Susan Harwood Program

OVERVIEW of the OSHA STANDARD

The University of Texas at Arlington

In Cooperation With

SPEED SHORE®
PIONEERING TRENCH SAFETY

Jack Pettyjohn
Training Department Manager
Cell (713) 376-9109
jpettyjohn@speedshore.com

Angela Baily
Training Department Administrator
(713) 943-0750
abailey@speedshore.com

Bill Staley
The University of Texas at Arlington
Division for Enterprise Development
(817) 272-0225 - wstaley@uta.edu

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Introduction to Excavation Safety

Excavating is one of the most hazardous forms of construction activity due to the possibility of cave-ins. While the number of excavation accidents is small when compared to the total number of accidents occurring in all types of construction activity, they occur more frequently than in other types of construction, and are far more likely to result in a serious injury or fatality. For these reasons OSHA has, historically, paid close attention to excavation work, elevating it to a "special emphasis" program in 1985, and making it the first construction standard they totally revised (in 1989).

OSHA Research

Research done by OSHA during the course of the revision of the Standard in the 1980's showed that the fatality rate in excavation work was as much as 112% greater than the rate for construction in general (.508 per 1000 employees in excavation work as opposed to .248 per 1000 for construction in general). In other words, an employee engaged in excavation activity was twice as likely to be killed as those engaged in other forms of construction work. Of special interest was a California OSHA report specifically related to cave-ins that revealed that while the ratio of lost time accidents to fatalities for all California industries was 250 to 1, the ratio for excavation work was 17 to 1. In other words, a person engaged in excavation work was nearly 15 times more likely to die from an accident (typically a cave-in) than in any other form of industrial activity.

Given the contributing factors involved in a cave-in, the numbers are not surprising. A cubic foot of soil weighs one hundred pounds on average. That would make a cubic yard, the capacity of most backhoe loader front buckets, twenty seven hundred pounds; the weight of a mid-sized automobile. A person working in an unprotected excavation eight feet deep on a sewer main could easily have 3-6 cubic yards (8,100-16,200 lbs.) bury him in a cave-in. The force of that impact could snap bones like matchsticks and crush soft tissue like gelatin. Even if the employee were to survive the initial impact, the weight of the soil on the chest and abdomen would typically prevent them from breathing, resulting in what is known as "compression asphyxia"; the leading cause of death in cave-ins. Additionally, there are those who survive the initial impact and are caught in a position where they can breathe long enough to be rescued, but sometimes die after extrication from complications resulting from trauma, or from the sudden restoration of blood circulation in what is known as "crush syndrome".

What are the true numbers?

As troubling as the numbers are, what is even more troubling is that, in some cases, they report totals that may be less than the true numbers. The databases are all insufficient to some degree. Small employers engaged in excavation activity, such as plumbing and light utility construction companies, may be exempt from the Bureau of Labor Statistic reporting requirements. Employees of political subdivisions of the states, who are outside federal OSHA jurisdiction, might not be counted. Employers who are not carrying Workers Compensation Insurance may not show up in the Workers Comp databases. Finally, even death certificates may fall short of providing the complete number of employees killed by cave-ins. Fatalities occurring as a consequence of cave-ins are often attributed to trauma, compression asphyxia, or drowning (if the event occurs in a submerged excavation) on the death certificate. As a consequence, the number of deaths reported by the standard databases may be less than the actual numbers. The databases have improved over the years, however. The numbers, while approximate, provide a reasonably reliable picture because the degree of accuracy or error tends to remain constant over the long term.

The data are certainly reliable enough to demonstrate trends and the impact of such events as the passage of affecting legislation. The studies conducted by OSHA during the revision of the Excavation Standard and during a special investigation in 2004 by the Office of the Directorate of Construction, as well as the numbers generated by other agencies also tracking construction accidents have demonstrated that the number of cave-in fatalities have dramatically decreased since the passage of the revised excavation standard (Figure 1).

OSHA Investigated Trench Related Fatalities

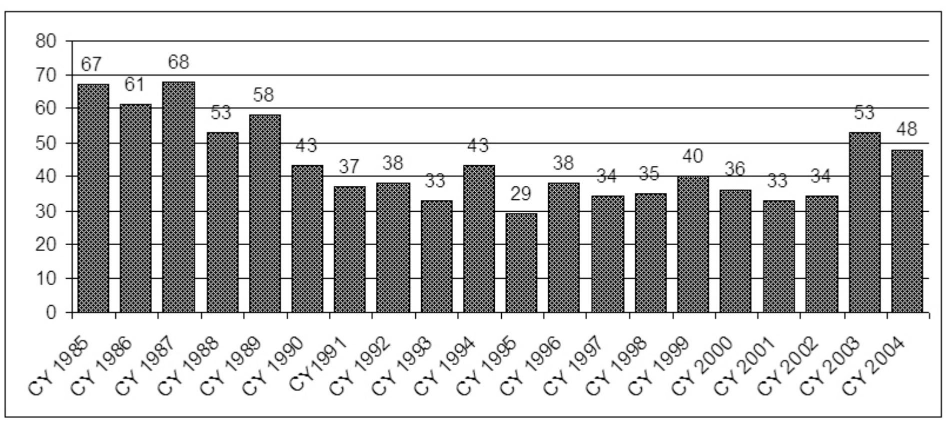

Figure 1

Further, the research has shown that now, as was the case thirty years ago, the accidents occur to employees who are either working in excavations without any protective system, or one where the protective system is clearly inadequate (Figure 2).

The Incident

The protective measure in this fatality was:

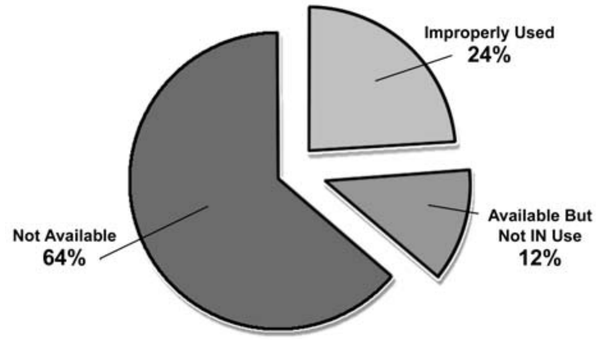

Figure 2

Source: OSHA Construction Directorate Office Review of 2003 Trench Fatalities

OSHA found that many, particularly the guilty, attributed the high frequency of cave-in fatalities to unstable soils and high volumes of construction activity. However, OSHA has been able to demonstrate that, even as far back as the 19th century, proven methods existed to protect workers in the poorest of soils. Further, work by those such as Dr. Dennis Perrotta of the Texas Department of Health, who undertook a study of cave-in fatalities in Texas in the 1980's, determined that the highest rate of cave-in fatalities occurred during periods of the lowest construction activity rather than during construction "boom" periods (Figure 3). A review of death certificates in Texas for 1976-1985 identified 93 fatalities resulting from 83 excavation cave-ins among male workers in that state. Thirty-five fatalities occurred in 30 incidents during the first five years (1975-1980), and 68 fatalities occurred in 51 incidents during the last five years (1981-1986). This is a 66 percent increase in the number of such deaths during the second five years.

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Dennis Perrota, Ph.D.
Director
Epidemiology Division
Texas Department of Health

Trench Fatalities in Texas

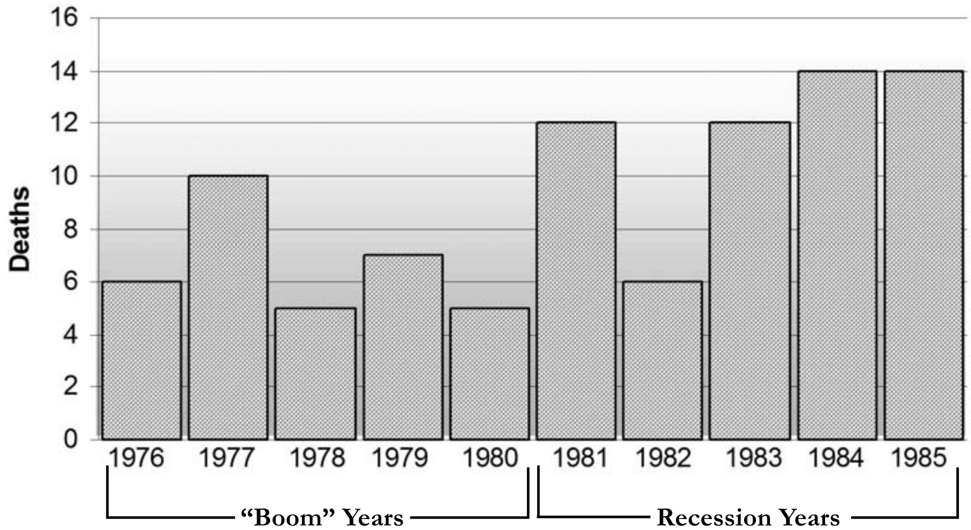


Figure 3

What history has clearly shown is that the real culprit is a triumvirate consisting of a lack of training leading to poor decisions concerning excavation safety practices, exacerbated by pressure to meet schedule and budgetary constraints. Simply stated, ignorance, stupidity and an unrealistic concern for time and money lead to dangerous corner cutting in order to get a job done cheap and fast. In the worst cases, some offenders considered the risks acceptable and the expense of the fines, accidents and fatalities the cost of doing business.

