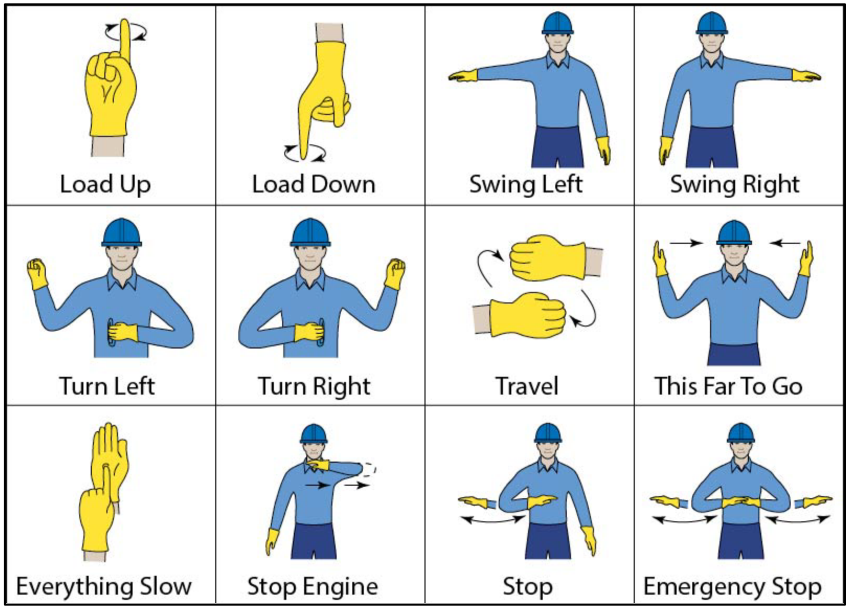
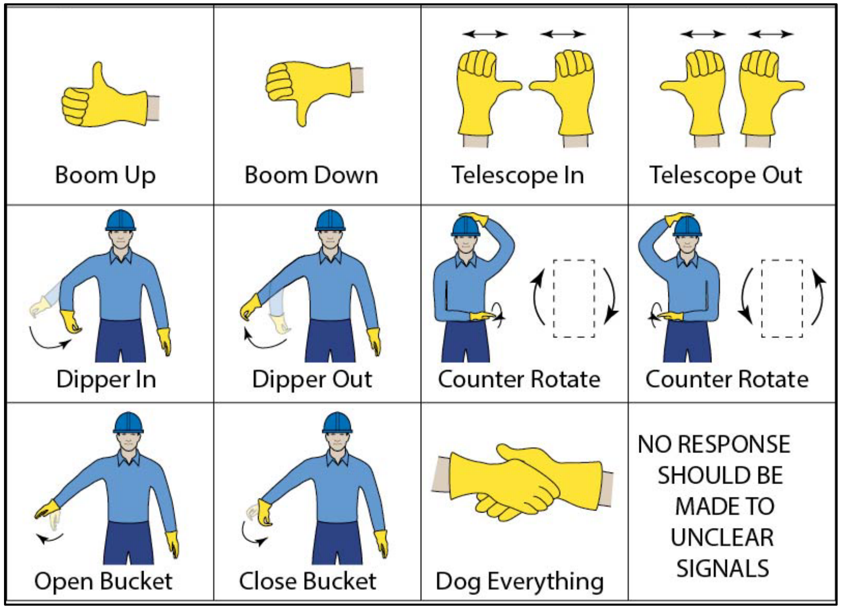
Hand Signals





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Summary

- The protective systems used at the majority of trench rescue incidents across the United States consist of panels, struts, wales, and support equipment.
- The sheeting and shoring techniques used by rescuers have evolved from the underground construction industry.

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Summary

- The benefits of having a default rescue shoring method are that it is well practiced and that placement of equipment should enable rapid deployment of primary and secondary shoring techniques.
- At each trench, you will need to decide which kind of lip protection is best suited for the specific situation.

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Summary

- Of all of the equipment in a trench rescue cache that can be used to make a trench safe, panels (sheeting), in combination with struts (shores), are used the most often.
- Pneumatic, hydraulic, timber, and screw jacks are common types of struts used by trench rescue teams. Each has advantages and disadvantages.

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Summary

- Timber shores have a long history in both construction and rescue shoring. In either application, they are very time consuming to install and create additional risks because they expose installers to the trench before it is safe.
- Wales are horizontal members used to span openings along the trench walls. They can be of the inside or outside variety, and can be made of timber, laminated beams, metal, or makeshift ladders.

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Summary

- The use of concrete manhole rings, pre-cast concrete catch basins, steel or concrete pipe, and concrete vaults to provide a measure of protection in a trench is not an OSHA-compliant technique for keeping construction workers safe. Their use can, however, provide a protective barrier for a victim involved in a trench accident.

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Summary

- A pre-engineered rescue shoring system that can resist the forces of extreme soil conditions and can be built with the shoring equipment carried on your rescue apparatus is a great addition to your tactical options.
- Equipment removal needs to be carefully planned and executed to avoid mistakes and injuries.

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Summary

- Deep trenches and extreme soil conditions (running soils) are beyond the scope of conventional rescue shoring operations. In these cases, professional engineers and construction workers should be called to assist with the extrication effort.

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Cecil V. "Buddy" Martinette, Jr., *and* Ron "Z" Zawlocki

Trench Rescue

Principles and Practice to NFPA 1006 and 1670

THIRD EDITION

Chapter 11

Trench Rescue Shoring Techniques

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Basic Considerations in Trench Protection

- Establish an incident command system.
- Provide hazard control.
- Monitor the area around and in the trench before and during the extrication effort.
- Consider ventilation.
- Install ground pads or lip bridges.

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Basic Considerations in Trench Protection

- Ladder placement
  - Place the first ladder near the victim.
  - Provide at least two points of egress and ingress.
  - Means of egress no more than 25 feet (7.6 m) from workers
  - Ladders spaced no more than 15 feet (4.6 m) apart

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Basic Considerations in Trench Protection

- Preoperational briefing
  - Overall goals of the operation
  - Specific protective system design
  - Assignments
  - Safety requirements
  - Accountability system
  - Emergency evacuation procedures
- Event documentation
- Postincident critique

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Basic Considerations in Trench Protection

- It is only after careful consideration and risk–benefit analysis that you should ever enter a trench before the complete protective system is in place.
- In a recovery situation, never enter the trench until the entire protective system is in place.

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Rescue Shoring Strategy

- Always start with what is required to immediately protect the victim.
- The strategy (and corresponding tactics) must be easily expanded from that point to create a safe working area for rescuers.
- The strategy is completed with a continuation of efforts to maximize rescuer and victim safety during the extrication process.

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Rescue Shoring Strategy

- The fundamental trench rescue shoring strategy consists of the following steps:
  - Primary shoring to quickly protect the victim
  - Secondary shoring to create a safe working area for rescuers
  - Complete shoring to maximize safety during the extrication and victim removal process

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Primary Shoring

- The purpose is to rapidly provide protection to the victim(s) by stabilizing the area(s) of the trench that is (are) most likely to collapse.
- The scope includes the use of strategically placed panels and struts, spot shores, and skip shores.
- Primary shoring is usually concluded with the placement of one or two struts.
- A good primary shoring plan must allow for future installation of secondary shoring.

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Secondary Shoring

- The purpose is to provide a safe zone for rescuers working inside the trench.
- The scope includes expanding and enhancing the area shored during primary shoring.
- The goal is the development of a safe zone that is 12 feet (3.7 m) wide (three-panel set).
- During secondary shoring, backfill is put in place and all struts are activated to the manufacturer's recommended pressures.

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Complete Shoring

- Its purpose is to maximize the safety of the rescuers and the victim during extrication and victim removal operations.
- The scope includes the creation of a safe zone that is at least as wide as it is deep.
- In complete shoring, all struts are pressurized to the manufacturer's specification, all strut bases are nailed, and supplemental shoring is in place.

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Straight-Wall Trench

- The straight-wall trench clearly shows the basis of the fundamental rescue shoring strategy.
- A straight-wall trench that is at least 12 feet (3.7 m) long requires the rescuer to use a minimum of three sets of panels.
- Straight-wall shoring
  - To shore a straight-wall trench, follow the steps in Skill Drill 11-1.

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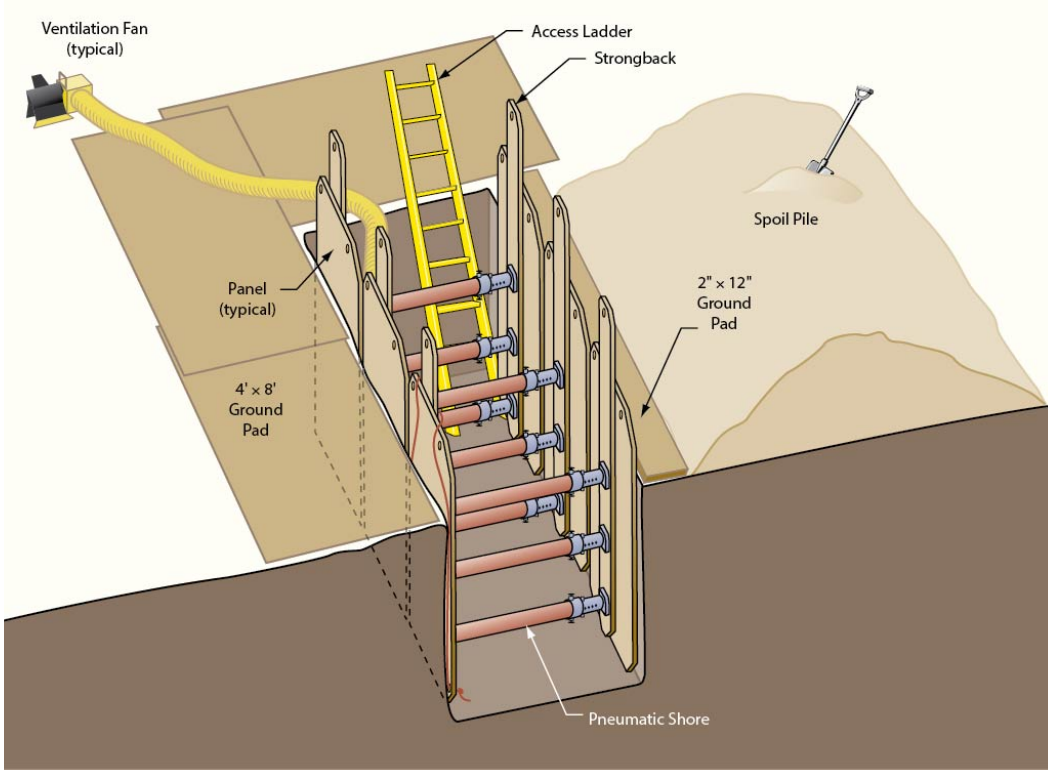
Straight-Wall Shoring



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Outside Wales

- An outside wale is used to span a large void in a trench wall.
- The void created in this collapse situation is usually larger than a void that can be filled with soil, timber, or single air bag backfill techniques.
- It requires that sets of outside wales (usually at least two sets) be installed to span the void created by the cave-in.

