Trenching and Shoring Safety - Competent Person

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Definition of Terms

ACCEPTED ENGINEERING PRACTICES are procedures compatible with the standards of practice required of a registered professional engineer.

ADJACENT STRUCTURE STABILITY refers to the stability of the foundation(s) of adjacent structures whose location may create surcharges, changes in soil conditions, or other disruptions that have the potential to extend into the failure zone of the excavation or trench.

COMPETENT PERSON is an individual who is capable of identifying existing and predictable hazards or working conditions that are hazardous, unsanitary, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate or control these hazards and conditions.

CONFINED SPACE is a space that, by design and/or configuration, has limited openings for entry and exit, unfavorable natural ventilation, may contain or produce hazardous substances, and is not intended for continuous employee occupancy.

EXCAVATION An Excavation is any man-made cut, cavity, trench, or depression in an earth surface that is formed by earth removal. A Trench is a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth of a trench is greater than its width, and the width (measured at the bottom) is not greater than 15 ft (4.6 m). If a form or other structure installed or constructed in an excavation reduces the distance between the form and the side of the excavation to 15 ft (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

HAZARDOUS ATMOSPHERE is an atmosphere that by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen-deficient, toxic, or otherwise harmful may cause death, illness, or injury to persons exposed to it.

INGRESS AND EGRESS mean "entry" and "exit," respectively. In trenching and excavation operations, they refer to the provision of safe means for employees to enter or exit an excavation or trench.

PROTECTIVE SYSTEM refers to a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, and from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.
REGISTERED PROFESSIONAL ENGINEER is a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer who is registered in any state is deemed to be a “registered professional engineer” within the meaning of Subpart P when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

SUPPORT SYSTEM refers to structures such as underpinning, bracing, and shoring that provide support to an adjacent structure or underground installation or to the sides of an excavation or trench.

SUBSURFACE ENCUMBRANCES include underground utilities, foundations, streams, water tables, transformer vaults, and geological anomalies.

SURCHARGE means an excessive vertical load or weight caused by spoil, overburden, vehicles, equipment, or activities that may affect trench stability.

TABULATED DATA are tables and charts approved by a registered professional engineer and used to design and construct a protective system.

TRENCH A trench refers to a narrow excavation made below the surface of the ground in which the depth is greater than the width and the width does not exceed 15 feet. Trenching is common in construction and utility work, where underground piping or cables are being installed or repaired.

UNDERGROUND INSTALLATIONS include, but are not limited to, utilities (sewer, telephone, fuel, electric, water, and other product lines), tunnels, shafts, vaults, foundations, and other underground fixtures or equipment that may be encountered during excavation or trenching work.

UNCONFINED COMpressive STRENGTH is the load per unit area at which soil will fail in compression. This measure can be determined by laboratory testing, or it can be estimated in the field using a pocket penetrometer, by thumb penetration tests, or by other methods.

CEMENTED SOIL Cemented soil. A soil in which the particles are held together by a chemical agent, such as calcium carbonate, such that a hand-size sample cannot be crushed into powder or individual soil particles by finger pressure.

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

**DRY SOIL** Dry soil. Soil that does not exhibit visible signs of moisture content.

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

**GRANULAR SOIL** Gravel, sand, or silt (coarse grained soil) with little or no clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion. Granular soil cannot be molded when moist and crumbles easily when dry.

**LAYERED SYSTEM** Layered system. Two or more distinctly different soil or rock types arranged in layers. Micaceous seams or weakened planes in rock or shale are considered layered.

**MOIST SOIL.** A condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before crumbling. Moist granular soil that contains some cohesive material will exhibit signs of cohesion between particles.

**PLASTIC** A property of a soil which allows the soil to be deformed or molded without cracking, or appreciable volume change.

**SATURATED SOIL** A soil in which the voids are filled with water. Saturation does not require flow. Saturation, or near saturation, is necessary for the proper use of instruments such as a pocket penetrometer or sheer vane.

**SOIL CLASSIFICATION SYSTEM** Soil classification system. A method of categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing order of stability. The categories are determined based on an analysis of the properties and performance characteristics of the deposits and the environmental conditions of exposure.

**STABLE ROCK.** Natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

**SUBMERGED SOIL.** Soil which is underwater or is free seeping.

**TYPE A SOIL** Cohesive soils with an unconfined, compressive strength of 1.5 ton per square foot (tsf) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, no soil is Type A if:
(1) The soil is fissured; or
(2) The soil is subject to vibration from heavy traffic, pile driving, or similar effects; or
(3) The soil has been previously disturbed; or
(4) The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater; or
(5) The material is subject to other factors that would require it to be classified as a less stable material.

**TYPE B SOIL:**

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

**TYPE C SOIL:**

(1) Cohesive soil with an unconfined compressive strength of 0.5 tsf or less; or
(2) Granular soils including gravel, sand, and loamy sand; or
(3) Submerged soil or soil from which water is freely seeping; or
(4) Submerged rock that is not stable, or
(5) Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper.
UNCONFINED COMPRESSIVE STRENGTH. The load per unit area at which a soil will fail in compression. It can be determined by laboratory testing, or estimated in the field using a pocket penetrometer, by thumb penetration tests, and other methods.

WET SOIL. Soil that contains significantly more moisture than moist soil, but in such a range of values that cohesive material will slump or begin to flow when vibrated. Granular material that would exhibit cohesive properties when moist will lose those cohesive properties when wet.

DEFINITIONS THAT ARE NO LONGER APPLICABLE. For a variety of reasons, several terms commonly used in the past are no longer used in revised Subpart P. These include the following:

1. **Angle of Repose** Conflicting and inconsistent definitions have led to confusion as to the meaning of this phrase. This term has been replaced by **Maximum Allowable Slope**.

2. **Bank, Sheet Pile, and Walls** Previous definitions were unclear or were used inconsistently in the former standard.

3. **Hard Compact Soil** and **Unstable Soil** The new soil classification system in revised Subpart P uses different terms for these soil types.
**Introduction**

Cave-ins can be deadly. No….in fact they usually are deadly! There are not too many survivors of cave-ins. Trench wall failures occur suddenly, with little or no time for the worker to react. The weight of the soil crushes and twists the body, usually causing suffocation and or internal bleeding in a matter of minutes. Excavations need not be deep or particularly large to create a life threatening hazard, so every excavation must be taken seriously.

Twenty-four states, Puerto Rico and the Virgin Islands have OSHA-approved State Plans and have adopted their own standards and enforcement policies. For the most part, these States adopt standards that are identical to Federal OSHA. However, some States have adopted different standards applicable to this topic or may have different enforcement policies.

As an example some of the California Standards and Documents are included in this manual. Some material in the Appendices is from the California web site.

**It is important that you check with your local agencies.**

This manual includes references and information regarding hazards associated with working in and around trenches where shoring is important. It also includes information about excavations and the role and responsibilities of a Competent Person as outlined in the Title 8 Trenching & Excavation Standards.

California code of regulations Title 8 Requirements for Protective Systems Subchapter 4 Construction Safety Orders Article 6. Excavations 1541.1 can be obtained from HTTP://WWW.DIR.CA.GOV/TITLE8/1541_1A.HTML

The federal standards can be found in the OSHA safety regulations 29 CFR1926.650 – 651 and 652. A copy of the standard can be obtained from http://www.osha.gov/SLTC/trenchingexcavation/construction.html.

Another link that provides useful information can be obtained from: http://www.osha.gov/Publications/OSHA2226/2226.html


Many references are provided in the Reference section of this manual.

The purpose of this manual is to acquaint you with the standards relating to trenching and shoring as adopted by State and Federal safety authorities. To be qualified as a Competent Person one must have a working knowledge of the materials covered in this manual and a basic understanding of the information covered in the references. This must include up-to-date continuing education.
Your organization will be required to provide additional training that is specific in the hazards, equipment and locations which may present trenching hazards for your projects.

Examples might include but not be limited to:

- Specific training in the types of soils, trenches and excavations found in your area
- Information regarding any special hazards that may be encountered, including safety equipment and organizational specific rescue requirements.
- Specific technical and hands-on training for the equipment that would be used in trenches and excavations such as shoring equipment, materials, instruments and specific techniques used to assess and determine soil type and conditions
- Familiarization with the elements of the companies written trench safety program as well as use of checklists and procedure

**Competent Person**

The term "Competent Person" is used in many OSHA standards and documents. As a general rule, the term is not specifically defined. In a broad sense, an OSHA competent person is an individual who, by way of training and/or experience, is knowledgeable of applicable standards, is capable of identifying workplace hazards relating to the specific operation, is designated by the employer, and has authority to take appropriate actions.

**How to Put Competence in a ‘Competent Person’**

It’s problematic to designate an employee as a “competent person,” if there’s an understanding (express or implied) that stopping work, or blowing the whistle on a dangerous condition, will subject the “competent person” to browbeating or reprisals.

By THOMAS H. WELBY, P.E., ESQ.

You have probably heard the term “competent person” used in connection with accident avoidance and OSHA compliance. Having employees who are fully qualified as “competent persons” should be a key part of your company’s safety and compliance program.

One reason for this is that failure to provide a “competent person” is one of the most frequently cited OSHA violations. Another is that, in terms both of legal compliance and avoiding jobsite accidents, it must not be assumed that experience and common sense equal “competence.” Thus, it’s critical to know the definition and qualifications of the “competent person.”

No less than 18 sub-parts of OSHA’s construction standards and six subparts of the general industry standards require a “competent person.” Overall, in construction standards, there are more than 120 references to a “competent person.” The needs of a particular employer, of course, in providing “competent persons” will vary according to the trade and the exact activities carried on by that employer.

The dangers of failing to give the “competent person” training to acquire the modest incremental knowledge needed to effectively discharge his duties are shown by the recent case of Secretary v. EMCON/OWT, Inc.

That case involved a crew of men working in an excavation at a Florida landfill.

Landfills are laid out in cells lined with high density polyethylene. As cells fill up and the garbage in the cell deteriorates, methane gas is produced. The methane must be collected by wells located around the landfill and vacuumed into gas headers to a central location, where it is burned off.

Perforated clean-out lines are installed beneath layers of gravel and sand in each cell prior to garbage being deposited. Leachate (rainwater falling onto the accumulating garbage) percolates through the sand and gravel into the perforated collecting lines, which drain it to the landfill’s sump area.
The five-man work crew at the landfill had excavated a trench, exposing the leachate clean-out pipe that they needed to cut into. One worker, Seaborn, tried to cut the pipe using a gasoline-powered chainsaw. The pipe released an odorous gas, and the chainsaw stopped working. Seaborn left the trench and went to retrieve an electric saw to use instead.

Returning, Seaborn noted a foul odor, and exited the trench. The crew foreman, Diloreti, entered the trench to make the cut, but likewise hesitated because of the odor. Warne, a third crew member, expressing impatience with his co-workers, entered the trench, bent over the pipe to make the cut, but stood up and said, “Whew.” A fourth worker, Garno, jumped into the trench, bent over the pipe, stood up, said, “Something is not right,” and passed out. Seaborn went to assist Garno. Diloreti tried to assist Warne, but passed out himself. All four crew members were removed to hospital, but Warne died shortly thereafter.

The employer was cited for three violations, one of which was a failure to inspect the area by a “competent person” following a “hazard-increasing occurrence.”

Meier, the supervisor (and only crew member not present when the workers were overcome) had inspected the excavation on the morning of the occurrence. The ALJ rejected the employer’s depictions of Meier as its “competent person,” and thus required inspection as constituting compliance with the standard. In addition to the required daily inspection, the ALJ found, an additional inspection must be made “after every rainstorm or other hazard-increasing occurrence.” The secretary considered Diloreti, the foreman, as the true “competent person,” and asserted that cutting into the leachate pipe was a “hazard-increasing occurrence.”

The ALJ agreed with the secretary that three incidents, over a 20-minute span, gave notice of likely employee exposure: the stoppage of the gas-powered chainsaw, indicating a shortage of oxygen; a strong, unpleasant odor arising from the pipe; and the immediate physical discomfort experienced by the crew members upon entering the trench to make the second cut.

Faced with these unusual incidents, the ALJ found that Diloreti (as the acting foreman) should have tested the atmosphere with a gas meter, available in the crew’s truck. He did not do so.

Diloreti had worked for the employer for 10.5 years, and had risen from laborer to technician to operator to foreman. He had never received “competent person” training, and only vaguely understood what the term meant. Although plainly conscientious and stricken by the death of his coworker, Diloreti testified that it had not occurred to him to test the excavation with a gas meter after the crew cut the pipe.

The ALJ held that Diloreti was unqualified to act as a “competent person”; that he had failed to identify a recognizable hazard; that an inspection required after a hazard-increasing occurrence was not made; and that Diloreti’s knowledge of the foul smell, and his crew members’ reactions, would be imputed to the employer and the employer had failed to be reasonably diligent in training its employees. Accordingly, a “serious” violation was found and a significant penalty imposed.

This occurrence would probably have been avoided and a life saved, had Diloreti had the modest incremental knowledge that would have led him to retrieve a gas meter and test the atmosphere in the trench.

The main lessons from the EMCON/OWT case are that experience must not be assumed to equal “competence,” and modest investments in “competent person” training afford employers serious “bang for the buck” and a sharp reduction in the likelihood of avoidable, and preventable, employee injury.

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The standard requires that each excavation or trench site must be monitored by a trained employee designated as a "Competent Person."

A competent person is not just any employee used to simply satisfy the standard. A competent person is defined as: One who is capable of identifying existing and potential hazards in the surroundings or working conditions which are: unsanitary, hazardous, or dangerous and has authorization to take prompt corrective action to eliminate the hazards.
By referring to this definition, a "Competent Person" (Though not required by standard) should be a designated employee working in a supervisory capacity. New hires or extra employees must not be used for this important task!

The employer designates who will be the Competent Person and is obligated to ensure that that person is competent to perform the task and is trained to recognize all hazards on the job site - this also applies to all the workers on the job site. Again, a competent person does not have to be a supervisor – however the employer must ensure that the supervisor does not try to supersede the authority of the Competent Person.

It is critical that management actively support the Competent Person!

A certificate or card does not constitute a competent person – compliance with the adopted definition does.

What Makes a “Competent Person?”

- Knowledge
- Skill
- Training
- Education
- Expertise
- Authority

The Competent Person Must:

- Be in direct charge of safety on the trenching and excavation project.
- Plan or co-plan all phases of the project (the key is to be involved!)
- Perform both visual and manual soils testing
- Determine which form of trench protection is appropriate in accordance with the standard, hazards and soil conditions.

Impact of Cave Ins

The National Institute for Occupational Safety and Health (NIOSH) has warned construction workers that they may be risking their lives when working in trenches or near potentially unstable ground. Based on NIOSH statistics, an average of 60 workers die in cave-ins each year.

According to NIOSH Director Dr. J. Donald Millar, these deaths are entirely preventable. He goes on to say: "It is appalling that workers continue to be buried alive in cave-ins. Almost without exception, these deaths can be prevented with existing safety precautions. These are not accidents, but incidents that can both be anticipated and avoided."

Of the 607 cave-in fatalities identified by NIOSH researchers over a ten year period from 1980 to 1989, construction workers accounted for 77% of these deaths. However, cave-ins are not the only threat to the safety of construction workers. These workers also face hazards associated with working at heights, working with heavy machinery, manually
handling materials, confined space hazards and working near sources of electricity, such as underground or overhead power lines. The new Cal/OSHA Trenching & Excavation Standard 1504 of the Construction Safety Orders detail the specific requirements for working in trenches and excavations. The new standard is based upon the adopted Federal Shoring Standard.

Each employee must be specifically trained in the hazards of working in trenches and be thoroughly familiar with the requirements of the standard.

Supervision is responsible for knowing and enforcing the requirements of the standard.

REMEmBER: WHiLE WORKING IN TRENCHEs AND EXCAVATIO.ns THERE IS ABLU.SU.UROOM FOR RISK-TAKING...ANY CONDITION YOU IGNOR.E OR OVERLOOK CAN BE FATAL!

Note: Due to the importance of this information, be sure to follow your companies' procedures and carefully read and follow the applicable Safety Regulations and Standards. If you do not understand any part of the standard, be sure to discuss it with your supervisor to acquire the knowledge.

CAVE-IN STORIES AND TRAGEDIES

COMPLIANCE OFFICER PROTECTS EMPLOYEES FROM TRENCH COLLAPSE

On June 7, while driving through Madison, Wis., Compliance Safety and Health Officer, Chad Greenwood of OSHA’s Madison area office observed work being performed at an excavation site. He saw a potentially unsafe trench and stopped to initiate an inspection. When the trench conditions were closely examined, the trench was found to be unsupported and unstable. He warned the foreman that no one should enter the trench. The contractor had been preparing to place an inlet box for a storm sewer. During the opening conference with the employer, a portion of the trench wall collapsed. Luckily, no one was hurt because of the CSHO’s quick actions.

OSHA’s Working Safely in Trenches QuickCard® (English/Spanish) offers tips to employers and employees on improving workplace safety and health while working in trenches. This QuickCard® can be found at http://www.osha.gov/Publications/quickcard/trenching_en.pdf.

EMPLOYEES REMOVED FROM EXCAVATION SITE MINUTES BEFORE COLLAPSE

OSHA’s role in the life of the American worker was exhibited once again when, at 10 a.m. on the morning of June 6 in Brooklyn, N.Y., OSHA Compliance Safety and Health Officer Bob Stewart requested that six construction employees be removed from a 22-foot deep excavation due to the hazardous 10-ton concrete abutment hanging above it. Fifteen minutes later, the overhang collapsed and fell, landing in the exact spot in which the
employees had been working. Stewart is a safety specialist assigned to OSHA’s Manhattan Area Office in New York.

**FAR TO CLOSE FOR COMFORT**

"Get out of that trench," OSHA Inspector Robert Dickinson ordered a worker in an unshored, unsloped, unsafe trench by the side of the road near El Paso, Texas. Good thing El Paso Assistant Area Director Mario Solano had spotted the trench earlier on September 13, 2001 and sent Dickinson and Elias Casillas to check it out. Because 30 seconds after the employee left the trench, the wall near where he had been standing collapsed. Heeding the compliance officer's warning and order to leave the trench kept the worker from experiencing a serious, perhaps life-threatening injury.