OSHA Takes Aim

By promulgating a new excavation standard, OSHA took direct aim on the problems of the past. OSHA eliminated the confusion that existed between trenches and other excavations by defining excavations to include trenches, thereby making all excavation requirements applicable to trenches. A single soil classification system was generated by the National Bureau of Standards (known in the OSHA Standard as Appendix A) and utilized in the sloping and shoring appendices as well as adopted by manufacturers of excavation safety equipment and excavation design engineers. Aluminum hydraulic shoring, which had gained significant popularity since the promulgation of the original standard, was included. Additionally, OSHA permitted the use of tabulated data, manufacturers' tabulated data, or site-specific designs provided by registered professional engineers as alternatives to the solutions provided in the standard. This not only provided a means for utilizing systems not included in the standard, such as sheet piling and slide rails, but also allowed for the development and utilization of future systems without requirement for a modification of the standard.

The Competent Person

Of critical importance was the role assigned to a special person on the jobsite; a person OSHA calls the "Competent Person". While there are many elements and roles involved in the creation of a safe work program, one of the most critical is that of the on-site supervisor. OSHA knew that if that supervisor cared as much about the safety of their employees as they did getting the pipe installed, the job would be a safe one. With the objective of putting the right person in that role, OSHA required employers to provide a competent person, which is defined as one, "…who is capable of recognizing existing and predictable hazards in the surroundings, and who has authorization to take prompt, corrective measures to eliminate them" on the excavation site. In the preamble to the standard, they further required that the competent person receive specific training in and be knowledgeable about: soils analysis, the use of protective systems, and the requirements of the standard.

It is interesting to note that in the OSHA Construction Directorate study of excavation fatalities occurring in 2003, the competent person was not on the site 86% of the time (figure 4). Clearly, the presence of a competent person when workers are at exposure is a critical element of a safe work program.

Was the competent person on the site?

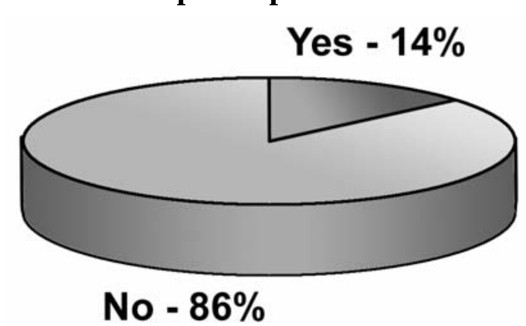


Figure 4

An Optimal Model

In the optimal model, the on-site supervisor would be assigned the role of the competent person and would be supported by the excavator operator, who could assume that role if the competent person had to leave the site or was preoccupied with other duties. The employees who would be at exposure would receive training in the recognition and avoidance of hazards, as well as the specific instruction of their protective system(s) and the safe work protocols which would allow them to work with the operator and supervisor to ensure that the work was done in a safe, compliant manner. For example, an employee working in an excavation who noticed that ground water was beginning to seep in would know to get out and call the problem to the attention of the competent person, who would immediately re-inspect the excavation and take any corrective action, such as increasing the slope of the excavation walls and pumping out the water, before anyone was allowed to re-enter.

Variations in the Model are Broad

The spectrum of variations on the model is obviously quite broad; a two man plumbing company repairing water main breaks differs greatly from a two hundred man highway/utility contractor for whom excavation is only part of the business. If multiple employers are involved on the same site, the issue is further complicated. None-the-less, OSHA expects each employer to take care of their own employees by providing the requisite training and a competent person to ensure their safety. In the case of a multi-employer worksite, OSHA would further expect coordination and cooperation amongst the employers involved to ensure that all employees were working safely during their particular part of the construction process.

These dramatic revisions in the OSHA Standard clearly impacted the number of excavation fatalities in the nation. Those who wished to comply finally had a standard that provided adequate resources and flexibility to allow them to do so. Those who did not, suddenly found that the excuses for not doing so in the past had been swept away.

Dramatic revisions to the OSHA Standard clearly impacted the number of excavation

Punishment for Non-Compliance

This, in turn, permitted the punishment for non-compliance to be more easily and severely applied. OSHA's revised penalty structure, in combination with excavations special emphasis status, allowed OSHA to assess fines of up to $70,000.00 per person at exposure in the most egregious cases. Fines totaling hundreds of thousands of dollars subsequently began to be assessed. While fines in that range could
easily devastate the finances of a non-compliant employer, they often proved to be only the tip of the iceberg. Increased workers compensation insurance rates resulting from the accident could severely impact a contractors ability to bid competitively. Further, bonding companies or safety conscious clients who reviewed contractors safety records as part of the bid or qualification process might exclude those with problematic histories. Finally, the non-compliant might find themselves squarely in the sights of two groups following closely on OSHA's heels who carried large clubs of their own; local criminal prosecutors and plaintiff's attorneys.

Combined Efforts in Texas

The combined efforts of OSHA, state legislators, local prosecutors and plaintiffs attorneys bear a notable testament in Texas. Texas is an interesting state, but sometimes for the wrong reasons. One of them is that Texas has led the nation in most categories of accidental deaths at one time or another. In some years during the 1980's, the rate of cave in fatalities in Texas was approximately eight times the national average. Houston typically laid claim to first place, followed closely by the Dallas/Ft. Worth and Austin/San Antonio metroplexes. In 1987, a Texas congresswoman named Ernestine Glossbrenner undertook correcting the problem by passing legislation affecting the manner in which excavation work was contracted and conducted. Ms. Glossbrenner's investigations had determined that approximately two thirds of the trenching fatalities had occurred on public sector utility projects. The reason was that, in far too many cases, the most irresponsible owners were married to the most irresponsible contractors under the vow of low bid. While a municipal contract might well require a contractor to abide by all federal, state and local statutes, the practical fact was that most city inspectors had little or no training in the requirements of the OSHA standard and were often told by city managers that safety issues were to be left to the contractor and OSHA. Insofar as the number of compliance officers in any OSHA office was generally exceeded by the number of counties they had to cover, the chances of an offender being caught and fined prior to the accident by OSHA were slim, and that fact was well known. Those who were prone to ignore safe work requirements did so and what resulted was a situation where unscrupulous contractors gained an unfair bidding advantage over their reputable counterparts by leaving the costs of safety equipment, training and programs out of the equation. Tragically, they were often rewarded with tax dollars for doing so.

Glossbrenner Seeks to Reverse Unfair Bidding Advantages

Ms. Glossbrenner sought to reverse the course by passing House Bills 662 and 665 in 1987. HB 662 required that, on construction projects where the depth of the excavation would exceed 5 feet, both the bid documents and contract must contain detailed plans and specifications which met the OSHA Standard, and that those plans must include a pay item for trench safety. It was believed that the use of a plan would ensure worker safety, as well as provide inspectors with a guidance tool for enforcement, and that the pay item would eliminate any contractor objections to the use the plan. Contractors were, after all, in the business of making money. Identifying trench safety as a pay item in the contract both declared its necessity and rewarded the contractor for taking measures to ensure it. HB 665 allowed for the inclusion of the bid requirement of HB 662 in building codes. The bills were enacted in September of 1987, a year in which fifteen people died in cave-ins. In 1988, the number dropped to two. In 1989, the number was zero.

House Bills Not Without Problems

Despite their impressive record, the bills were not without problems. Questions such as who was going to design the plan and whether the only person submitting it should be the successful bidder quickly arose. Liability, a matter everyone wished to attempt to foist off on someone else, became a subject of great concern. In an attempt to resolve these and other issues, Ms. Glossbrenner enacted HB 1569 in the fall of 1989. That bill eliminated the requirement for trench safety plans, making them a matter of option. The bill did retain the requirement for a pay item for trench safety, a reference to the OSHA Standard, a copy of any available geotechnical information and any specific shoring requirements of the political subdivision, but the requirement for plans was eliminated. The created much cause for concern among those who supported the use of trench plans. They were fearful that the State was poised to return to the dark days and fatality rates prior to 1988. Fortunately, that did not prove to be the case, for several reasons.

First, the major municipalities who were using trench safety plans liked them and continued to use them. The inspectors had a useful tool in the form of a clear drawing to help them enforce the safe trenching intent of the law. Second, the revised OSHA Standard was enacted, which required that employers either used methods provided by the OSHA Standard, or by a Registered Professional Engineer. Third, local prosecutors and plaintiff's attorneys had made clear that they could likewise hold the offenders and those who permitted them to work in violation of the law accountable.