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Outside Wales

- The wales provide a backing or foundation that supports the panels.
- They also provide a temporary point of resistance for the struts and any subsequent forces (soil pressure) being transferred from the opposing wall.
- To install outside wales, follow the steps in Skill Drill 11-2.

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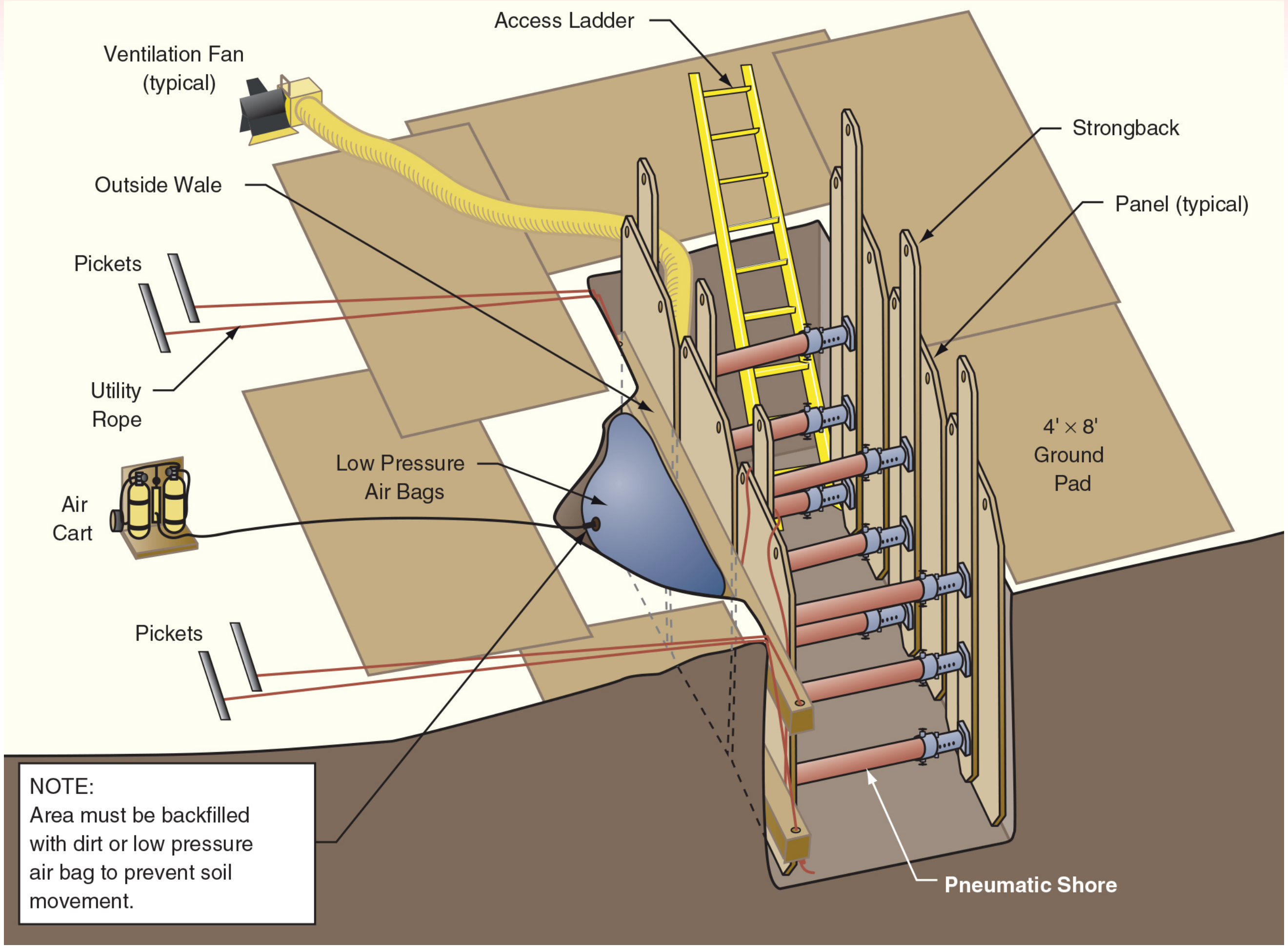
Outside Wales



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Outside Wales

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Inside Wales

- Inside wales are commonly used to span a set of panels to create an open space.
- The open space may be required to provide room for digging or extrication operations or to shore around an obstruction that cannot be moved.
- Whenever a rescue or recovery will require significant digging activity, using inside wales to create an open work area is a preferred technique.

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Inside Wales

- The open space created around the victim facilitates rescuer movement and eliminates strut-related obstructions as a concern for victim packaging and extrication.
- To use inside wales, follow the steps in Skill Drill 11-3.

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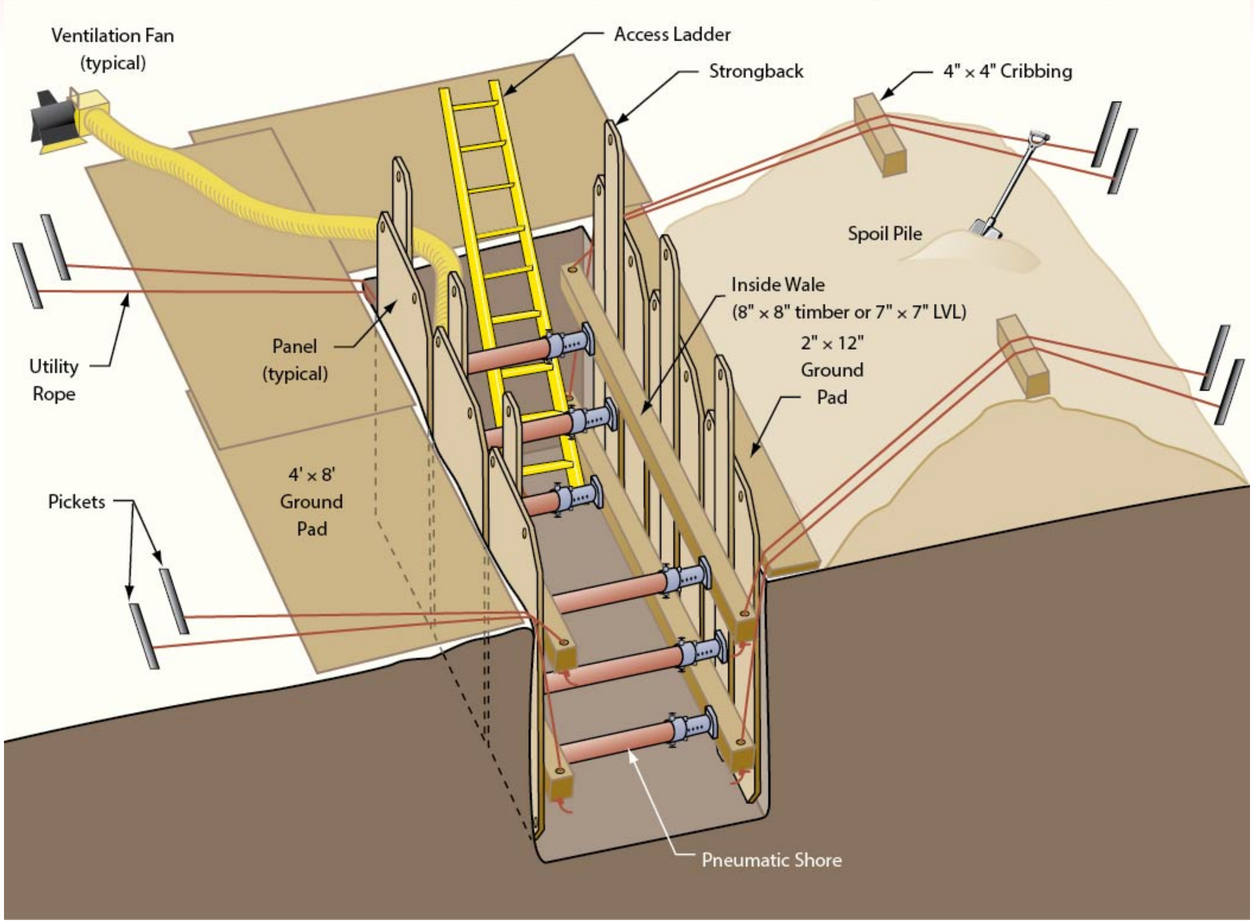
Inside Wales



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Supplemental Shoring

- After secondary shoring has been installed, rescuers may need to add modified sheeting and shoring to complete the shoring task.
- This process can be used to extend shoring either between (vertical) or under existing shoring systems.
- The need to extend under existing shoring usually stems from removal of soil while digging to extricate a buried victim.

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Supplemental Shoring

- The soil can be removed using a variety of techniques, including:
  - Entrenching shovels
  - Buckets
  - Air-knives
  - Vacuum systems
- Exposed portions of a trench wall are subject to collapse and must be shored.

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Supplemental Shoring

- Whenever 2 vertical feet (0.6 m) of wall is exposed, additional (supplemental) shoring must be added.
- Supplemental sheeting
  - ¾-inch FinnForm cut into 2 × 4-foot (0.6 × 1.2-m) sections or 2 × 12-inch lumber cut 4 feet (1.2 m) long.

