1. Excavations and Shoring

1.1 Purpose

This chapter describes minimum safety requirements for excavation and shoring activities, including trenches.

1.2 References

Saudi Aramco (SA) General Instructions (GIs):

GI 2.100, *Work Permit System*

GI 2.709, *Gas Testing Procedure*

GI 1021.000, *Street and Road Closure, Excavation Reinstatement and Traffic Controls*

SA Engineering Standards (SAESs):

SAES-A-111, *Borrow Pit Requirements*

SAES-A-114, *Excavation and Backfill*

SAES-O-119, *Work Permit Procedures*

SAES-Q-006, *Asphalt Concrete Paving*

SA Safety Handbook

SA Standard Drawing (SASD):

AB-036899, *Standard Specifications for Shoring Trenches*

American National Standards Institute (ANSI)/American Society of Safety Engineers (ASSE):

ANSI/ASSE A10.12, *Safety Requirements for Excavation*

U.S. Code of Federal Regulations (CFR):

29 CFR 1926 Subpart P, *Excavations* (OSHA 1926, Subpart P)

1.3 Excavation Planning

1.3.1 Before excavation activities begin, the following factors shall be evaluated by an excavation competent person who has the proper training and/or experience:

A. Purpose, size of excavation and work to be performed.

B. Soil classification (best if determined by a geotechnical/soil analysis).

C. Stability and proximity of adjacent structures, including the location and depth of foundations.

D. Location of underground obstructions such as pipes, electric cables and other utilities.

E. Presence of nearby process equipment or piping with the potential for release of hydrocarbon or toxic materials (e.g., H_2S).

F. Weather and soil moisture conditions, especially high water table.

G. Sources of soil vibrations (highway traffic, machinery, railroads, etc.).

H. Location and type of barricades, signs and lighting.

I. Method of excavating and removal of soil.

J. Protective system to be used (i.e., benching, sloping or shoring). See photo below for an example of benching.

K. Emergency rescue equipment required.

L. The impact the excavation will have on access for emergency vehicles/personnel and egress of personnel in the event of an emergency.

M. Means of entry and exit.

1.3.2 A Pre-Excavation Checklist shall be properly completed and made available upon request. See Appendix B for a sample Pre-Excavation Checklist.

1.3.3 Adequate and suitable protective systems (i.e., benching, sloping or shoring) shall be planned for if the excavation will be at a depth of 1.2 m (4 ft) or more in soil other than stable rock, as per Section 1.7. Excavations less than 1.2 m (4 ft) deep may also require protective systems if sidewall cave-in hazards exist.

1.3.4 An excavation plan shall be prepared as follows:

A. For excavations greater than 2.4 m (8 ft) deep in Type B or C soil, an excavation plan (e.g., shoring design calculations and drawings) that meets the requirements of this chapter shall be developed by a degreed civil/structural engineer. See Table 1.1.

B. For excavations greater than 6 m (20 ft) deep, regardless of soil type, an excavation plan (e.g., shoring design calculations and drawings) that meets the requirements of this chapter shall be developed by a degreed civil/structural engineer and reviewed by the SA Consulting Services Department (CSD).

C. If an excavation plan is required and shoring is used, the plan shall:

- Describe the materials and shoring system to be used.
- Indicate whether or not any shoring components will remain after filling or backfilling.
- Provide plans, sketches and/or details along with calculations.
- Indicate the sequence and method of shoring installation and removal.

1.4 Permits

1.4.1 SA work permit(s) per GI 2.100 shall be obtained as required before excavation work is started.

1.4.2 The work permit issuer shall ensure that underground utilities/installations have been located and marked (e.g., by flags or chalk) before excavation activities begin.

1.4.3 For grassroots projects, the contractor shall develop and implement its own work permit procedures until such time as the SA work permit system goes into effect. These work permit procedures shall incorporate the excavation safety provisions and checklists from this chapter.