A County Attorney Takes Action

Ken Oden, the Travis County Attorney, was also alarmed by the trench fatality rates of the 1980's. He likewise noted that OSHA had criminally prosecuted only a handful of employers in their history and imprisoned only one. It seemed clear to him that OSHA could not be relied upon to prosecute the guilty so he took it upon himself to do so. In 1987, he and his assistant, Alia Moses, successfully prosecuted three contractors whose unsafe trenching practices led to deaths on their jobs in the Austin area: Sabine Consolidated, Peabody Southwest and Joe Bland Construction. The appeals took some four years to settle, but the State

Ken Oden, the Travis County Attorney, was alarmed by the fatality trench rates of the 1980's. It seemed clear to him that OSHA could not be relied on to prosecute the guilty so he took it upon himself to do so.

finally decided that the prosecutions did not represent a pre-emption of OSHA and were within the bounds of the County Attorney's authority. A final appeal to the United States Supreme Court in December of 1992 resulted in the convictions being allowed to stand. This sent a shock wave through the industry. Contractors who once thought they might be able to fold their tent and slip away to establish business under another name in another location now knew they personally could face criminal prosecution and imprisonment.

The Final Blow

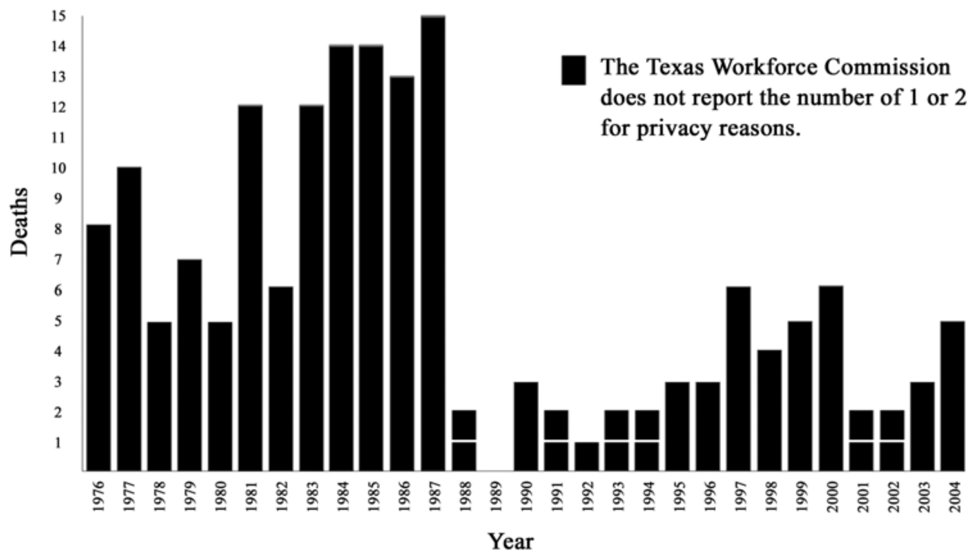
The plaintiff's attorneys delivered the final blow. Trench fatalities had long been a favorite of plaintiff's attorneys because employer negligence was almost always a given. Again, the investigation of the accidents showed that, in nearly all cases, no protection, or clearly inadequate protection was provided. Plaintiff's attorneys found them simple to win. Those who hired the contractors typically felt that they were protected from prosecution by the use of clauses in the contract indemnifying them from the actions of the contractor. Much to their chagrin, they discovered that was not the case, as the attorneys began to ensnare them in their nets, as well.

Carmen Mitchell, a Dallas based attorney who successfully sued a contractor and the City of Grand Prairie, Texas in the wake of a cave-in in which a sub-contractor's employee was injured notes that,

> "*Regardless of how many times a witness recites the incantation that the contractor used his own ways means and methods, he will not be believable if he contends that the city does not have some control over the contractor. It simply flies in the face of logic that a city paying hundreds of thousands of dollars for a job does not have the right to control the party who is installing it*". *(C. Mitchell "Legal Aspects of Trench Failure)*

What the record has clearly shown is that when conscientious owners hire conscientious contractors who use means and methods required by the law, the fatalities stop. If the disreputable find sanctuary where they are permitted to avoid their responsibilities, however, they continue to occur. Figure 5, below shows the record of trench fatalities in Texas prior to and after the efforts of local legislators, prosecutors, and the enactment of the revised Federal OSHA Standard.

Trench Fatalities in Texas



Sources:

1976-85
State Dept. of Health

1986-87
Travis County Attorney's Office

1988-92
TEEX – network

1993-2002
Texas Worker's Compensation Commission

A Thumbnail Sketch of the OSHA Standard for Excavations

OSHA Standard 29 CFR 1926.650-652
Subpart P

OSHA is the Occupational Safety and Health Administration, which is an agency within the Federal Department of Labor. They are charged with promulgating and enforcing the safe work regulations, which are found in Title 29 of the Code of Federal Regulations, which is the Labor title. Part 1926 contains the regulations for the Construction Industry. Sections 650-652 contain the Excavation regulations, which are also known as Subpart P.

Scope and Application

This standard applies to all open evacuations made in the earth's surface. Excavations are defined to include trenches.

Excavation

Any man made cut cavity, trench or depression in an earth surface, formed by earth removal.

Trench Excavation

A narrow excavation (in relation to its length). In general the depth is greater than the width, but the width of a trench (measured at its bottom) is not greater than 15 feet.

General Requirement for Protection

Each employee is an excavation five feet deep or deeper shall be protected from cave-ins by an adequate protective system, unless the excavation is made entirely in stable rock.

Under 5 Feet

Under 5 feet, the requirement for a protective system is a judgment call for the "Competent Person."

Competent Person

Means "…one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous or dangerous to the employees and who has authorization to take prompt corrective measures to eliminate them."

Note: The primary candidate for the Competent Person role is the onsite supervisor, backed up by the backhoe or excavator operator.

Training Requirements for the Competent Person

In the preamble to the Standard, OSHA says that, "… for the purposes of this standard, one must have had specific training in and be knowledgeable about soils analysis, the use of protective systems and the requirements of the standard. One who does not have such training or knowledge cannot possibly be capable of recognizing existing and predictable hazards in excavation work or taking prompt corrective measures."

In Subpart C, OSHA also requires that all employees be trained in the "recognition and avoidance of hazards", so they will not unwittingly expose themselves to unsafe conditions.

Specific Responsibilities of the Competent Person

- Conducts tests for soil classification
- Understand standards and any data provided
- Determine proper protective system
- Recognize and reclassify soil after changes in conditions
- Determine whether damage to excavation safety equipment renders it unusable
- Conducts tests for hazardous atmospheres
- Design of structural ramps*
- Location of underground installations/utilities
- Monitor water removal equipment and operation*
- Perform daily inspections
- Determine the necessity for a protective system if less than 5 feet deep

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General Responsibility of the Competent Person

It is the general responsibility of the Competent Person to ensure that all aspects of the excavation process are in compliance with the excavation standard and the General Duty Clause of the OSHA Act (5a1.), which requires the employer to provide a safe, healthful workplace, free of unknown or recognizable hazards.

Options of the Competent Person

1. Use the OSHA Standard for guidance with:
   - Sloping
   - Shoring with timber or aluminum hydraulic shoring
   - Shielding

2. Use a Registered Professional Engineer to provide:
   - Tabulated data
   - Manufacturers tabulated data
   - A site specific design *

   * Must be registered in the state where the work is being done.

Registered Professional Engineers must be used if:

- The excavation is deeper than 20 feet
- An "alternate system" (such as sheet piling) that the Standard does not provide guidance for is used
- If the excavator is at "variance" with the Standard (i.e. doing less than the standard requires)

Note: OSHA expects that the engineer will be registered in a related area, such a civil, mechanical, geotechnical, or architectural engineering.

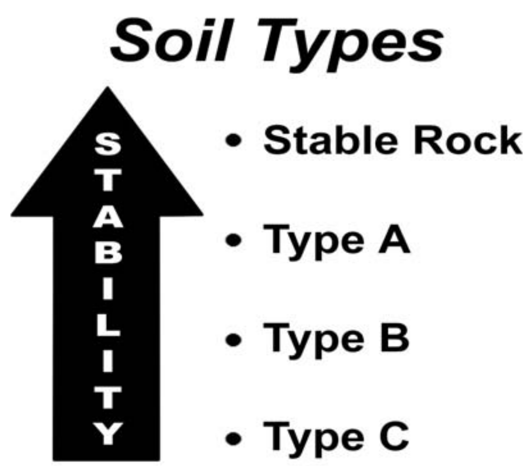
It is a 'Show Me In Writing' Standard

Excavation protection solutions must either come from the OSHA Standard or a Registered Professional Engineer.

