

Safety Manual for Excavation



Table of Contents

Chapter	Subject	Page No.
	Introduction	4
1	Before beginning the job	5
2	Cave-ins and protective support systems	9
3	Sloping and benching	11
4	Other safety considerations	12
5	Soil mechanics	14
6	Materials and equipment	16
7	Falls and exposure to falling loads	18
8	Heat- and cold-related illnesses and treatments	19
9	Lockout/tagout	21
10	Hazardous atmospheres and confined spaces	21
11	Personal protective equipment	24
12	Lasers (non-ionizing radiation)	24
13	Traffic control and fleet safety	25
14	Site assessment questions	26
15	Glossary	27

Introduction

By combining proactive safety strategies with hands-on claims management, you will reduce injuries and lower your workers' compensation costs. Safe and efficient operations go hand in hand; both are products of good management. They result from the joint effort and participation of management and employees.

A business' safety and health effort may succeed or fail depending upon the degree to which all members of the safety team fulfill their responsibilities. Everyone in the organization is a member of the team.

This manual can also provide your company's safety teams with information to meet its goals and obligations. It contains information on incident prevention, together with a complete explanation of its use, and benefits and methods of application. BWC urges you to consider

this manual's contents carefully and apply them thoroughly. If properly applied, these techniques will prevent and reduce incidents, injuries and illnesses.

Improved safety and health procedures benefit management and labor. Everyone is better off when the job is less physically demanding and stressful, when there is less chance that operational errors will occur and when workers receive training. Taking these and other steps associated with a safe, healthful work place will increase efficiency and quality. It also will ensure that workers perform their jobs at the optimum level.

Please join BWC and the Ohio construction industry in making occupational safety and health a way of life.

Chapter 1

Before beginning the job

An excavation is any man-made cut, cavity, trench or depression in the earth's surface formed by earth removal. This can include anything from cellars to highways. The Occupational Safety and Health Administration's (OSHA's) standard (29 CFR 1926 subpart P) covers all open excavations, including trenches, where the depth is greater than the width and the width at the bottom does not exceed 15 feet.



Many on-the-job incidents result from incomplete planning. If you are correcting mistakes after work has begun, it slows down the job, adds costs and increases the possibility of an excavation failure. If you're a contractor, you need to build safety into the pre-bid planning in the same way you consider all other pre-bid factors. Develop safety check lists before preparing a bid to make certain there is adequate information about the job site and all needed items are on hand. Make sure these check lists incorporate elements of relevant OSHA standards and other information necessary for safe operations.

Before preparing a bid, take these specific site conditions into account:

- Traffic;
- Nearness of structures and their conditions;
- Soil;
- Surface and ground water;
- The water table;
- Overhead and underground utilities;
- Weather.

Use job-site studies, observations and test borings for soil type or conditions and consultations with local officials and utility companies to determine the site conditions. Before any excavation begins, locate utility installations that you may encounter during digging. Also, contact the utility companies or owners involved and inform, within established or customary local response times, of the proposed work. Ask the utility companies

or owners to find the exact location of the underground installations.

If they cannot respond within 24 hours — unless the period required by state or local law is longer — or if they cannot find the exact location of the utility installations, proceed with caution. To find the exact location of underground installations, use safe and acceptable means. If you expose underground installations, OSHA regulations also require removal, protection or proper support.

When all the necessary specific information about the job site is assembled, determine the amount, type and cost of the safety equipment needed. Make an inventory of the safety items on hand before deciding what additional safety material you must acquire. No matter how many trenching, shoring and backfilling jobs you have done in the past, approach each job like it is your first, with the utmost care and preparation.

It is important, before beginning the job, to establish and maintain a safety and health program for the work site that provides adequate systematic policies, procedures and practices to protect employees, and allow them to recognize job-related safety and health hazards.

An effective program includes provisions for the systematic identification, evaluation and prevention or control of general work-place hazards, specific job hazards and potential hazards that may arise from foreseeable conditions. Write the program to reflect the unique characteristics of the job site.

To ensure that safety policies are implemented effectively, supervisors, employee groups including unions, and individual employees must cooperate. Each supervisor must understand the degree of responsibility and authority he or she holds in a particular area. For effective labor support, notify affected unions of construction plans and ask for their cooperation.

It also is important to provide employees that are exposed to public vehicular traffic with warning vests or other suitable garments marked with or made of reflective or high-visibility material. Ensure employees wear their vests. Instruct workers to remove or neutralize surface encumbrances that may create a hazard.

In addition, ensure no employee operates a piece of equipment without first receiving training on how to handle it and fully alert him or her to its potential hazards.

Incorporate procedures for fast notification and investigation of accidents in the training and site-safety and health program.

Competent person

The designated competent person should have training, experience and knowledge of the following:

- Soil analysis;
- Use of protective systems;
- Requirements of 29 CFR Part 1926 Subpart P.

Ability to detect:

- Conditions that could result in cave-ins;
- Failures in protective systems;
- Hazardous atmospheres;
- Other hazards, including those associated with confined spaces;
- Existing and predictable hazards, and authority to take prompt corrective measures to eliminate or stop work when required.

Inspections

A competent person makes inspections and documents them. The following guide specifies the frequency and conditions requiring inspections:

- Daily and before the start of each shift;
- As dictated by the work being done in the trench;
- After every rainstorm;
- After other events that can increase hazards, such as a snowstorm, windstorm, thaw, earthquake, etc.;
- When fissures, tension cracks, sloughing, undercutting, water seepage, bulging at the bottom or other similar conditions occur;
- When there is a change in the size, location or

placement of the spoil pile;

- When there is any indication of change or movement in adjacent structures.

On-the-job evaluation

The competent person must inspect excavations and adjacent areas for possible cave-ins on a daily basis, for failures of protective systems and equipment, hazardous atmospheres or other hazardous conditions. If you encounter these conditions, remove exposed employees from the hazardous area until you take the necessary safety precautions. Inspections also are required after natural events, such as heavy rains or man-made events, such as blasting that may increase the hazard potential.

For larger and more complex operations, it is important to have a full-time safety official to make recommendations to improve the safety plan implementation. In a smaller operation, the safety official may work on safety part-time and usually will be a supervisor.

Supervisors are the contractor's representatives on the job. They conduct inspections, investigate accidents, anticipate hazards and ensure that employees receive on-the-job safety and health training. Part of their job is to review and strengthen overall safety and health precautions to guard against potential hazards, obtain the necessary worker cooperation in safety matters and make frequent reports to the contractor.