1.4.4 For other work sites not covered by the SA work permit system (e.g., nonrestricted areas), the SA proponent organization (SAPO) shall develop and implement excavation safety procedures in accordance with this chapter. Development of these excavation procedures shall include participation by Utilities, Communications, Power Operations Department (POD), Pipelines, etc., as applicable.

1.4.5 A properly completed Confined Space Entry Permit shall be obtained to enter excavations equal to or greater than 1.2 m (4 ft) deep.

1.5 Underground Utilities and Installations

1.5.1 Before excavation activities begin, the SAPO (e.g., engineering/technical) shall confirm and mark (e.g., by flags or chalk) the location of any known or suspected underground pipes, cables, vessels, structures, etc., that are in the area of the proposed excavation.

1.5.2 The SAPO shall contact appropriate SA organizations, such as Utilities, Communications, POD, Pipelines, etc., and request them to accurately mark the locations of their underground utilities/installations.

1.5.3 The SAPO shall ensure that non-SA underground cables or utilities are also located and marked prior to excavating. SAPO inquiries may be addressed to Government Affairs.

1.5.4 Underground utilities and installations shall be located by reference to drawings, discussion with the relevant organizations and by use of cable/pipe locators.

1.5.5 Mechanical excavators shall not be used until all underground utilities and installations have been exposed by hand digging.

1.5.6 Mechanical excavators shall not be used within 3 m (10 ft) of underground utilities or installations. Pneumatic breakers shall only be used where necessary to break concrete or other hard materials.

1.5.7 Excavations are not permitted under an existing foundation. Excavations are not allowed to intersect a forty-five degree (45°) plane extending downward from the bottom edge of an existing foundation, unless a properly engineered support system is installed prior to start of work or the excavation is in stable rock.

1.5.8 Existing underground piping, manholes, electrical cables, duct banks, sidewalks, etc., that could be undermined by an excavation shall be properly braced or shored.

1.6 Dewatering

1.6.1 Employees shall not work in excavations where there is pooled water, or in excavations in which water is accumulating, unless adequate precautions have been taken to protect employees. The necessary precautions vary with each situation, but shall include water removal (dewatering) to control the level of accumulating water (e.g., by pumping) and may also include support shield or shoring systems to protect from cave-ins (see Figures 1.3, 1.6, 1.9, 1.14, etc).

1.6.2 If water is controlled or prevented from accumulating by the use of water-removal equipment, the water-removal equipment and operations shall be regularly monitored to verify proper operation.

1.6.3 If excavation work interrupts the natural drainage of surface water (e.g., streams), then diversion ditches, dikes or other suitable means shall be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation.

1.6.4 Excavations that have been subject to runoff (e.g., from a rain storm) shall be inspected before use by the excavation competent person in accordance with Section 1.13.

1.7 Protection Against Sidewall Cave-In

1.7.1 Protective Systems

A. Suitable shoring shall be installed, or the sides benched or sloped back to a safe angle, for all excavations 1.2 m (4 ft) deep or greater, or for soil piles over 1.5 m (5 ft) high. Refer to Table 1.3 and Figures 1.1 to 1.8 of this chapter for details.

B. The determination of slope angle, benches or choice and design of shoring shall be based on an evaluation by the excavation competent person of pertinent factors, such as:

- Type of soil (i.e., stable rock, Type A, B or C soil) (see Appendix A, Table 1.2 and Glossary).
- Depth of excavation.
- Possible variation in water content of the soil while the excavation is open.
- Anticipated changes in soil from exposure to air, sun or water.
- Loading imposed by structures, equipment, overlying material or stored material.
- Vibrations from equipment, blasting, traffic or other sources.

C. Since any previously disturbed soil is considered to be Type C soil, excavations in previously disturbed soil (e.g., fill) shall not be sloped at an angle greater than 1½ horizontal to 1 vertical, measured from the horizontal.