Using the resources of the OSHA Standard in lieu of engineered plans

When OSHA revised the Excavation Standard, they knew full well that most jobs would not require a site-specific plan drafted by a registered professional engineer. Many jobs would be fairly simple and straightforward in nature. In those cases, OSHA allows the contractor to use tabulated or manufacturers tabulated data (discussed above), or the resources of the Excavation Standard itself. Appendix A of the revised Excavation Standard provides a soil classification system that allows the contractor to identify the soil "Type" present on their site. They also provide Tabulated Data for the use of sloping, timber shoring and aluminum hydraulic shoring, and guidance for the use of shield systems that would be used in conjunction with the engineered data provided by the manufacturer or designer of the shield.

OSHA enlisted the aid of the National Bureau of Standards to create their soil classification system. It was their intention to make the system as easy as possible for the non-engineer to use; literally, one as easy as ABC. What they developed came to be known as the simplified soil classification system, one that consists of 4 Types: stable rock, and Types A, B and C. Stable rock was the most stable type, followed in decreasing order by A, B, and C.



OSHA provided definitions for each soil type, as well as a series of manual and visual tests to be performed by the Competent Person to determine the type (or types) of soil present on their site. The competent person is required to make at least one manual and one visual test to determine the soil type. Note: the competent person should not enter an unprotected excavation to test the soil. They should test freshly excavated material from the spoil pile. The competent person should be mindful that the soil type might change from the top to the bottom of the excavation, and from end to end. They should test each different layer or zone to see if a change in the soil classification is warranted.

Once the competent person determines the soil “type”, they can turn to the other appendices in the Excavation Standard for specific guidance with sloping or shoring systems.

Stable Rock

Stable rock is defined as natural, solid mineral matter that can be excavated with vertical sides and remain intact while it is exposed. As noted earlier, many believe rock to be stable simply because it is hard. That is simply not true. If the rock is fractured, faulted or fissured, if the rock consists of beds that are inclined steeply into the excavation, if some of the beds are grease layers such as coal or mudstone, if water is seeping through the layers, it might become unstable and fail as soon as the excavation is opened. Blasting and rock sawing might further destabilize the rock. It is for good reason the departments of transportation place, “Danger, Watch Out for Falling Rock”, signs alongside roadways and use such methods as building fences or barrier walls at the base of rock faces to prevent their failure from harming motorists.

Most rock has stability problems. The competent person should downgrade unstable, dry rock to Type B, and unstable wet or submerged rock to Type C. If a contractor believes they truly have Stable Rock, as they might if they were excavating a single, monolithic, horizontal bed or layer, they should still examine it closely for evidence of weak zones, and consult a geotechnical engineer to confirm its stability, or obtain guidance for making it so.

Type A Soil

Defined as:

1. Cohesive soil with an unconfined compressive strength of 1.5 tons per square foot or greater (these would be hard clays). Examples of cohesive soils are clay, silty clay, sandy clay and, in some cases, silty and sandy clay loams.

2. Cemented soils, such as caliche and hard pan, are also considered to be Type A (because of their high unconfined compressive strength).

However, no soil is considered to be Type A if:

1. It is fissured

2. The soil is subject to vibration from heavy traffic, pile driving, or similar effects.

3. The soil has been previously disturbed.

4. The soil is part of a layered system (cracks or fissures count as layers) where the layers dip into the excavation on a slope of 4 horizontal to 1 vertical or greater.

5. The material is subject to other factors that would require it to be classified as a less stable material.

The exclusions for Type A typically eliminate the possibility of its existence on a construction site. Practically speaking, B is the optimum soil type than can be expected. Simply stated, B is the best it can be.

Type B Soil

Defined as:

1. Cohesive soil with an unconfined compressive strength greater than .5 but less than 1.5 tons per square foot (this would be medium stiff clay).

2. Granular cohesion-less soils including angular gravel, silt, silt loam, sandy loam and, in some cases, silty and sandy clay loams.

   Speed Shore Note: #2 is a troublesome definition. As will be seen in the Type C definitions, most granular cohesion-less soils are classified as type C and it is our view that all of them should be. Angular gravel may well stand at the slope profile dictated for Type B soils by the OSHA Standard, but it cannot be shored in the manner of a Type B soil by such systems as timber when gaps are left in the uprights or sheeting. Silty and sandy clay loams have enough clay to exhibit cohesive behavior and shouldn't be classified as granular cohesion-less soils at all. Silt, the finest of the granular soils, will sometimes exhibits cohesive behavior and one particular kind of silt known as a loess is characterized by its ability to maintain near vertical slopes but is subject to failure when disturbed by excavating or the imposition of surcharge loads. For these reasons, we recommend that all granular cohesion-less soils be classified as the worst case, Type C, in order to safeguard workers.

3. Previously disturbed soils except those that would be classified as Type C soil.

   Speed Shore Note: This is probably this most misunderstood definition in Appendix A. It is OSHA's view that a previously disturbed soil never returns to its original state and should, for that reason, be automatically downgraded to Type B soil. This is the reason they say Type B is a previously disturbed soil. The additional verbiage that says "…except those that would be Type C soils", refers to further downgrading the soil due to other reasons such as an unconfined compressive strength below .5 tsf or submersion. A common misperception is that all previously disturbed soil is Type C soil. That is simply not what the definition says. A previously disturbed soil cannot be Type A. It is automatically downgraded to Type B, but only further downgraded to Type C if other conditions require it.

4. Soil that meets the unconfined compressive strength or cementation requirements for Type A but is fissured or subject to vibration.

5. Dry rock that is not stable.

6. Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep that four horizontal to one vertical or greater, but only if the material would otherwise be classified as Type B soil.

Type C Soil

Defined as:

1. Cohesive soil with an unconfined compressive strength of .5 tsf or less (this would be a soft, wet, clay).

2. Granular soil including gravel, sand and loamy sand.

3. Submerged soil or soil from which water is freely seeping.

4. Submerged rock that is not stable.

5. Material in a sloped, layered system where the layers dip into the excavation on a slope of 4 horizontal to one vertical or greater.

Practically speaking, there are only two soil types that can be present on a jobsite; Types B and C. Relatively stiff cohesive (clay rich) soils, or cemented soils that are free of fissures or layers dipping into the excavation at a slope of 4 horizontal to 1 vertical or greater are Type B soils. Loose granular soils such as sand or gravel, soft wet clays, or cemented or clays soils with fissures that dip into the excavation on a slope of 4 horizontal to 1 vertical or greater are Type C soils.

In some cases, a competent person may have their soil type determined for them. For example, it is common for a refinery located on the coast to declare their site “C by Decree”, due to the presence of a water table near the surface, the effect of daily tides on the water content of the soil, and the enormous amount of soil mixing that occurs on such sites as a result of continual maintenance and construction operations. Contractors working in areas such as southern Louisiana where rain and groundwater are continually present often use protective systems for Type C soil automatically; as they know they will encounter wet soil conditions routinely and plan for them from the outset. It is perfectly fine with OSHA for the contractor to simply declare “worst case”, i.e. Type C, and go forward with protective systems designed for those soils.

If a contractor has a Type B soil, however, and may rely upon weather and water conditions allowing it to remain Type B for the duration of the work, there is nothing wrong with declaring it Type B and using protective systems intended for that Type. However, a competent person cannot just declare the soil Type B; they must prove that it is Type B by performing a series of manual and visual tests on the soil to verify it.

Protective Systems: Sloping, Shoring & Shielding

The OSHA Standard provides guidance for the use of three protective systems: sloping, shoring (with timber and aluminum hydraulic shoring systems) and shielding. After determining the soil type(s) on their construction site, the competent person can refer to the Standard for guidance in the correct use of those systems.

Sloping

Sloping prevents cave-ins by removing the unstable wedge of soil from the walls of an excavation. Excavators are typically used to slope the walls back to a safe angle from which they will not fail. OSHA incorrectly used the term "angle of repose" in the first excavation standard for that angle. Angle of repose is actually a stockpiling term. If dry soil is run up a conveyor and dropped, it will form a cone whose sides will automatically form the angle of repose. Since the term is properly a stockpiling term, OSHA substituted the term safe angle in the new standard. The safe angle is the angle at which the soil will stand. OSHA also uses the term maximum allowable slope, which is the maximum angle, measured from the horizontal, that they permit for a given soil type, and actual slope, which is the actual angle, measured from the horizontal, of the sloped wall.

The requirements for sloping are found in Appendix B of the excavation standard, which is found elsewhere in this manual. The OSHA Standard provides for four sloping options:

1. Slope the excavation 1 ½ horizontal to 1 vertical. In this case, the competent person will slope the excavation as though it were a Type C, worst case soil. If the competent chooses this option, they are not required to classify the soil, as they will be defaulting to a worst case condition.

2. Classify the soil using Appendix A of the excavation standard, and then use the sloping chart and diagrams in Appendix B to design the slope.