**LAGUNA BEACH MAN KILLED IN TRENCH CAVE-IN**

A 50 year old community activist died after the walls of a 12-foot trench collapsed while he was trying to install electrical wiring on his property. He was buried under six feet of earth when the sides of the unshored trench caved in. "He was conscious and talking at one point" said a Laguna Beach fire captain. "He may have been yelling, but we could barely hear him through the dirt. Then, there was a sound of panic and we didn't hear from him after that." A second man was buried to his waist by the cave-in, but managed to dig himself out after firefighters threw him a shovel.

The survivor said "All day he had been asking me, 'If this caves in, where are you gonna go?' I asked him this morning, let's get some boards to shore this thing up and he said, 'We're almost done.' In five more minutes we would have been sitting at the table eating lunch." It took firefighters an hour to reach the man's wrist and determine he was dead. It took them another five hours to pull his body from the trench.

Other stories and accounts of trench cave-ins may be found at www.trenchsafety.org/trench/sample/archives

**WHY DO CAVE-INS OCCUR?**

Undisturbed soil is kept in place by natural horizontal and vertical forces of the nearby soil as well as cohesive properties of some soils. When we dig in the earth, these natural forces are no longer able to hold back the soil left behind. With no support, eventually the laws of gravity take over, and the soil from the excavation walls move downward and inward into the excavation. The result is a cave-in.

Cave-ins are more likely to occur in unprotected excavations where:

- The excavation is dug in unstable soil, or in soil that has been dug in before;
- There is excessive vibration from construction equipment or vehicle traffic around the excavation;
• Too much weight near the sides of an excavation, most frequently from equipment or the excavated material (spoil pile) too near to the edge;

• Water has collected in the excavation;

• Changes in weather conditions (freezing, melting, sudden heavy rain, etc.)

**OTHER CAUSES OF DEATHS**

**A. ABSENCE OF TRENCH PROTECTION:**

Employees may risk working in an unprotected trench to save time and money, cut costs or even peer pressure. Risk – Reward systems do not work!

**B. LACK OF KNOWLEDGE:**

Employees are often not aware of the hazards and precautions required to minimize the risk of a cave-in. In addition, employees are often not trained in trench safety techniques.

**C. POOR JUDGMENT:**

Misinterpreting trench stability, soil conditions, slope or using improper trench protection methods

**DISTURBING STATISTICS**

Trench fatalities are a serious problem in construction. According to the Occupational Safety and Health Administration (OSHA), in 2003, **53 workers** were killed in trenching and excavation mishaps. This compares to **33 in 2002 and 36 in 2001**. Indeed, since 1990, trench fatalities had never exceeded 43 in any given year. After the spike in 2003, OSHA investigated **34 of the deaths** and reported its key findings. Trench fatalities are a serious problem in construction. According to the Occupational Safety and Health Administration (OSHA), in 2003, **53 workers** were killed in trenching and excavation mishaps. This compares to **33 in 2002 and 36 in 2001**. Indeed, since 1990, trench fatalities had never exceeded **43 in any given year**. After the spike in 2003, OSHA investigated **34 of the deaths** and reported its key findings.

In the investigated fatalities, protective systems were found to be properly employed in only **24 percent** of the trenches. In the remainder, a protective system was either improperly used (24%), available but not in use (12%) or simply unavailable (64%).

Further, despite the fact that environmental conditions were a contributing factor in **68 percent** of the fatalities, the competent person was not onsite when the fatality occurred **86 percent** of the time. Most of the time (65%) the employer had not identified the soil type even though soil type is a factor in trench cave-ins.
"Also, a disproportionate number of fatalities (36%) occurred on Mondays. "This is probably because rain or other factors changed conditions over the weekend," says Schneider. "A competent person has to inspect trench work in progress before each shift and after any changes in conditions."

The OSHA investigations showed that schedule time was more important than safety in 88% of the incidents. "It happens all the time," says Schneider. "It's a shallow trench, not too long. Everyone there wants to keep moving, and they don't take the time to ensure protection."

In 2003, 72% of the fatalities occurred in trenches less than nine feet deep. Only nine percent occurred deeper than 15 feet.

The most commonly killed employees were construction laborers (53%), with plumbers and pipe fitters following next at nine percent. Most (58%) were killed while installing pipe.

Fifty-six percent of these fatalities were Hispanics, and 52% were foreign-born. For 44%, Spanish was their primary language. At least 30 percent had been working for their employer for less than a year, and most (59%) worked for a subcontractor.

Construction is one of the most hazardous industries. Each year a substantial number of construction workers lost their lives; many others are injured. OSHA estimates of the number of fatalities range from several hundred to over 2,000 per year. (OSHA, 1990). During 2000, construction again recorded the highest number of fatal work injuries of any industry with 1,154 fatalities reported. Although the total for the industry was down about 3% - the first decline for construction since 1996, if compared with 1999. (BLS, 2001).

Trenching fatalities continue to plague the construction industry. While accurate records of the actual number of fatalities occurring in trenching incidents are not maintained, the estimate of 100 fatalities per year is perhaps a reasonable approximation of the magnitude of the problem.

According to an analysis by the National Institute for Occupational Safety and Health (NIOSH) of worker’s compensation claims in the Supplementary Data System of the Bureau of Labor Statistics, there are approximately 1000 work related injuries each year due to excavation cave-ins. Of these, about 140 result in permanent disability and 75 in death. (NIOSH-1995).

**Excavations and Trenching**

**OSHA Requirements for Excavations and Trenching**

Excavation and trenching are among the most hazardous construction operations. The Occupational Safety and Health Administration’s (OSHA) Excavation and Trenching standard, *Title 29 of the Code of Federal Regulation (CFR),* Part 1926.650, covers
requirements for excavation and trenching operations. There is a booklet titled “Excavations”, OSHA 2226 2002 (Revised). This booklet highlights key elements of the standard, shows ways to protect employees against cave-ins, and describes safe work practices for employees. A copy can be viewed on the OSHA web site at http://www.osha.gov/Publications/OSHA2226/2226.html

Definitions of Excavation and Trenching

OSHA defines an excavation as any man-made cut, cavity, trench, or depression in the earth’s surface as formed by earth removal. This can include anything from excavations for home foundations to a new highway.

A trench refers to a narrow excavation made below the surface of the ground in which the depth is greater than the width-and the width does not exceed 15 feet. Trenching is common in construction and utility work, where underground piping or cables are being installed or repaired.

If an excavation is more than 5 feet in depth, there must be a protective system in place while workers are in the excavation.

THE KEY TO PROTECTING YOURSELF

A. Knowing the hazards you and your co-workers face while working in trenches and excavations

B. Protecting yourself by using common sense, following established safe work practices and adhering to accepted safety standards

C. Avoid taking risks!

There should be no excuse for an injury resulting from a cave-in, as cave-ins are both predictable and preventable!

Preplanning

Pre-job or project planning is an extremely important aspect of a safe trenching and excavation project. This is where many incidents can be avoided well before any soil is excavated.

The competent person must take an active role in the process.

Important tasks & considerations would include:

**Surface Encumbrance Assessment** –
Surface encumbrances are essentially any object or structure which could pose a hazard during the project. Prior to beginning any project, all potential surface encumbrances must be identified and addressed to ensure safety.

Examples of surface encumbrances can include but are not limited to:
Note: adjacent utilities must be located, removed or supported to protect employees from potential injury.

**Utility Locations**
All underground utilities must be located to determine their approximate location. Remember, locators dispatched by utility companies can only provide approximate locations of their lines and systems.

By law, Under Ground Service Alert, Dig Alert or any other underground utility locating service must be contacted at least two working days prior to excavation. Emergency repair is generally exempted, but every effort must be made to safely locate underground utilities.

Many states have specific training requirements for employees involved in utility location. Be sure any employees involved in this activity are properly trained for the activity. Also be sure that any location services have properly trained personnel as well.

Once the approximate location of utilities has been determined, the actual location must be accomplished by carefully digging with hand tools. Avoid using metal handled tools as they can provide a direct link for electrocution. Wood or fiber glass handled tools are generally a good choice. If there is an electrical hazard, it's a good idea to use lineman's gloves for extra protection.

Never use backhoes, breakers, digging bars or other metal tools to locate or work around utilities due to the electrocution and spark hazard potential.

While the trench or excavation is being opened, utilities must be protected or supported or removed to prevent injury to workers should a pole or other object happen to fall.

**Access and Egress**
Ladders, ramps and stairways must be provided in all excavations 4 feet or more in depth. Secured ladders must be placed every 25 feet of lateral travel. In addition, ladders must
extend at least 2-3 feet above the top of the excavation. Employees must never be allowed to climb in and out of the trench by means of the shoring system.

Again be very careful as the type and condition of the ladder you choose to use. Due to electrical hazards metallic ladders must be avoided, good choices are fiberglass or wood ladders maintained in good condition.

Hand made construction ladders must conform to CAL/OSHA Article 25 Section 1676 "JOB-MADE LADDERS". Be sure that the ladder is safely secured to a stationary object to prevent the ladder from tipping or slipping during use.

Where employees are permitted to cross an excavation, a walkway constructed with standard 42" guard rails must be provided.

**Open Trenches**

Shafts, pits, wells etc, must be barricaded or covered when not in use and back filled when the job is complete. In cases where employees may fall into the excavation, a protection system must be employed.

This is especially important to also protect the public and children from an accidental fall.
**Traffic Control**

Employees exposed to vehicular or construction traffic must wear orange vests. If the lighting is poor or work is performed at night, reflectorized vests would be required as well as appropriate lighting in order to work safely.

![Image of flagging instructions]

**Flagging Operations**

Employees used for flagging operations must be specifically trained for that activity. A person should be chosen to be a flagger because the supervisor feels the person is physically able, mentally alert, and sufficiently commanding in appearance to properly control traffic through construction, maintenance, and utility work areas.
A flagger’s chief duties are to guide traffic safely through work areas, protect fellow workers, prevent unreasonable delays for road users, and answer motorists’ questions politely and knowledgeably.

**Manufacturer's Tabulated Data**

Any shoring material/equipment that is to be used on site must be accompanied with current manufacturers’ tabulated data. Should an OSHA official ask to see the documentation; a citation will be issued if it is not readily available.

![Figure 3 Manufacturer's Tabulated Data for Shoring Equipment]

**Training**

**Training Components**

Many of the specific examples used in this manual came from material for UC Irvine. The company or contractor must coordinate all trenching and shoring training and provide a training program that will teach employees, who might be exposed to Trenching and Shoring hazards, how to recognize such hazards and how to minimize them.

**Employee Training**

Employees should be trained in the following areas:

(a) The nature of Trenching and Shoring hazards in the work area;
(b) The correct procedures for erecting, maintaining, disassembling, and inspecting Trenching and Shoring protection systems;
(c) The use and operation of Trenching and Shoring equipment
(d) The role of each employee in the Trenching and Shoring safety monitoring system when the system is in use;
(e) The limitations of safety equipment during the performance of work;
(f) The correct procedures for equipment and materials handling and storage;

(g) Employees’ roles Trenching and Shoring Program; and
(h) The details in the specific plan.

_Trenching and Shoring Training Details_

Additional Trenching and Shoring training details:
(a) The company or contractor will conduct all Trenching and Shoring training. 
(b) New employees should be trained with Trenching and Shoring Program in force when they are employed. 
(c) All Facilities Maintenance employees will be trained in General Awareness Level Trenching and Shoring training every three years.
(d) All designated Competent Persons will sign off on all safety training related to Trenching and Shoring.
(e) Any employee who has not received appropriate training in the UC Irvine Trenching and Shoring Program will not be allowed to work with Excavations until the employee has been trained and understands the program. 
(f) The Trenching and Shoring Program is based on published standards and these standards are considered to be a minimum program. The UC Irvine Excavations Plan has been designed to exceed the minimum requirements.

_Trainer:_

The trainer must prepare a written certification that identifies the employee trained and the date of the training. The trainer must sign the training certification record for each employee. This certification record and training documentation are evidence of an employee receiving Trenching and Shoring training. Completion of this training equals competency in Trenching and Shoring activities.

_Construction Equipment_

Construction, by its nature, is an ever-changing environment and involves a constant movement of personnel and materials. The use of mechanized equipment poses significant crushing and striking hazards, particularly in excavation work.

_Examples of Safe Work Practices_

Below are some examples of safe work practices when working around mechanized equipment:

- Mark off areas around the swing radius of digging equipment and move the barriers with the progress of the work. This is particularly important when the back-hoe is operating in close proximity to people, trees and other solid objects such as sections of pre-cast. Most track-type back-hoes have a serious blind-spot that’s usually the rear of the machine on a diagonal to the operator’s position.

- Remember that loaders and backhoes are primarily earth-moving equipment. Traveling with material suspended from buckets poses a special hazard. Swinging loads may catch a worker between the suspended load and the machinery or the worker may trip on uneven grade and be run over by the equipment.

- Back-up alarms and other warning devices tend to be "tuned out" over time. In many pieces of equipment, the operators may only have a partially unobstructed vision to
the rear. Still other types of equipment, such as track equipment and skid-steer loaders make it difficult for an operator to turn completely around when backing up. Don’t rely on back-up alarms as the sole warning of which direction a machine is going to move. Always make sure the operator is aware of your position.

- You may not be working next to an active motor way, but reflective vests or clothing is still a good idea. Never assume an equipment operator can see you.

- When any load is brought under tension, regardless of the equipment being used to hoist it, stay away! The load should be controlled with a tag line while aloft and only after being positioned in the location of placement should workers be anywhere near it.

- No one should have any part of their body under any portion of a suspended load.

Figure 4 Construction Equipment

Construction equipment can present a number of hazards in and around trenching and excavation projects. Moving equipment can be a hazard to workers while traveling about the project. Vibrations transmitted by heavy equipment can weaken trench walls, causing a cave-in. Allowing a vehicle to approach too closely the edge of a trench, can cause a cave-in pulling in the vehicle and soil on top of employees.

Mobile equipment must be kept a safe distance from the edge of an excavation.

*Methods to Keep Equipment a Safe Distance from the Edge of an Excavation*

A number of methods can be employed to prevent equipment from approaching too close:

**STOP LOGS**

Timbers or logs can be placed a safe distance from an excavation to prevent vehicles from getting too close

**BARRICADES**

Standard barricades and warning tape can also be employed to help warn approaching drivers
HAND SIGNALS

Trained employees can be posted near the edge of an excavation to help direct traffic well away from danger.

Depending upon the size of vehicle, load and the trench depth, it is best to keep equipment at least 10 feet or more away from the edge of a trench. If this is not possible, sloping the grade away from the excavation may help.

Note: the standard does not indicate how far to keep equipment back, so good judgment comes into play.

Hazardous Atmosphere

We often take the air we breathe for granted. However, many gases in the work environment have no color or smell, and we can not tell if the air is dangerous simply by looking at it. In excavations, these **hazardous atmospheres** may go unrecognized by workers until it’s too late. Then workers rush in to rescue their co-workers and often become the victims as well. Indeed, 60% of all workers who die from such atmospheres are the rescuers themselves.

The OSHA standard states that when working in trenches **deeper than four feet** that are dug in locations where hazardous atmospheres are likely to be present, atmospheric testing, ventilation, and respiratory protection, must be provided. Areas such as landfills, hazardous waste sites, chemical plants, refineries, and areas where underground storage tanks are present are all locations which may produce hazardous atmospheres. Planners who perform pre-construction site surveys should look for potential atmospheric hazards as well as the physical conditions of the area to be excavated.

**Hazardous atmospheres include:** *Oxygen deficient environments, flammable, combustible, explosive, and toxic environments*. An oxygen-deficient atmosphere means there is not enough oxygen in the space. Normal air has 20.8% oxygen. Levels **below 19.5%** are considered oxygen-deficient. Oxygen deficient atmospheres are dangerous and can cause unconsciousness, brain damage, and death.
Flammable/combustible/explosive atmospheres contain gases or vapors in a certain concentration that can catch fire or explode if there is an ignition source.

Toxic atmospheres contain gases or vapors which, if breathed in, can make you sick, or even die. Here are a few examples of the most common sources for hazardous atmospheres in excavations:

**Oxygen deficient atmospheres:**
In an open excavation, rain water passing over limestone, causes an acidity reaction, and in turn produces carbon dioxide. Carbon dioxide is a simple asphyxiant which replaces oxygen in the air we breathe and can result in death. Landfill gases can displace oxygen.

**Flammable/combustible/explosive atmospheres:**
Volatile organic compounds found in petroleum products can move through small spaces in soils and accumulate in excavations. This can create both a fire and toxic hazard. Buried tanks next to an excavation site are a common source of these compounds as well as leaking gas mains and services.

Another common flammable gas is Methane. Methane occurs naturally from the breakdown of organic materials, such as sewage, leaves or weeds.

**Toxic atmospheres:**
Carbon monoxide from vehicles or equipment too near the excavation can accumulate and create a toxic environment for the workers.

When dealing with potential hazardous environments, early recognition is very important. Years ago, miners had to rely on canaries to tell them if the air they were breathing was hazardous. In today’s world, testing equipment for atmospheric hazards are compact and easy to use. One instrument can be purchased to detect the three most common atmospheric hazards found in excavations.

The competent person should understand and uses these direct reading instrument(s) that can detect the most common atmospheric hazards found in excavations. Continuous air monitoring is always a good idea because of changing conditions that can occur at a construction site.

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**Figure 6** Examples of Handheld Air Monitoring Instruments
In certain cases, an excavation may have the potential to contain hazardous atmospheres.

**Confined Spaces**

Before any work is attempted in confined spaces, all employees must be thoroughly trained in all aspects of the standard and safe work practices of confined space entry. No employee may be allowed to work or enter without training and understanding of Confined Space hazards.