D. Shoring materials shall be in good condition.

E. Workers shall be trained to look for signs of shoring or sidewall bulge, surface cracking, sand penetration from behind shoring or cracked shoring, which can be a warning sign of a collapse that is about to happen.

1.7.2 Excavation Boxes and Trench Shields (see Figure 1.9)

A. Portable excavation boxes or trench shields may be used for the protection of personnel instead of shoring, benching or sloping.

B. Excavation boxes and trench shields shall be designed, constructed and maintained to provide protection equal to or greater than the required shoring, sloping or benching. The design for custom-made excavation boxes or trench shields shall be reviewed by CSD before use.

C. Excavation boxes and trench shields shall be installed in accordance with the manufacturer's instructions and to restrict lateral or other movement of the box or trench shield. Excavation boxes and trench shields shall be capable of withstanding any sudden application of lateral loads.

D. Excavation boxes and trench shields shall be extended a minimum of 0.45 m (1.5 ft) above the excavation.

1.7.3 Hydraulic Shoring for Excavations

Hydraulic shoring can be used for protection against cave-ins in excavations that do not exceed 6 m (20 ft) in depth (see Figures 1.12 and 1.13, and Tables 1.4 to 1.6).

1.7.4 Timber Shoring for Excavations (see Figure 1.14)

A. Timber shoring can be used as a method of protection against cave-ins in excavations that do not exceed 6 m (20 ft) in depth.

B. Timbers shall be sound, free from large or loose knots and have proper dimensions.

C. Timber shoring shall be designed in accordance with Tables 1.7 to 1.9 or SA Standard Drawing AB-036899. Layout and shoring for trenches not greater than 1.2 m (4 ft) wide and not more than 2.4 m (8 ft) deep may be as per Figure 1.16.

D. Timber used as cross braces or stringers (wales) for shoring shall not be less than 10 cm x 10 cm (4 inches x 4 inches) actual cross-section size. Larger timber braces and stringers may be required, including for excavations in soft or loose soils more than 1.2 m (4 ft) wide or more than 2.4 m (8 ft) deep. Refer to Tables 1.7 to 1.9 or SA Standard Drawing AB-036899 for details.

E. The cross-section sizes of cross braces, stringers and uprights listed in Tables 1.7 to 1.9 refer to minimum actual dimensions (not nominal dimensions) of oak timber or equivalent with a bending strength of not less than 850 psi. Use of nominal sizes is permitted only if: (1) all nominal size timber is certified and permanently marked by the lumber mill and/or supplier as being Douglas fir or equivalent with a bending strength of not less than 1,500 psi, and (2) shoring layout is per Tables C4 to C6 of ANSI A10.12 or Tables C-2.1 to C-2.3 of OSHA 1926, Subpart P, Appendix C, "Timber Shoring for Trenches."

F. Vertical spacing of cross braces and stringers (wales) down the sidewall of the excavation shall not exceed 1.2 m (4 ft), unless a greater vertical

spacing is allowed by Tables 1.7 to 1.9 or SA Standard Drawing AB-036899. Cross braces shall always be used with stringers (wales).

G. Horizontal spacing of cross braces (e.g., along the length of a trench) shall not exceed 1.8 m (6 ft), unless a longer horizontal spacing is allowed by Tables 1.7 to 1.9 or SA Standard Drawing AB-036899). At least two cross braces (upper and lower) shall be used at each bracing location.

1.7.5 Scaffold Tubing Cross Braces for Excavations

A. Scaffold tubing, with compatible screwjacks and base plates, may be used as cross braces for excavations not more than 1.2 m (4 ft) wide and not more than 2.4 m (8 ft) deep. Scaffold tubing shall not be used as stringers (wales) or uprights.

B. For excavations less than 1.8 m (6 ft) deep, scaffold tubing cross braces shall be horizontally spaced not more than 1.8 m (6 ft) apart.