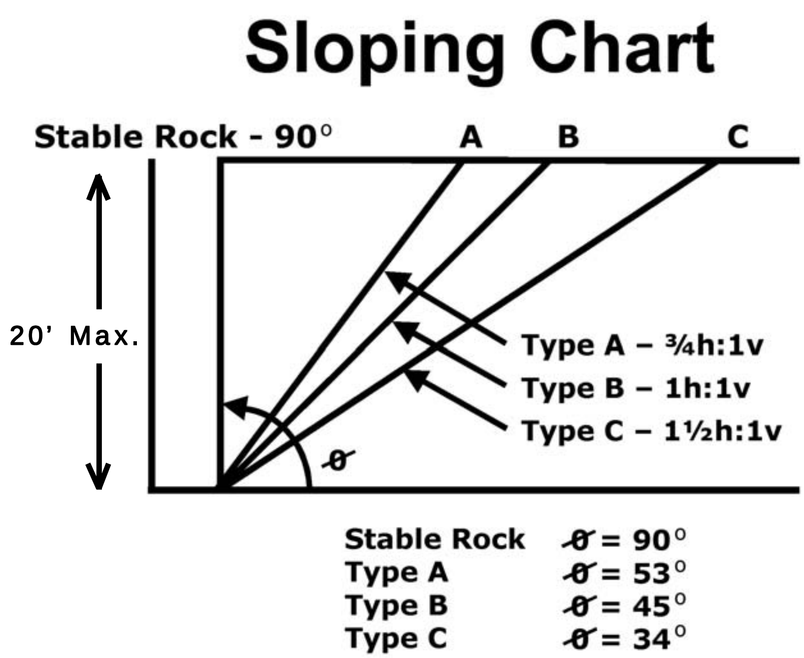
3. Use tabulated data, created by a registered professional engineer, to design the slope.

4. Use a site specific design prepared by a registered professional engineer.

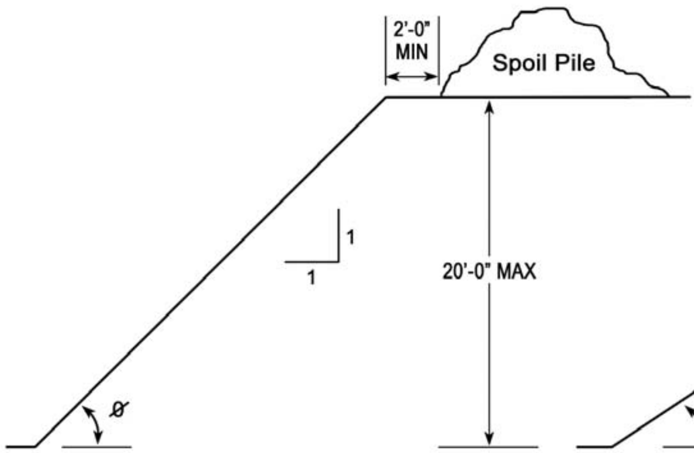
Option 1 is a common practice, particularly on the part of contractors whose jobs are of sufficient duration to anticipate weather conditions turning the soil to Type C during the course of the work. If the excavation is sloped for Type C, they simply have to eliminate any accumulated water, inspect the excavation to ensure the slope profile is performing as intended, and return to work. Likewise, some plant sites where continuous construction activity resulting in the mixing of a variety of soils over the years is coupled with a high annual rainfall, ground water and tidal flows declare themselves "Type C by decree" to ensure that workers will always be safe by preparing for worst case conditions.

Option 2 is the one most commonly used, especially when the contractor is confident that weather and groundwater conditions are such that they may rely upon the soil to remain the same "Type" for the duration of the job. Stable rock and Type A soil are not often found on construction sites, so the contractor typically determines whether they have a Type B or C soil, then refer to the chart and diagrams of Appendix B to design their slope. It is important to remember that a single rain shower can turn Type B into Type C soil by either causing it to soften into the unconfined compressive strength range of Type C soil, or become submerged, which is a definition of Type C soil. In such an event, the contractor who had classified their soil as Type B and proceeded to slope on that basis would have to either wait until the soil returned to a Type B condition by drying out, or re-slope their excavation for Type C soil.

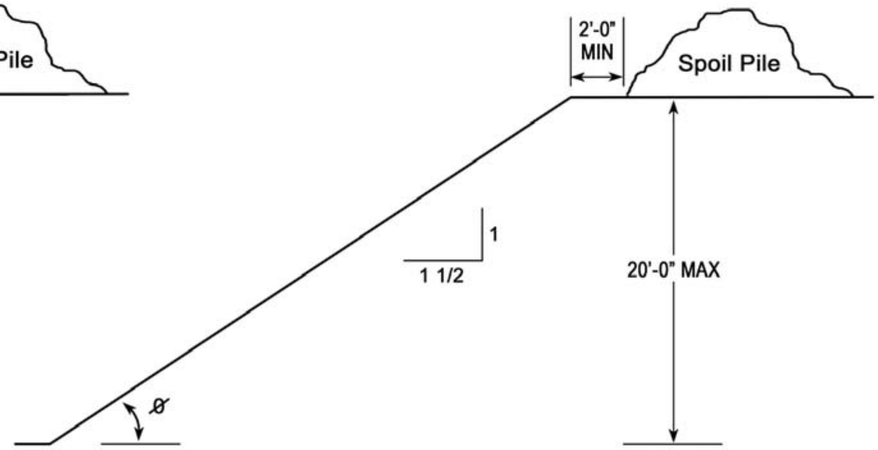
The OSHA standard assigns the following slopes to the four soil types:



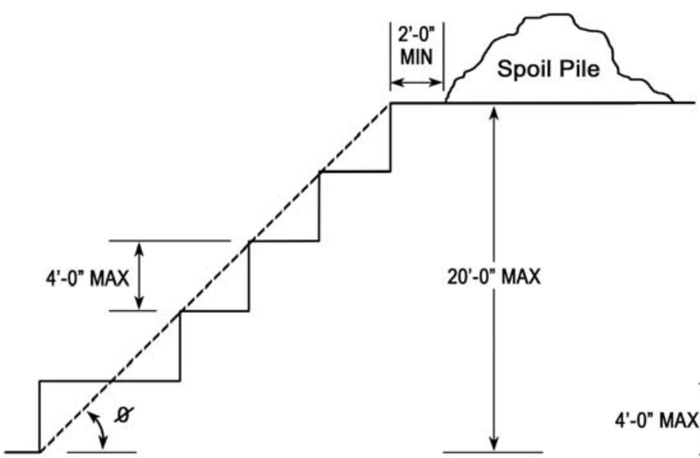
SLOPING - TYPE B SOIL



SLOPING - TYPE C SOIL



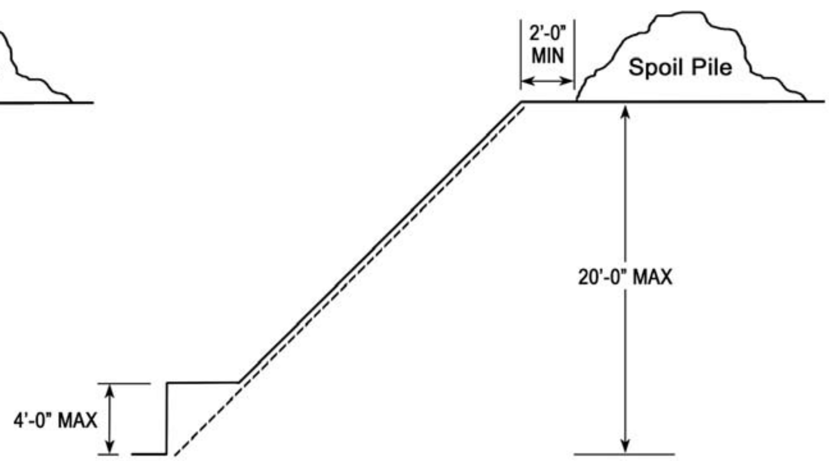
BENCHING



Ø = 45° FOR TYPE B SOIL

NOTE: BENCHING IS NOT PERMITTED IN TYPE C SOIL, ONLY TYPE B

BENCHING AND SLOPING

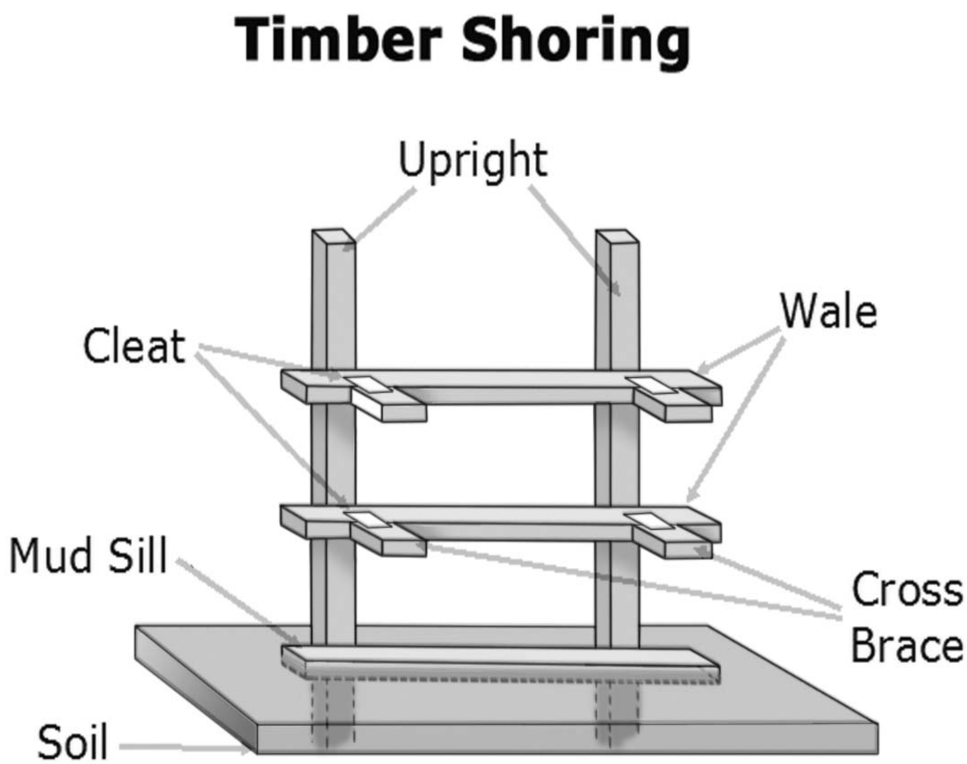


OSHA provides guidance for the use of Timber Shoring in Appendix C.

Note #1: The timber must be full dimensional Oak or normal dimensional Douglas Fir or equivalent.

Note #2: The shoring must be constructed using the dimensions and spacing required by OSHA's Shoring Charts or one designed by a registered professional engineering.

The OSHA Shoring Chart for Type B soil using Oak timbers is on the next page.



Soil Type B Pa = 45 x H + 72 psf (2ft surcharge)

Depth of Trench (ft)	Size (actual) and Spacing of Members[1]													
	Cross Braces							Wales		Uprights				
	Horiz Space (ft)	Width of Trench (ft)					Vert Space (ft)	Size (in)	Vert Space (ft)	Max Allowable Horiz Spacing (ft)				
		Up to 4	***Up to 6***	Up to 9	Up to 12	Up to 15				Close	2	3		
5 to 10	Up to 6	4 x 6	***4 x 6***	6 x 6	6 x 6	6 x 6	5	6 x 8	5			2 x 6		
	Up to 8	***6 x 6***	***6 x 6***	***6 x 6***	***6 x 8***	***6 x 8***	***5***	***8 x 10***	***5***			***2 x 6***		
	Up to 10	6 x 6	***6 x 6***	6 x 6	6 x 8	6 x 8	5	10 x 10	5			2 x 6		
	See Note 1													
10 to 15	Up to 6	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	5	8 x 8	5		2 x 6			
	Up to 8	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	10 x 10	5		2 x 6			
	Up to 10	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	5	10 x 12	5		2 x 6			
	See Note 1													
15 to 20	Up to 6	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	8 x 10	5	3 x 6				
	Up to 8	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	5	10 x 12	5	3 x 6				
	Up to 10	8 x 10	8 x 10	8 x 10	8 x 10	10 x 10	5	12 x 12	5	3 x 6				
	See Note 1													
Over 20	*See Note 1*													

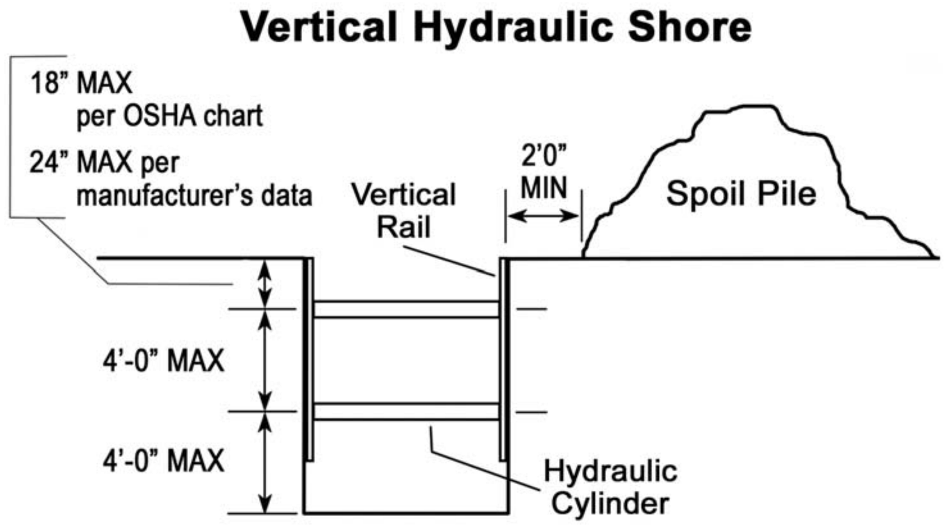
Figure 1: Timber Trench Shoring — Minimum Requirements[2]

(Footnotes)

[1] Mixed Oak or equivalent with a bending strength not less than 850 psi.

[2] Manufactured members of equivalent strength may be substituted for wood.

Aluminum Hydraulic Shoring



Aluminum hydraulic shoring is a system that uses extendable aluminum cylinders operated by fluid pressure to support the walls of an excavation. The walls of the excavation are literally jacked apart and supported by the cylinders. Invented in the late 1950's, they were pioneered by the Speed Shore Corporation in the 1960's. The light weight, ease of installation, multiple configurations and ability to compress the soil (which increased its stability) resulted in hydraulic shoring becoming a very popular method. When OSHA revised the excavation standard, they decided to include two kinds of hydraulic shoring systems (vertical shores and horizontal walers) in what became Appendix D. The vertical shore mounts two cylinders in aluminum rails and is used in a vertical orientation. The horizontal waler mounts two cylinders in aluminum rails used in a horizontal orientation with sheeting behind the rails.

The manufacturers of aluminum hydraulic shoring all make their vertical shores and wales so that they can be used in the manner required by the Standard. Manufacturers also generate their own tabulated data to provide additional options for vertical shores and walers, and for other systems not covered by the Standard, such as single shores and 4-way manhole braces. The single shore is a single cylinder mounted to two short foot pads, or rails. The four-way manhole brace uses four, 2 or 3-inch cylinders mounted in steel sleeves which, when connected together, creates a 4-sided bracing system which can support square or rectangular excavations.

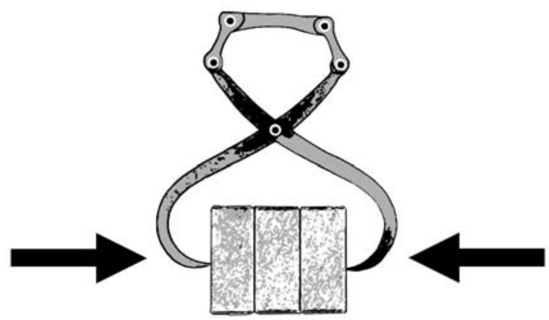
The Standard requires that the cylinders be a minimum of 2 inches in diameter, and have an axial compressional load rating of at least 17,000 pounds. The aluminum rail to which the cylinders are attached must be 6061t aircraft grade aluminum. Heavy-duty 3-inch cylinders can also be used to support trenches up to 15 feet in width.

The OSHA Standard, and Speed Shore's manufacturers tabulated data appears elsewhere in the standard, but there are a number of points that bear consideration here.