**Examples of Confined Spaces**

**EXAMPLES MAY INCLUDE BUT NOT BE LIMITED TO:**

<table>
<thead>
<tr>
<th>HAZARDOUS WASTE</th>
<th>OLD DUMP SITES</th>
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<tr>
<td>LANDFILLS</td>
<td>LEAKING GAS STATIONS</td>
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<td>CUTTING OPERATIONS</td>
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<td>WELDING &amp; CUTTING</td>
<td>COATING APPLICATIONS</td>
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<tr>
<td>CAD-WELDING</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 More Examples of Confined Spaces


**Conditions for a Confined Space**

A Confined Space means a space that:

1) Is large enough and so configured that an employee can bodily enter and perform assigned work; and

2) Has limited or restricted means for entry or exit (for example: tanks, vessels, silos, storage bins, hoppers, vaults and pits are spaces that may have limited means of entry); and

3) Is not designed for continuous employee occupancy.

**Confined Space Defined**

Section 5158 defines a Confined Space by the concurrent existence of the following conditions:

A) Existing ventilation is insufficient to remove dangerous air contamination and/or oxygen deficiency with may exist or develop.

B) Ready access or egress for removal of a suddenly disabled employee is difficult due to the location and/or size of the opening(s).
Where oxygen deficiency or a hazardous atmosphere exists or could reasonably be expected to exist, such excavations such as in landfills and where hazardous substances are stored nearby, the atmospheres must be tested before employees enter excavations greater than 4 feet in depth.

Adequate precaution must be taken to provide ventilation, to prevent employee exposure to an atmosphere containing a concentration in excess of 10% of the lower flammable limit of that gas.

When engineering controls such as ventilation is employed to reduce contaminants to a safe level, re-testing must be conducted periodically to assure the atmosphere remains safe.

Specialized confined space training, assignment of an entry supervisor, emergency standby by and emergency rescue equipment such as SCBA’s, safety harnesses and life line or basket stretcher must be readily available where atmospheric hazards exists or may be reasonably expected to exist or develop during excavation work.

Should employees have to enter bell-bottom pier holes or similar deep footing excavations, the workers must wear a safety harness, with life line attached as called for in the Confined Space Safety Standard. The life line may not have any other purpose other than rescue, such as tool and equipment transfer.

Where hazardous atmospheres may be present, the excavation must be tested in accordance with Confined Space Safety Standards.

A minimum of 19.5% oxygen and safe levels of Carbon Monoxide, Hydrogen Sulfide, Combustibles or other hazardous atmospheres are required to work safely in excavations which may become a confined space.

TESTS MUST BE CONDUCTED TO ASSURE THAT THE ATMOSPHERE IS NOT:

- FLAMMABLE
- EXPLOSIVE
- TOXIC
- OXYGEN DEFICIENT

Any time fuel powers equipment or cutting or welding is performed in any excavation; the atmosphere must be monitored and augmented by ventilation. If a confined space condition exists all the provisions of the Confined Space Safety Standards are required to be followed.

**Overhead Loads**

No employee should be permitted under loads handled by lifting or digging equipment. It is recommended that loads which need personal control be directed by the use of ropes or poles from a safe distance.
Under no circumstances are employees allowed to work under an overhead load. When a vehicle such as a dump truck is depositing or picking up a load, employees are required to stand away from the vehicle to avoid being struck or buried by spilled or falling materials. Employees have been killed when the material dropped by a dump truck buried them or the weight of the vehicle and load collapsed the trench.

**Water Accumulation**

![Water Removal Pump](image)

Figure 7 Water Removal Pump

Employees may not work in an excavation where water has or is accumulating unless adequate steps have been taken to de-water and properly support the trench walls. Methods of water control may include but not be limited to:

- Water removal pumps
- Well points
- Water diversion
- Shield systems

Water accumulation and removal must be supervised, monitored and inspected by the job site Competent Person to assure proper operation and water control is effective.

Heavy rain will require more frequent inspection and controls to assure safety.

If work interrupts natural drainage or water courses such as streams etc, methods to divert the water must be applied such as the use of ditches, dikes, etc. to prevent water from entering the work area.

In certain circumstances extra safety precautions may include but not be limited to special supports, well points, and use of a safety harness, lifeline and personal floatation device.

**Adjacent Structures**

Excavations which may affect the stability of any adjacent structure such as a building, wall, sidewalk, telephone pole, concrete conduits, undermined pavement, etc. will require additional support systems such as shoring, underpinning or bracing to ensure stability.
Employees must never be allowed to work below the base or level of the footing or foundation of any excavation - except:

- Where a support system has been installed to provide structural stability and safety for the employees, or
- The excavation is in stable rock; or
- A registered professional engineer has determined that such work will not pose a hazard to employees

Protection from Loose Rock

Employees working in excavations must be protected from the hazard of loose rock and soil falling from the face of a trench wall. Loose material must be controlled by scaling the sides of the trench to remove loose material or installation of plywood to help contain loose material.

Note: Plywood is only intended to prevent unraveling of loose material, the plywood must be a minimum of 3/4 inch material meeting OSHA specifications for this purpose.

Excavated material and equipment must be kept at least 2 feet from the edge of a 5’ trench. A clear pathway must be maintained at all times to:

A. Prevent material from being kicked onto workers
B. Prevention of accidental falls

IMPORTANT! Super-imposed loads, (spoil, pipe, vehicles, equipment and material) can affect trench stability. This will require that the distance soil or material is kept from the edge of the trench, increases as the trench depth increases.

For example: In a 5 foot trench, material must be kept a minimum of two feet from the edge of the trench. For every additional 5 feet, the distance must be increased by an additional 2-3 feet.

If non-native material will be back filled and it is possible to transport spoil away from the site, this option should be seriously considered.

Inspectors

The competent person must conduct frequent inspections of the excavation site starting at the beginning of the day and periodically throughout the shift. Additional inspections must also be performed after any hazard increasing event such as rain storms, Santa Ana conditions, traffic, earthquake tremors, etc.

**DAILY MINIMUM INSPECTIONS**

Daily (Minimum) inspections by the Competent Person include:

- Trenches
- Soil
- Excavations
- Protective systems
- Water control systems
- Surrounding areas

The Competent Person must inspect the trench or excavation for any evidence of any situation which could result in:
  - Cave-ins
  - Indications of a trench protective system failure
  - Hazardous Atmospheres
  - Other hazardous conditions

Where there is evidence of a potential cave-in or other hazardous condition, the Competent Person must remove the affected employees until the necessary precautions have been taken to assure safety.

**Competent Person Checklists for Trenching and Excavation**

Checklists for Trenching and Excavation Competent Person and an Excavation Safety: Daily Inspection are provided. They request information about the contract name and number, contractor or subcontractor, government inspector; location of the project, contractor inspector and date the checklist is filled. The form also contains information about the competent person, general topics, water conditions, egress, and confined spaces. The first checklist is based on EM 385-1-1, dated 3 September 1996. Use of this checklist is optional. The second checklist is dated 18 Nov 2005 (updated 18 Sep 2008) SLAC-I-730-0A23J-003-R001.

The two checklists are separated by section breaks and can be copied as a document to carry into the field.
## TRENCHING AND EXCAVATION COMPETENT PERSON CHECKLIST

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**COMPETENT PERSON INFORMATION**

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Does the designated individual have training in:

- Soil Analysis?
- Use of protective Systems?
- Requirements of 29 CFR 1926.650-652?

List Training Experience:

Does the designated individual have knowledge about:

- Soil Analysis? (Describe types of soils and properties)
- Use of protective systems? (What method is being used and how was it determined)
<table>
<thead>
<tr>
<th>Requirements of 29 CFR 1926.650-652?</th>
<th>YES</th>
<th>NO</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the designated individual have authority to:</td>
<td>YES</td>
<td>NO</td>
<td>N/A</td>
</tr>
<tr>
<td>Take prompt corrective action to eliminate existing and predictable hazards?</td>
<td>YES</td>
<td>NO</td>
<td>N/A</td>
</tr>
<tr>
<td>Stop Work?</td>
<td>YES</td>
<td>NO</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**GENERAL**

<table>
<thead>
<tr>
<th>When was the last inspection of the excavation conducted?</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Was an inspection done and documented prior to the start of work?</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Were inspections done and documented as needed throughout the work shift?</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Were inspections done and documented after rainstorms or other hazard-increasing occurrence?</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Is the excavation deeper than 4 feet?</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAS</td>
</tr>
</tbody>
</table>

**WATER CONDITIONS**

<table>
<thead>
<tr>
<th>Is dewatering equipment being used on the site?</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>If yes, is the competent person monitoring the equipment and its proper operation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Has the excavation been subject to water accumulation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Has the soil in the trench been adversely affected?</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>If yes, has the competent person inspected the excavation and taken actions?</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAS</td>
</tr>
</tbody>
</table>
### EGRESS

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is a means of egress (exit) provided every 25 feet?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is a ramp used for access or egress to the excavation? (If no, skip to the next section.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the ramp used solely for employee access?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, was it designed by a competent person for safe access and egress?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, is the competent person who designed the ramp qualified?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the ramp meet specifications?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### CONFINED SPACES

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is there a potential for a hazardous atmosphere in the trench? If not, why?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is air monitoring equipment on site?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has a qualified person been assigned to assess the hazards of confined space? (OSHA Definition: A Qualified Person is designated by the employer in writing, as capable (by education and/or specialized training) of anticipating, recognizing and evaluating employee exposure to hazardous substances or other unsafe condition in a confined space. This person shall be capable of specifying necessary control and/or protective equipment to ensure safety.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is emergency rescue equipment as outlines in 29 CFR 1926.651 (g)(2)(l) readily accessible to employees?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Government QAR

Signature of Competent person (contractor)
Table 2  Competent Person Checklist for Trenching and Shoring
Excavation Safety: Daily Inspection Checklist

Department: Chemical and General Safety
Program: Excavation Safety
Owner: Program Manager
Authority: ES&H Manual, Chapter 11, Excavation Safety

Introduction

The following checklist is to be completed by the excavation competent person (and the checklist signed by a project manager / university technical representative for subcontracted work) for required daily inspections of excavation operations, defined in Chapter 11, “Excavation Safety”, as “operations where contact with soil is expected, such as trenching and removing soil”, that meet any of the following conditions, at any time:
1. Are one foot or more in depth
2. Involve the use of power tools
3. In which utilities are identified or any hazardous conditions are likely to be encountered

See Excavation Safety: Excavation Procedures for more information.

Checklist

Job Site Location ___________________________ Permit Number______________________
Date of Inspection___________________________ Time of Inspection____________________
Competent Person___________________________ Phone______________________________
Contractor________________________________ UTR______________________________

Reason for Inspection (Check One)

_____ Prior to Start of Work (Daily) Routine Inspection during Work
_____ After Rainstorm After a Hazardous Condition (Explain)

________________________________________________________
Other (Explain)

General Observations and Conditions

Weather__________ Traffic_____________ Terrain__________________
Spoil Location____________ Building Proximity________________
Heavy Equipment Location________ Heavy Materials Location______________
Water Accumulation _______________ Possible Vibration Sources__________
Utilities Located ______ Proper Markings in Place ___ Previously Disturbed Soil ______
Trench Width __________ Trench Depth ____________


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Excavation Safety: Daily Inspection Checklist
Other Trench Characteristics ______________________________________________________

Atmospheric Test Results

\[ \text{%O}_2 \quad \text{% LEL} \]

Toxic Source of Hazardous Atmosphere ____________________________________________

Soils Analysis and Classification

Soil Analysis Method(s) Used (Check all that apply)

- Visual
- Manual
- Tabulated Data

Soil Characteristics (Check all that apply)

- Cemented
- Cohesive
- Dry
- Fissured
- Granular
- Layered
- Moist
- Plastic
- Saturated
- Submerged

Soil Classification (Check all that apply)

- Type A
- Type B
- Type C
- Stable Rock

Avg. Compressive Strength _____ tsf

Compressed Strength Data __________

Manual Test Used (Check all that apply)

- Plasticity
- Dry Strength
- Thumb Penetration
- Pocket Penotrometer
- Drying Test
- Other ___________________________________

Protective Systems Options (Check one)

- Option (1) slope is 1.5:1 (34°) (Type C)
- Option (2) slope is _____ based on soil type
- Trench Shield: Manufacturer Name ____________________________________________
- Aluminum Hydraulic Shoring System: Manufacturer Name: _____________________

Supporting Information: _______________________ Tabulated Data on Site: ___________

General

Is excavation within original scope of excavation permit? ___ Yes ___ No

Are recommendations for disposal, shielding, and training from excavation permit being adhered to? ___ Yes ___ No

Utility survey markings legible? ___ Yes ___ No

Storm drains adequately protected from sediment? ___ Yes ___ No

Stockpiles/excavated materials at least two feet from edge of excavation? ___ Yes ___ No

Describe any changing conditions, plans, or shoring equipment damage:

Signatures

Excavation Competent Person

______________________________________________________________________________

Project Manager / University Technical Representative

______________________________________________________________________________

18 Nov 2005 (updated 18 Sep 2008) SLAC-I-730-0A23J-003-R001

Excavation Safety: Daily Inspection Checklist

Table 3 Evacuation Safety: Daily Inspection Checklist
Fall Protection

Figure 8 Walkway equipped with standard guardrails to allow employees to cross excavations or trenches

In situations in which employees are permitted to cross over excavations or trenches walkways or bridges equipped with standard guardrails must be provided.

In cases where there is other potential of falling into an excavation, the general area must be protected by using guard rails or other method to prevent falls.

In cases where projects are in a remote location, all shafts, wells, pits, etc., must be barricaded or covered. Immediately upon completion of the job requiring this type of excavation, the shaft, pit, well, etc., must be back filled.

Soil Classifications

OVERVIEW: SOIL MECHANICS.

A number of stresses and deformations can occur in an open cut or trench. For example, increases or decreases in moisture content can adversely affect the stability of a trench or excavation. The following diagrams show some of the more frequently identified causes of trench failure.

**TENSION CRACKS**

Tension cracks usually form at a horizontal distance of 0.5 to 0.75 times the depth of the trench, measured from the top of the vertical face of the trench. See the accompanying drawing for additional details.

Figure 9 Diagram Illustrating Tension Cracks
**SLIDING**

Sliding or sluffing may occur as a result of tension cracks, as illustrated below.

![Figure 10: Graphic Illustration Sliding or Sluffing](image)

**TOPPLING**

In addition to sliding, tension cracks can cause toppling. Toppling occurs when the trench's vertical face shears along the tension crack line and topples into the excavation.

![Figure 11: Graphic Illustrating Toppling](image)

**SUBSIDENCE AND BULGING**

An unsupported excavation can create an unbalanced stress in the soil, which, in turn, causes subsidence at the surface and bulging of the vertical face of the trench. If uncorrected, this condition can cause face failure and entrapment of workers in the trench.

![Figure 12: Graphic Illustrating Subsidence and Bulging](image)

**HEAVING OR SQUEEZING**

Bottom heaving or squeezing is caused by the downward pressure created by the weight of adjoining soil. This pressure causes a bulge in the bottom of the cut, as illustrated in the drawing above. Heaving and squeezing can occur even when shoring or shielding has been properly installed.
BOILING

Boiling is evidenced by an upward water flow into the bottom of the cut. A high water table is one of the causes of boiling. Boiling produces a "quick" condition in the bottom of the cut, and can occur even when shoring or trench boxes are used.

UNIT WEIGHT OF SOILS

Unit weight of soils refers to the weight of one unit of a particular soil. The weight of soil varies with type and moisture content. One cubic foot of soil can weigh from 110 pounds to 140 pounds or more, and one cubic meter (35.3 cubic feet) of soil can weigh more than 3,000 pounds.

Determination of Soil Type

Four Soil Types as Defined by OSHA

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

STABLE ROCK

Stable Rock is natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed. It is usually identified by a rock name such as granite or sandstone. Determining whether a deposit is of this type may be difficult unless it is known whether cracks exist and whether or not the cracks run into or away from the excavation.

TYPE A SOILS

Type A Soils are cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (tsf) (144 kPa) or greater. Examples of Type A cohesive soils are often: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. (No soil is Type A if it is fissured, is subject to vibration of any type, has previously been disturbed, is part of a sloped,
layered system where the layers dip into the excavation on a slope of 4 horizontal to 1 vertical (4H:1V) or greater, or has seeping water.

**TYPE B SOILS**

Type B Soils are cohesive soils with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa). Examples of other Type B soils are: angular gravel; silt; silt loam; previously disturbed soils unless otherwise classified as Type C; soils that meet the unconfined compressive strength or cementation requirements of Type A soils but are fissured or subject to vibration; dry unstable rock; and layered systems sloping into the trench at a slope less than 4H:1V (only if the material would be classified as a Type B soil).

**TYPE C SOILS**

Type C Soils are cohesive soils with an unconfined compressive strength of 0.5 tsf (48 kPa) or less. Other Type C soils include granular soils such as gravel, sand and loamy sand, submerged soil, soil from which water is freely seeping, and submerged rock that is not stable. Also included in this classification is material in a sloped, layered system where the layers dip into the excavation or have a slope of four horizontal to one vertical (4H:1V) or greater.

**Layered Geological Strata**

Where soils are configured in layers, i.e., where a layered geologic structure exists, the soil must be classified on the basis of the soil classification of the weakest soil layer. Each layer may be classified individually if a more stable layer lies below a less stable layer, i.e., where a Type C soil rests on top of stable rock.

**More on Soil Classifications**

Soil is a mixture of sand, gravel, silts, clay, water, and air. The amount of these ingredients determines its "cohesiveness", or how well a soil will hold together.

**Cohesive Soil**

Cohesive soil does not crumble. It can be molded easily when wet, and is hard to break up when dry. Clay is a very fine grained soil, and is very cohesive or “sticky”. Calcium carbonate also may be present and it may provide a cemented property.

**Granular Soils**

Sand and gravel are course grained soils, having little cohesiveness and are often called granular. Generally speaking, the more clay that is in the soil being excavated, the better the trench walls will hold up.