C. For excavations between 1.8 m (6 ft) and 2.4 m (8 ft) deep, scaffold tubing cross braces shall be horizontally spaced not more than 1.2 m (4 ft) apart.

D. Scaffold tubing used as cross braces for shoring shall have at least a 4.0 mm wall thickness and shall be permanently embossed (stamped) before galvanizing with "BS 1139" or "EN39-4" (Type 4). Refer to Chapter II-2, *Scaffolding*, of this manual, for further information.

1.7.6 When used, excavation screw jacks shall be installed in accordance with Figure 1.11 and the manufacturer's instructions, including being equally spaced and properly aligned.

1.7.7 The top cross brace shall not be more than 0.6 m (2 ft) below the top of the excavation and the lowest cross brace shall not be more than 0.6 m (2 ft) above the bottom of the excavation.

1.7.8. Steel sheet piling or other comparable material used as shoring shall be designed by a degreed civil/structural engineer.

1.7.9 Materials and spoils shall be set back at least 0.6 m (2 ft) from the edge of the excavation (see Figure 1.16).

1.7.10 Where personnel, equipment or members of the general public are allowed to cross an excavation, a tightly planked bridge or walkway with standard guardrails shall be provided and kept clear of excavated materials or other tripping hazards.

1.8 Entry and Exit

1.8.1 Stairways, ladders, ramps and/or other safe means of egress shall be located in excavations that are 1.2 m (4 ft) or more in depth so as to require no more than 7.5 m (25 ft) of lateral travel distance for personnel (i.e., ladders shall be spaced at least every 15 m [50 ft] along a trench).

1.8.2 Ladders shall conform to the requirements in Chapter II-3, *Ladders and Stepladders*.

1.8.3 Ladders shall rest on the bottom of the excavation and shall extend at least 1 m (3 ft) above the top landing point.

1.8.4 Personnel shall not be in or near an excavation where they could be struck by operating heavy equipment (e.g., trackhoes, rock breakers, backhoes). Personnel shall not be within the operating radius of the equipment.

1.8.5 Personnel shall not be in an excavation where they could be exposed to a possible cave-in, such as could be caused by equipment operating or passing nearby. Personnel shall not be within a distance less than the depth of the excavation from the edge where equipment is located. See Figure 1.15.

1.9 Hazardous Atmospheres and Materials

1.9.1 Atmospheric Testing

A. Gas tests shall be performed per GI 2.709 when there is reason to suspect oxygen deficiency or the presence of a flammable/toxic atmosphere in an excavation.

B. When using controls for the purpose of reducing atmospheric contaminants to acceptable levels, gas testing shall be conducted on a regular basis and before the work crew is to re-enter the excavation (e.g., after breaks, lunch) to ensure that the atmosphere remains safe. See Chapter I-6, *Confined Spaces*.

1.9.2 Exhaust Gases

When an internal combustion engine is used in or near an excavation, precautions shall be taken to ensure that exhaust gases are discharged so as not to be a hazard to personnel working in the excavation.

1.9.3 Hazardous Materials

A. When hazardous materials are known or suspected (e.g., sludge, asbestos), excavation work shall not be started until the SA Environmental Protection Department (EPD) is contacted and has evaluated the potential hazard(s) and specified the precautions to be taken.

B. If materials suspected of being hazardous are unearthed during excavation activities, all work shall stop until the material is identified by the SA EPD, appropriate removal and disposal procedures are established, and work practices are modified as needed.

1.10 Emergency Response

1.10.1 Appropriate emergency rescue equipment (e.g., breathing apparatus, full-body harness and lifeline, basket stretcher) shall be readily available during work.

1.10.2 A standby man shall be in attendance until the work is completed for any excavation that has been determined to be a confined space (see Chapter I-6, *Confined Spaces*).

1.10.3 A fire watch shall remain in place any time an ignition source (e.g., welding, cutting) is present in the excavation and for 30 minutes after the ignition source has been removed.