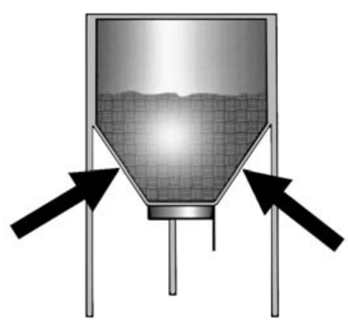
1. Hydraulic shoring is installed and removed from the top of the excavation; no employee exposure is required. Special installation tools (hooks) are used to install vertical and single shores and release the hoses. Walers are typically installed by backhoes using standard rigging bridles.
2. The spacing of the cylinders is the critical factor. The standard requires that the top cylinder on a vertical shore be no more than 18" from the top of the excavation. Manufacturer's data allows the top cylinder to be between 12" and 24" from the top. There can be a maximum of 4 feet vertical spacing between the cylinders on a vertical shore installation. The bottom cylinder on a vertical shore can be no more than 4' above the bottom of the trench. The horizontal spacing between the cylinders is a function of soil type and depth and is found in the tabulated data.
3. For waler systems, the top cylinders, or center line of the rail, can be no more than 2 feet below the top of the trench. There can be a maximum of 4' vertical spacing between the waler systems vertically, and the bottom waler can be no more than 4 feet above the bottom of the trench. The "section modulus" column of the waler charts in the OSHA Standard refers to the size of the rail in cross section and corresponds to light, standard and heavy-duty rail. As the rail size increases, the horizontal spacing between the cylinders also increases.
4. OSHA requires 3"x12" timber uprights as sheeting for waler systems, but manufacturers provide alternatives such as aluminum and fiber composite materials.
5. There is a 20,000 pound surcharge load limit from equipment alongside the excavation when OSHA's charts are used.
6. Three vertical shores, evenly spaced in a group and equally pressurized are required by OSHA to make a system, but manufacturers' data will allow the use of two.
7. The fluid used in these systems is a bio-degradable, environmentally friendly formulation.
8. The Standard provides charts for the use of vertical shores in Types A and B soils, and the use of waler systems in Types B and C. Manufacturers will allow the use of vertical shores in the better range of Type C soils, known as C-60 soil. For a full explanation of C-60 soil, please refer to the manufacturer's tabulated data section of this manual.

9. Plywood may be used for sheeting to control local raveling, or sloughing, of the trench face, but it is not intended as a structural member. In other words, it is not a requirement to use it if there is no raveling of the trench wall between the shores. If plywood is used, however, it must be 1 1/8" thick softwood or ¾" hardwood (Fin-Form) plywood. Manufacturers' data provides alternative sheeting, including two sheets of ¾" softwood plywood.

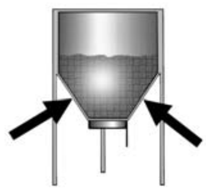
The question is often asked, "Why is no sheeting required in between adjacent vertical shores? Won't the soil fall out between them?" The answer is no. When the cylinders are pumped out and the soil is compressed, the soil becomes more stable due to a principle known as soil arching. If you have ever observed brick masons carrying brick in a brick clamp, you know that as long as the lateral pressure exerted by the clamp exceeds the pull of gravity, the row of brick will not fall out of the clamp.

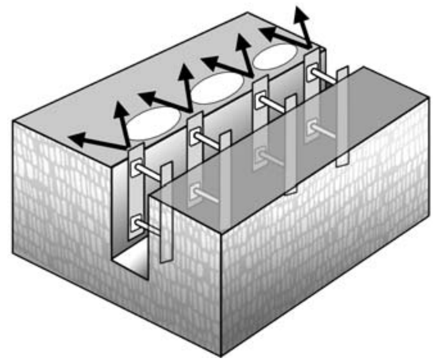


The lateral pressure can be applied at a more oblique angle to produce the same result. Consider the silo. Sometimes, when the gate is opened, the material is too tightly compressed by the configuration of the silo to allow it to flow out.



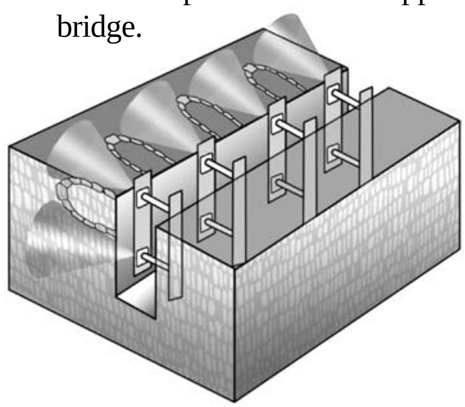
When the shores are pumped out against the trench walls, they produce the same effect. They not only push directly into the walls, but at angles. The space between the shores where the soil is being compressed at an angle corresponds to the space at the gate of the silo.

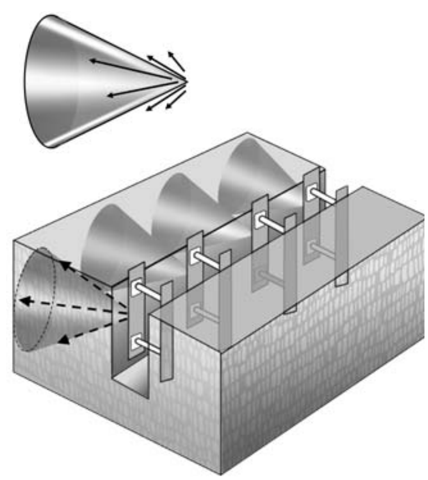




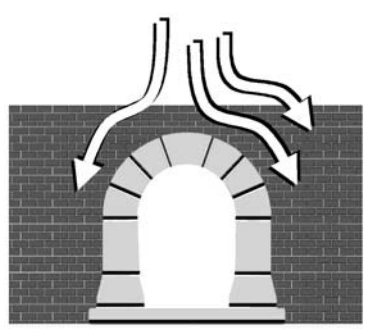
One might ask, “That’s fine for the face of the wall, but how about the weight of the wall bearing down behind the face, particularly as you get deeper?

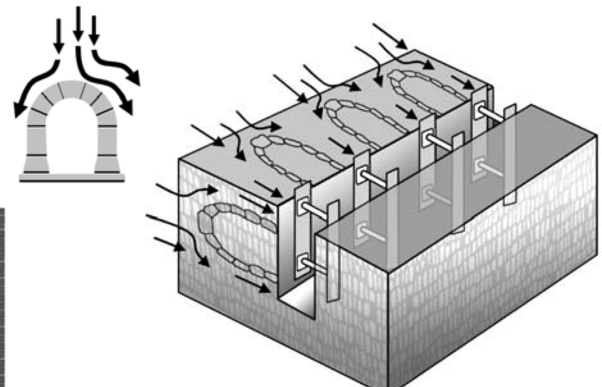
That’s the other interesting aspect of soil arching. When the cylinders compress the soil, they create 360 degree compression cones in the walls that link up to create what appears to be a structure much like an arched bridge.





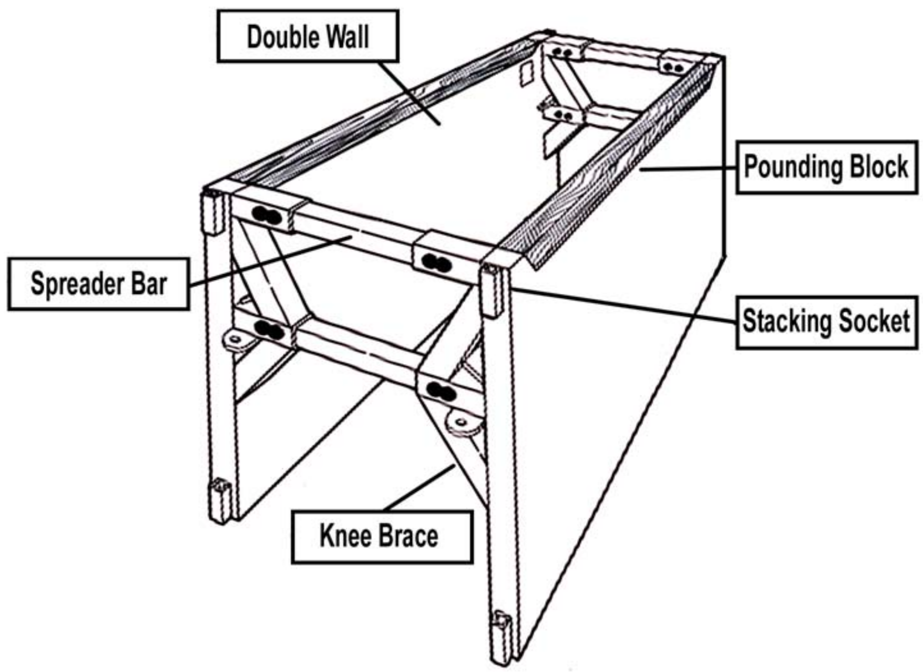
When a load is imposed on an arch, the arch transfers the load to the legs. The compression cones likewise transfers the load of the wall to the cylinders. It is on the cylinders, not in the gaps between them, that the load rests.





Shield Systems

Shield Systems



Shield systems differ significantly from sloping and shoring systems in that they are not designed to prevent cave-ins, but rather to protect the workers when a cave-in occurs. In a real sense, they function like bomb shelters. They are structures, typically "box-like" in design, that are placed in the excavation to provide worker protection. They typically consist of two flat, parallel walls supported by cross braces (known as spreader bars). If a point repair is required, the contractor simply excavates around the damaged area, and lowers the shield in on top of the pipe to provide a safe workplace. If installation of a new pipe service is required, the contractor excavates the area for the installation of the first joint, and then lowers the shield in place. After the first joint is installed and aligned, the excavator backs up, excavates in front of the shield, then pulls it forward by either pulling on the spreader bars, or a pulling bridle attached to pulling lugs on the front of the shield. After the next joint of pipe is installed, the process is repeated. Contractors typically cover the pipe with the fill material as the box is pulled forward. This is what is known as a cut and cover operation. At the end of the day, the trench is closed up to the shield, keeping the right of way requirements minimized. In unstable soils, the contractor may have to dig until the soil begins to fail, then install the shield and force it downward by pushing on the pounding blocks atop the side-walls as they excavate to deeper levels.