It is important that managers and supervisors set the example for safety at the job site. It is essential that all managers wear the prescribed personal protective equipment (PPE), such as safety shoes, safety glasses, hard hats and other necessary gear when visiting the job site. Employees also must take an active role in job safety. It is the responsibility of the contractor and supervisor to make certain that workers have been properly trained in the use and fit of the prescribed protective gear and equipment. They also must ensure they wear and use the equipment correctly, and that they use safe work practices.

A cave-in is the primary hazard to which employees may be exposed during excavation work. A cave-in occurs when the soil forming the side of the excavation can no longer resist the forces being applied to it, when the soil's frictional and cohesive capacities to resist forces are reduced. Changing environmental conditions, such as freezing and thawing, or the addition or removal of water from the soil's pores can reduce the soil's ability to resist forces. Dynamic loads from vibrations caused by nearby traffic or construction operations can also cause cave-ins.

To the untrained and inexperienced eye, a deep trench wall of seemingly firm clay can be deceptive. But trench collapse can occur without warning, regardless of the depth. Most trenching fatalities occur in trenches 5 to 15 feet deep. Because these depths invite taking chances, tragedies can and do occur even in small excavations or trenches. A trench just 4 feet deep can become a shallow grave. Many fatal accidents have occurred in shallow trenches because the victims were working in a bent-over or lying position when the trench sides collapsed. Even those who manage to survive often suffer severe and lifelong disabling injuries because of the crushing weight.

One cubic yard of earth can weigh 1.5 tons or more, and one cubic foot can weigh more than 100 pounds. Perhaps only those fortunate enough to survive a cave-in can appreciate the tremendous crushing and suffocating force of a load of dislodged earth.

Tragically, hundreds of workers are killed and thousands are injured while doing excavation work every year. When a person is trapped and caught by a cave-in, the crushing pressure from the material gradually restricts breathing. Each time the victim exhales a breath, the weight of the load restricts inhalation of the next breath. A slow suffocation death usually follows, unless rescue is immediate.

Most rescue effort results are unsuccessful. There are too many things working against a successful rescue — time, weight of the soil and restricted access to the site. Many times, co-workers and rescue personnel also are exposed to additional cave-ins and hazards.

Trenching and excavation safety guidelines

- Establish the locations of underground and overhead utilities and services before beginning excavation. Contact utility companies and municipally-owned utilities and advise them prior to the start of actual excavation.
- Make an inspection after every rainfall or other hazard-producing occurrence, if you are the competent person.
- Do not allow water to accumulate in excavations.
- Use heavier sheet piling, shoring or bracing with superimposed loads, such as cranes working close to excavation edges. Using mobile equipment near excavations also requires extensive barricades or stop logs.
- Make sure employees working in trenches 4 feet deep or more have an adequate and safe means of exit, such as ladders, steps or ramps available at no more than 25 feet of lateral travel. In excavations more than 20 feet deep, equip ladders with ladder platforms at 20 foot intervals.
- Make sure a competent person capable of identifying existing and predictable hazards, and with the authority to take prompt corrective action to eliminate them is on the site. The person should be able to identify soil classifications and the protective systems to use in accordance with the OSHA trenching standard.
- Ensure that trenches more than 5 feet deep have shoring or are laid back to a stable slope. In unstable soil, you must protect trenches less than 5 feet deep.
- Design, construct and maintain portable trench boxes or sliding trench shields used in place of shoring and sloping to provide protection at least equal to the required sheeting and shoring. Ensure a registered professional engineer designs the shields.
- Install shields to restrict lateral or other hazardous movement.

- Make sure trench boxes and shields extend to the bottom of the trench and no less than 6 inches above the vertical part of the trench face, except in certain cases (see OSHA 1926.652).
- Do not allow employees in shields during their installation, removal or relocation.
- Provide a means of attaching trench boxes when they are stacked to prevent them from separating.
- Do not work outside of trench shields or shoring protection in unprotected trenches.
- Do not ride buckets to enter or leave a trench.
- Avoid jumping into or across trenches.
- Place trench jacks or cross braces in true horizontal position, spaced vertically and secured to prevent sliding, falling or kick outs.
- Use ropes to pull out jacks or braces after employees have vacated the trench;
- Perform backfilling and trench support removal together from the bottom of the trench. Release jacks and supports slowly.
- Make sure qualified personnel design and install piling, sheeting, shoring, shields and support systems. Ensure the shoring system can withstand all loads imposed upon it.
- Ensure that material and equipment used for sheeting, sheet piling, bracing, shoring and underpinning are in good serviceable condition. Use timbers that are sound and free of defects.
- Store spoil at least 2 feet away from where employees enter excavations, or use effective retaining devices.
- Install additional underpinning shoring or bracing when required in cases where adjoining utility lines, foundations, walks and footings are endangered;
- Extend vertical supports in the bracing system to an elevation no less than one foot above the top of the trench face.
- Erect standard guard railing or solid sheeting no less than 42 inches above ground level around all tunnel shafts and bore pits.
- Protect employees in bell-bottom pier holes by removable type steel casings and individually-manned lifelines and harnesses. Follow confined-space entry procedures.
- Protect each employee from falling by using guardrail systems, fences, barricades or covers at the edge of a well, pit, shaft and similar excavation 6 feet or more in depth.
- Install standard guardrail systems along ramps, runways or bridges over excavations that are more than 6 feet deep.
- Backfill trenches as the work progresses.

Cave-ins and protective support systems

Working in an excavation exposes employees to many hazards of which a cave-in is the chief hazard. You must protect employees exposed to potential cave-ins in all excavations by one of the following:

- Sloping or benching the sides of the excavation;
- Supporting the sides of the excavation;
- Placing a shield between the side of the excavation and the work area.

Designing a protective system can be complex because of the number of factors involved — soil classification, depth of cut, water content of soil, changes due to weather and climate, or other operations in the vicinity. The OSHA standard, however, provides several methods and approaches for designing protective systems that can provide the required level of protection against cave-ins.

One method of ensuring the safety and health of workers in an excavation is to slope the sides to an angle not steeper than 1.5 horizontal to one vertical — 34 degrees measured from the horizontal. Excavate these slopes to form configurations in accordance with those for Type C soil found in Appendix B of the standard. A slope of this gradation or less is considered safe for any type of soil. All simple slope excavations that are 20 feet or less in depth shall have a maximum allowable slope of 1.5-to-1.