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Supplemental Shoring

- Strongbacks
  - 2 × 12 inches at 36 inches (0.9 m)
  - Bolted or screwed to the supplemental sheeting or nailed together at the scene.
- To install supplemental shoring, follow the steps in Skill Drill 11-4.

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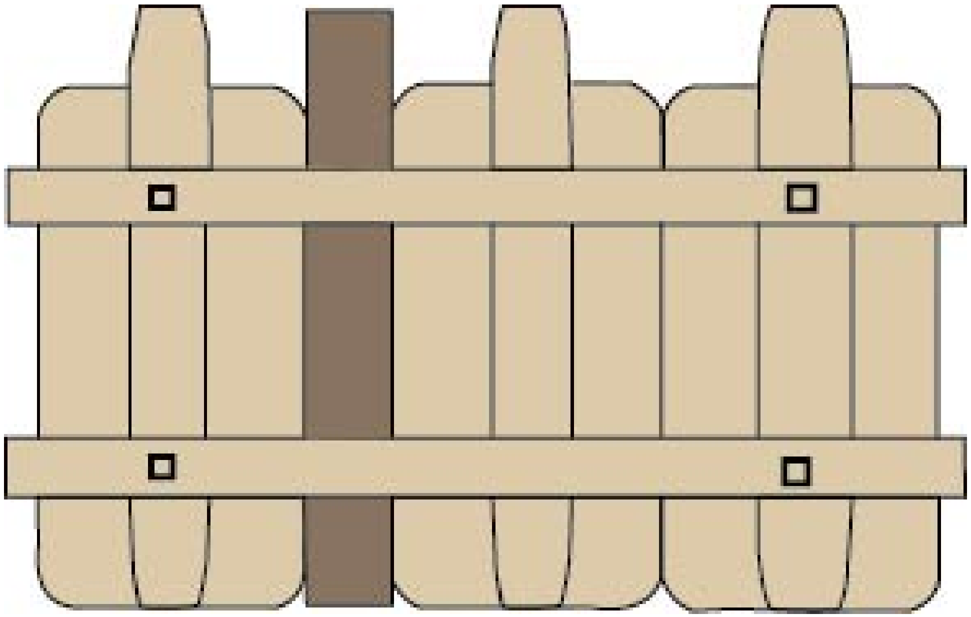
Supplemental Shoring

- Vertical supplemental sheeting.



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T-Trench

- Intersecting trenches are significantly less stable than straight trenches.
  - Have more exposed surface areas
  - Higher probability for collapse
- The area where the two unsupported wall surfaces meet is the most susceptible to collapse.
  - A T-trench has two such (corner) areas.
- The key is to capture (support) the inside corners as quickly as possible.

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T-Trench

- A typical shallow T-trench requires the use of inside wales and a minimum of seven panels.
  - Less than 10 feet (3 m) deep
- The inside wales act as headers or simply supported beams and carry the load (soil forces) between the struts.

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T-Trench

- The objective is to immediately protect the victim and then create a shoring system that supports both the corners and the area directly across from the opening.
  - Try to capture the corners first.
  - Limit personnel and equipment at the corners.
- To shore a T-trench, follow the steps in Skill Drill 11-5.

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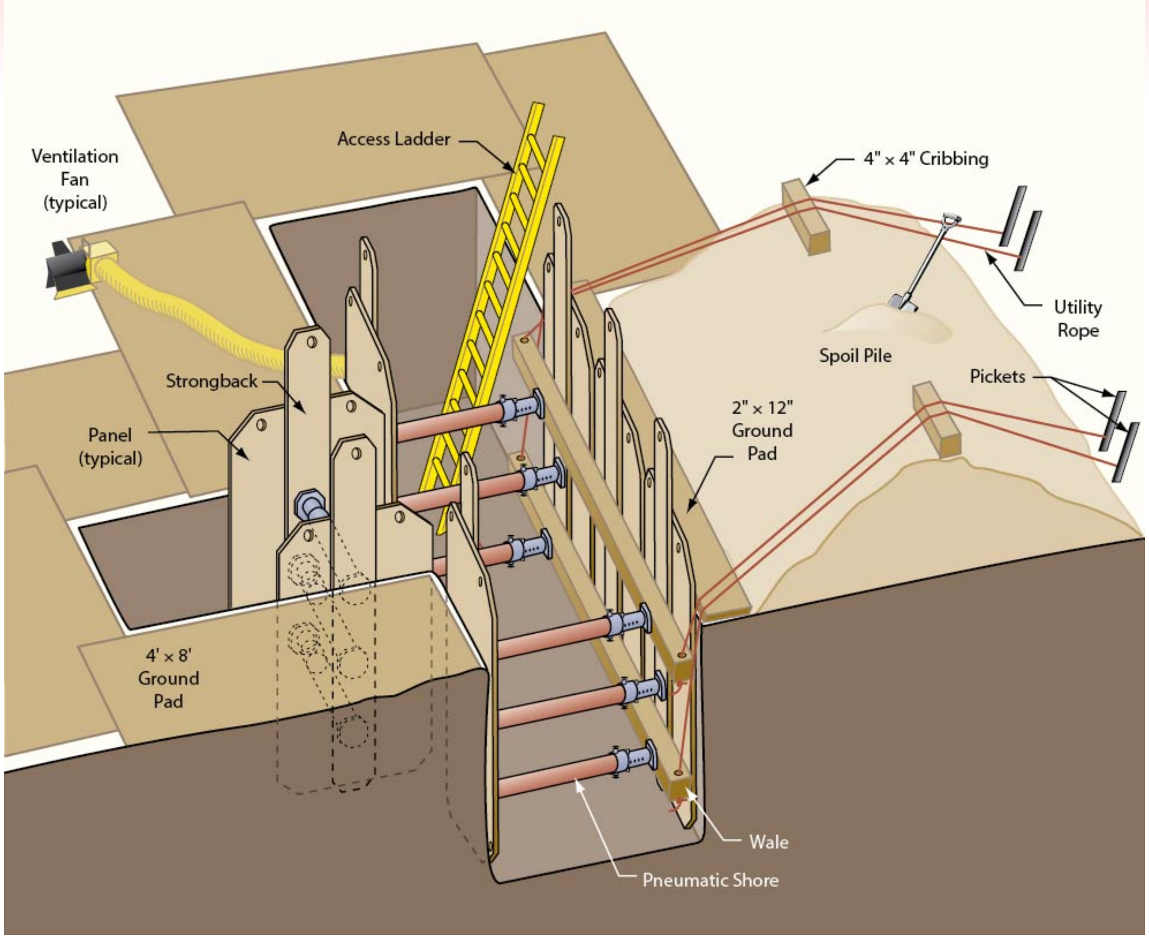
T-Trench



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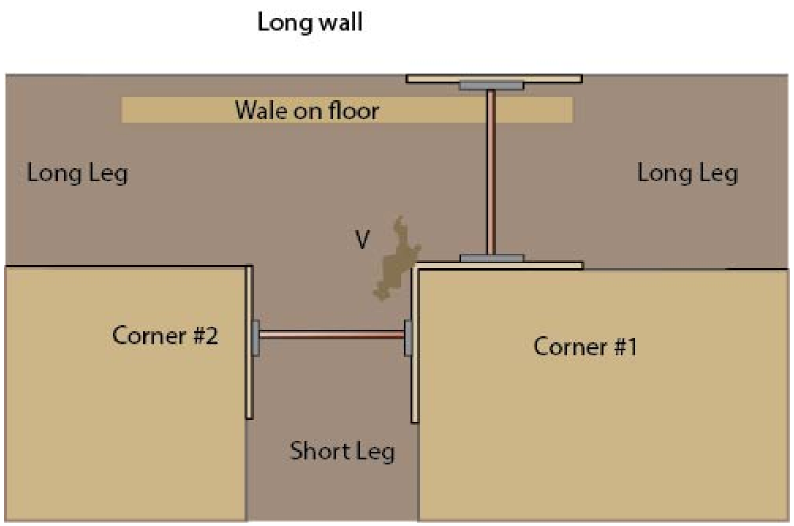
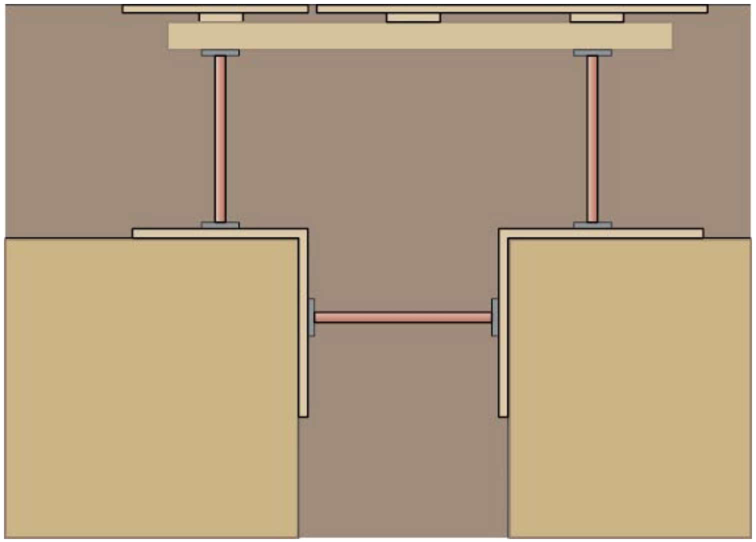
T-Trench

Primary shoring plan



Secondary shoring plan



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L-Trench

- The L-trench consists of two trench cuts or legs that converge at a single point, commonly forming a right angle.
- The inside and outside corners formed by the intersection are difficult to shore with standard trench rescue equipment and techniques.

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L-Trench

- There are two methods for shoring an L-trench.
  - One method uses thrust blocks to shore an L-trench that has not yet collapsed.
  - The other method uses corner brackets to shore an L-trench with a moderate-sized inside corner collapse.
- Both methods are effective for shoring either of these two conditions (collapsed or not).