**Water Content of Soil**

Another factor in soil cohesiveness is water. Soil that is filled with water is termed saturated. Saturated soil does not hold together well, and is particularly dangerous in excavation work. However, the opposite can also be true. Another dangerous soil is soil that has little or no water in it, or if oven-dry, can crumble easily, and will not hold together when excavated.
Weight of Soil

Soil is heavy. A cubic foot can weigh as much as 125 pounds, and a cubic yard can weigh over 3,000 lb. — as much as a pick-up truck!

Most workers don’t realize the force that will hit them when a cave in occurs. A person buried under only a few feet of soil can experience enough pressure in the chest area to prevent the lungs from expanding. Suffocation can take place in as little as three minutes. Heavier soils can crush and distort the body in a matter of seconds. It’s no wonder trench accidents involve so many deaths and permanently disabling injuries.

Discussion of Four Categories of Soil

OSHA classifies soils into four categories: Solid Rock, Type A, Type B, and Type C. Solid Rock is the most stable, and Type C soil is the least stable. Soils are typed not only by how cohesive they are, but also by the conditions in which they are found. Stable rock is practically unachievable in the excavation of a trench. This is because the excavation of rock typically requires drilling and blasting, which fractures the rock, making it less stable. Type “A” soil can be clay, silty clay, or sandy clay.

A soil cannot be considered Type A if it is fissured (Has cracks) or other conditions exist that can adversely affect it, such as:

- Subject to vibration from heavy traffic, pile driving, or similar effects
- Having been previously disturbed/excavated
- Where it is part of a layered system, where less stable soil is near the bottom of the excavation, with the more stable soils on top.
- Subject to other factors which would make it unstable—such as the presence of ground water, or freezing and thawing conditions.

Many OSHA compliance personnel believe that construction equipment at the site create enough vibrations to prevent any soil from being typed as “A”. If vibrations can be felt while standing next to an excavation, the competent person should consider downgrading Type A soil to Type B or C.

Type B soils include both cohesive and non-cohesive soils. They include silts, sandy loams, medium clays, and unstable rock. Soils that might be classified as A, but have fissures, or are subject to vibration, may also be classified as "B" soils.

Type C soils are the most unstable (and therefore most dangerous) of the four soil types. They are easily recognized by the continual sloughing of the sides of the walls of excavation. If soil is submerged, or water is seeping from the sides of an excavation, it’s very probably "C" soil. Soil may be classified as Type C if an excavation is dug in "layered" soils, where different soil types lay on top of each other. When an unstable soil type is underneath a stable soil type in an excavation, the "weakest link" will soon give way.
Previously Disturbed Soil

In many construction projects, the soil that is being excavated has been previously disturbed. This means the soil has been dug up or manipulated in the past. This is another factor a competent person must consider when typing soils. Previously disturbed soils are rarely as strong as undisturbed soils, and are usually typed as type "C" soil.

Previously disturbed soil is commonly found above existing utilities, such as water, sewer, electrical and gas lines. This could also apply to lots where the solid has been disturbed in order to build homes. This makes work around these utilities more dangerous due to the unstable nature of the soil. Much of the work utility worker perform in excavations are along right-of-ways, where the soil is almost always likely to be Type C. Because of where you may dig, it’s important to understand that once soil has been excavated, it will never be returned to the way it was naturally formed.

To Type or Classify Soils

Per standard, a competent person must type or classify soils by using at least one visual and one manual test. A visual test can include inspecting the soil as it is being removed, and examining the spoil pile and the color and make-up of the excavation walls.

A manual test means working with the soil with either your hands or with an instrument designed to measure soil strength. For example, if you can roll the soil in your hands into a long "worm" or ribbon, the soil is cohesive and may be classified as A or B, depending on other conditions. One useful instrument for measuring soil strength is a pocket penetrometer. When you press this instrument into a soil sample, it measures its unconfined compressive strength in tons per square foot (tsf).

Regardless of the methods used, the typing of soils must be done by the competent person prior to anyone entering the excavation. The weaker or less stable the soil, the greater the need for protective systems.

Note: If you are uncertain of the soil type, ALWAYS assume Type C soil!

Remember: soil can be very heavy, weighing as much as 125 lbs per cubic foot. A typical cave-in often covers a victim with 4-6 yards of soil, this equates to 18,000 pounds of material. By law, all soil must be classified prior to work to determine the proper trench protection methods. Generally the Competent Person will be responsible for classifying the soil typically found in excavations. In large projects 20’ or more or where feasible, soil testing might be performed by a soils engineer.

Each excavation must be classified by a Competent Person as either:

- Solid Rock
- Type A
- Type B
- Type C
The classification must be based upon at least one visual and one manual soils test.

Note: Previously disturbed soil can never be Type "A" soil.

**VISUAL EXAMINATION**

Visual tests are conducted to determine general information regarding:
- The general site
- Soil adjacent to the excavation
- Soil forming sides of trench
- Samples from excavated soil
- Water content

1. Visually look to determine soil condition:
   - If the soil remains in clumps and is usually cohesive
   - Soil that breaks up easily and does not stay in clumps may be granular

2. Observe the sides of the excavation, looking for:
   - Cracks
   - Fissures
   - Other evidence of moving ground
   - Layered soil types, determine if layers slope toward the excavation and estimate the degree of the slope into the layers
   - Water in the trench
   - Sources of vibration

3. Carefully check the surrounding area for sources of vibration and other hazards which may affect stability.

**MANUAL TESTS**

The standard allows for a number of tests to be performed to help determine soil classification. Manual tests help to better identify the soil type and cohesiveness. It is recommended that your organization retain the services of a soils engineer to provide further training on how best to determine soil type.

The following are common tests that are used for soil classification:

**Plasticity:**

The plasticity test helps to determine if soil contains cohesive material. To perform this test, find a palm sized sample of moist or wet soil and mold it into a ball, and then attempt to roll it into threads about 1/8” in diameter.

If the soil contains cohesive properties, it can usually be rolled into threads without crumbing. If at least a two inch length of 1/8” thread can be held on one end without tearing, the soil appears to be cohesive.
**Dry Strength:**

The dry strength test help determine the soil type.

Obtain an undisturbed soil sample from the spoil pile and use your thumb or fingers to apply light to moderate pressure to the sample. If the sample crumbles into individual grains or powder with moderate pressure, the soil is usually considered granular. (combinations of gravel, silt or sand)

If the soil is dry and falls into clumps which in turn break into smaller clumps, which can only be broken with difficulty, it may be clay in combination with gravel, sand or silt.

If the dry soil breaks into clumps which do not break up into small clumps and again can only be broken up with difficulty and there is no visual fissures, the soil may be considered un-fissured.

**Thumb Penetration Test:**

The Thumb Penetration Test can be used to estimate the Unconfined Compressive Strength of cohesive soil material. When performing the thumb penetration test it must be done on an undisturbed excavated soil sample such as a large lump of material. This test should be performed as soon as possible after excavation as to reduce the effects of drying or additional water.

Type "A" soils have an "Unconfined Compressive Strength" of 1.5 tsf or greater, and can not readily be indented by thumb pressure.

Type "B" soils are those with .5 to 1.5 tsf of "Unconfined Compressive Strength" and can generally be penetrated to the first joint of the thumb.

Type "C" soil has an "Unconfined Compressive Strength" of 0.5 tsf or less and can easily be fully penetrated by the thumb, and can be molded by light finger pressure.

NOTE: Type "A" soil is not common, as many factors can reduce the soils stability qualities.

**Pocket Penetrometer**

Figure 15 Pocket Penetrometer
A "Pocket Penetrometer" may also be used to perform estimates of the compressive strength of soils.

**USING THE PENETROMETER:**

1. Perform the test on a large undisturbed excavated sample of soil such as a large clump. Shave a clean spot that is free of voids and rocks, etc.

2. Following the manufacturers instructions, move the ring toward the handle to the lowest reading on the handle.

3. Grip the handle and with steady pressure, push slowly until the soil reaches the marking on the piston, about 1/4" from the end.

4. Read the "Unconfined Compressive Strength" in tons/square foot or tsf on the low side of the ring. (be sure to follow the manufacturers' instructions for your instrument)

5. Take 8-10 readings, throwing out high and low and calculating an average.

If using a "Shear Vane" again carefully read and follow the instructions. Depending upon the instrument, the reading will need to be doubled to get the correct result.

**Drying Test:**

The basic purpose of the drying test is to differentiate between cohesive material with fissures, un-fissured cohesive material and granular material. The drying test should be performed by a qualified individual, but the following information is for general awareness only.

The drying test is performed by using a sample about one inch thick and six inches in diameter. A small portable stove or engine manifold is often used for this purpose to heat the sample until thoroughly dry.

- If the sample develops cracks as it dries, significant fissures are indicated.
- Samples that dry without cracking are to be broken by hand. If considerable force is needed to break the sample, the soil generally has cohesive material content.
- If the sample is easily broken by hand, it is either fissured cohesive material or granular material. In order to tell which is cohesive and granular, attempt to pulverize the sample with hand or foot pressure. If they do not pulverize easily, the material is generally cohesive with fissures. If they easily break into small fragments, the material is usually granular.
**Sedimentation or Olive Jar Test:**

The "Olive" jar test can be used to estimate the amount of clay, silt, sand etc in a soil sample. 4-6 shovel full's of soil are mixed and all rock and debris discarded, cut sample into quarters and throw out two, mix and repeat at least two more times, mixing the final sample again. Generally a tall olive jar is used with a mark about 1 1/2" from the bottom. The soil sample is placed in the jar up to the line and water added to the top (about 5-6" of water). The jar is shaken vigorously, given a twist and the sample timed. The types of soil within the jar will dictate how quickly they settle out.

For example: If 80% of the soil settles out within the first 30 seconds; the soil is generally Type "C" material. If after 30 seconds 70-80% of the material does not settle out; it could be Type "B" soil.

**A DISCUSSION OF SOIL TYPES**

**Cemented Soil**

A cemented soil is a soil in which particles are held together by a natural chemical such as calcium carbonate. Usually hand sized samples can not be crushed by thumb pressure.

**Cohesive Soil**

A Cohesive Soil has a high clay content providing cohesive properties. A Cohesive soil does not crumble and can easily be excavated with vertical sides. Cohesive soils include: sandy clay, silty clay, clay, etc....Often Type "A" unless previously disturbed or wet.

**Dry Soil**

A dry soil is one that does not exhibit any visible signs of moisture. This is usually a Type "B" or "C" soil.

**Fissured Soil**

A fissured soil has a tendency to crack with little resistance such as tension cracks. This is a very hazardous type of soil.

**Granular Soil**

A granular soil has little or no clay content and no cohesive strength. Can not be molded when moist and crumbles easily when dry. Never Type "A" soil.

**Plastic Soil**

A plastic soil can be rolled into 1/8" threads and held with out cracking. A plastic soil can be a Type "A" soil if previously undisturbed.
**Saturated Soil**

A saturated soil is a soil in which the voids are filled with water. If submerged or has been under water then always Type "C" soil.
### Trench Protection Requirements

<table>
<thead>
<tr>
<th>Strength Characteristics</th>
<th>STABLE ROCK</th>
<th>TYPE &quot;A&quot;</th>
<th>TYPE &quot;B&quot;</th>
<th>TYPE &quot;C&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid Mineral Material</td>
<td>1.5 tsf &gt; Unconfined Compressive Strength</td>
<td>0.5-1.5 tsf Unconfined Compressive Strength</td>
<td>0.5 or less Unconfined Compressive Strength</td>
<td></td>
</tr>
<tr>
<td>Physical Make-up</td>
<td>Natural Mineral Material</td>
<td>Highly Plastic Cohesive Soil</td>
<td>Plastic Cohesive Soil</td>
<td>Running, Granular Flowing OR Submerged</td>
</tr>
<tr>
<td>Maximum Allowable Slope</td>
<td>0:1 90 degrees</td>
<td>53 Degrees from horiz.</td>
<td>3/4:1 53 degrees</td>
<td>1:1/2 34 degrees</td>
</tr>
</tbody>
</table>

Table 4 Soil Categories for Strength Characteristics, Physical Makeup and Maximum Allowable Slope

Protective systems are methods of protecting workers from cave-ins of material that can collapse into an excavation. As mentioned earlier if an excavation is less than 5 feet deep, OSHA does not require a protective systems unless the competent person sees signs of a potential cave-in. (It is important to remember that a wall collapse in a trench four and 1/2 feet deep can still have serious results!)
For trenches between 5 feet and 20 feet deep, **shoring and sheeting**, **shielding, sloping and benching** are all acceptable protective measures. It is up to the planners of the construction project and the competent person to determine which systems will work best. If an excavation is greater than 20 feet deep, a **registered professional engineer** must design the protective system.

All employees must be protected from the hazard of a potential cave-in by the use of trench protection systems designed in accordance with the standard. Except when:

A. The excavation is made entirely in stable rock. Be aware, cutting, blasting or breaking rock can de-stabilize it.

B. The excavation is less than 5 feet in depth and after examination by the Competent Person is deemed safe and there is no potential for a cave-in.

Any excavation 5 feet or greater will always require the use of a protective system. In certain circumstances excavations less than 5 feet may also require protection depending upon the judgment of the Competent Person and soil stability.

REMEMBER: Protective systems in trenches or excavations greater than 20 feet in depth will require design by a registered civil engineer.

**Shoring Systems**

Shoring systems are structures of timber, mechanical, or hydraulic systems that support the sides of an excavation and which are designed to prevent cave-ins. **Sheeting** is a type of shoring system that keeps the earth in position. It can be driven into the ground or work in conjunction with a shoring system. Driven sheeting is most frequently used for excavations open for long periods of time. Another type of sheeting, in which plates or shoring grade plywood (sometimes called Finland form) is used in conjunction with strutted systems such as hydraulic or timber shoring. These strutted systems are also referred to as **active systems**. The most frequently used strutted system involves **aluminum hydraulic shores** which are lightweight, re-usable and installed and removed completely from above ground.

Design of slope or benching systems must comply with current standards.

Depending upon the soil classification, excavations will be sloped no greater than 3/4 horizontal to one vertical or 53 degrees, measured from the horizontal.

Slopes and benching systems will be selected and used by the employer and their designee (Competent Person or Registered Civil Engineer) must be in compliance with the requirements of the standard. (Sections 1541.1(b)(1) or in the alternative, Section 1541.(b)(3) or Section 1541.(b)(4))

Slopes 20 feet or greater designed by a professional engineer using the options in 1541.1(b) must be in written form and include the following at a minimum:
(A) The magnitude of slopes that were determined to be safe for the particular project

(B) The configurations that were determined to be safe for the project

(C) The identity of the Registered Professional Engineer

At least one copy of the design must be maintained at the job site while the slopes are being constructed. After that time a copy must be made available to CAL/OSHA upon request.

**Sloping and Benching Systems**

Sloping and benching are another means of protecting workers from cave-in hazards. Sloping is a method of cutting back the trench walls at such an angle that there is little chance of collapse. This is sometimes referred to as an "angle of repose", and must be suitable to the type of soil.

![Simple Slope Type A](image)

**Figure 17 Diagram Illustrating Simple Slope Type A**

Benching is a process of stepping off the earthen walls of an excavation.

![Benching](image)

**Figure 18 Diagram Illustrating Benching**

Sloping can be used as a system by itself or in conjunction with benching.
In the real world, there are very few applications where sloping and/or benching can be used. Why? Most often, the luxury of available space is the first consideration. Many excavations are dug in right-of-ways where the presence of other utilities and traffic become major considerations. Moreover, for every cubic yard of soil that is removed, it is very likely that nearly the same amount of material must be put back, and compacted as well.

**Simple Slope in Type C Soil**

If the location to be excavated has been previously disturbed, as it frequently is along a right-of-way, the soil type will very likely be classified as "C". With Type C soil, the excavation walls must be sloped back on each side of the excavation one and one half feet for every foot of depth.

Add all these factors up and it soon becomes clear: sloping, even in conjunction with benching, may be desirable—but not always very practical and economical.

A competent person must be familiar with the various sloping and benching configurations available, should that be the choice for protecting workers. In sloping and benching, important points to remember are the "weakest link" in determining what type of soil is supporting what type. If type C is supporting type B or any other type of combination, the sloping and benching configuration chosen must be in accordance with the OSHA standard. Refer to Appendix A of this workbook for the various conditions in which sloping and/or benching can be used.

**MAXIMUM ALLOWABLE SLOPES**
<table>
<thead>
<tr>
<th>STABLE ROCK</th>
<th>VERTICAL 90 DEGREES</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE &quot;A&quot; SOIL</td>
<td>3/4 TO 1 OR 53 DEGREES</td>
</tr>
<tr>
<td>TYPE &quot;B&quot; SOIL</td>
<td>1 TO 1 OR 45 DEGREES</td>
</tr>
<tr>
<td>TYPE &quot;C&quot; SOIL</td>
<td>1 1/2 TO 1 OR 34 DEGREES</td>
</tr>
</tbody>
</table>

Table 5 Maximum Allowable Slopes

**PROTECTIVE SYSTEMS**

There are a number of ways to protect employees from the hazards of moving ground. Shoring should be your last consideration, as other means of protection should be considered first such as: Sloping and/or benching which cuts back the soil to prevent a cave-in from occurring.

**Shoring Types**

Shoring is the provision of a support system for trench faces used to prevent movement of soil, underground utilities, roadways, and foundations. Shoring or shielding is used when the location or depth of the cut makes sloping back to the maximum allowable slope impractical.

Shoring systems consist of posts, wales, struts, and sheeting. There are two basic types of shoring, timber and aluminum hydraulic.

![Figure 21 Components of a Shoring System Illustrating Sheet, Posts, Wales, and Struts](image)

**TIMBER**

Timber used has been used for shoring material for centuries. Timber does have its place in trenching and excavations work but can be costly and a laborious process.
Timber used may be used as a method of trench protection in excavations less than 20 feet in depth.