A second design method, which you apply for both sloping and shoring, involves using tabulated data, such as tables and charts, approved by a registered professional engineer. These data must be in writing and must include sufficient explanatory information to enable the user to make a selection, including the criteria for determining the selection and the limits on the use of the data.

Keep at least one copy of the information, including the identity of the registered professional engineer who approved the data, at the work site during construction of the protective system. When the system is complete, store the data away from the job site, but make a copy available, upon request.

Contractors also may use a trench box or shield that is either designed or approved by a regis-

tered professional engineer or is based on tabulated data prepared or approved by a registered professional engineer. OSHA standards permit the use of a trench shield — also known as a welder's hut. It must provide protection equal to or greater than the protection the appropriate shoring system would provide. The shield can be constructed of timber, aluminum or other suitable material.

Employers can choose the most practical design approach for any particular circumstance. Once you select an approach, however, the system must meet the required performance criteria.

The standard does not require the installation and use of a protective system when an excavation is made entirely in stable rock or less than 5 feet deep and a competent person has examined the ground and found no indication of a potential cave-in.

Installation and removal

The following procedures are required for the protection of employees when installing support systems:

- Securely connect members of support systems;
- Safely install support systems;
- Never overload members of support systems;
- Install other structural members to carry loads imposed on the support system when temporary removal of individual members is necessary.

In addition, the standard permits excavation of 2 feet or less below the bottom of the members of a trench's support or shield system if:

- The system is designed to resist the forces calculated for the full depth of the trench;
- There are no indications, while the trench is open, of a possible cave-in below the bottom of the support system.

Also, the installation of support systems must be closely coordinated with the excavation of trenches.

As soon as work is completed, backfill the excavation as you dismantle the protective system. After clearing the excavation, have workers slowly remove the protective system from the bottom up, taking care to release members slowly.

Shoring types

Shoring is the provision of a support system for trench faces used to prevent movement of soil, underground utilities, roadways and foundations. Use shoring or shielding when the location or depth of the cut makes sloping back to the maximum allowable slope impractical. Shoring systems consist of uprights, wales, struts and sheeting. There are two basic types of shoring: timber and aluminum hydraulic.

Today's trend is toward using 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 that one worker can install it;
- 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;
- Are easily adapted to various trench depths and widths.

Install all shoring from the top down and remove from the bottom up. Check hydraulic shoring at least once per shift for leaking hoses and/or cylinders, broken connections, cracked nipples, bent bases and any other damaged or defective parts.

Pneumatic shoring works in a manner similar to hydraulic shoring. The primary difference is that pneumatic shoring uses air pressure in place of hydraulic pressure. A disadvantage of using pneumatic shoring is that an air compressor must be on site.

Screw jack systems differ from hydraulic and pneumatic systems in that you must adjust manually the struts of a screw jack system. This creates a hazard because the worker must be in the trench to adjust the strut. In addition, uniform preloading cannot be achieved with screw jacks, and their weight creates handling difficulties.

Single-cylinder hydraulic shores are generally used in a water system as an assist to timber

shoring systems and in shallow trenches where face stability is required.

The underpinning process involves stabilizing adjacent structures, foundations and other intrusions that may have an impact on the excavation. As the term indicates, underpinning is a procedure in which the foundation is physically reinforced. Conduct underpinning only under the direction and with the approval of a registered professional engineer.

Shielding types

Trench boxes are different from shoring because, instead of shoring up or otherwise supporting the trench face, they primarily protect workers from cave-ins and similar incidents. Make the excavated area between the outside of the trench box and the face of the trench as small as possible. Back fill the space between the trench boxes and the excavation side to prevent lateral movement of the box. Do not subject shields to loads exceeding those that the system was designed to withstand.

Combined use

Trench boxes are generally used in open areas, but you can also use them in combination with sloping and benching. Make sure the box extends at least 18 inches above the surrounding area if there is sloping toward excavation. You can accomplish this by providing a benched area adjacent to the box.

Earth excavation to a depth of 2 feet below the shield is permitted, but only if:

- The shield is designed to resist the forces calculated for the full depth of the trench;
- There are no indications while the trench is open of possible loss of soil from behind or below the bottom of the support system.

Conditions of this type require observation on the effects of bulging, heaving and boiling, as well as surcharging, vibration, adjacent structures, etc., on excavating below the bottom of a shield. Careful visual inspection of the conditions previously mentioned is the primary and most prudent approach to hazard identification and control.

Sloping and benching

Sloping

Maximum allowable slopes for excavations less than 20 feet based on soil type and angle to the horizontal are:

Soil type	Height/Depth ratio	Slope angle
Stable rock	Vertical	90 degrees
Type A	.75-to-1	53 degrees
Type B	1-to-1	45 degrees
Type C	1.5-to-1	34 degrees
Type A (short-term)	.5-to-1	63 degrees

Benching

There are two basic types of benching: simple and multiple. The type of soil determines the horizontal-to-vertical ratio of the benched side. As a general rule, the trench's bottom vertical height must not exceed 4 feet for the first bench. Subsequent benches may be up to a maximum of 5 feet vertically in Type A soil and 4 feet in Type B soil for a total trench depth of 20 feet. All subsequent benches must be below the maximum allowable slope for that soil type. For Type B soil, the trench excavation is permitted in cohesive soil only.

Place temporary spoil no closer than 2 feet from the surface edge of the excavation, measured from the nearest base of the spoil to the cut, not from the crown of the spoil deposit. This distance requirement ensures that loose rock or soil from the temporary spoil will not fall on employees in the trench.

Place spoil so that it channels rainwater and other run-off water away from the excavation, so that it cannot accidentally run, slide or fall back into the excavation.

Place permanent spoil at some distance from the excavation. Permanent spoil is often created where underpasses are built or utilities are buried. The improper placement of permanent spoil can cause an excavation to be out of compliance with the horizontal-to-vertical ratio requirement for a particular excavation. You usually determine this through visual observation. Permanent spoil can change undisturbed soil to disturbed soil and dramatically alter slope requirements.

Other safety considerations

Pile driving

- Use a blocking device when working under leads or hammers where a brake or cable failure can result in injuries.
- Make sure employees are not on the leads when hoisting piling into place.
- Make sure that no part of the body is exposed to pinch points between piling, leads and hammers when making final adjustments before driving.
- Stack piling in an orderly manner to prevent shifting.
- Inspect air- and steam-line connections daily. Attach a chain or rope at the coupling points to prevent whipping.
- Make sure the hammer is at the lowest possible level when leads and hammers connected to the crane are moved.
- Make sure the person securing piling in the leads is using a safety harness;
- Designate one worker to signal the operator.
- Inspect slings and bridles and replace damaged cables daily.
- Use tag lines to guide the piles to the leads.