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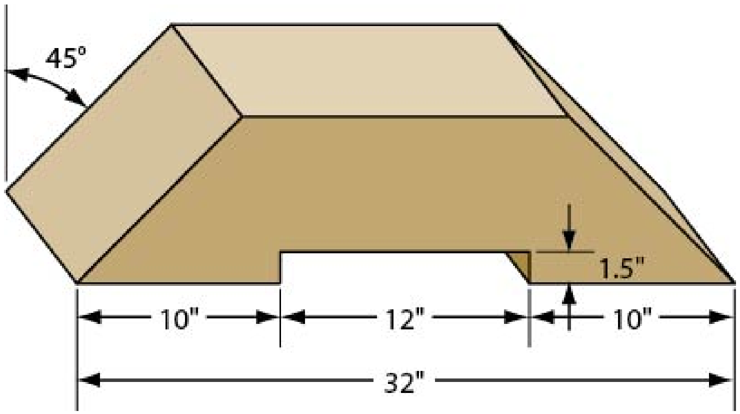
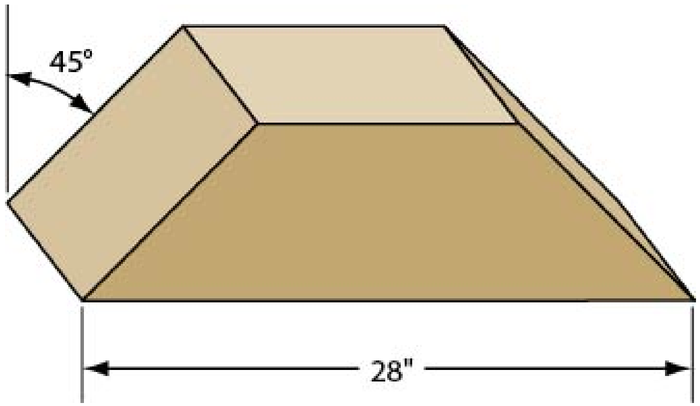
Thrust Blocks and Corner Blocks

Thrust blocks



Corner Blocks



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L-Trench

- The chosen method must be predetermined so that the correct specialty equipment is purchased and its use mastered before it is needed at a rescue incident.
- The techniques described in this section are useful for shoring L-trenches that are up to 8 feet (2.4 m) deep.
- By adding a third tier of shoring, these techniques could be used in L-trenches up to 10 feet (3 m) deep.

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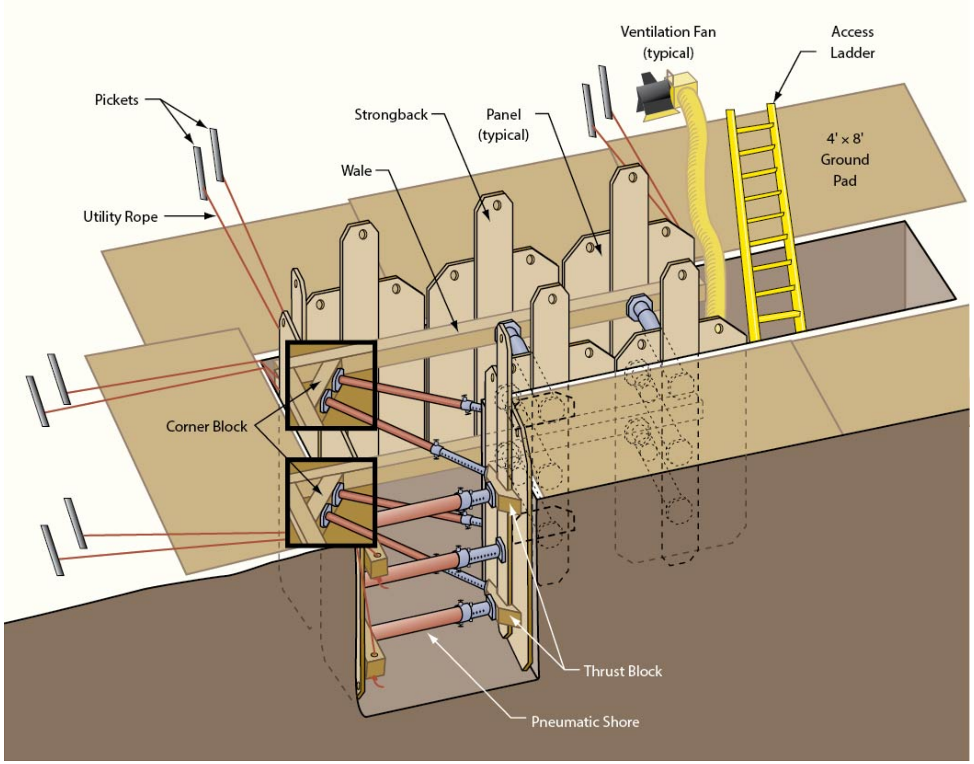
L-Trench



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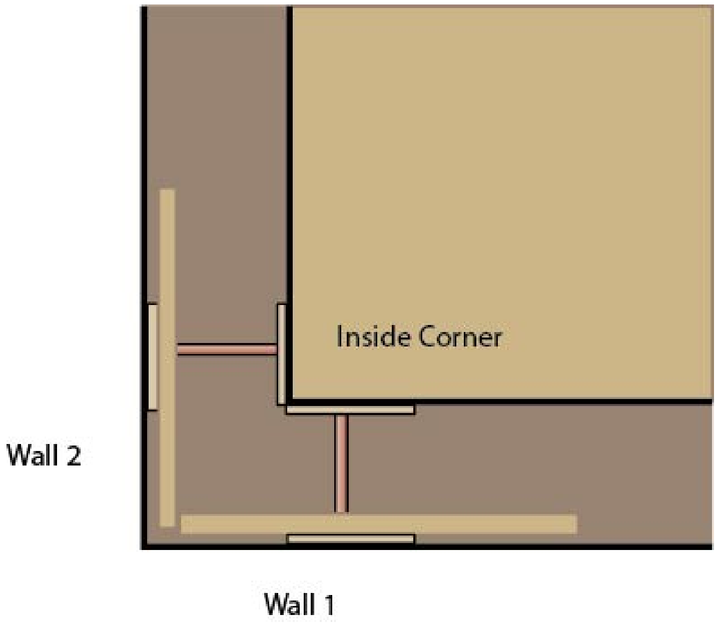
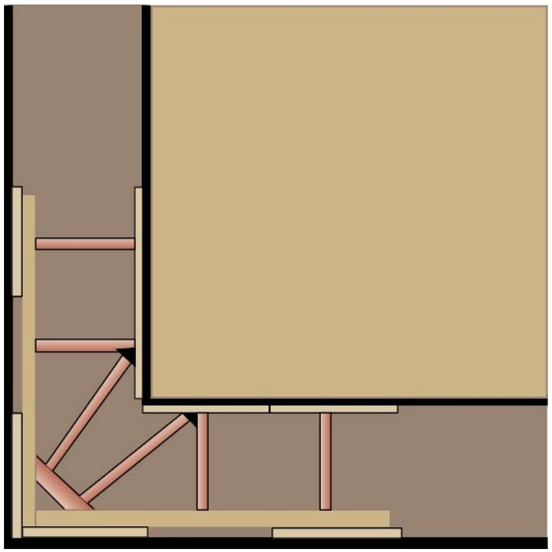
L-Trench

Primary shoring plan

Secondary shoring plan





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Shoring with Thrust Blocks

- Thrust blocks fit over the strongbacks and have both an angled surface and a flat surface from which struts can be shot.
- The number of wales, corner blocks, and thrust blocks needed is determined by the depth of the trench.
- For each tier of shoring, you will need two wales, two thrust blocks, and corner blocks.

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Shoring with Thrust Blocks

- The final position of the thrust block will need to meet the maximum vertical strut spacing requirements:
  - 2 feet (0.6 m) below the lip
  - 2 feet (0.6 m) above the floor
  - Not more than 4 feet (1.2 m) apart
- To shore an L-trench using thrust blocks, follow the steps in Skill Drill 11-6.

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Shoring with Corner Brackets

- Corner brackets are metal brackets that bolt on to pre-drilled panels.
- They hold the two panels together at a 90-degree angle and allow both panels to be installed at the same time.
- Especially safe and efficient when dealing with inside corner collapse conditions

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Shoring with Corner Brackets

- Install the bolted corner panels using the opposite-side technique from the outside wall.
- To minimize panel adjustments, slide the panels in on the high side of the cave-in pile.
- To shore an L-trench using corner brackets, follow the steps in Skill Drill 11-7.

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Deep-Wall Trench

- Deep-trench shoring procedures apply in situations when shores are placed at depths of more than 10 feet (3 m) below the trench lip.
- Shoring below this point requires rescue panels to be stacked because the depth of the trench will exceed the vertical dimension of a standard 8-foot (2.4-m) panel.

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Deep-Wall Trench

- OSHA allows construction workers to shore trenches up to 20 feet (6.1 m) deep, provided that they follow the manufacturer's tabulated data or a shoring plan designed by a registered professional engineer (RPE).
  - For rescue purposes, the deep trench shoring procedure recommended in this section uses a maximum vertical and horizontal spacing of 4 feet (1.2 m).

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Deep-Wall Trench

- Deep trenches that can be shored with the techniques found in this chapter are those defined as more than 10 feet (3 m) deep but not more than 20 feet (6.1 m) deep.

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Deep-Wall Trench

- When confronted with extreme conditions, rescuers may be able to initially protect the victim with rescue shoring but should immediately request an RPE and a contractor with expertise in using specialized shoring equipment and techniques designed for these conditions.

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Deep-Wall Trench

- Well-prepared trench rescue teams should always have a prearranged response plan and have trained with both of those important resources.

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Deep-Wall Trench Shoring

- Consider using lip bridges
- When ground pads are deemed appropriate, make sure that personnel remain attached (class III harness) to an anchored retrieval line/edge limiters and that they never operate off the ground pads.
  - Secondary collapse of a deep trench can be catastrophic.

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Deep-Wall Trench Shoring

- While the lip team is setting up lip protection, the panel team should be installing pickets and moving roped panels off the rescue unit and close to the trench.
- To support a deep trench, follow the steps in Skill Drill 11-8.