Timber used may not be just any type of material purchased at the local do it yourself store. It must meet certain criteria such as actual and not nominal wood dimensions. In general, 4 inch material means four inch material, not 3 3/4 inch. Refer to the bending strength of wood for mixed oak and Douglas fir.

Timber may also be used in conjunction with or in place of other types of shoring such as hydraulic and pneumatic systems.

Generally timber is used in excavations that are at least Type "A" or "B" soil. Be sure to refer to the tables provided by CAL/OSHA for minimum size, dimension, wood type and placement of timber to be used in a shoring system. (Refer to appendix C to section 1554.1)

Though timbers can provide very good trench protection, consideration must be given to the cost of material, its working life, and the labor to construct to a shoring system.

Timbers can be used as typical shores, constructed into waler systems such as what would be used for "tight sheathing" situations in saturated soil or other Type "C" material.

Refer to the tables for the proper size and spacing of cross braces.

![Illustration of Timbers being used as Typical Shores](image)
ALUMINUM HYDRAULIC SHORING

The trend today is toward the use of hydraulic shoring, a prefabricated strut and/or wale system manufactured of aluminum or steel. Hydraulic shoring provides a critical safety advantage over timber shoring because workers do not have to enter the trench to install or remove hydraulic shoring. Other advantages of most hydraulic systems are that they:

- Are light enough to be installed by one worker;
- Are gauge-regulated to ensure even distribution of pressure along the trench line;
- Can have their trench faces "preloaded" to use the soil's natural cohesion to prevent movement; and
- Can be adapted easily to various trench depths and widths.

All shoring should be installed from the top down and removed from the bottom up. Hydraulic shoring should be checked at least once per shift for leaking hoses and/or cylinders, broken connections, cracked nipples, bent bases, and any other damaged or defective parts.

Aluminum hydraulic shoring again is only to be used as a trench protection method in excavations that do not exceed 20 feet in depth and only if the type of soil allows the use.

Aluminum hydraulic shoring is intended to be used in Type A and B soil only, and in trenches that do not exceed 20 feet in depth.

Like timber, this type of shoring must also meet certain specifications for us in trenches. Note: The width of the trench will dictate the cylinder diameter to be used.

The soil type and trench depth will also determine how far apart to space the shores.

Like timbers, this type of shoring can be used individually or in a waler system for greater protection.

Remember that the manufacturers’ tabulated data must be on site for this equipment.

2 inch cylinders must have a minimum of 2” inside diameter with a safe working load of no less than 18,000 pounds compressive load.

3 inch cylinders must have a 3 inch inside diameter with a safe working load of no less than 30,000 pounds.

A hydraulic hand pump is required to apply the proper pressures to the wall of the trench. Depending up the manufacturer, the pump is charged into the green zone or about 750 psi – which causes the shoring to be squeezed against the
trench wall at about 2250 psi. The pump uses water and water soluble oil for the hydraulic fluid. Caution must be taken when working with aluminum hydraulic shoring as there are several pinch points, therefore be sure to use only shoring with guards in these areas. Shoring can be heavy and care must be taken to avoid back injuries by using good lifting techniques and/or using help. Be sure to take advantage of the shoring release tools provided with the equipment. Not only do they speed installation, but make it safer.

Be sure to inspect the shoring prior to use to ensure that they are in good condition and have no leaks.

![Vertical Aluminum Hydraulic Shoring](image1)

![Vertical Aluminum Hydraulic Shoring (With Plywood)](image2)

![Vertical Aluminum Hydraulic Shoring (Stacked)](image3)

![Aluminum Hydraulic Shoring Water System (Typical)](image4)

Figure 23 Illustrations of Aluminum Hydraulic Shoring

**SCREW JACKS**

![Illustration of a Screw Jack](image5)

Figure 24 Illustration of a Screw Jack
Screw jacks are generally used to hold and separate uprights in a shoring system.

Screw jacks must only be used with the proper type of iron pipe (schedule 40) cut to length to fit the trench opening.

The concern with screw jacks is that there is no means to determine what pressures you are exerting upon the trench sides. In addition, to install the shores it requires that an employee enter the unprotected trench to apply the screw jack to the timber. This flies in the face of trench safety recommendations.

The safest method to install this jack would be to place the ladder in the middle of the trench, stand on a ladder beginning at 2 feet from the top of the trench and step down the ladder to within 2 feet of the bottom of the trench; tightening the jack handle as you proceed down the ladder.

Be sure to nail the feet of the screw jack to the timber to prevent the jack from falling out when tightening the other screw jacks.

TRENCH SHIELDS

A shield, also known as a trench box, is another common protective system used by contractors. Trench boxes are not designed to prevent cave-ins, but rather serve to "shield" workers within the structure should a cave-in occur. This is an excellent choice when placing continuous installations, as in pipe laying. The box is placed in the trench and dragged along with the progress of the work. A few important points about shields:

- Personnel should be out of the box and above ground when the shield is being moved. You could be caught between the moving box and fixed object(s);
- Employees must remain in the confines of the box when working
- The top of the shield should extend at least eighteen (18) inches above the level of any materials that could cave or roll into the trench;

- Some shields are designed to be stacked, one on top of another. Never stack shields that are not designed for that purpose, and do not stack shields from different manufacturers, as they may not be compatible.

- The forces of a cave-in can literally push a box sideways, causing a crushing hazard. After a box is positioned for the work, the voids between the box and the trench wall should be filled with excavated material to prevent displacement caused by a cave-in.

- Shielding should always be used according to manufacturer’s tabulated data.

Trench shields are an effective means of providing trench protection in poor soil conditions.

Shields allow employees to work safely in an enclosed area. Shields can be very versatile allowing the units to be stacked for very deep trenches. Remember: Be sure a Registered Professional Engineer approves systems for trenches that exceed 20 feet in depth.

Shield systems must be designed to have the capacity to resist without failure all loads that are intended or could reasonably be expected to be transmitted to the trench protective system.
References

CONSTRUCTION

Alliances

- Construction. OSHA's Alliance Program. This is one of OSHA's Strategic Management Plan Focus Areas.

e-Tools

- Construction. OSHA. A Spanish version is also available. Helps workers identify and control the hazards that cause serious construction-related injuries.
  - Trenching and Excavation

Trenching and Excavation

Cave-ins are perhaps the most feared trenching hazard. But other potentially fatal hazards exist, including asphyxiation due to lack of oxygen in a confined space, inhalation of toxic fumes, drowning, etc. Electrocution or explosions can occur when workers contact underground utilities.

OSHA requires that workers in trenches and excavations be protected, and that safety and health programs address the variety of hazards they face. The following hazards cause the most trenching and excavation injuries:

- No Protective System
- Failure to Inspect Trench and Protective Systems
- Unsafe Spoil-Pile Placement
- Unsafe Access/Egress

OSHA Standards

Trenching and excavation hazards are addressed in specific standards for the construction industry. This section highlights OSHA standards, the Regulatory Agenda (a list of actions being taken with regard to OSHA standards), directives (instructions for compliance officers), and standard interpretations (official letters of interpretation of the standards) related to trenching and excavation.

Highlighted Standards

Construction Industry (29 CFR 1926)

- 1926 Subpart P, Excavations
  - 1926.650, Scope, application, and definitions applicable to this subpart
  - 1926.651, Specific excavation requirements
  - 1926.652, Requirements for protective systems
  - Appendix A, Soil classification
  - Appendix B, Sloping and benching
  - Appendix C, Timber shoring for trenches
  - Appendix D, Aluminum hydraulic shoring for trenches
Appendix E, Alternatives to timber shoring
Appendix F, Selection of protective systems

- 1926 Subpart S, Underground construction, caissons, cofferdams, and compressed air
  - 1926.800, Underground construction
- 1926 Subpart V, Power transmission and distribution
  - 1926.956, Underground lines

For additional information on specific state plan states or other general standards, see the general industry OSHA Standards page.

Regulatory Agenda

The OSHA Regulatory Agenda contains an entry related to Construction - Trenching and Excavation. OSHA has announced its intent to conduct a Section 610 review (also known as a “Lookback review”) of the Excavation Standard (29 CFR 1926, Subpart P). OSHA regularly reviews existing standards to determine whether the standards should be maintained without change, rescinded or modified.

Directives

- Inspection Procedures for Enforcing the Excavation Standard, 29 CFR 1926, Subpart P. CPL 02-00-087 [CPL 2.87], (1990, February 20). Establishes inspection procedures and provides clarification to ensure uniform enforcement of the Excavation Standards.
- Search all available directives.

Standard Interpretations

- 29 CFR 1926.651(i)(1); excavation operations. (2006, January 10).
- Search all available standard interpretations.

Hazards and Possible Solutions

Excavation cave-ins cause serious and often fatal injuries to workers in the United States. The following references aid in recognizing and evaluating trenching and excavation hazards in the workplace.

  - Excavations: Hazard Recognition in Trenching and Shoring. Summarizes the OSHA regulations for trenching.
  - Site Assessment Questions
- US Department of Labor (DOL), North Aurora, IL Area Office. Aurora OSHA Construction News 3.2(2002, Fall). Also available as a 454 KB PDF, 6 pages. Provides articles discussing trenching contractors not in compliance and their top ten reasons for noncompliance with the trenching standards, reports fatalities and injuries investigated in Illinois, ranks most frequently cited standards, discusses protective systems and the competent person.
- Excavations. OSHA Publication 2226, (2002). Also available as a 533 KB PDF, 44 pages. Highlights key elements of 29 CFR 1926.650, shows ways to protect employees against cave-ins, and describes safe work practices for employees.
The 100 Most Frequently Cited OSHA Construction Standards in 1991: A Guide for the Abatement of the Top 25 Associated Physical Hazards. OSHA Publication, (1995, March). Also available as a 2 MB PDF, 100 pages. Helps employers and employees identify and correct hazards related to the most frequently cited OSHA standards found on construction sites throughout the United States. PPE-related standards were found at the number 2, 7, and 19 positions on this list of 100.


Preventing Deaths and Injuries From Excavation Cave-Ins. National Institute for Occupational Safety and Health (NIOSH), (1997, March 11). Provides several case reports, OSHA standards that apply to these cases, and recommended courses of action.


Trenching and Shoring Procedures. Oklahoma State University, Environmental Health & Safety (EHS) Manuals, (2002, March 19). Sets forth the official practices required for excavations made by Oklahoma State University employees on property owned by Oklahoma State University.

Additional Information

Related Safety and Health Topics Pages

- Construction Industry

News Releases

- Potential trenching hazards bring fines to company in LA. OSHA Region 6 News Release, (2003, May 9). Failure to protect employees from potential trenching and excavation hazards has brought Coushatta Empire Inc. of Oakdale, La., $99,400 in proposed penalties from the Baton Rouge area office of the US Department of Labor's Occupational Safety and Health Administration.

  - Hazards Associated with Striking Underground Gas Lines. OSHA Safety and Health Information Bulletin (SHIB), (2003, May). Also available as a 24 KB PDF.

for Safety and Construction have formed an alliance designed to assist in identifying and removing safety hazards at construction sites.

**Training**

- **Excavation.** Oregon-OSHA. Includes publications, fact sheets, workbooks/instructor guides, and a video/DVD library.
  - *Excavation Safety.* Oregon-OSHA Workshop 302, 2 MB PDF, 94 pages. Provides information on excavation work in construction, discussing specific hazards resulting from excavation work and requirements for protective systems. A 3 MB PDF, 34 page instructor guide is also available.
  - *Excavations.* Oregon-OSHA Publication 2174, 2 MB PDF, 32 pages. Describes differences between excavations and trenches, the role of a competent person, how cave-ins occur, how soil is tested, protective systems, and getting in and out of an excavation. Includes a safe practice checklist.
- **Trench Safety - A Tutorial for Constructors.** Auburn University, Building Science Department.

**Other Resources**


**Standard Reference**

Documents referencing 1926 Subpart P

[Find It! in DOL]

**Directives**


**Federal Registers**

1. 2001 - 08/17/2001 - Submission for OMB Review; Comment Request - 66:43268-43272


**Standard Interpretations**


3. 1991 - 08/30/1991 - Placement of vertical hydraulic shoring members; Bending strength of plywood; use of non-structural sheeting.

Appendix 1: Code of Safe Work Practices

Trenching and Shoring Activities

The federal standards can be found in the OSHA safety regulations 29 CFR1926.650 – 651 and 652.

1. Before excavation, underground utilities must be located and marked. Adjacent structures must be stabilized, as needed, using shoring, bracing, or underpinning techniques.

2. Appropriate barricades, fences, protected walkways and signs must be provided to protect the public.

3. A competent person must be in charge of each excavation who is trained to identify hazardous conditions and who has the authority to take corrective action. The competent person must inspect excavations on a daily basis and after every rain.

4. Examine the trench or excavation before entry.

5. An access ladder or other safe access must be provided.

6. Install barricades, fences, protected walkways and/or signs to protect the public and other campus users from the excavation site.

7. Ensure all equipment and materials are in good, working condition.

8. Pre-plan the trenching, excavation operation to include safety work practices, hazard recognition procedures, and soil determination/analysis tasks.

9. Workers must be protected from cave-ins by either an adequate sloping system or an adequate support or protective system.

10. Stairs or ladders must be provided when workers enter excavations over 4 feet deep.

11. A means of exiting the trench must be provided every 25 feet.

12. Workers must stay always from any equipment loading or unloading material.

13. Excavated or other material must be retained 2 feet or more from the edge of the excavation.
14. Workers must not enter or work in trenches with hazardous atmosphere without adequate controls. Test excavation and trench sites for oxygen deficiency or the presence of other hazardous atmosphere prior to entry.

15. Workers must wear all required personal protective equipment including hardhats, safety footwear, gloves, eye protection, hearing protection, and fall protection devices, as needed.

16. Additional shoring and bracing must be provided when excavations or trenches are located adjacent to previously backfilled excavations or where excavations are subjected to vibrations from railroad or highway traffic, operation of machinery, or other sources.

17. Discourage surface crossing of trenches.

18. Protect employees from loads or objects falling from lifting or excavating equipment.

19. Keep rocks, soil, equipment, and other materials from falling into the trench.

20. Prevent water accumulation whenever possible.

21. Keep excavations and trenches open the minimum amount of time needed to complete work tasks.

22. Evaluate the excavation and trenching operation at the conclusion of the work activity.
Appendix 2: Cal/OSHA Reporting Process Checklist

Cal/OSHA Reporting Process Checklist

Whenever any trenching and shoring activity is about to take place, Facilities Management must notify Environmental Health & Safety (EH&S) as soon as possible, or at least 48 hours before the work has been scheduled. All emergency trenching work must also be reported to EH&S as soon as it has been determined that the activity will take place. The following people have been designated as the EH&S Department contacts:

Primary contact:

Secondary contact:

The following information must be provided to EH&S when notifying them about trenching and shoring activities:

1. Has the Hazard Assessment and Trench Entry and Authorization Form (Appendix C) been completed?

2. Who is the Competent Person on site?

3. What is the depth of the trench?

4. What is the length of the trench?

5. What method of trench protection is being used?

6. What are the results of the soil analysis?

Competency Assessment Tool for Competent Persons at UC Irvine
This form is used in determining the competency of UC Irvine employees on the topic of Trenching and Shoring. All employees being considered as a Competent Person should be able to show and demonstrate knowledge of all items listed on this assessment form.

UC IRVINE EMPLOYEE BEING CONSIDERED AS A COMPETENT PERSON:

________________________________________________________________

Can the employee identify if a trench or excavation meets the definition of confined space? _____
If yes, is the employee trained to evaluate confined space hazards?

Is the employee capable of specifying necessary safety control measures to assure employee safety?

INSPECTIONS
When performing inspections of the excavation, is the employee able to thoroughly conduct inspections of the excavation?

Of adjacent structures?

Of protective systems?

Is the employee able to identify when to conduct inspections (prior to the start of work, as needed throughout the shift, after rainstorm or hazard-increasing occurrence)?

Can the employee exercise the authority to remove employees from a hazardous area until proper precautions are taken?

PROTECTIVE SYSTEMS
Is the employee able to recognize that a protective system is needed for any excavation less than 5 feet in depth?

WATER CONDITIONS
If using dewatering equipment on site, is the employee able to monitor the equipment and its proper operation?

Is the employee able to identify if the excavation been subjected to heavy rainfall?

Is the employee able to inspect the excavation and ensure that it complies with the precautions set forth in the Excavations Standard, part (h)(1) and (h)(2)?

RAMPS
Is the employee able to evaluate the use of a structural ramp for trenching activities?

Is the employee able to examine any damaged equipment or materials used, and evaluate its suitability for continued use?
Is the employee able to distinguish between Option 1 (Select and construct a protective system) and Option 2 (Design a sloping and shoring system) and which one is appropriate to be used at a job site?

Is the employee able to properly classify soil using either a manual test or pocket penetrometer OR a visual test and a pocket penetrometer?

What type of soil was identified in the excavation?

What visual tests were used?

What manual tests were performed?

How was the proper sloping or benching configuration chosen?

If the ramp is used for employees, is the employee able to evaluate it for safe access and egress?

If the ramp is used for access and egress of equipment, is the employee able to identify that the ramp must be qualified in structural design?

List qualifications of equipment ramp:

Was the employee able to determine if the ramp meets design qualifications?

CONCLUSION
List all qualifications of UC Irvine employee being evaluated as a Competent Person:

Has the competent person performed all tasks required by the Excavations standard? __________
Is the person capable of identifying existing and predictable hazards in the surrounding or working conditions, which are unsanitary, hazardous, or dangerous to employees?

—

Is the competent person authorized to take prompt corrective measures to eliminate such hazards or conditions?

—
Appendix 3: General Requirements-Excavations

§1541. General Requirements

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

(b) Subsurface installations.

(1) The approximate location of subsurface installations, such as sewer, telephone, fuel, electric, water lines, or any other subsurface installations that reasonably may be expected to be encountered during excavation work, shall be determined by the excavator prior to opening an excavation.