Cofferdams

The following guidelines are recommended for cofferdams:

- Provide a means for controlled flooding of the work area if overtopping of cofferdams by high waters is possible;
- Develop and post instructions for warning

signals for employee evacuation in case of an emergency;

- Provide and equip standard guardrails along cofferdam walkways, bridges or ramps with no fewer than two means of rapid exit;
- Mark cofferdams located close to navigable shipping channels to protect them from vessels in transit.

Entrance and exit

The employer must provide safe access and egress to all excavations. According to OSHA regulations, when employees are in trench excavations 4 feet deep or more, you must provide adequate means of exit within 25 feet of lateral travel. This can include ladders, steps, ramps or other safe means. If you use structural ramps as a means of access or exit for employees, a competent person must design them. A competent person qualified in structural design must design ramps used by vehicles. Also, structural members used for ramps or runways must be uniform in thickness and joined in a manner to prevent tripping or displacement. Secure ladders and extend them a minimum of 36 inches above the landing. Use metal ladders with caution, particularly when electric utilities are present.

While trenching and excavation work presents serious risks to all workers involved, the greatest risk, and one of primary concern, is that of a cave-in. When cave-in accidents occur, they are much

more likely to result in worker fatalities than other excavation-related accidents. Strict compliance with all sections of the standard will prevent or greatly reduce the risk of cave-ins as well as other excavation-related accidents.

Standing water and water accumulation

Employees are prohibited from working in excavations where water has accumulated or is accumulating unless adequate protection is provided. If you use water removal equipment to control or prevent water from accumulating, a competent person must monitor the equipment and operations to ensure proper use.

OSHA standards also require employers use diversion ditches, dikes or other suitable means to prevent surface water from entering an excavation and to provide adequate drainage of the area adjacent to the excavation. Also, a competent person must inspect excavations subject to run-offs from heavy rains.

Provide methods for controlling standing water and water accumulation that consist of the following if you permit employees to work in the excavation:

- Use of special support or shield systems approved by a registered professional engineer;
- Water removal equipment, such as well pointing, used and monitored by a competent person;
- Safety harnesses and lifelines used in conformance with 29 CFR Part 1926.104;
- Surface water diverted away from the trench;
- Employees removed from the trench during rainstorms;
- Trenches carefully inspected by a competent person after each rain and before employees are permitted to re-enter the trench.

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. 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. Sliding or sloughing may occur as a result of tension cracks. 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.

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.

The downward pressure created by the weight of adjoining soil causes bottom heaving or squeezing, causing a bulge in the bottom of the cut. Heaving and squeezing can occur even when shoring or shielding is properly installed.

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 you use shoring or trench boxes.

Determination of soil type

OSHA categorizes soil and rock deposits into four types.

- Stable rock is natural solid mineral matter that you can excavate with vertical sides. It remains intact while exposed. It is usually identified by a rock name, such as granite or sandstone. Determining this type may be difficult unless you know whether cracks exist and whether or not the cracks run into or away from the excavation.
- Type A soils are cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (tsf) 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 four horizontal to one vertical or greater, or has seeping water.

- Type B soils are cohesive soils with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf. 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 a 4-to-1 ratio (only if the material would be classified as a Type B soil).
- Type C soils are cohesive soils with an unconfined compressive strength of 0.5 tsf 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 or greater.

Where soils are configured in layers, such as where a layered geologic structure exists, you must classify the soil on the basis of the soil classification of the weakest soil layer. You must classify each layer individually if a more stable layer lies below a less stable layer, such as if a Type C soil rests on top of stable rock.

Test equipment and methods for evaluating soil type

Many kinds of equipment and methods are used to determine the type of soil prevailing in an area.

- Pocket penetrometer — A direct reading, spring-operated instrument used to determine the unconfined compressive strength of saturated cohesive soils. Once pushed into the

soil, an indicator sleeve displays the reading. The instrument is calibrated in tsf or kilograms per square centimeter (kPa). However, penetrometers have error rates in the range of \pm 20 percent to 40 percent.

- Shearvane (Torvane) — A device used to determine the unconfined compressive strength of the soil. With a shearvane, press the blades of the vane into a level section of undisturbed soil and turn the torsional knob slowly until soil failure occurs. Multiply the direct instrument reading by two to provide the results in tsf or kPa.
- Thumb penetration test — A procedure that involves pressing the thumb firmly into the soil in question. If the thumb makes an indentation in the soil only with great difficulty, the soil is probably Type A. If the thumb penetrates no further than the length of the thumb-nail, it is probably Type B soil. If the thumb penetrates the full length of the thumb, it is Type C soil. The thumb test is subjective and therefore, is the least accurate of the three methods.
- Dry strength test — A test that determines if dry soil crumbles into individual grains freely or with moderate pressure. Dry soil that falls into clumps that subsequently break into smaller clumps — and you can break the smaller clumps only with difficulty — is probably clay in combination with gravel, sand or silt. If the soil breaks into clumps that do not break into smaller clumps — and you can break the soil only with difficulty — the soil is considered unfissured unless there is visual indication of fissuring.

- Plasticity or wet thread test — A test conducted by molding a moist sample of the soil into a ball and attempting to roll it into a thin thread approximately one-eighth inch in diameter by 2 inches in length. Hold the soil sample by one end. If the sample does not break or tear, the soil is considered cohesive.
- Visual test — A qualitative evaluation of conditions around the site. Observe the entire excavation site, including the soil adjacent to the site and the soil you are excavating. If the soil remains in clumps, it is cohesive; if it appears to be coarse-grained sand or gravel, it is considered granular.

The competent person also checks for any signs of vibration. During a visual test, the competent person checks for crack-line openings along the failure zone that indicates tension cracks, looks for existing utilities that indicate that the soil has previously been disturbed and observes the open side of the excavation for indications of layered geologic structuring.

It is the responsibility of the competent person to look for signs of bulging, boiling or sloughing, as well as for signs of surface water seeping from the sides of the excavation or from the water table. If there is standing water in the cut, the competent person checks these conditions. In addition, the competent person checks the area adjacent to the excavation for signs of foundations or other intrusions into the failure zone, and for surcharging and the spoil distance from the edge of the excavation.