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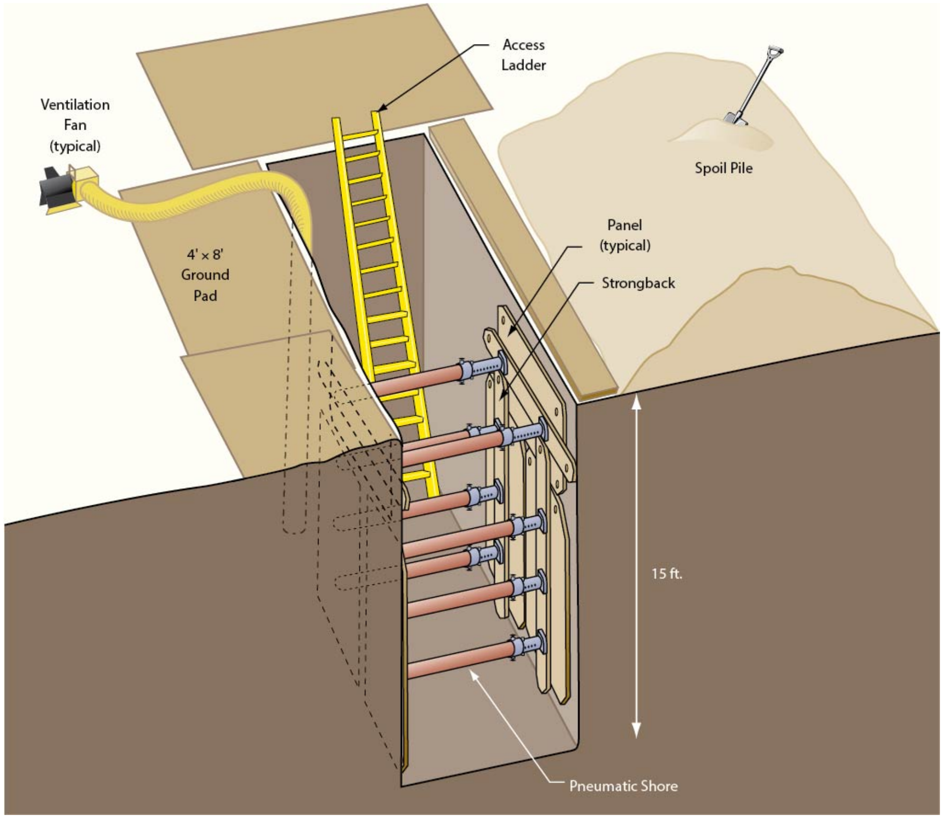
Deep-Wall Trench Shoring



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Excavation Shoring

- Excavations are human-made cuts in the earth's surface that are wide.
  - In relationship to their depth
- Excavation shoring situations occur whenever horizontal struts cannot reach from one soil wall to another.

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Excavation Shoring

- The same basic mechanics behind trench rescue shoring apply to excavation rescue shoring, but the struts need to be installed at angles, which requires additional shear force resistance.

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Excavation Shoring

- The shores used to resolve these issues are called excavation raker shores.
- Raker designs were borrowed from building collapse rescue shoring guidelines.
- Installing a raker system on an excavation wall takes preparation, coordination, and practice.

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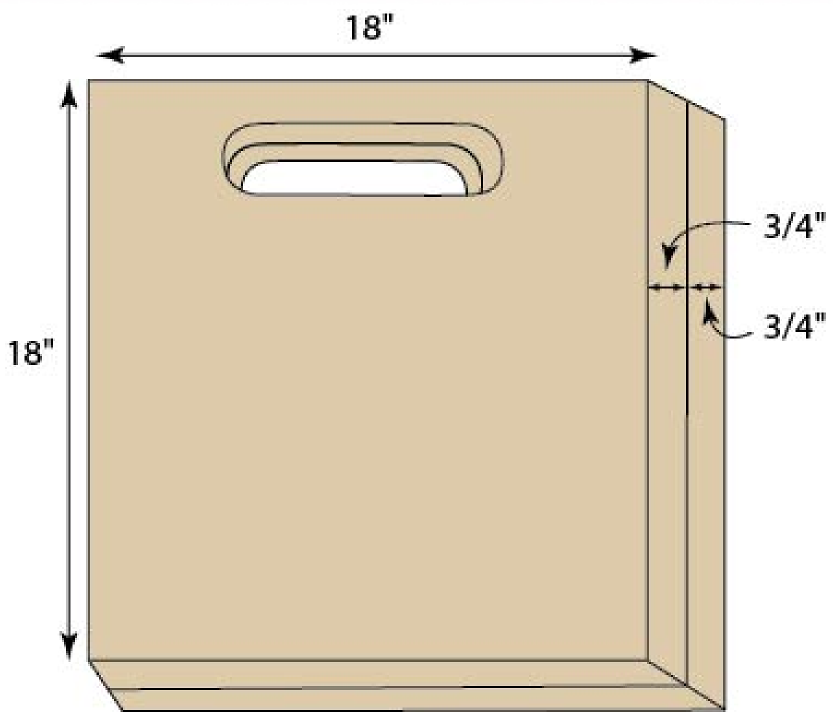
Excavation Shoring

- A minimum of six rescuers on each team is recommended.
- An achievable goal for a practiced panel and shoring team would be to build and install an excavation raker in less than 20 minutes.
  - Primary and secondary shoring
- To build and install the excavation raker, follow the steps in Skill Drill 11-9.



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Excavation Shoring

- Additional considerations with excavation rakers include the following:
  - To minimize exposure time, rescuers must assemble the raker, attach it to the wales/panels, and lower the system into the excavation from a safe position on the lip.

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Excavation Shoring

- Additional considerations (cont.)
  - The excavation rescue shoring system that is used at an incident must have been tested using vectors that closely replicate the pressures of a damaged soil wall.
  - Equipment modifications must be made when a system fails to resist at least two times the potential soil pressure.

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Excavation Shoring

- Additional considerations (cont.)
  - A wall anchor team and a ground anchor team should enter the excavation simultaneously with all needed equipment and materials.
  - Use of hydraulic, pneumatic, or electric hammer tools with picket driving bits significantly reduces the time needed to anchor the system.

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Equipment List

Table 11-1 Equipment Lists

Shoring Team Equipment	Panel Team Equipment
Paratech excavation raker shore Four 610 struts (Gold) Two 235 extensions (Gold) Two B-23 struts Two raker junctions Two rail junctions Two rail latches Four angled (excavation) bases Six nail blocks Paratech wale Paratech air system Air bottle Regulator Controller Five hoses Four hammers and 16d nails Two raker tie-off ropes	Wood brace kit (pre-cut 2 × 6-inch lumber) Excavation panels (pre-drilled with T-nuts) Lowering system • ½-inch main line with two steel pickets (42 inches) • Two tag lines • Three carabiners Wall anchor kit • Six steel pickets (42 inches) • Two sledge hammers or air hammer Sole anchor kit • 6-inch × 6-inch × 8-foot timber • Eight steel pickets (42 inches) • Two sledge hammers Two sole feet Two 4 × 4-inch × 8-foot timbers (rails) Back-fill (as needed)

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Summary

- At a minimum, all systems being installed should be capable of resisting at least twice the potential load of the soil at the trench rescue site.
- Procedures used for underground construction shoring fail to address the most important element of shoring for rescue: protecting the victim.

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Summary

- A straight-wall trench that is at least 12 feet (3.7 m) long requires the rescuer to use a minimum of three sets of panels.
- An outside wale is used to span a large void in a trench wall that cannot be filled with soil, timber, or single air bag backfill techniques.

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Summary

- Inside wales are commonly used to span a set of panels to create an open space (e.g., to provide room for digging or extrication operations or to shore around an obstruction that cannot be moved).
- After secondary shoring has been installed, rescuers may need to add modified (cut-down) sheeting and shoring to complete the shoring task—a process called supplemental shoring.

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Summary

- All things being equal (considering the same soil conditions), intersecting trenches are significantly less stable than straight trenches.
- The L-trench consists of two trench cuts or legs that converge at a single point, commonly forming a right angle.

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Summary

- If you are not sure of the capacity (strength) of the panels/strongbacks in your equipment cache, you may want to consider using alternative methods to strengthen your shoring system.
- Excavation shoring situations occur whenever horizontal struts cannot reach from one soil wall to another.

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Cecil V. "Buddy" Martinette, Jr., *and* Ron "Z" Zawlocki

Trench Rescue

Principles and Practice to NFPA 1006 and 1670

THIRD EDITION

Chapter 12

Victim Access and Care

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Approaching Victim Access

- To be successful in trench rescue, you need to mitigate the incident in a manner that brings no further harm to the victim and absolutely no harm to the rescue personnel.
- Use all of the information at your disposal to make a decision about the most appropriate method of gaining access to the victim and then provide the appropriate level of care.

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Non-Entry Rescue and Victim Self-Rescue

- These are the preferred methods to reduce the risk to rescue personnel, and they should be considered in every incident.
- This may be as simple as a worker who is only partially buried being able to dig himself or herself out or a non-entry rescue where responders extricate the victim without ever going into the trench.

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Non-Entry Rescue and Victim Self-Rescue

- The best scenario is the one in which an individual just needs a ladder to get out of the trench.
  - Even individuals with broken bones will climb a ladder if they think a potential for collapse exists.

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Non-Entry Rescue and Victim Self-Rescue

- If the victim is hurt and only partially able to help himself or herself, pass down a modified packaging device such as the chest portion of a class III rope rescue harness.
  - Instruct the victim on how to secure the harness and then pull him or her up the ladder to safety with the retrieval line.

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Non-Entry Rescue and Victim Self-Rescue

LSP cinch collar

Courtesy of CMC Rescue, Inc.

Class III harness

Courtesy of CMC Rescue, Inc.

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Non-Entry Rescue and Victim Self-Rescue

- In other cases, a non-entry rescue could take the form of a hauling device attached to an elevated platform that removes the victim vertically.
- Never attempt to pull a partially buried victim from the trench.