(A) Excavation shall not commence until:

1. The excavation area has been marked as specified in Government Code Section 4216.2 by the excavator; and

2. The excavator has received a positive response from all known owner/operators of subsurface installations within the boundaries of the proposed project; those responses confirm that the owner/operators have located their installations, and those responses either advise the excavator of those locations or advise the excavator that the owner/operator does not operate a subsurface installation that would be affected by the proposed excavation.

(B) When the excavation is proposed within 10 feet of a high priority subsurface installation, the excavator shall be notified by the facility owner/operator of the existence of the high priority subsurface installation before the legal excavation start date and time in accordance with Government Code Section 4216.2(a), and an onsite meeting involving the excavator and the subsurface installation owner/operator's representative shall be scheduled by the excavator and the owner/operator at a mutually agreed on time to determine the action or activities required to verify the location of such installations. High priority subsurface installations are high pressure natural gas pipelines with normal operating pressures greater than 415 kPA gauge (60 p.s.i.g.), petroleum pipelines, pressurized sewage pipelines, conductors or cables that have a potential to ground of 60,000 volts or more, or hazardous materials pipelines that are potentially hazardous to employees, or the public, if damaged.

(C) Only qualified persons shall perform subsurface installation locating activities, and all such activities shall be performed in accordance with this section and Government Code Sections 4216 through 4216.9. Persons who complete a training program in accordance with the requirements of Section 1509, Injury and Illness Prevention Program (IIPP), that meets the minimum training guidelines and practices of the Common Ground Alliance (CGA) Best Practices, Version 3.0, published March 2006, or the standards of the National Utility Locating Contractors Association (NULCA), Standard 101: Professional Competence Standards for Locating Technicians, 2001, First Edition, which are incorporated by reference, shall be deemed qualified for the purpose of this section.
(D) Employees who are involved in the excavation operation and exposed to excavation operation hazards shall be trained in the excavator notification and excavation practices required by this section and Government Code Sections 4216 through 4216.9.

(2) All Regional Notification Centers as defined by Government Code Section 4216(j) in the area involved and all known owners of subsurface facilities in the area who are not members of a Notification Center shall be advised of the proposed work at least 2 working days prior to the start of any digging or excavation work. EXCEPTION: Repair work to subsurface facilities done in response to an emergency as defined in Government Code Section 4216(d).

(3) When excavation or boring operations approach the approximate location of subsurface installations, the exact location of the installations shall be determined by safe and acceptable means that will prevent damage to the subsurface installation, as provided by Government Code Section 4216.4.

(4) While the excavation is open, subsurface installations shall be protected, supported, or removed as necessary to safeguard employees.

(5) An excavator discovering or causing damages to a subsurface installation shall immediately notify the facility owner/operator or contact the Regional Notification Center to obtain subsurface installation operator contact information immediately after which the excavator shall notify the facility operator. All breaks, leaks, nicks, dents, gouges, grooves, or other damages to an installation's lines, conduits, coatings or cathodic protection shall be reported to the subsurface installation operator. If damage to a high priority subsurface installation results in the escape of any flammable, toxic, or corrosive gas or liquid or endangers life, health or property, the excavator responsible shall immediately notify 911, or if 911 is unavailable, the appropriate emergency response personnel having jurisdiction. The facility owner/operator shall also be contacted.

Note: The terms excavator and operator as used in Section 1541(b) shall be as defined in Government Code Section 4216(c) and (h) respectively. The term "owner/operator" means an operator as the term "operator" is defined in Government Code Section 4216(h).

(c) Access and egress.

(1) Structural ramps.

(A) Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person. Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.

(B) Ramps and runways constructed of two or more structural members shall have the structural members connected together to prevent displacement.

(C) Structural members used for ramps and runways shall be of uniform thickness.
(D) Cleats or other appropriate means used to connect runway structural members shall be attached to the bottom of the runway or shall be attached in a manner to prevent tripping.

(E) Structural ramps used in lieu of steps shall be provided with cleats or other surface treatments to the top surface to prevent slipping.

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

(d) Exposure to vehicular traffic. Employees exposed to public vehicular traffic shall be provided with, and shall wear; warning vests or other suitable garments marked with or made of reflectorized or high-visibility material.

(e) Exposure to falling loads. No employee shall be permitted underneath loads handled by lifting or digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles are equipped, in accordance with Section 1591(e), to provide adequate protection for the operator during loading and unloading operations.

(f) Warning system for mobile equipment. When mobile equipment is operated adjacent to an excavation, or when such equipment is required to approach the edge of an excavation, and the operator does not have a clear and direct view of the edge of the excavation, a warning system shall be utilized such as barricades, hand or mechanical signals, or stop logs. If possible, the grade should be away from the excavation.

(g) Hazardous atmospheres.

(1) Testing and controls. In addition to the requirements set forth in the Construction Safety Orders and the General Industry Safety Orders to prevent exposure to harmful levels of atmospheric contaminants and to assure acceptable atmospheric conditions, the following requirements shall apply:

(A) Where oxygen deficiency (atmospheres containing less than 19.5 percent oxygen) or a hazardous atmosphere exists or could reasonably be expected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, the atmospheres in the excavation shall be tested before employees enter excavations greater than 4 feet in depth.

(B) Adequate precautions shall be taken to prevent employee exposure to atmospheres containing less than 19.5 percent oxygen and other hazardous atmospheres. These precautions include providing proper respiratory protection or ventilation.

(C) Adequate precaution shall be taken such as providing ventilation, to prevent employee exposure to an atmosphere containing a concentration of a flammable gas in excess of 10 percent of the lower flammable limit of the gas.
(D) When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, testing shall be conducted as often as necessary to ensure that the atmosphere remains safe.

(2) Emergency rescue equipment.

(A) Emergency rescue equipment, such as breathing apparatus, a safety harness and line, or a basket stretcher, shall be readily available where hazardous atmospheric conditions exist or may reasonably be expected to develop during work in an excavation. This equipment shall be attended when in use.

(B) Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, shall wear a harness with a lifeline securely attached to it. The lifeline shall be separate from any line used to handle materials, and shall be individually attended at all times while the employee wearing the lifeline is in the excavation.

(h) Protection from hazards associated with water accumulation.

(1) Employees shall not work in excavations in which there is accumulated water, or in excavations in which water is accumulating, unless adequate precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions necessary to protect employees adequately vary with each situation, but could include special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water, or use of a safety harness and lifeline.

(2) If water is controlled or prevented from accumulating by the use of water removal equipment, the water removal equipment and operations shall be monitored by a competent person to ensure proper operation.

(3) If excavation work interrupts the natural drainage of surface water (such as streams), diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation. Excavations subject to runoff from heavy rains will require an inspection by a competent person and compliance with Sections 1541 (h)(1) and (h)(2).

(i) Stability of adjacent structures.

(1) Where the stability of adjoining buildings, walls, or other structures is endangered by excavation operations, support systems such as shoring, bracing, or underpinning shall be provided to ensure the stability of such structures for the protection of employees.

(2) Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be permitted except when:

(A) A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure; or

(B) The excavation is in stable rock; or
(C) A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.

(3) Sidewalks, pavements and appurtenant structure shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures.

(j) Protection of employees from loose rock or soil.

(1) Adequate protection shall be provided to protect employees from loose rock or soil that could pose a hazard by falling or rolling from an excavation face. Such protection shall consist of scaling to remove loose material; installation of protective barricades at intervals as necessary on the face to stop and contain falling material; or other means that provide equivalent protection.

(2) Employees shall be protected from excavated or other materials or equipment that could pose a hazard by falling or rolling into excavations. Protection shall be provided by placing and keeping such materials or equipment at least 2 feet from the edge of excavations, or by the use of retaining devices that are sufficient to prevent materials or equipment from falling or rolling into excavations, or by a combination of both if necessary.

(k) Inspection.

(1) Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a competent person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions. An inspection shall be conducted by the competent person prior to the start of work and as needed throughout the shift. Inspections shall also be made after every rain storm or other hazard increasing occurrence. These inspections are only required when employee exposure can be reasonably anticipated.

(2) Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

(l) Fall protection.

(1) Where employees or equipment are required or permitted to cross over excavations over 6-feet in depth and wider than 30 inches, walkways or bridges with standard guardrails shall be provided.

(2) Adequate barrier physical protection shall be provided at all remotely located excavations. All wells, pits, shafts, etc., shall be barricaded or covered. Upon completion of exploration and other similar operations, temporary wells, pits, shafts, etc., shall be backfilled.

<General Materials (GM) - References, Annotations, or Tables>

The above information is provided free of charge by the Department of Industrial Relations from its web site at www.dir.ca.gov.
Protection of Employees in Excavations

Requirements for Protective Systems

§1541.1. Requirements for Protective Systems. (a) Protection of employees in excavations.

(1) Each employee in an excavation shall be protected from cave-ins by an adequate protective system designed in accordance with Section 1541.1(b) or (c) except when:

(A) Excavations are made entirely in stable rock; or
(B) Excavations are less than 5 feet in depth and examination of the ground by a competent person provides no indication of a potential cave-in.

(2) Protective systems shall have the capacity to resist without failure all loads that are intended or could reasonably be expected to be applied or transmitted to the system.

(b) Design of sloping and benching systems. The slopes and configurations of sloping and benching systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of Section 1541.1(b)(1), Section 1541.1(b)(2), Section 1541.1(b)(3), or Section 1541.1(b)(4), as follows:

(1) Option (1) --Allowable configurations and slopes.

(A) Excavations shall be sloped at an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal), unless the employer uses one of the other options listed below.

(B) Slopes specified in Section 1541.1(b)(1)(A) shall be excavated to form configurations that are in accordance with the slopes shown for Type C soil in Appendix B to this article.

(2) Option (2) --Determination of slopes and configurations using Appendices A and B. Maximum allowable slopes, and allowable configurations for sloping and benching systems, shall be determined in accordance with the conditions and requirements set forth in Appendices A and B to this article.

(3) Option (3) --Designs using other tabulated data.

(A) Designs of sloping or benching systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

(B) The tabulated data shall be in written form and shall include all of the following:

1. Identification of the parameters that affect the selection of a sloping or benching system drawn from such data;
2. Identification of the limits of use of the data, to include the magnitude and configuration of slopes determined to be safe;
3. Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.
4. At least one copy of the tabulated data which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Division upon request.

(4) Option (4) --Design by a registered professional engineer.

(A) Sloping and benching systems not utilizing Option (1) or Option (2) or Option (3) under Section 1541.1(b) shall be stamped and signed by a registered professional engineer.

(B) Designs shall be in written form and shall include at least the following:

1. The magnitude of the slopes that were determined to be safe for the particular project;
2. The configurations that were determined to be safe for the particular project;
3. The identity of the registered professional engineer approving the design.

(C) At least one copy of the design shall be maintained at the jobsite while the slope is being constructed. After that time the design need not be at the jobsite, but a copy shall be made available to the Division upon request.

(c) Design of support systems, shield systems, and other protective systems. Designs of support systems, shield systems, and other protective systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of Section 1541.1(c)(1); or, in the alternative, Section 1541.1(c)(2); or, in the alternative, Section 1541.1(c)(3); or, in the alternative, Section 1541.1(c)(4) as follows:

(1) Option (1) --Designs using Appendices A, C and D. Designs for timber shoring in trenches shall be determined in accordance with the conditions and requirements set forth in Appendices A and C to this article. Designs for aluminum hydraulic shoring shall be in accordance with Section 1541.1(c)(2), but if manufacturer's tabulated data cannot be utilized, designs shall be in accordance with Appendix D.

(2) Option (2) --Designs Using Manufacturer's Tabulated Data.

(A) Design of support systems, shield systems, or other protective systems that are drawn from manufacturer's tabulated data shall be in accordance with all specifications, recommendations, and limitations issued or made by the manufacturer.

(B) Deviation from the specifications, recommendations, and limitations issued or made by the manufacturer shall only be allowed after the manufacturer issues specific written approval.

(C) Manufacturer's specifications, recommendations, and limitations, and manufacturer's approval to deviate from the specifications, recommendations, and limitations shall be in written form at the jobsite during construction of the protective system. After that time this data may be stored off the jobsite, but a copy shall be made available to the Division upon request.
(3) Option (3) --Designs using other tabulated data.

(A) Designs of support systems, shield systems, or other protective systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

(B) The tabulated data shall be in written form and include all of the following:
1. Identification of the parameters that affect the selection of a protective system drawn from such data;
2. Identification of the limits of use of the data;
3. Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(C) At least one copy of the tabulated data, which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time, the data may be stored off the jobsite, but a copy of the data shall be made available to the Division upon request.

(4) Option (4) --Design by a registered professional engineer.

(A) Support systems, shield systems, and other protective systems not utilizing Option 1, Option 2, or Option 3, above, shall be approved by a registered professional engineer.

(B) Designs shall be in written form and shall include the following:
1. A plan indicating the sizes, types, and configurations of the materials to be used in the protective system; and
2. The identity of the registered professional engineer approving the design.

(C) At least one copy of the design shall be maintained at the jobsite during construction of the protective system. After that time, the design may be stored off the jobsite, but a copy of the design shall be made available to the Division upon request.

(d) Materials and equipment.

(1) Materials and equipment used for protective systems shall be free from damage or defects that might impair their proper function.

(2) Manufactured materials and equipment used for protective systems shall be used and maintained in a manner that is consistent with the recommendations of the manufacturer, and in a manner that will prevent employee exposure to hazards.

(3) When material or equipment that is used for protective systems is damaged, a competent person shall examine the material or equipment and evaluate its suitability for continued use. If the competent person cannot assure the material or equipment is able to support the intended loads or is otherwise suitable for safe use, then such material or equipment shall be removed from service, and shall be evaluated and approved by a registered professional engineer before being returned to service.

(e) Installation and removal of supports.
(1) General.
(A) Members of support systems shall be securely connected together to prevent sliding, falling, kickouts, or other predictable failure.
(B) Support systems shall be installed and removed in a manner that protects employees from cave-ins, structural collapses, or from being struck by members of the support system.
(C) Individual members of support systems shall not be subjected to loads exceeding those which those members were designed to withstand.
(D) Before temporary removal of individual members begins, additional precautions shall be taken to ensure the safety of employees, such as installing other structural members to carry the loads imposed on the support system.
(E) Removal shall begin at, and progress from, the bottom of the excavation. Members shall be released slowly so as to note any indication of possible failure of the remaining members of the structure or possible cave-in of the sides of the excavation.
(F) Backfilling shall progress together with the removal of support systems from excavations.

(2) Additional requirements for support systems for trench excavations.
(A) Excavation of material to a level no greater than 2 feet below the bottom of the members of a support system shall be permitted, but only if the system is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the support system.
(B) Installation of a support system shall be closely coordinated with the excavation of trenches.
(f) Sloping and benching systems. Employees shall not be permitted to work on the faces of sloped or benched excavations at levels above other employees except when employees at the lower levels are adequately protected from the hazard of falling, rolling, or sliding material or equipment.
(g) Shield systems.

(1) General.
(A) Shield systems shall not be subjected to loads exceeding those which the system was designed to withstand.
(B) Shields shall be installed in a manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads.
(C) Employees shall be protected from the hazard of cave-ins when entering or exiting the areas protected by shields.
(D) Employees shall not be allowed in shields when shields are being installed, removed, or moved vertically.

(2) Additional requirements for shield systems used in trench excavations. The sides of the shield shall extend a minimum of 18 inches above the vertical walls of compound excavations as shown in Appendix B, figures B-1, B-1.2 and B-1.3.
On vertically cut trenches, the shield shall extend to at least the catch point of the trench. Excavations of earth material to a level not greater than 2 feet below the bottom of a shield shall be permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the shield.

(h) Uprights shall extend to the top of the trench with the lower end of the upright not more than 2 feet from the bottom of the trench.


Appendix A http://www.dir.ca.gov/title8/1541_1a.html
Appendix B http://www.dir.ca.gov/title8/1541_1b.html
Appendix C http://www.dir.ca.gov/title8/1541_1c.html
Appendix D http://www.dir.ca.gov/title8/1541_1d.html
Appendix E http://www.dir.ca.gov/title8/1541_1e.html
Appendix F http://www.dir.ca.gov/title8/1541_1f.html

Article 6 Table of Contents: http://www.dir.ca.gov/title8/sb4a6.html
http://www.dir.ca.gov/samples/search/query.htm

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§1541.1. Requirements for Protective Systems, Appendix A

(a) Scope and application.

(1) Scope. This appendix describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits. The appendix contains definitions, sets forth requirements, and describes acceptable visual and manual tests for use in classifying soils.

(2) Application. This appendix applies when a sloping or benching system is designed in accordance with the requirements set forth in Section 1541.1(b)(2) as a method of protection for employees from cave-ins. This appendix also applies when timber shoring for excavations is designed as a method of protection from cave-ins in accordance with Appendix C to this article, and when aluminum hydraulic shoring is designed in accordance with Appendix D. This appendix also applies if other protective systems are designed and selected for use from data prepared in accordance with the requirements set forth in Section 1541.1(c), and the use of the data is predicated on the use of the soil classification system set forth in this appendix.

(b) Definitions.

Cemented soil: A soil in which the particles are held together by a chemical agent, such a calcium carbonate, such that a hand-size sample cannot be crushed into powder or individual soil particles by finger pressure.

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

Dry soil. Soil that does not exhibit visible signs of moisture content.

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

Granular soil. Gravel, sand, or silt (coarse grained soil) with little or no clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion. Granular soil cannot be molded when moist and crumbles easily when dry.

Layered system. Two or more distinctly different soil or rock types arranged in layers. Micaceous seams or weakened planes in rock or shale are considered layered.

Moist soil. A condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before
crambling. Moist granular soil that contains some cohesive material will exhibit signs of cohesion between particles.

Plastic. A property of a soil which allows the soil to be deformed or molded without cracking, or appreciable volume change.

Saturated soil. A soil in which the voids are filled with water. Saturation does not require flow. Saturation, or near saturation, is necessary for the proper use of instruments such as a pocket penetrometer or sheer vane.