Materials and equipment

Heavy equipment

Guidelines for operating heavy equipment include:

- Inspect equipment carefully at the beginning of each shift;
- Learn the safest method of mounting and leaving machines;
- Know the limitations of operating machines on slopes and rough terrain;
- Report malfunctions to the supervisor or master mechanic;
- Ensure all equipment is secured to prevent it from being started or moved by an unauthorized person;
- Make turns on steep grades in an uphill direction;
- Block the apron on scrapers before changing blades;
- Follow established traffic patterns on haul roads;
- Make sure the brake is operative before moving equipment;
- Climb down from equipment. Do not jump;
- Keep your equipment a safe distance from the edge of embankments;
- Shut off the engine on all equipment before making adjustments or repairs;
- Do not engage in horseplay;
- Maintain all required lights, reflectors and accessories on equipment;
- Do not travel with the bucket of an end-loader raised above the top of the radiator of the machine, since it will obstruct the operator's view;
- Look in the direction that the equipment is traveling;
- Before loading a truck, find out what is on the other side of it;
- Lower loader buckets to the ground when not in use;
- Keep reverse alarms operable and free of anything that will muffle the sound;
- Wear seat belts on equipment with a rollover protection system;
- Make sure equipment used in site-clearing operations has substantial overhead guards, shields, canopies and grills;
- Do not use the blade to brake bulldozers on downhill runs except in emergencies;
- Do not allow passengers on a machine while it is in use;
- Be certain everyone is out of the way before pushing over trees, rolling logs or dozing rocks;
- Remain clear of the towrope when towing a machine;
- Read the operator's manual. It contains important information on the equipment being operated;
- Ensure other workers are out of the way before starting the machine;
- Inspect the equipment daily. Be certain all safeguards are in place on the equipment and report any defects immediately;
- Place a warning tag on the steering wheel or ignition switch of all unsafe equipment being repaired;
- Guard or insulate all hot surfaces of the equipment, including exhaust pipes or other lines, to prevent injury or fire;
- Make sure that exhaust or discharges from the equipment are directed so they do not endanger people or obstruct the operator's view.

Warning systems for mobile equipment

The following guidelines will help prevent vehicles from accidentally falling into the trench:

- Install barricades where necessary;
- Use hand or mechanical signals as required;
- Install stop logs if there is a danger of vehicles falling into the trench;
- Grade soil away from the excavation; this will assist in vehicle control and channeling of runoff water.

Manual material handling

We recommend the following guidelines for manual material handling and lifting:

- Never smoke during refueling. Before starting to refuel, turn motors off;
- Know the location of firefighting equipment;
- Prohibit unauthorized riding on equipment;
- Know your limits. Get help with heavy or awkward loads, or use mechanical equipment;
- Try a preliminary lift first to be sure you can raise the load easily. If it is too heavy, get help;
- When lifting, make sure you have solid footing and get a firm grip;
- Walk; never run with a load;
- Never twist your body when turning with a load. Instead, turn your feet;
- Arrange to carry the load so your vision is unobstructed.

The employer is responsible for the safe condition of materials and equipment used for protective systems. Defective and damaged materials and equipment can result in failure of a protective system and cause excavation hazards.

To avoid possible protective-system failure, the employer must ensure:

- Materials and equipment are free of damage or defects;
- Manufactured materials and equipment are used and maintained in a manner consistent with the manufacturer's recommendations, and in a way that prevents employees' exposure to hazards;
- A competent person examines damaged materials and equipment to determine suitability for continued use. If materials and equipment are not safe for use, you must be remove them from service. These materials cannot be returned to service without the evaluation and approval of a registered professional engineer.

Falls and exposure to falling loads

In addition to cave-in hazards and related secondary hazards, employers must protect workers from other hazards during excavation-related work. These hazards include exposure to falls, falling loads and mobile equipment. To protect employees from these hazards, employers must:

- Keep materials or equipment that might fall or roll into an excavation at least 2 feet from the edge of excavations or have retaining devices, or both;
- Provide warning systems, such as mobile equipment, barricades, hand or mechanical signals, or stop logs to alert operators of the edge of an excavation. If possible, keep the grade away from the excavation;
- Provide scaling to remove loose rock or soil, or install protective barricades and other equivalent protection to protect employees from falling rocks, soil or materials;
- Prohibit employees from working on faces of sloped or benched excavations at levels above other employees unless employees at lower levels are adequately protected from the hazard of falling, rolling or sliding material and equipment;
- Prohibit employees from areas beneath loads that are handled by lifting or digging equipment. To avoid being struck by any spillage or falling materials, require employees to stand away from vehicles being loaded or unloaded. If a vehicle's cab provides adequate protection from falling loads during loading and unloading operations, the operator may remain in it.

Surface crossing of trenches

Discourage crossing trench surfaces. However if trenches must be crossed, such crossings are permitted only under the following conditions:

- Design and install vehicle crossings under the supervision of a registered professional engineer;
- Provide walkways or bridges for foot traffic;
- Make sure these structures have:
 - A safety factor of four;
 - A minimum clear width of 18 inches;
 - Standard rails.

Exposure to falling loads

Employers must protect employees from loads or objects falling from lifting or digging equipment. Procedures to ensure their protection include:

- Not allowing employees to work under raised loads;
- Requiring employees to stand away from equipment that is being loaded or unloaded;
- Allowing equipment operators or truck drivers to stay in their equipment during loading and unloading if properly equipped with a cab shield or adequate canopy.

Heat- and cold-related illnesses and treatments

Heat

Overexposure to heat can cause heat cramps, heat exhaustion or heatstroke, serious illnesses that need treated immediately. Get the person out of the sun as quickly as possible.

Heat cramps — painful muscle spasms that usually occur in the legs and abdomen — are the least severe and are often the first signal that the body is having trouble with the heat. If a person has heat cramps, take him or her to a cool place, loosen clothing and give him or her cool water or a commercial sports drink. Allow the person to drink about one glass of liquid every 15 minutes. Keep the person drinking fluids and watch for any further signs of heat-related illness.

Heat exhaustion is more serious than heat cramps. Symptoms include cool, moist, pale or flushed skin, headache, nausea, dizziness, weakness and exhaustion. As with heat cramps, get the person to a cool place and loosen the victim's clothing. Give plenty of fluids to a heat exhaustion victim, and apply cold, wet compresses to cool the person.