Courtesy of Captain David Jackson, Saginaw Township Fire Department

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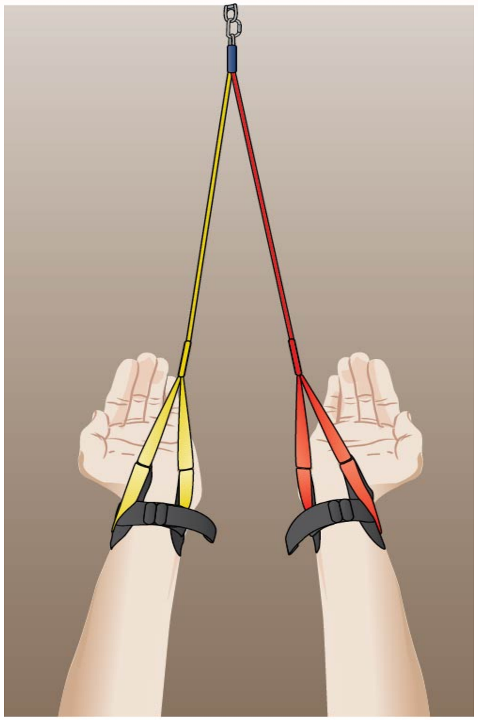
Non-Entry Rescue and Victim Self-Rescue

- Another method of performing non-entry rescue is to have the victim place a pair of wristlets on his or her wrists and then haul the victim out by whatever method you have.



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Pre-Entry Briefing

- Conducting a pre-entry or preaction briefing allows the incident commander, operations chief, or rescue leader to think out loud one more time.
- It also enables personnel to question openly the assumptions on which the incident commander devised the plan.

Courtesy of Captain David Jackson, Saginaw Township Fire Department

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Pre-Entry Briefing

- Items to include in the pre-entry briefing include:
  - The overall goal of the operation
  - Position assignments
  - Protective system design
  - Known, suspected, or possible hazards
  - Safety requirements
  - Accountability system
  - Emergency procedures

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Pre-Entry Briefing

- No action should take place in the immediate rescue area until the pre-entry briefing is conducted for required personnel and an equipment/systems safety check is completed.
  - Rescue personnel need to understand the desired outcome and the strategic steps that are part of the overall rescue plan.

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Gaining Access to the Victim

- Only two types of incidents can really occur at a trench site:
  - Incidents that involve a cave-in
  - Incidents that do not involve a cave-in
- These situations should be evaluated from the same standpoint, regardless of the circumstances.

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Gaining Access to the Victim

- Pipes and other heavy objects may have to be lifted off the victim using air bags or another type of mechanical lifting device.
  - These lifts can be done from inside the trench or from above the trench using lifting straps.

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Incidents Without a Cave-in

- Trench accidents that do not involve a cave-in will almost always be more difficult to handle than those in which a cave-in has buried the victim.
  - It is more stressful to deal with a situation when someone's life is hanging in the balance.

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Incidents Without a Cave-in

- The extrication method for a deceased victim will not affect the outcome for the victim.
  - Remember to protect your personnel.
- Your success will be determined by following a safe and logical plan.

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Cave-in Incidents

- Incidents with a cave-in can be organized into two different categories:
  - Those involving a partially buried victim
  - Those in which the victim is completely buried
- Both types will be challenging, because each may involve a substantial amount of work, depending on the entrapping mechanism.

Courtesy of Chuck Wehrli

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Excavation Techniques

- Working with existing systems
  - Before extricating the victim consider what to do with the existing protective system.
  - Determine its functionality and identify whether it is sufficient for rescue personnel to operate in.
  - Make a recommendation concerning removal or replacement of the system.

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Working with Existing Systems

- Rescue personnel may arrive on the scene and be faced with existing, substandard sheeting and shoring.
  - Technician-level trench rescue teams need to be able to recognize substandard shoring and to use the materials in place while reinforcing the safety margin to meet a suitable rescue standard.

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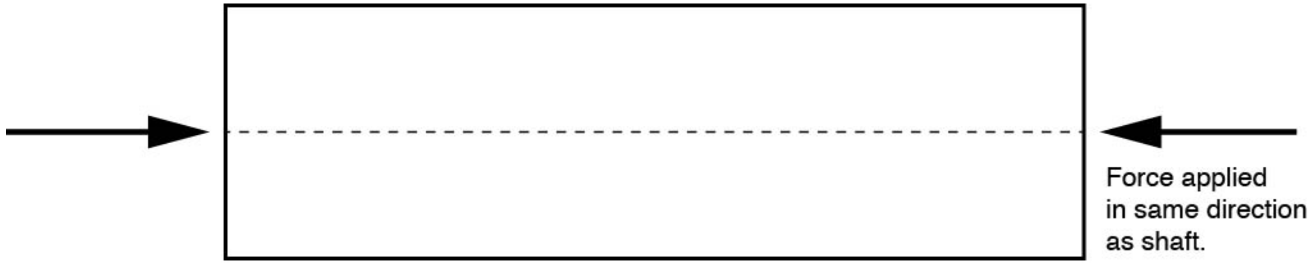
Working with Existing Systems

- A risk–benefit analysis should include, but is not limited to:
  – Wooden shores are of dimensions that are smaller than the rescue shoring standard.
  – Shores are placed in a fashion that does not provide axial loading.



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Working with Existing Systems

- Risk–benefit analysis (Cont.):
  - Shores are not adequately compressed.
  - Sheeting is neither plywood (1-inch minimum) and strongback (2 × 12 inches) nor a rated panel.
  - Gap management (voids created by cave-in areas) is inadequate to create pressurization zones.
  - Vertical spacing is greater than 4 feet (1.2 m) on center.
  - Horizontal spacing is greater than 4 feet (1.2 m) on center.

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Working with Existing Systems

- Other hazards associated with removing existing or substandard shoring:
  - Removing substandard shores before the installation of replacement shoring may result in a trench cave-in.
  - Installing and compressing replacement shoring may loosen up the substandard shores and cause them to drop into the trench, injuring the victim.
  - Ground pads and lip safety must be in place prior to replacement shoring operations.

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Working with Existing Systems

- In many cases, tons of dirt may have to be removed from the trench by hand.

Courtesy of Cecil V. "Buddy" Martinette, Jr.

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Working with Existing Systems

- Regardless of the type of digging equipment used to remove a buried victim, there are a few rules:
  - Never use a mechanical device or backhoe to dig up or pull out a partially buried victim.
  - Never attempt to pull out a partially buried victim.
  - Dig by hand when you get near or around the victim.
- Resist the urge to pull or otherwise try to remove the victim before completely freeing him or her from the entrapment mechanism.

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Vacuum Systems

- In a more heavily populated area, there is a good possibility that one of the local utility companies has a vacuum truck.

Courtesy of Larry Collins

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Centrifugal Vacuum Truck

- This system uses a large fan to create suction in the intake line.
- This system works effectively if the soil is granular or loose in consistency.

Courtesy of Rescue Vac

Courtesy of Rescue Vac

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Positive-Displacement Vacuum Truck

- This type of vacuum truck has a much greater vacuum pressure than centrifugal units and is generally used in instances that require a high lifting capacity.
- Because of the high vacuum pressure at the hose tip, rescue personnel should use extreme caution to avoid injury.

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Hydro Vac Truck

- Water is used as a reduction method to make the soil run so that it can be picked up and then vacuumed to the debris.

Courtesy of Badger Daylighting

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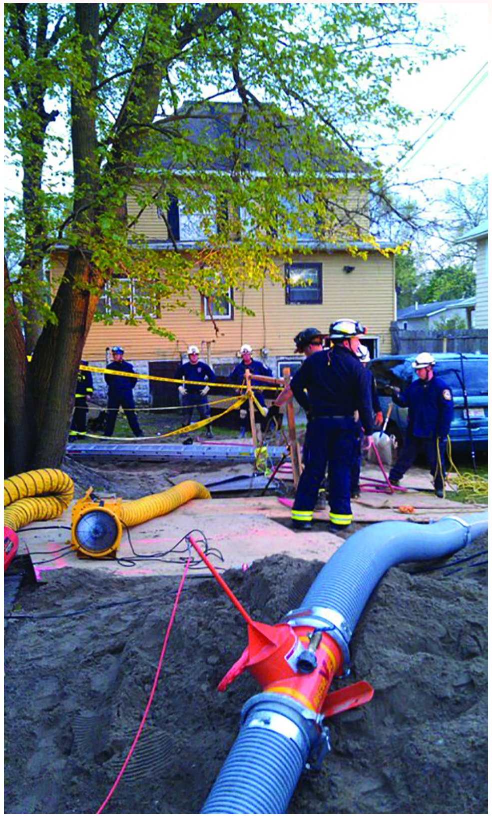
Vacuum System

- Uses several specially designed nozzles to vacuum the soil.
- The vacuum truck can be placed as far as 200 feet (60 m) above or 800 feet (240 m) away from your incident.



Courtesy of Rescue Vac

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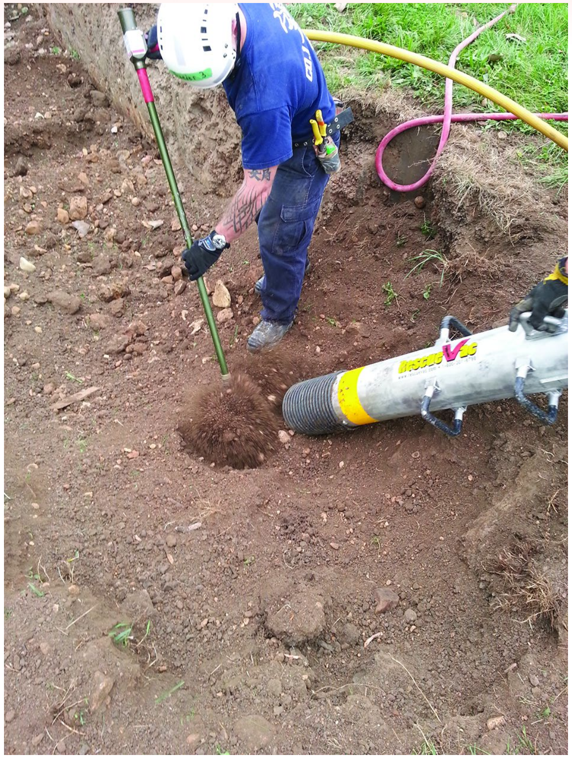
Air Knife

- Injects air into the soil at approximately 100 pounds per square inch (7 kg/cm) to break the soil into smaller particles.
- The smaller particles can then effectively be picked up and moved through the vacuum system.