Soil classification system. A method of categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing order of stability. The categories are determined based on an analysis of the properties and performance characteristics of the deposits and the environmental conditions of exposure.

Stable rock. Natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Submerged soil. Soil which is underwater or is free seeping.

Type A soil. Cohesive soils with an unconfined, compressive strength of 1.5 tons per square foot (tsf) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam, and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, no soil is Type A if:

1) The soil is fissured; or
2) The soil is subject to vibration from heavy traffic, pile driving, or similar effects; or
3) The soil has been previously disturbed; or
4) The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater; or
5) The material is subject to other factors that would require it to be classified as a less stable material.

Type B soil:
1) Cohesive soil with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf; or
2) Granular cohesionless soils including: angular gravel (similar to crushed rock), silt, silt loam, sandy loam, and, in some cases, silty clay loam and sandy clay loam.
3) Previously disturbed soils except those which would otherwise be classed as Type C soil.
4) Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or
5) Dry rock that is not stable; or
6) Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.
Type C soil:
(1) Cohesive soil with an unconfined compressive strength of 0.5 tsf or less; or
(2) Granular soils including gravel, sand, and loamy sand; or
(3) Submerged soil or soil from which water is freely seeping; or
(4) Submerged rock that is not stable, or
(5) Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper.

Unconfined compressive strength. The load per unit area at which a soil will fail in compression. It can be determined by laboratory testing, or estimated in the field using a pocket penetrometer, by thumb penetration tests, and other methods.

Wet soil. Soil that contains significantly more moisture than moist soil, but in such a range of values that cohesive material will slump or begin to flow when vibrated. Granular material that would exhibit cohesive properties when moist will lose those cohesive properties when wet.

(c) Requirements.
(1) Classification of soil and rock deposits. Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C in accordance with the definitions set forth in paragraph (b) of this appendix.

(2) Basis of classification. The classification of the deposits shall be made based on the results of at least one visual and at least one manual analysis. Such analyses shall be conducted by a competent person using tests described in paragraph (d) below, or in other approved methods of soil classification and testing such as those adopted by the American Society for Testing Materials, or the U.S. Department of Agriculture textural classification system.

(3) Visual and manual analyses. The visual and manual analyses, such as those noted as being acceptable in paragraph (d) of this appendix, shall be designed and conducted to provide sufficient quantitative and qualitative information as may be necessary to identify properly the properties, factors, and conditions affecting the classification of the deposits.

(4) Layered systems. In a layered system, the system shall be classified in accordance with its weakest layer. However, each layer may be classified individually where a more stable layer lies under a less stable layer.

(5) Reclassification. If, after classifying a deposit, the properties, factors, or conditions affecting its classification change in any way, the changes shall be evaluated by a competent person. The deposit shall be reclassified as necessary to reflect the changed circumstances.

(d) Acceptable visual and manual tests.
(1) Visual tests. Visual analysis is conducted to determine qualitative information regarding the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the open excavation, and the soil taken as samples from excavated material.
(A) Observe samples of soil that are excavated and soil in the sides of the excavation. Estimate the range of particle sizes and the relative amounts of the particle sizes. Soil that is primarily composed of fine-grained material is cohesive material. Soil composed primarily of coarse-grained sand or gravel is granular material.

(B) Observe soil as it is excavated. Soil that remains in clumps when excavated is cohesive. Soil that breaks up easily and does not stay in clumps is granular.

(C) Observe the side of the opened excavation and the surface area adjacent to the excavation. Crack-like openings such as tension cracks could indicate fissured material. If chunks of soil spall off a vertical side, the soil could be fissured. Small spalls are evidence of moving ground and are indications of potentially hazardous situations.

(D) Observe the area adjacent to the excavation and the excavation itself for evidence of existing utility and other underground structures, and to identify previously disturbed soil.

(E) Observe the opened side of the excavation to identify layered systems. Examine layered systems to identify if the layers slope toward the excavation. Estimate the degree of slope of the layers.

(F) Observe the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation, or the location of the level of the water table.

(G) Observe the area adjacent to the excavation and the area within the excavation for sources of vibration that may affect the stability of the excavation face.

(2) Manual tests. Manual analysis of soil samples is conducted to determine quantitative as well as qualitative properties of soil and to provide more information in order to classify soil properly.

(A) Plasticity. Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as 1/8-inch in diameter. Cohesive material can be successfully rolled into threads without crumbling. For example, if at least a two inch length of 1/8-inch thread can be held on one end without tearing, the soil is cohesive.

(B) Dry strength. If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it is granular (any combination of gravel, sand, or silt). If the soil is dry and falls into clumps which break up into smaller clumps, but the smaller clumps can only be broken up with difficulty, it may be clay in any combination with gravel, sand or silt. If the dry soil breaks into clumps which do not break up into small clumps and which can only be broken with difficulty, and there is no visual indication the soil is fissured, the soil may be considered un-fissured.

(C) Thumb penetration. The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated
several inches by the thumb, and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a minimum the effects of exposure to drying influences (rain, flooding), the classification of the soil must be changed accordingly.

(D) Other strength tests. Estimates of unconfined compressive strength of soils can also be obtained by use of a pocket penetrometer or by using a hand-operated shearmene.

(E) Drying test. The basic purpose of the drying test is to differentiate between cohesive material with fissures, un-fissured cohesive material, and granular material. The procedure for the drying test involves drying a sample of soil that is approximately one inch thick and six inches in diameter until it is thoroughly dry:

1. If the sample develops cracks as it dries, significant fissures are indicated.

2. Samples that dry without cracking are to be broken by hand. If considerable force is necessary to break a sample, the soil has significant cohesive material content. The soil can be classified as an un-fissured cohesive material and the unconfined compressive strength should be determined.

3. If a sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

Appendix B Sloping and Benching

§1541.1. Requirements for Protective Systems, Appendix B

(a) Scope and application. This appendix contains specifications for sloping and benching when used as methods of protecting employees working in excavations from cave-ins. The requirements of this appendix apply when the design of sloping and benching protective systems is to be performed in accordance with the requirements set forth in Section 1541.1(b).

(b) Definitions.

Actual slope means the slope to which an excavation face is excavated.

Distress means that the soil is in a condition where a cave-in is imminent or is likely to occur. Distress is evidenced by such phenomena as the development of fissures in the face of or adjacent to an open excavation; the subsidence of the edge of an excavation; the slumping of material from the face or the bulging or heaving of material from the bottom of an excavation; the spalling of material from the face of an excavation; and raveling, i.e., small amounts of material such as pebbles or little clumps of material suddenly separating from the face of an excavation and trickling or rolling down into the excavation.

Maximum allowable slope means the steepest incline of an excavation face that is acceptable for the most favorable site conditions as protection against cave-ins, and is expressed as the ratio of horizontal distance to vertical rise (H:V).

Short term exposure means a period of time less than or equal to 24 hours that an excavation is open.

(c) Requirements.

(1) Soil classification. Soil and rock deposits shall be classified in accordance with Appendix A to Section 1541.1.

(2) Maximum allowable slope. The maximum allowable slope for a soil or rock deposit shall be determined from Table B-1 of this appendix.

(3) Actual slope.

(A) The actual slope shall not be steeper than the maximum allowable slope.

(B) The actual slope shall be less steep than the maximum allowable slope, when there are signs of distress. If that situation occurs, the slope shall be cut back to an actual slope which is at least 1/2 horizontal to one vertical (1/2H:1V) less steep than the maximum allowable slope.

(C) When surcharge loads from stored material or equipment, operating equipment, or traffic are present, a competent person shall determine the degree to which the actual slope must be reduced below the maximum allowable slope, and shall assure that such reduction is achieved. Surcharge loads from adjacent structures shall be evaluated in accordance with Section 1541(i).
(4) Configurations. Configurations of sloping and benching systems shall be in accordance with Figure B-1.

**TABLE B-1**
MAXIMUM ALLOWABLE SLOPES

<table>
<thead>
<tr>
<th>SOIL OR ROCK TYPE</th>
<th>MAXIMUM ALLOWABLE SLOPES (H:V)(1) FOR EXCAVATIONS LESS THAN 20 FEET DEEP(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STABLE ROCK</td>
<td>VERTICAL (90 Deg)</td>
</tr>
<tr>
<td>TYPE A (2)</td>
<td>3/4:1 (53 Deg.)</td>
</tr>
<tr>
<td>TYPE B</td>
<td>1:1 (45 Deg.)</td>
</tr>
<tr>
<td>TYPE C</td>
<td>1 1/2:1 (34 Deg.)</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.
2. A short-term maximum allowable slope of 1/2H:1V (63 degrees) is allowed in excavations in Type A soil that are 12 feet (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 m) in depth shall be 3/4H:1V (53 degrees).
3. Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer.

Figure B-1
Slope Configurations
(All slopes stated below are in the horizontal to vertical ratio)
B-1.1 Excavations made in Type A soil

4. All simple slope excavations 20 feet or less in depth shall give a maximum allowable slope of 3/4:1.
Simple Slope-General
Exception: Simple slope excavations which are open 24 hours or less (short term) and which are 12 feet or less in depth shall have a maximum allowable slope of 1/2:1.

Simple Slope- Short Term
2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of 3/4 to 1 and maximum bench dimensions as follows:

Simple Bench
Multiple Bench

3. All excavations 8 feet or less in depth which have unsupported vertically sided lower portions shall have a maximum vertical side 3 1/2 feet.

Unsupported Vertically Sided Lower Portion-Maximum 8 Feet Depth

All excavations more than 8 feet but not more than 12 feet in depth with unsupported vertically sided lower portions shall have a maximum allowable slope of 1:1 and a maximum vertical side of 3 1/2 feet.

Unsupported Vertically Sided Lower Portion-Maximum 12 Feet in Depth
All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded shall have a maximum allowable slope of 3/4:1. The support or shield system must extend at least 18 inches above the top of the vertical side.

**Supported or Shielded Vertically Sided Lower Portion**

- Supported or Shielded Vertically Sided Lower Portion
- B- 1.2 Excavations Made in Type B Soil
- 1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1.

**Simple Slope**

- Simple Slope
- 2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1 and maximum bench dimensions as follows:
Single Bench

This bench allowed in cohesive soil only.

Multiple Bench

3. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1:1

Vertically Sided Lower Portion

Vertically Sided Lower Portion

B- 1.3 Excavations Made in Type C Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1 1/2:1
Simple Slope

2. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1 1/2:1.

Vertically Sided Lower Portion

3. All other sloped excavations shall be in accordance with the other options permitted in 1541.1(b)

B- 1.4 Excavations Made in Layered Soil

1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below:

B OVER A
2. All other sloped excavations shall be in accordance with the other options permitted in 1541.1(b).

Appendix C Timber Shoring for Trenches

§1541.1. Requirements for Protective Systems, Appendix C

Timber Shoring for Trenches

(a) Scope. This appendix contains information that can be used when timber shoring is provided as a method of protection from cave-ins in trenches that do not exceed 20 feet in depth. This appendix must be used when design of timber shoring protective systems is to be performed in accordance with Section 1541.1(c)(1). Other timber shoring configurations; other systems of support such as hydraulic and pneumatic systems; and other protective systems such as sloping, benching, shielding, and freezing systems must be designed in accordance with the requirements set forth in Section 1541.1(b) and 1541.1(c).

(b) Soil Classification. In order to use the data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in Article 6.

(c) Presentation of Information.

Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables C-1.1, C-1.2 and C-1.3, and Tables C-2.1, C-2.2 and C-2.3 following Section (g) of Appendix C. Each table presents the minimum sizes of timber members to use in a shoring system, and each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. The data are arranged to allow the user the flexibility to select from among several acceptable configurations of members based on varying the horizontal spacing of the crossbraces. Stable rock is exempt from shoring requirements and therefore, no data are presented for this condition.

(2) Information concerning the basis of the tabular data and the limitations of the data is presented in Section (d) of this appendix, and on the tables themselves.

(3) Information explaining the use of the tabular data is presented in Section (e) of this appendix.

(4) Information illustrating the use of the tabular data is presented in Section (f) of this appendix.

(5) Miscellaneous notations regarding Tables C-1.1 through C-1.3 and Tables C-2.1 through C-2.3 are presented in Section (g) of this appendix.

(d) Basis and limitations of the data.

(1) Dimensions of timber members.

(A) The sizes of the timber members listed in Tables C-1.1 through C-1.3 are taken from the National Bureau of Standards (NBS) report, ``Recommended Technical Provisions for Construction Practice in Shoring and Sloping of Trenches and Excavations." In addition, where NBS did not recommend specific sizes of members, member sizes are
based on an analysis of the sizes required for use by existing codes and on empirical practice.

(B) The required dimensions of the members listed in Tables C-1.1 through C-1.3 refer to actual dimensions and not nominal dimensions of the timber. Employers wanting to use nominal size shoring are directed to Tables C-2.1 through C-2.3, or have this choice under Section 1541.1(c)(3).

(2) Limitation of application.

(A) It is not intended that the timber shoring specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be designed as specified in Section 1541.1(c).

(B) When any of the following conditions are present, the members specified in the tables are not considered adequate. Either an alternate timber shoring system must be designed or another type of protective system designed in accordance with Section 1541.1.

1. When loads imposed by structures or by stored material adjacent to the trench weigh in excess of the load imposed by a two-foot soil surcharge. The term “adjacent” as used here means the area within a horizontal distance from the edge of the trench equal to the depth of the trench.

2. When vertical loads imposed on crossbraces exceed a 240-pound gravity load distributed on a one-foot section of the center of the crossbrace.

3. When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

4. When only the lower portion of a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) Use of Tables. The members of the shoring system that are to be selected using this information are the crossbraces, the uprights, and the wales, where wales are required. Minimum sizes of members are specified for use in different types of soil. There are six tables of information, two for each soil type. The soil type must first be determined in accordance with the soil classification system described in Appendix A. Using the appropriate table, the selection of the size and spacing of the members is then made. The selection is based on the depth and width of the trench where the members are to be installed and, in most instances, the selection is also based on the horizontal spacing of the crossbraces. Instances where a choice of horizontal spacing of crossbracing is available, the horizontal spacing of the crossbraces must be chosen by the user before the size of any member can be determined. When the soil type, the width and depth of the trench, and the horizontal spacing of the crossbraces, the size and vertical spacing of the crossbraces are known, the size and vertical spacing of the crossbraces, the size and vertical spacing of the wales, and the size and horizontal spacing of the uprights can be read from the appropriate table.

(f) Examples to Illustrate the Use of Tables C-1.1 through C-1.3.
(1) Example 1.
A trench dug in Type A soil is 13 feet deep and five feet wide. From Table C-1.1, four acceptable arrangements of timber can be used.
Arrangement #1
Space 4X4 crossbraces at six feet horizontally and four feet vertically. Wales are not required.
Space 3X8 uprights at six feet horizontally. This arrangement is commonly called ``skip shoring.``
Arrangement #2
Space 4X6 crossbraces at eight feet horizontally and four feet vertically.
Space 8X8 wales at four feet vertically.
Space 2X6 uprights at four feet horizontally.
Arrangement #3
Space 6X6 crossbraces at 10 feet horizontally and four feet vertically.
Space 8X10 wales at four feet vertically.
Space 2X6 uprights at five feet horizontally.
Arrangement #4
Space 6X6 crossbraces at 12 feet horizontally and four feet vertically.
Space 10X10 wales at four feet vertically.
Space 3X8 uprights at six feet horizontally.
(2) Example 2.
A trench dug in Type B soil is 13 feet deep and five feet wide. From Table C-1.2 three acceptable arrangements of members are listed.
Arrangement #1
Space 6X6 crossbraces at six feet horizontally and five feet vertically.
Space 8X8 wales at five feet vertically.
Space 2X6 uprights at two feet horizontally.
Arrangement #2
Space 6X8 crossbraces at eight feet horizontally and five feet vertically.
Space 10X10 wales at five feet vertically.
Space 2X6 uprights at two feet horizontally.
Arrangement #3
Space 8X8 crossbraces at 10 feet horizontally and five feet vertically.
Space 10X12 wales at five feet vertically.
Space 2X6 uprights at two feet vertically.
(3) Example 3.
A trench dug in Type C soil is 13 feet deep and five feet wide.
From Table C-1.3 two acceptable arrangements of members can be used.

Arrangement #1
Space 8X8 crossbraces at six feet horizontally and five feet vertically.
Space 10X12 wales at five feet vertically.
Position 2X6 uprights as closely together as possible.
If water must be retained use special tongue and groove uprights to form tight sheeting.

Arrangement #2
Space 8X10 crossbraces at eight feet horizontally and five feet vertically.
Space 12X12 wales at five feet vertically.
Position 2X6 uprights in a close sheeting configuration unless water pressure must be resisted. Tight sheeting must be used where water must be retained.

(4) Example 4.
A trench dug in Type C soil is 20 feet deep and 11 feet wide. The size and spacing of members for the section of trench that is over 15 feet in depth is determined using Table C-1.3. Only one arrangement of members is provided.

Space 8X10 crossbraces at six feet horizontally and five feet vertically.
Space 12X12 wales at five feet vertically.
Use 3X6 tightsheeting.

Use of Tables C-2.1 through C-2.3 would follow the same procedures.

(g) Notes for all Tables.
1. Members sizes at spacing’s other than indicated are to be determined as specified in Section 1541.1(c), “Design of Protective Systems.”
2. When conditions are saturated or submerged use Tight Sheet. Tight Sheet refers to the use of specially-edged timber planks (e.g., tongue and groove) at least three inches thick, steel sheet piling, or similar construction that when driven or placed in position provide a tight wall to resist the lateral pressure of water and to prevent the loss of backfill material. Close Sheet refers to the placement of planks side-by-side allowing as little space as possible between them.
3. All spacing indicated is measured center to center.
4. Wales to be installed with greater dimension horizontal.
5. If the vertical distance from the center of the lowest crossbrace to the bottom of the trench exceeds two and one-half feet, uprights shall be firmly embedded or a mudsill shall be used. Where uprights are embedded, the vertical distance from the center of the lowest crossbrace to the bottom of the trench shall not exceed 36 inches. When mudsills are used, the vertical distance shall not exceed 42 inches. Mud-sills are wales that are installed at the toe of the trench side.
6. Trench jacks may be used in lieu of or in combination with timber crossbraces.
7. Placement of crossbraces. When the vertical spacing of crossbraces is four feet, place the top crossbrace no more than two feet below the top of the trench. When the vertical
spacing of crossbraces is five feet, place the top crossbrace no more than 2.5 feet below the top of the trench.