Heat stroke is the most severe heat condition, developing when the body systems are overwhelmed by heat and begin to stop functioning. The signals include red, hot, dry skin; changes in consciousness; rapid, weak pulse; and rapid, shallow breathing. Work to cool the person, as in the other two heat-related illnesses, but also call for medical help.

Refusing water, vomiting and changes in consciousness indicate the person's condition is worsening. Get medical attention immediately. If the person vomits, do not give any more fluids and put the victim on his or her side to prevent the person choking on vomit. Watch for breathing problems and keep the victim lying down. Cool the body as much as possible. Place cold, wet cloths or ice packs on the victim's wrists, ankles, groin area, armpits and neck to cool the large blood vessels. Do not apply rubbing alcohol.

To help prevent heat-related illnesses:

- Become acclimated to the heat gradually before working in hot temperatures for a long time;
- Always drink plenty of cool water;
- Wear hats and sunglasses to help stay cool;
- Take frequent breaks in a cool place, if possible;
- Wear loose clothing that allows the skin to breathe, such as cotton;
- Protect your skin from the sun. Keep as much of it covered with clothing as possible. Wearing long-sleeved shirts will help;
- Use sunscreen or sunblock on unprotected skin. Physicians recommend a sunblock with a sun-protection factor of 15 or greater. Re-apply sunblock regularly if perspiring heavily. Make sure to apply sunblock to hands, face (especially nose) and ears;
- Conduct periodic self-examination to aid in early recognition of new or developing lesions.

Cold

Cold weather primarily affects the body's extremities because the extremities are thinner than the core and cool down faster. Hands and feet are farthest from the body core and have less blood flow than the core. Cold exposure can occur in weather that is not freezing. When the wind blows, the wind chill factor takes effect. The wind, humidity and moisture remove body heat.

Dress according to the weather. Wear several layers of loose, bulky clothing to provide better insulation. You can remove a layer if the body becomes overheated. Avoid wearing tight clothing, it reduces blood circulation. In extremely cold weather, protect the ears, face, hands and feet. A hat will keep your entire body warmer by reducing heat loss from the head. Wear a couple pairs of socks and insulated, waterproof boots.

On extremely cold days, limit the amount of time outside. Move into a warm location periodically. Carry cold weather survival gear, including a thermos of hot liquid, a change of clothes, extra socks, gloves, hats, a jacket and blankets.

When it is cold, do not touch or brush up against metal surfaces with bare skin because the skin may stick to it and get immediate frostbite. Greases and oils get thick and hard, which makes equipment difficult to use. If you must heat equipment to make it work, follow the proper procedures and use the right tools. Tools also get brittle in the cold, so use caution.

Working with the feet under cold water or in wet fields for a long time causes trench foot or immersion foot. The feet feel cold and numb, and blisters often form. As the feet begin to warm, they become red and feel hot. To care for trench foot, gradually warm and elevate the feet. Put on a sterile dressing, taking care not to break the blisters. Get medical attention, because trench foot can cause severe disability.

Repeated, prolonged exposure to cold weather can cause chilblains — red, swollen areas that feel hot, tender and itchy. Chilblains can occur on the ears, fingers and toes and are chronic, which means they can re-occur when there is another prolonged exposure to cold weather. If chilblains occur, cover the affected area and see a physician.

Hypothermia is the general cooling of the entire body. When body temperature drops much below normal, problems can arise. Symptoms of hypothermia include uncontrollable shivering, numbness, drowsiness and difficulty doing simple tasks. As hypothermia progresses, the shivering

stops, breathing and pulse rate slow down and eyesight may begin to fail. The person may begin to stagger and become uncoordinated. If the person does not receive treatment, he or she may become unconscious and possibly die.

To treat hypothermia victims, immediately get them into a warm environment and gradually warm them. Never immerse the person in warm water; the water warms the victim too quickly. Remove any wet clothing, dry the person and dress him or her in dry clothing. Wrap him or her in blankets, and use heating pads and other heat sources to warm them. Keep a barrier, such as a blanket, towel or clothing between the person and the heat source. If the person is alert, give him or her warm liquids. Get medical treatment for the victim immediately. Handle the person gently until medical help arrives.

Frostbite occurs when parts of the body freeze. Ice crystals, which can destroy the tissue and kill the affected part, form inside the skin. The areas most often affected are the ears, nose, fingers and toes. Frostbitten areas in white-skinned people turn reddish and can be painful. Frostbitten areas turn pale on dark-skinned people. The pain subsides and the area can become numb. The area then becomes white or grayish-yellow and very cold to the touch.

To treat victims of frostbite, gradually warm the area. Do not use alcohol or rub the frostbitten skin. Use lukewarm water to soak the affected part. Loosely bandage the area with a dry, sterile dressing, taking care not to break any blisters. Get medical attention as soon as possible.

Lockout/tagout

Workers are killed or seriously injured when machinery starts to operate and becomes energized when it is supposed to be turned off. These types of incidents happen most often while machinery is being repaired or maintained. Electricity is the most common type of energy used to run machinery, but hydraulic, pneumatic, mechanical, gravity, heat or chemical energy are other types of energy used to run equipment.

The two most common ways to protect workers from injuries caused by the operation of machinery when its supposed to be shut off are:

- Lockout — The on/off switch or valve is set in the off position. A key or combination lock is placed over the device that turns on the machinery so that it stays in the off position until the machine is serviced and ready to be started up again;
- Tagout — A tag is attached to the switch, circuit breaker or valve when the machinery is turned off to keep the equipment from being used until the tag is removed. Lockout is safer than tagout. Use the lockout method whenever possible.

Hazardous atmospheres and confined spaces

Under this provision, a competent person must test excavations greater than 4 feet deep. He or she must also test excavations where oxygen deficiency or a hazardous atmosphere exists or you could reasonably expect it to exist. You must complete testing before an employee enters the excavation. If hazardous conditions exist, provide controls, such as proper respiratory protection or ventilation. Also, regularly test controls used to reduce atmospheric contaminants to acceptable levels.

Where adverse atmospheric conditions may exist or develop in an excavation, the employer also must provide and ensure emergency rescue equipment is readily available. Emergency equipment can include a breathing apparatus, a safety harness or line, basket stretcher, etc. This equipment must be attended when in use.

When an employee enters bell-bottom pier holes and similar deep and confined footing excavations, the employee must wear a harness with a lifeline. You must securely attach the lifeline to the harness. It must be separate from any line used to handle materials. Also, while the employee wearing the lifeline is in the excavation, an observer must be present to ensure the lifeline is working properly and to maintain communication with the employee.