Courtesy of Rescue Vac

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Vacuum Systems

- These methods can add risks to the situation if the soil evacuation process gets too far out in front of the protective system.
- Careful consideration should be given to ensuring all elements of the protective system are in place and to maintaining a proper balance among speed, efficiency, and the safety of all those involved in the incident.

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Victim Care Considerations

- It is imperative that each rescuer, regardless of assignment, helps those performing other functions to improve the victim survivability profile.
  - A determination based on a thorough risk–benefit analysis and other incident factors that address the potential for a victim to survive or die with or without rescue intervention

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Victim Care Considerations

- Under the incident command system, each person has a primary assignment to perform even though he or she may be cross-trained.
- The information included here is not meant to take the place of any specific local medical protocols.
  - It is provided so that trench rescuers will have an idea of the factors that they should consider when dealing with a viable patient.

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Providing EMS Care

- The removal of a partially buried victim will likely take some time, and patient care typically starts before victim removal and continues during packaging.
  - Make certain you have the right people with the right medical skills as a part of any trench response

Photo by Martin C. Grube

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Providing EMS Care

- After the rescue team establishes a safe zone around the victim, the extrication officer should assign a paramedic in the trench to perform a primary assessment and begin patient care.
  - This person needs to be nimble and fit.
  - Anyone sent to assist with patient care should be comfortable with the environment and have specialized training in trench rescue.

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Concerns for All Patients

- All providers of patient care should be aware of and practice local authority having jurisdiction (AHJ) requirements regarding universal and/or standard precautions.
- Such precautions cover protection of both the provider and the patient from exposure to blood, other body fluids, and/or airborne products that could pass from the rescuer to the victim or from the victim to the rescuer.

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Concerns for All Patients

- Examples of these protections include:
  - Hand washing
  - Gloves
  - Gowns
  - Masks
  - Eye protection
  - Respiratory protection

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Concerns for All Patients

- Remember the first rule of medicine:
  - Do no harm.
  - Always protect the victim from further injury and proceed with caution.
- During scene size-up, determine whether the victim has suffered some type of injury or experienced a medical problem.
  - If an injury has occurred or the patient has fallen, use C-spine precautions, if possible.

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Concerns for All Patients

- Start the assessment with a primary survey, checking the ABCs.
  - Airway, breathing, and circulation
- First, check for an open airway and secure it as necessary.
- After you have secured the airway, assess the victim's breathing.
- Next, assess the victim's circulation.

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Concerns for All Patients

- After the primary survey has been completed, proceed with the secondary survey.
  - If additional life-threatening problems are found, treat them as quickly as possible.
  - You will have additional time to control bleeding after the victim has been removed from the trench.

Courtesy of Brad Ferguson

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Concerns for All Patients

- Fractures that are not life threatening should be stabilized by securing the patient to a long backboard.
- Do not take the time to splint these injuries in the trench unless the victim is completely stable and the scene is safe.
- After the patient has been removed from the trench environment, treat the patient as you would any other victim of trauma or illness.

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Victim Care Involving a Collapse

- If the victim is completely covered, try to determine where the victim’s head is, and uncover the head and chest first.
  - The victim’s mouth and airway may be full of dirt and foreign matter.
  - Clear the airway as quickly as possible by any means available.

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Victim Care Involving a Collapse

- After the airway is clear, check for adequate breathing.
  - If the patient’s chest and abdomen are covered by soil, breathing may be restricted and compromised.
  - It is essential to clear the dirt from around the victim’s chest to allow proper lung expansion as soon as possible.

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Victim Care Involving a Collapse

- If a rated sling or rescue-quality rope is placed on the victim, make sure that it is not restricting the patient's breathing or complicating his or her condition.
- After the head and neck are clear, place a cervical collar to stabilize any possible C-spine injury.

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Victim Care Involving a Collapse

- If the victim can communicate with you, ask whether he or she is aware of any injuries in the area still covered by dirt.
- Uncovering a victim's buried limbs can be slow work.
  - Provide emotional support.
  - Use this time to plan how to manage additional injuries.

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Victim Care Involving a Collapse

- As soon as an extremity is uncovered and accessible, establish an intravenous (IV) line of normal saline with a 16- or 18-gauge catheter.
  - Be sure to secure the IV.
- If possible, place a cardiac monitor on the victim and check for abnormal heart rhythms.

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Special Considerations

- Hypothermia
  - Prolonged contact with cool soil can lower the patient's core temperature.
  - Consider the use of heated forced-air blowers or the administration of heated IV fluids.
- Crush syndrome
  - A condition that occurs in prolonged entrapments where the victim's body tissue is crushed and circulation to the tissue is restricted

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Special Considerations

- If the patient's condition continues to deteriorate and he or she progresses to asystole, carefully consider all factors before starting resuscitation efforts.
  - Asystole is the absence of electrical activity in the heart.
- If you have a question regarding whether you should begin CPR, contact medical control and seek advice.

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Victim Packaging and Removal

- Trench rescue victim packaging and removal techniques are not all that different from the other technical rescue techniques that you have learned up to this point, with a few extra considerations.
- While working to remove a victim from a trench, extreme care must be taken not to dislodge any of the shoring material.

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Victim Packaging and Removal

- When deciding on patient packaging devices, consider the limiting factor of the shoring system.
- It is not uncommon for rescuers to place their shoring material so close to the victim that it is impossible to remove him or her.

Courtesy of Brad Ferguson

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Victim Packaging and Removal

- If the victim is large or the packaging device is cumbersome, you may want to implement some sort of mechanical advantage system.

Courtesy of Captain David Jackson, Saginaw Township Fire Department

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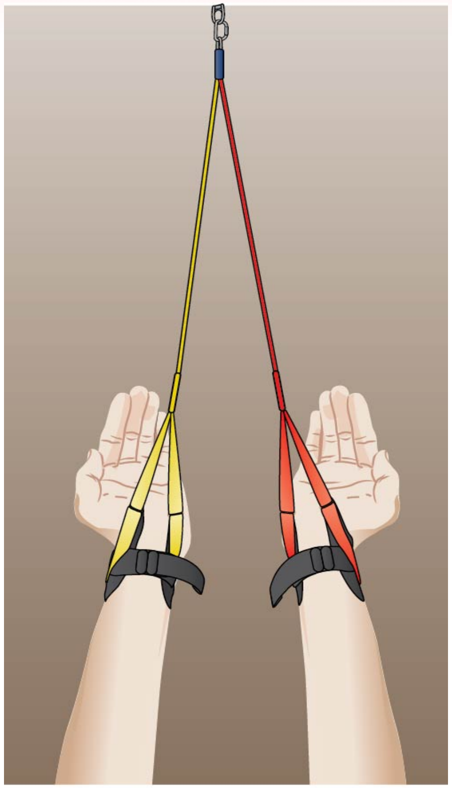
Victim Packaging and Removal

- The method used to secure the victim during digging operations may be as simple as wristlets attached to an elevated platform.



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Victim Packaging and Removal

- The best practice is to find an elevated attachment point and remove the victim vertically.
- This can both support an unresponsive victim during the digging process and remove the victim once he or she is free.

Courtesy of Lance Cpl. Angel J. Velasquez/U.S. Marines

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Summary

- To be successful in trench rescue, you need to mitigate the incident in a manner that brings no further harm to the victim and absolutely no harm to the rescue personnel.
- Non-entry and victim self-rescue are always the preferred rescue methods, as they reduce the risk to rescue personnel; they should be considered in every incident.

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Summary

- Conducting a pre-entry or preaction briefing allows the incident commander, operations chief, or rescue leader to discuss the plan with personnel.
- Applying the same evaluation criteria to both cave-in and non–cave-in incidents will keep you from making a mistake and operating in an unsafe area or a potentially hazardous environment.

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Summary

- Excavation techniques include working with existing systems and vacuum systems.
- It is imperative that each rescuer, regardless of assignment, helps those performing other functions to improve the victim survivability profile.

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Summary

- After the rescue team establishes a safe zone around the patient, the extrication officer should assign a paramedic in the trench to perform a primary assessment and begin patient care.
- Always protect the victim from further injury and proceed with caution.

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Summary

- Clear the victim's airway as quickly as possible by any means available.
- During a prolonged extrication, the trench environment will be cooler than the surrounding area, and hypothermia could be a concern—even in summer.

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Summary

- Trench rescue victim packaging and removal techniques are not very different from other technical rescue victim packaging techniques.

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Cecil V. "Buddy" Martinette, Jr., *and* Ron "Z" Zawlocki

Trench Rescue

Principles and Practice to NFPA 1006 and 1670

THIRD EDITION

Chapter 13

Rescue Team Leadership

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Rescue Team Leadership

- Having a rigorously trained and well-equipped team results from a very strategic and well-conceived plan that addresses every aspect of strong and competent team building.
- Fire fighters, middle managers, and chief officers all have very important leadership roles in high-achieving, innovative, and progressive trench rescue teams.

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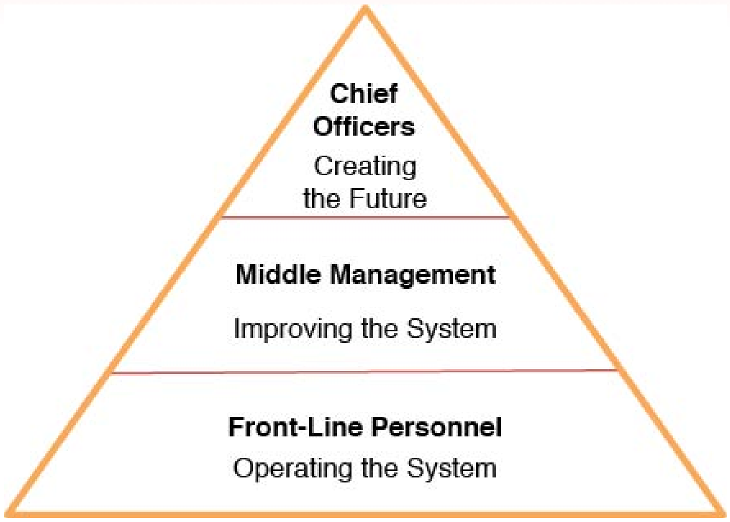
Rescue Team Leadership

- The organizational pyramid represents a simple view of leadership in organizations.