**TABLE C-1.1**

**TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS**

SOIL TYPE A  
\[ P(a) = 25 \times H + 72 \text{ psf} \]  (2 ft Surcharge)

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<th>VERT. SPACING</th>
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OVER 20
TABLE C-1.1
TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE A  \( P(a) = 25 \times H + 72 \) psf (2 ft Surcharge)

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* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may be substituted for wood.
TABLE C-1.2
TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B  \( P(a) = 45 \times H + 72 \) psf (2 ft Surcharge)

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*See Note 1

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### TABLE C.1.2

**TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS**

SOIL TYPE B \( P(a) = 45 \times H + 72 \) psf (2 ft Surcharge)

[Continued]

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** Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may be substituted for wood.
### TABLE C-1.3
TIMBER TRENCH SHORING — MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C  \( P(a) = 80 \times H + 72 \) psf (2 ft Surcharge)

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TABLE C-1.3
TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C  \( P(a) = 80 \times H + 72 \) psf (2 ft Surcharge)

[Continued]

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* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may be substituted for wood.
### TABLE C-2.1

**TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS**

SOIL TYPE A  \( P(a) = 25 \times H + 72 \) psf (2 ft Surcharge)

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### TABLE C-2.1

**TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS**

**SOIL TYPE A**  
\[ P(a) = 25 \times H + 72 \text{ psf} \]  
(2 ft Surcharge)

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| 8X12  | 4     | 3X6   | 4x12  |       |       |       |
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* Douglas fir or equivalent with a bending strength not less than 1500 psi.
** Manufactured members of equivalent strength may be substituted for wood.

### TABLE C-2.2

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B $P(a) = 45 \times H + 72$ psf (2 ft Surcharge)

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SEE NOTE 1
TABLE C-2.2
TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B \( P(a) = 45 \times H + 72 \text{ psf (2 ft Surcharge) } \)

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OVER | SEE NOTE 1
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* Douglas fir or equivalent with a bending strength not less than 1500 psi.
** Manufactured members of equivalent strength may be substituted for wood.
### TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C  \( P(a) = 80 \times H + 72 \) psf (2 ft Surcharge)

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*Note 1: See other tables for additional information.*
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### TABLE C-2.3

**TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS**

SOIL TYPE C  \( P(a) = 80 \times H + 72 \text{ psf} \) (2 ft Surcharge)

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TO

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</tr>
</thead>
</table>

OVER | SEE NOTE 1
20   |

* Douglas fir or equivalent with a bending strength not less than 1500 psi.
** Manufactured members of equivalent strength may be substituted for wood.

The above information is provided free of charge by the Department of Industrial Relations from its web site at www.dir.ca.gov.
Appendix D Aluminum Hydraulic Shoring for Trenches

§1541.1. Requirements for Protective Systems, Appendix D

(a) Scope. This appendix contains information that can be used when aluminum hydraulic shoring is provided as a method of protection against cave-ins in trenches that do not exceed 20 feet in depth. This appendix must be used when design of the aluminum hydraulic protective system cannot be performed in accordance with Section 1541.1(c)(2).

(b) Soil Classification. In order to use data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in Appendix A of this Article.

(c) Presentation of Information. Information is presented in several forms as follows:

1) Information is presented in tabular form in Tables D-1.1, D-1.2, D-1.3 and D-1.4. Each table presents the maximum vertical and horizontal spacing’s that may be used with various aluminum member sizes and various hydraulic cylinder sizes. Each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. Tables D-1.1 and D-1.2 are for vertical shores in Types A and B soil. Tables D-1.3 and D-1.4 are for horizontal waler systems in Types B and C soil.

2) Information concerning the basis of the tabular data and the limitations of the data is presented in Section (d) of this appendix.

3) Information explaining the use of the tabular data is presented in Section (e) of this appendix.

4) Information illustrating the use of the tabular data is presented in Section (f) of this appendix.

5) Miscellaneous notations (footnotes) regarding Table D-1.1 through D-1.4 are presented in Section (g) of this appendix.

6) Figures, illustrating typical installations of hydraulic shoring, are included just prior to the Tables. The illustrations page is entitled "Aluminum Hydraulic Shoring: Typical Installations."

(d) Basis and limitations of the data.

1) Vertical shore rails and horizontal wales are those that meet the Section Modulus requirements in the D-1 Tables. Aluminum material is 6061-T6 or material of equivalent strength and properties.

2) Hydraulic cylinders specifications.

A) 2-inch cylinders shall be a minimum 2-inch inside diameter with a minimum safe working capacity of no less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.
(B) 3-inch cylinders shall be minimum 3-inch inside diameter with a safe working
capacity of not less than 30,000 pounds axial compressive load at extensions as
recommended by product manufacturer.

(3) Limitation of application.

(A) It is not intended that the aluminum hydraulic specification apply to every situation
that may be experienced in the field. These data were developed to apply to the situations
that are most commonly experienced in current trenching practice. Shoring systems for
use in situations that are not covered by the data in this appendix must be otherwise
designed as specified in Section 1541.1(c).

(B) When any of the following conditions are present, the members specified in the
Tables are no considered adequate. In this case, an alternative aluminum hydraulic
shoring system or other type of protective system must be designed in accordance with
Section 1541.1.

1. When vertical loads imposed on crossbraces exceed a 100 pound gravity load
distributed on a one foot section of the center of the hydraulic cylinder.

2. When surcharge loads are present from equipment weighing in excess of 20,000
pounds.

3. When only the lower portion of a trench is shored and the remaining portion of the
trench is sloped or benched unless: The sloped portion is sloped at an angle less steep
than three horizontal to one vertical; or the members are selected from the tables for use
at a depth which is determined from the top of the overall trench, and not from the toe of
the sloped portion.

(e) Use of Tables D-1.1, D-1.2, D-1.3 and D-1.4. The members of the shoring system that
are to be selected using this information are the hydraulic cylinders, and either the
vertical shores or the horizontal wales. When a waler system is used the vertical timber
sheeting to be used is also selected from these tables. The Tables D-1.1 and D-1.2 for
vertical shores are used in Type A and B soils that do not require sheeting. Type B soils
that may require sheeting, and Type C soils that always require sheeting, are found in the
horizontal wale Tables D-1.3 and D-1.4. The soil type must first be determined in
accordance with the soil classification system described in Appendix A to Section
1541.1. Using the appropriate table, the selection of the size and spacing of the members
is made. The selection is based on the depth and width of the trench where the members
are to be installed. In these tables the vertical spacing is held constant at four feet on
center. The tables show the maximum horizontal spacing of cylinders allowed for each
size of wale in the waler system tables, and in the vertical shore tables, the hydraulic
cylinder horizontal spacing is the same as the vertical shore spacing.

(f) Example to Illustrate the Use of the Tables:

(1) Example 1.
A trench dug in Type A soil is 6 feet deep and 3 feet wide. From Table D-1.1: Find
vertical shores and 2 inch diameter cylinders spaced 8 feet on center (o.c.) horizontally
and 4 feet on center (o.c.) vertically. (See Figures 1 & 3 for typical installations.)

(2) Example 2:
A trench is dug in Type B soil that does not require sheeting, 13 feet deep and 5 feet
wide. From Table D-1.2: Find vertical shores and 2 inch diameter cylinders spaced 6.5
feet o.c. horizontally and 4 feet o.c. vertically. (See Figures 1 & 3 for typical installations.)

(3) Example 3:
A trench is dug in Type B soil that does not require sheeting, but does experience some minor raveling of the trench face. The trench is 16 feet deep and 9 feet wide. From Table D-1.2: Find vertical shores and 2 inch diameter cylinder (with special over-sleeves as designated by footnote #2) spaced 5.5 feet o.c. horizontally and 4 feet o.c. vertically. Plywood (per footnote (g)(7) to the D-1 Table) should be used behind the shores. (See Figures 2 & 3 for typical installations.)

(4) Example 4:
A trench is dug in previously disturbed Type B soil, with characteristics of a Type C soil, and will require sheeting. The trench is 18 feet deep, and 12 feet wide. 8 foot horizontal spacing between cylinders is desired for working space. From Table D-1.3: Find horizontal wale with a section modulus of 14.0 spaced at 4 feet o.c. vertically and 3 inch diameter cylinder spaced at 9 feet maximum o.c. horizontally. 3 x 12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(5) Example 5:
A trench is dug in Type C soil, 9 feet deep and 4 feet wide. Horizontal cylinder spacing in excess of 6 feet is desired for working space. From Table D-1.4: Find horizontal wale with a section modulus of 7.0 and 2 inch diameter cylinders spaced at 6.5 feet o.c. horizontally. Or, find horizontal wale with a 14.0 section modulus and 3 inch diameter cylinder spaced at 10 feet o.c. horizontally. Both wales are spaced 4 feet o.c. vertically, 3x12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(g) Footnotes, and general notes, for Tables D-1.1, D-1.2, D-1.3, and D-1.4.
(1) For applications other than those listed in the tables, refer to Section 1541.1(c)(2) for use of manufacturer's tabulated data. For trench depths in excess of 20 feet, refer to Section 1541.1(c)(2) and 1541.1(c)(3).

(2) 2-inch diameter cylinders, at this width, shall have structural steel tube (3.5 x 3.5 x 0.1875) over sleeves, or structural over sleeves of manufacturer's specification, extending the full, collapsed length.

(3) Hydraulic cylinders capacities.
(A) 2-inch cylinders shall be a minimum 2-inch inside diameter with a safe working capacity of not less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(B) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe work capacity of not less than 30,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(4) All spacing indicated is measured center to center.

(5) Vertical shoring rails shall have a minimum section modulus of 0.40 inch.
(6) When vertical shores are used, there must be a minimum of three shores spaced equally, horizontally, in a group.

(7) Plywood shall be 1.125 inches thick of wood or 0.75 inch thick, 14 ply, arctic white birch (Finland form). Please note that plywood is not intended as a structural member, but only for prevention of local raveling (sloughing of the trench face) between shores. Equivalent material may be used if it has been approved in accordance with Section 1505(a).

(8) See Appendix C for timber specifications.

(9) Wales are calculated for simple span conditions.

(10) See Appendix D, Section (d), for basis and limitations of the data.

FIGURE NO.1 VERTICAL ALUMINUM HYDRAULIC SHORING (SPOT BRACING)
FIGURE NO. 2 VERTICAL ALUMINUM HYDRAULIC SHORING (WITH PLYWOOD)

FIGURE NO. 3 VERTICAL ALUMINUM HYDRAULIC SHORING (STACKED)
FIGURE NO. 4 ALUMINUM HYDRAULIC SHORING WALER SYSTEM (TYPICAL)


<table>
<thead>
<tr>
<th>Table D - 1.1</th>
<th>ALUMINUM HYDRAULIC SHORING VERTICAL SHORES FOR SOIL TYPE A</th>
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<tbody>
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<td>MAXIMUM HORIZONTAL</td>
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<tr>
<td>TRENCH (FEET)</td>
<td>SPACING (FEET)</td>
</tr>
<tr>
<td>OVER 5</td>
<td>8</td>
</tr>
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<tr>
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OVER 20 | NOTE(1)

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g).

Note (1): See Appendix D, Item (g)(1)
Note (2): See Appendix D, Item (g)(2)
### TABLE D - 1.2
ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES
FOR SOIL TYPE B

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<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td>OVER 5 UP TO 10</td>
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</tr>
<tr>
<td>OVER 10 UP TO 15</td>
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<td>4</td>
</tr>
<tr>
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<tr>
<td>OVER 15 UP TO 20</td>
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<td>OVER 20</td>
<td>NOTE(1)</td>
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Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)

Note (1): See Appendix D, Item (g)(1)

Note (2): See Appendix D, Item (g)(2)
### TABLE D - 1.3
**ALUMINUM HYDRAULIC SHORING WALER SYSTEMS FOR SOIL TYPE B**

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Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g)(1)
Note (2): See Appendix D, Item (g)(2)
*Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.
**Douglas fir or equivalent with a bending strength not less than 1500 psi.
### TABLE D - 1.3
ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL TYPE B

[Continued]

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| OVER | 20 | NOTE (1) |

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g).

Note (1): See Appendix D, Item (g)(1)

Note (2): See Appendix D, Item (g)(2)

*Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

**Douglas fir or equivalent with a bending strength not less than 1500 psi.
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<th>OVER 8 UP TO 12</th>
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<td>2 IN</td>
</tr>
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<td>NOTE (2)</td>
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Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g)(1)
Note (2): See Appendix D, Item (g)(2)
*Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.
**Douglas fir or equivalent with a bending strength not less than 1500 psi.
TABLE D - 1.4
ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL TYPE C

[Continued]

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Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g).

Note (1): See Appendix D, Item (g)(1)
Note (2): See Appendix D, Item (g)(2)

*Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

**Douglas fir or equivalent with a bending strength not less than 1500 psi.

Appendix E Alternatives to Timber Shoring

Requirements for Protective Systems, Appendix E

Figure 1. Aluminum Hydraulic Shoring

Figure 2. Pneumatic/hydraulic Shoring
Figure 3. Trench Jacks (Screw Jacks)

Figure 4. Trench Shields

Figure 3. & Figure 4. Trench Jacks (Screw Jacks) & Trench Shields
Appendix F Summary of Requirements for Excavations 20 feet or less

Requirements for Protective Systems, Appendix F

The following figures are a graphic summary of the requirements contained in Article 6 for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer in accordance with 1541.1(b) and (c).

FIGURE 1 - PRELIMINARY DECISIONS
Sloping selected as the method of protection.

Will soil classification be made in accordance with Sec. 1926.652(b)?

YES  NO

Excavation must comply with one of the following three options:

Option 1:
Sec. 1926.652(b)(3) which requires Appendices A and B to be followed.

Option 2:
Sec. 1926.652(b)(3) which requires other tabulated data (see definition to be followed).

Option 3:
Sec. 1926.652(b)(4) which requires the excavation to be designed by a registered professional engineer.

Excavations must comply with Sec. 1926.652(b)(1) which requires a slope of 1 1/2 H:1V (34 deg.).

Shoring or shielding selected as the method of protection.

Soil Classification is required.
when shoring or shielding is used. The excavation must comply with one of the following four options:

<table>
<thead>
<tr>
<th>Option 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sec. 1926.652(c)(1) which requires Appendices A and C to be followed (e.g. timber shoring).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Option 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sec. 1926.652(c)(2) which requires manufacturers data to be followed (e.g. hydraulic shoring, trench jacks, air shores, shields).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Option 3</th>
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<tbody>
<tr>
<td>Sec. 1926.652(c)(3) which requires tabulated data (see definition) to be followed (e.g. any system as per the tabulated data).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Option 4</th>
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</thead>
<tbody>
<tr>
<td>Sec. 1926.652(c)(4) which requires the excavation to be designed by a registered professional engineer (e.g. any designed system).</td>
</tr>
</tbody>
</table>

FIGURE 3 - SHORING AND SHIELDING OPTIONS

Note: Authority cited: Section 142.3, Labor Code. Reference: Section 142.3< Labor Code
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Trenching and Shoring Safety
- Competent Person

Name:__________________________ Date:_____________________

QUESTIONS

TRUE/FALSE

1. According to NIOSH, trench cave-ins are predictable and preventable.
   True   False

2. A person buried under only a couple of feet of soil can experience enough pressure to the chest area causing suffocation.
   True   False

3. Training and understanding the trenching and shoring regulations are keys to working safely in trenches.
   True   False

4. A trench refers to a narrow excavation made below the surface of the ground where the width is greater than the depth.
   True   False

5. The key component of the 1990 OSHA new standard requires a competent person, preferably a supervisor, be placed in charge of excavation and safety on the job.
   True   False

6. Granular soil can be molded when moist.
   True   False

7. A competent person does not have to perform visual and manual soils testing.
   True   False

8. It is not necessary for the competent person to conduct an inspection after every rain storm or other weather event.
   True   False

9. It is not permissible to use backhoes, breakers, digging bars or other metal tools to locate or work around utilities.
   True   False

10. The competent person is responsible to ensure that ladders, ramps and/or stairways are provided for all excavations 10 feet or more in depth.
True  False

11. A competent person must classify the soil by using ________ test.
   a. a computerized  
   b. a taste  
   c. one visual and one manual  
   d. strength

12. When taking a soil sample, you should look for ________.
   a. type of soil  
   b. size of the individual grains  
   c. soil that breaks up easily  
   d. all of the above

13. Soil is heavy. A cubic foot generally weighs as much as _____ pounds or more.
   a. 50  
   b. 75  
   c. 80  
   d. 100

14. Trench cave-in fatalities are caused by __________.
   a. absence of trench protection  
   b. unaware of hazards  
   c. poor judgment  
   d. all of the above

15. If a trench is more than _____ feet in depth, there must be a protective system in place while workers are in the excavation.
   a. 3  
   b. 4  
   c. 5  
   d. 6

16. Secure ladders must be placed every ____ feet of lateral travel.
   a. 10  
   b. 15  
   c. 20  
   d. 25

17. OSHA classifies soils into four categories: Type A, Type B, Type C and ________.
   a. stable rock  
   b. clay  
   c. cohesive soil  
   d. solid rock
18. Type A soil is generally made up of _________.
   a. includes cohesive and non-cohesive soils
   b. soil that is most unstable
   c. clay, silty clay and sandy clay
   d. all of the above

19. Manual tests help to better identify the soil type and _________.
   a. cohesiveness
   b. strength
   c. weakness
   d. stability

20. A_________ is used to measure the strength of the soil.
   a. pedometer
   b. I-pod
   c. pocket penetrometer
   d. odometer
TRUE/FALSE

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   True False

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