Do not permit employees to work in hazardous and/or toxic atmospheres. Such atmospheres include those with:

- Less than 19.5 percent or more than 23.5 percent oxygen;
- A combustible gas concentration greater than 20 percent of the lower flammable limit;
- Concentrations of hazardous substances that exceed those specified in the Threshold Limit Values for Airborne Contaminants established by the American Conference of Governmental Industrial Hygienists (ACGIH).

When testing for atmospheric contaminants:

- Conduct tests before employees enter the trench and then re-test regularly to ensure that the trench remains safe;
- Increase the frequency of testing if equipment is operating in the trench;
- Increase testing frequency if welding, cutting or burning is done in the trench;
- Train, fit-test and enroll employees required to wear respiratory protection in a respiratory protection program;
- Some trenches qualify as confined spaces. When this occurs, comply with OSHA's Confined Space Standard.

Confined spaces

A confined space is an area with a small opening that is large enough for someone to enter and work. The size and shape of the space can make it hard to move around or work in for a long time. Examples of confined spaces include manholes, tunnels, sewers and sewer silos, sewage digesters, utility vaults, pumping stations, storage tanks and pits, vats and process vessels.

The air in a confined space can be an unsafe. It may contain hazardous atmosphere for a number of reasons, including:

- Not enough oxygen — air that has less than 19.5 percent oxygen is dangerous. Without enough oxygen, workers will die because they will not be able to breathe;
- Too much oxygen — air that has more than 23.5 percent oxygen increases fire hazards;
- Flammable gases (gases that will ignite) — Methane is the most common flammable gas in sewers. Methane is formed when materials decompose;
- Toxic gases and vapors can kill when levels are high. Hydrogen sulfide smells like rotten eggs and sinks to the bottom of the space. Carbon monoxide is a deadly gas that you cannot smell.

Other hazards of confined work space include loud noises, and slips and falls caused by wet surfaces.

Take these actions to protect workers from the hazards that can be present in confined spaces:

1. Train workers and supervisors about the hazards of confined spaces and how to protect workers.
2. Fill out an entry permit before a worker enters a confined space. The permit should contain the following information:
 - The location of the space, when employees will be enter it and for what purpose;
 - The supervisor in charge;
 - The person outside of the space (attendant) responsible for letting workers know if they must evacuate the space or who to call for help in an emergency;
 - Test results for dangers in the air;
 - Hazards in the space and how they will be controlled;
 - Emergency and rescue services that you can call.
3. Test the air for hazards before entering. Hold the monitor — the device used to measure the air — from outside the confined space. First test the area for oxygen. The air must have between 19.5 and 23.5 percent oxygen. Make sure the monitor reaches the lowest point in the space. Gases, such as hydrogen sulfide are heavier than air and sink to the bottom. Other gases, such as methane are lighter than air and rise to the top. Take samples from the bottom, middle and top levels.
4. Ventilate the area before entering if the monitor shows there is not enough oxygen or if it contains toxic gases. Air that is safe to breathe is forced into the confined space. Monitor the air again to make sure the ventilation has removed the hazards in the air.
5. Use the right protective equipment. The type of protective equipment needed depends on the hazards that are present. Equipment commonly used for confined space work includes:
 - An air-supplied respirator when there is too little oxygen or toxic gases;
 - A full body or chest harness and a lifeline to make a rescue;
 - Hard hats, safety goggles, face shields, gloves, disposable suits and ear protection;
 - A non-sparking flashlight.

6. Be ready to make a rescue without having to enter the area! Too often, workers die in confined spaces while trying to rescue a co-worker. Train employees on rescue procedures. Be prepared to make a non-entry rescue in case of an emergency. You can make a rescue without having to enter the space by using tripods, winches and other types of retrieval systems. The attendant may not enter the space to make a rescue until another attendant has arrived on the scene.

Procedures for safe confined-space entry

We recommend the following guidelines for safe confined-space entry:

- Establish and use a procedure for safe entry into confined spaces;
- Check for and remove rodents, insects, debris and water from the space;
- Ensure these recommended procedures comply with the standards;
- Designate at least one trained person to be responsible for adherence to entry procedures. Require written approval by that person before permitting anyone to enter the confined space;
- Post established entry procedures immediately adjacent to all confined-space entry ports. Post requirements for respiratory equipment and testing equipment on crew trucks;
- Provide periodic instruction and training in proper entry procedures;
- Require standby personnel, where provided, to be in communication at all times with the employee within the confined space. An alarm or two-way radio system for the standby employee is effective;
- Make sure approved rescue equipment is available. Since entry ports for confined spaces vary in size, take care to obtain equipment of the proper size;
- Establish procedures to prevent ignition of combustible atmospheres or re-entry of gases or liquids by locking out switches and blanking off transmission pipes. Use non-sparking tools;
- Prevent the generation of contaminants by neutralizing or flushing out residual materials;

- Use only approved instruments in proper working order when testing for contaminants;
- Continually monitor oxygen and contaminant concentrations during occupancy;
- Make sure if respiratory equipment leading to an air compressor piped system is used, it meets the specifications of the Compressed Gas Association. This ensures a supply of uncontaminated air;
- Ensure personnel who will use supplied-air or self-contained respiratory apparatus are trained in its safe and proper use;
- Consider using tags to show that a confined space may be entered safely.

Emergency rescue procedures and equipment

In all cases when an employee is stationed outside a compartment, tank or space as a tender for employees working inside, make sure the tender has all necessary PPE immediately available for emergency use. Have the tender wear PPE if exposed for prolonged periods to substances that are hazardous to the tender's health.

Emergency rescue equipment is required when a hazardous atmosphere exists or you can reasonably expect it to exist. Requirements are:

- Respirators must be of the type suitable for the exposure. Employers must train employees in their use and institute a respirator program;
- You must provide lifelines — attended at all times — when employees enter bell-bottom pier holes, deep confined spaces, a toxic or flammable atmosphere or other similar hazard areas;
- You must train employees who enter confined spaces.

Hazard communication standard

Make employees aware of the hazardous substances to which they are exposed. A written hazard communication program, including labels, material safety data sheets and training, is required.

Personal protective equipment

PPE is required to reduce employees' exposures to hazards when engineering or administrative controls are not feasible or effective in reducing these exposures to acceptable levels. Employers must determine all exposures to hazards in their workplaces and determine if workers should use PPE for protection.