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Rescue Team Leadership

- The organizational pyramid of a trench rescue organization has three basic levels:
  - Frontline personnel
    - Responsible for operating the system
  - Middle management
    - Responsible for improving the system
  - Chief officers
    - Responsible for creating the future

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Rescue Team Leadership

- All of us, regardless of rank, spend time in one of these areas, and in many cases, we are involved in all three areas at one time or another.
- In the strongest teams, all members address all three functions to some degree.

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Frontline Personnel: Operating the System

- The largest component of any rescue team is made up of the personnel who perform rescue work, their first-line supervisors, and the officers who provide direct oversight.

Courtesy of Tim Olk

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Frontline Personnel: Operating the System

- The operations roles become much easier when leaders provide the necessary tools, empower the workers to make decisions, and trust that they will do what is necessary to get the job done.

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Frontline Personnel: Operating the System

- Things start getting a little cloudy when leaders at the "improving the system" and the "creating the future" levels start spending too much time directing the "operating the system" personnel.
  - This practice is commonly referred to as micromanagement.

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Activities and Responsibilities

- In operations, officers should give workers control to operate the system and, to some extent, accountability for the outcome of the operation.
  - This process cannot begin until the operations activities are defined.

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Safety

- Each member of the trench rescue team is responsible for his or her own safety.
- Safety culture starts with each member having a good grasp of the standard operating procedures (SOPs).
- This extends to a comprehensive understanding of OSHA regulations and other state and local compliance considerations.

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Compliance

- Compliance with NFPA 1006, *Technical Rescuer Professional Qualifications*, and NFPA 1670, *Standard on Operations and Training for Technical Search and Rescue Incidents*, must be documented.
- This will ultimately determine the degree to which team members can participate in the rescue.

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Community Needs

- It is up to you to recognize and anticipate the needs of the community and make specific recommendations to address the formalization of best practices for that situation.
- This may require:
  - Brainstorming new ideas
  - Recommending the proper equipment
  - Making sure you have requested adequate equipment and resources to do the job

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Environment

- Individual team members have a responsibility to understand the environment in which they will be required to operate.
- Understanding the limitations of your equipment and knowing how it will perform in a variety of circumstances are best achieved through training and practice.

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Equipment

- The people required to use the equipment in an emergency situation should make sure that the equipment is assembled, stored, and maintained so it is ready when needed.
- The set of rescue equipment is your tools.
  - They must work when needed to save a life.

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Strengths and Abilities

- Be prepared to respond to an incident.
- Make sure associate team members are physically able to do their jobs.
- Establish and maintain regular training cycles.
- Continually recruit new team members.
- Establish testing processes.
- Create, monitor, and maintain team loyalty and focus.

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Middle Management: Improving the System

- Middle managers and battalion and division chiefs should concentrate on how alignment occurs at the rescue scene.
- Their efforts should be directed at improving the efficiency and effectiveness of operations.

Courtesy of Cecil V. "Buddy" Martinette, Jr.

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Middle Management: Improving the System

- The most important aspect of middle management and on-scene operations is the establishment of a strong and reliable incident command system.
- Your first responsibility and main objective is to organize and maintain accountability of personnel.
  - Best done through effective incident management

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Communication

- Middle management personnel are a conduit by which vital communications make it from the bottom to the top of the organizational pyramid, and then from the top back down again.
- Middle-management leadership needs to provide a platform for effective communication between government leadership and the community.

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Evaluating Personnel, Training, and Equipment

- Middle management should be receiving a lot of information from frontline rescue personnel.
  - It is necessary to analyze the statistical data and then get them the appropriate resources to be effective.

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Evaluating Personnel, Training, and Equipment

- Another function of middle management is making sure the system that you are working so hard to build and support actually meets the needs of the community.
  - You should use your leadership position to advocate for a good balance between personnel and equipment.

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Evaluating Personnel, Training, and Equipment

- You are responsible for developing procedures for each team function so that individuals in those positions do the right things.
- Middle managers are in a unique position to recommend and even in some cases develop new training curricula.

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Evaluating Personnel, Training, and Equipment

- Middle management creates and maintains a process to benchmark team members' skills.
- The process to improve rescue operations may also extend to recommending improved uses and functions for existing equipment and to evaluating new technology.

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Mentoring, Coaching, and Team Building

- While mentoring and coaching in healthy teams takes place at all levels, middle managers must ensure that it is happening.
- Middle managers help establish new teams and bring new members onto existing ones.
  - They also establish testing benchmarks for new team members.

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Mentoring, Coaching, and Team Building

- They are responsible for developing policies regarding:
  - Who can be on the team
  - How long they can stay
  - How active they should be to maintain team affiliation
- This function is performed by communicating written guidelines, then holding the team members accountable and responsible.

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Chief Officers: Creating the Future

- Chiefs and other senior staff personnel should plan for and create outcomes that will help the organization adapt to the future.
  - This place in the time allocation model is called "creating the future."
  - This top level of the organization has less to do with what we are doing now than with what we will be doing next.

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Chief Officers: Creating the Future

- It is imperative that senior management create open communications through all levels of the team's organization.

Courtesy of Cecil V. "Buddy" Martinette, Jr.

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Chief Officers: Creating the Future

- Many resourceful chief officers spend much of their time developing innovative funding sources for equipment purchase and replacement.
- Developing partnerships with local utility contractors or finding a sympathetic social organization in your community can be just the steps that your team needs to keep things running.

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Values and Culture

- The job of those at the highest levels of the organization is to ensure that the desired team values are ingrained into the culture of the team and permeate every aspect of its decision-making system.
- Mentoring, coaching, and developing the team's culture ensure that common goals are aligned and decision making is consistent through all levels of the team.

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Strategic Planning

- As a leader, you should never expect your people to pay close attention to what is happening at the street level and then hold them accountable when they are run over by a truck they did not know was coming.
  - Looking out for the truck is your primary function at the chief officer level, not the team's.

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Strategic Planning

- Looking to the future and then creating systems to match expectations is most effective when data are used to support the future needs of the team.
- It is the leader's primary goal to evaluate the entire system constantly to ensure current service level goals and objectives are being met.

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Recruitment

- The leader should:
  - Continually recruit new team members
  - Anticipate future requirements of the team along with the subsequent training versus real-time experience necessary to maintain team member competency.
- The highest levels of the organization must be able to understand enough about the team's functions and goals to make competent and consistent decisions.

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Communication with Stakeholders

- Another aspect of rescue team leadership is creating a system for communicating effectively with policy makers and other key stakeholders outside of the organization.
  - This may involve inviting local, state, and federal elected officials to witness actual calls or training evolutions.
  - Money flows from citizens to trench rescue teams through elected officials.

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Budgeting

- Part of the “creating the future” responsibility includes budgeting for and securing capital equipment.
- Money for specialized operations teams often comes from grants.
  - Paying attention to the local, state, and federal grants available can mean the difference between having a fully functional rescue team or one that is only marginally capable.

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Education

- The leader may need to challenge the team by expanding the educational requirements, or frequency of recertification requirements, of team members to meet the expected future challenges.
  - It does no good for us to embrace technology in the rescue business if no one is prepared to use it in an efficient manner.

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Developing Partnerships

- A very important function of upper management in rescue team leadership is that of maintaining partnerships with those customer groups that can help the team get resources and recognition.
  - The media and the local business community
- These partnerships can take the form of contractor outreach programs.

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Developing Partnerships

- Take every opportunity to publicly recognize these partners for the special attributes they bring to the table.
- Making good use of the taxpayers’ dollars by trying your best not to duplicate the same resources in every community is a good business practice.
  - Cultivate good jurisdictional relationships.

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Summary

- Building a great rescue team involves people in various job functions within the team understanding their own roles and recognizing the expectations of others with regard to work outcomes.
- The largest component of any rescue team is the personnel who perform rescue work, their first-line supervisors, and the officers who provide direct oversight.

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Summary

- In operations, officers should give workers control to operate the system and also accountability for the outcome of the operation.
- Middle managers (battalion and division chiefs) should concentrate on how alignment occurs at the rescue scene and how their efforts can be directed toward improving the efficiency and effectiveness of operations.

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Summary

- Middle management is the conduit by which vital communications make it from the bottom of the organizational pyramid to the top, and then from the top back down again.
- A large part of the middle manager's job is focused on evaluating people, training, and equipment.

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Summary

- Middle managers frequently have valuable experience and can relay tough lessons learned to less experienced team members. Such experience can also help bring about a sense of calmness to team operations.
- Chiefs and other senior staff personnel should plan for and create outcomes that will help the organization adapt to the future.

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Summary

- The job of those at the highest levels of the organization is to ensure that the desired values are ingrained into the culture of the team and used in every aspect of its decision-making system.
- Looking to the future and then creating systems to match those expectations are most effectively accomplished by using data to support the future needs of the team.

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Summary

- To maintain a functional and healthy team, the leader should anticipate the future requirements of the team and consider the subsequent training versus real-time experience necessary to maintain team member competency.

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Summary

- Communicating effectively with policy makers and other key stakeholders outside the organization may be accomplished by inviting local, state, and federal elected officials to witness actual calls or training evolutions.
- Part of the “creating the future” responsibility includes budgeting for and securing the capital equipment the team needs to do its job effectively and efficiently.

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Summary

- The leader may need to challenge the team by expanding the educational requirements, or frequency of recertification requirements, of team members to meet the expected future challenges.
- A critical function of upper management is maintaining partnerships with those customer groups that can help the team get resources and recognition.

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