Shields have become the preferred means of providing worker protection when possible, due to their ease of use, the minimum time required to install move and remove them, the minimum right of way requirements, and the fact that they can be used in unstable soils where vertical walls can't be relied upon.
OSHA does not provide an Appendix for the use of shield systems. What guidance they do provide is found in the General Requirements for Protective Systems in 1926.652. Those paragraphs require the following:

1. Shields must be designed by a registered professional engineer. A copy of the design, with the identity of the engineer who provided it must be made available to OSHA upon request. Few contractors design and build their own shields. Most rent or buy them from manufacturers who provide written certifications for their products. The certifications may also appear in the form of plates affixed to the shield. OSHA compliance officers like to match the numbers on the shield to the numbers on the certification documents.

2. Shields cannot be used in excess of the loads they are rated for. Never use the shield at a depth greater than the rating provided by the certification. Never increase the height or length of the shield walls by installing metal plates above, below, or behind them unless a registered professional engineer has approved it in writing. Be wary of shields that limit the use of the shields to anything other than C or C-80 soils or do not permit its use in a trench for over 24 hours. In most cases, contractors expect their shields to stay in use until the job is complete, and to bear worst case weather conditions (read C soils).

3. You cannot make any additions to, any subtractions from, or any alterations to any shield without written consent from the manufacturer or designing engineer. This includes stacking pins for stacker shields and keeper pins.

4. Any structural damage, such as bending a spreader bar or breaking a socket weld, is cause for taking the shield out of service until repairs have been made in accordance with manufacturer's guidelines and requirements.

5. Shields must be installed in a manner to restrict lateral movement. While OSHA does not officially permit a gap between the shield wall and the excavation, they are aware that the contractor intends to raise, lower and pull the shield, so they "unofficially" allow about 4" as long as there is no danger of an employee being injured if the box were to shift the distance of that gap if a cave-in were to occur.

6. If the shield does not reach the top of the excavation, the section above the shield must be sloped to a point at least 18" below the top of the shield, or, if the shield is designed for use in a stacking configuration, a second shield may be stacked atop it.

7. Workers may remain inside a shield when it is pulled forward, but they cannot remain in it when it is installed, removed, or raised vertically.

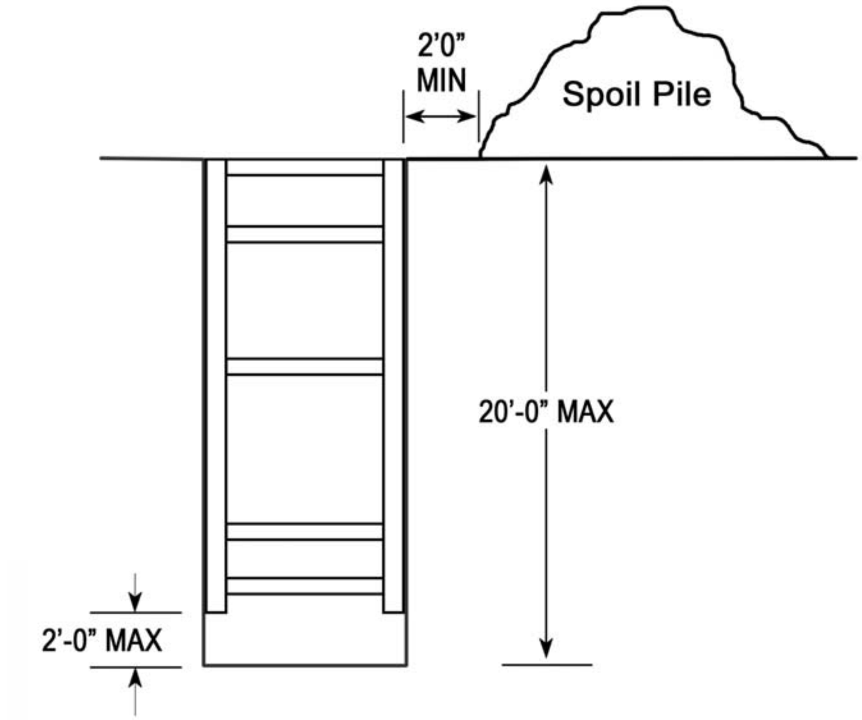
8. Workers must enter and exit the shield in a protected area, which is to say a ladder used for that purpose must be inside the shield, not outside it in the unprotected trench.

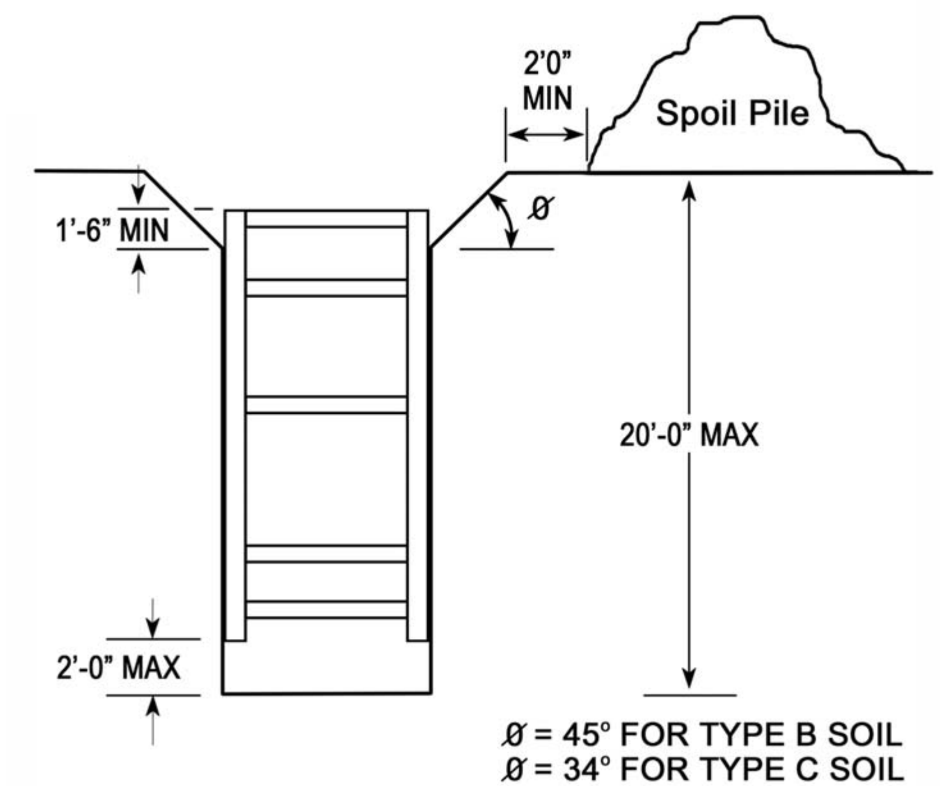
9. Shields may be raised two feet off the bottom of the trench as long as it is rated for the full depth of the excavation, and as long as no soil caves out from under it.

10. The workers must not be exposed to walls at the end of the trench. If the trench cannot be sloped in front of the shield, end plates must be installed to protect the workers from cave-ins at the open end.

Shield systems come in an enormous variety of sizes and configurations. Lightweight shields may be constructed of aluminum or fiber composite materials. Some shields, known as manguard rings, are round in shape. Shields may have cut out panels to allow pipe to be installed through the sides or under closed end plates. Other may have special high clearance spreader bars or arched spreaders to allow for clearance over large diameter pipe. Manufacturers continue to modify and create shield systems to meet the needs of constructors.

Shield Installation





SPEED SHORE®

PIONEERING TRENCH SAFETY

TABULATED DATA AND TRENCH SHIELD CERTIFICATION

SERIAL NUMBER: 3-2091		MODEL: TS-08 16 DW 6
HEIGHT = 8 feet	LENGTH = 16 feet	THICKNESS = 6 inches
MAXIMUM LATERAL EARTH PRESSURE = 2,047 pounds per square foot		

MAXIMUM DEPTH OF EXCAVATION		
O.S.H.A. Soil Type	Equivalent Weight Effect *(p.c.f.)*	Depth "H" (feet)
A	25	50
B	35	50
B	45	48
C	60	37
C	80	29
Spreader Size = 8 inch Schedule 80 Pipe / Maximum Spreader Length = 20 feet		

This shield is manufactured to meet the requirements of O.S.H.A. CFR 29, Part 1926, Subpart P. This shield must be used in a manner consistent with safe working procedures, federal, state, and local regulations, and manufacturer's instructions. Contact manufacturer for any non-standard use of this trench shield.