If using PPE to reduce employee exposure to hazards, start and maintain a PPE program including:

- Methods to identify and evaluate workplace hazards and determine if issuing PPE is an appropriate control measure;
- Plan development to select, maintain and evaluate its use;
- Training of employees using the PPE;
- Program vigilance to determine its effectiveness in preventing employee injury or illness.

We recommend the following guidelines for PPE use:

- Wear hard hats for protection from falling or flying objects, physical contact with rigid objects, electrical shock and hair entanglement;
- Wear a shirt at all times for protection from burns, abrasions, insect bites and lacerations;
- Maintain work shoes in good condition for solid and secure footing;
- Wear a warning vest in traffic areas;
- Use proper eye and face protection when operating saws and other cutting or chipping tools;
- Wear gloves when there is danger of burns, abrasions, cuts or lacerations. Wear rubber or neoprene gloves when working with chemicals harmful to the skin;
- Wear respirators approved by the National Institute for Occupational Safety & Health where and when job hazards make them necessary. Use and maintain them according to the manufacturer's recommendations;
- Work in a well-ventilated area;
- Wear hearing protection when exposed to excessive noise levels. The confined space of a trench can increase noise hazards;
- Use proper PPE when handling waste or potentially hazardous materials;
- Comply with applicable safety rules when using material-handling equipment;
- Wear rubber boots, gloves and aprons when exposed or in contact with raw sewage of wastewater systems. Provide sanitary washing facilities for cleanup.

Lasers (Non-ionizing radiation)

We recommend the following guidelines for laser systems with less than five milliwatts of power — 0.005 watts:

- Assign only qualified and trained employees to install, adjust and operate laser equipment. Ensure that proof of the laser equipment operator's qualification is available and in the operator's possession at all times;
- Use only mechanical or electronic means as a detector for guiding the internal alignment of the laser;
- Do not look directly into the laser beam or direct the laser beam at employees;
- Position the laser at a level other than the eye level of persons in the area, when possible;
- Post laser warning signs: "Notice — Laser in Use;"
- Turn the laser off or cap the lens when it's not in use or is unattended;
- Provide laser equipment with labels stating its light intensity and the manufacturer's name and address;
- Prohibit the operation of laser systems when it is raining or snowing, or when there is dust or fog in the air, where practicable. Always keep employees out of source and target areas during such weather conditions.

Traffic control and fleet safety

A proper traffic control program should:

- Get the driver's attention in time to follow directions;
- Warn the driver of the situation ahead;
- Slow the vehicle;
- Guide the driver safely around the work site;
- Return the driver to the normal traffic flow.

Warning signs of standard color, shape, size and symbols are the most common way to make drivers aware of work zones. Flaggers also can let drivers know about roadwork being performed and direct traffic.

To ensure safe traffic control:

- Make sure workers are easy to see. Have flaggers wear hard hats, red or orange reflective warning vests and use sign paddles;
- Ensure work zones are well-lit if work is done in the dark, reducing the chance of a worker being struck by passing vehicles or by other equipment used on the job;
- Use "Flagger Ahead" signs at the approach to your location;
- Use cones or barrels to channel traffic. Traffic control devices, such as cones, delineators, drums, vertical panels and barricades, are used to channel vehicles when a traffic lane must be used;
- Begin lane closings far enough in advance of the work to allow drivers to move gradually to a new lane;

- Make sure flaggers are clearly visible to approaching traffic at all times. They should stand alone far enough in front of the work crew to permit a proper response by the motorist to the flagging instructions and to permit traffic to reduce speed before entering the work site;
- Ensure that flaggers' signals conform to American National Standards Institute (ANSI) and uniform traffic control standards (ANSI D6. 1-1971).

Fleet safety

No one should drive an unsafe vehicle or drive without adequate training. A fleet safety program includes vehicle maintenance and qualified drivers.

Check vehicles and make necessary repairs problems before use. Do a spot check for problems before driving the vehicle. Make sure brakes, lights, tires, horn, wipers, mirrors, coupling devices and other parts are in good working order. Note any problems with the vehicle before returning it.

Site assessment questions

During first and subsequent visits to a construction or facility maintenance location, the compliance officer, the site's safety officer or other competent person may find the following questions useful:

1. Is the cut, cavity or depression a trench or an excavation?
2. Is the cut, cavity or depression more than 4 feet deep?
3. Is there water in the cut, cavity or depression?
4. Are there adequate means of access and egress?
5. Are there any surface encumbrances?
6. Is there exposure to vehicular traffic?
7. Are adjacent structures stabilized?
8. Does mobile equipment have a warning system?
9. Is a competent person in charge of the operation?
10. Is equipment operating in or around the cut, cavity or depression?
11. Are procedures required to monitor, test and control hazardous atmospheres?
12. Does a competent person determine soil type?
13. Was a soil testing device used to determine soil type?
14. Is the spoil placed 2 feet or more from the edge of the cut, cavity or depression?
15. Is the depth 20 feet or more for the cut, cavity or depression?
16. Has a registered professional engineer approved the procedure if the depth is more than 20 feet?
17. Does the procedure require benching or multiple benching?
18. Does the procedure require shoring or shielding?
19. If provided, do shields extend at least 18 inches above the surrounding area if it is sloped toward the excavation?
20. If shields are used, is the depth of the cut more than 2 feet below the bottom of the shield?
21. Are any required surface crossings of the cut, cavity or depression at the proper width and fitted with handrails?
22. Are means of egress from the cut, cavity or depression no more than 25 feet from the work?
23. Is emergency rescue equipment required?
24. Is there documentation of the minimum daily excavation inspection?

Glossary

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 capable of identifying existing and predictable hazards or working conditions that are hazardous, unsanitary or dangerous to employees. He or she 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, has unfavorable natural ventilation, may contain or produce hazardous substances, and is not intended for continuous employee occupancy.

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 feet or 4.6 meters. 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 feet or 4.6 meters or less as measured at the bottom of the excavation, the excavation is also considered 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 during a cave-in 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 registered as a professional engineer in the state where the work is performed. However, a professional engineer who is registered in any state is deemed to be a "registered professional engineer" within the meaning of OSHA's standard 29 CFR 1926 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. It also refers to an 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.

Underground installations include, but are not limited to, utilities, tunnels, shafts, vaults, foundations and other underground fixtures, or equipment that employees may encounter during excavation or trenching work.

Unconfined compressive strength is the load per unit area at which soil will fail in compression. Laboratory testing can determine this measure. You can estimate it in the field using a pocket penetrometer, thumb penetration tests or by other methods.