1.10.4 Personnel entering bell-bottom pier holes or other similar deep and confined excavations shall wear a full-body harness with a lifeline attached to it. The lifeline shall be separate from any line used to handle materials and shall be individually attended at all times while the employee wearing the lifeline is in the excavation. Mechanical devices shall be available on site to lift incapacitated workers from the excavation.

1.11 Edge Protection, Markers and Fixed Lighting

1.11.1 Whenever it is necessary to place or operate power shovels, derricks, trucks, materials, soil banks or other heavy objects near an excavation, the sides of the excavation shall be sheet-piled, shored and braced as necessary to safely resist the extra pressure.

1.11.2 Only excavating and backfilling equipment (trackhoes, rock breakers, backhoes, front loaders, etc.) are permitted within 2 m (6.5 ft) of the edge of an excavation.

1.11.3 Motor vehicles, cranes and heavy equipment shall be kept away from the edge of the excavation a distance of 2 m (6.5 ft) or the depth of the excavation, whichever is greatest, unless the excavation is in stable rock or is protected against collapse by shoring that has been designed or approved by a degreed civil/structural engineer (see Section 1.7 and Figure 1.10).

1.11.4 Hard barricades (e.g., concrete or water-filled plastic “jersey” barriers, metal fencing) shall be used to keep motor vehicles, cranes and heavy equipment at the proper distance away from the excavation.

1.11.5 When use of hard barriers is impractical inside a fenced SA plant area (i.e., does not involve public access), vehicular traffic near the excavation shall be controlled by flagmen and the excavation shall be flagged with caution tape and well lit for night (see GI 1021.000).

1.11.6 Pedestrian barricades shall be placed no less than 1 m (3 ft) from the edge of the excavation.

1.11.7 If people or vehicles could be in the vicinity of the excavation after dark, warning lights shall be used to mark the limits of the work. If possible, the grade should slope away from the excavation.

1.12 Roads, Streets and Sidewalks

1.12.1 Excavation work on or near roads, streets and sidewalks shall meet the requirements of GI 1021.000 and shall not be performed without prior approval of the relevant authorities.

1.12.2 Saudi Arabian Government approval shall be obtained through SA Government Affairs prior to excavation work on, under (e.g., thrust boring), or near a public highway, railway or utility right-of-way (see Chapter II-11, *Roadworks*).

1.12.3 Trenches in roads and streets shall be completely covered with properly designed steel plates where traffic flow needs to be maintained over the trench. Such trenches shall be properly shored to prevent cave-in (see Section 1.7). The trench cover plate thickness shall be selected based on the width of the trench, grade of steel and weight of heaviest expected traffic (e.g., fire truck, fully loaded tractor-trailer truck). See Figures 1.17 to 1.20 for typical cover plates for road trenches. Figure 1.21 shows typical sidewalk protection.

1.13 Inspections

1.13.1 A documented inspection shall be performed by an excavation competent person before workers are allowed to initially enter an excavation or after a change in site conditions (e.g., rain storm, groundwater infiltration, sidewall deterioration, adjacent ground fissuring). For excavations greater than 2.4 m (8 ft) deep, a documented inspection by the excavation competent person shall be performed each morning before workers shall be allowed to enter the excavation.

1.13.2 An excavation safety checklist shall be used to document these initial/daily inspections (see Appendix B for a sample excavation inspection checklist that shall be completed and signed each day by the excavation competent person). If there is an unsafe condition, workers shall not be allowed to enter the excavation.

1.13.3 Appendix B also contains a sample excavation safety pocket card that is to be used by others at any other time (e.g., work permit issuers/receivers, SA and contractor employees who work in or near excavations, Project Management and proponent personnel). These excavation safety pocket cards are available from the area Loss Prevention office.

1.14 Backfilling

Backfilling and removal of shoring shall be accomplished first by backfilling up to a level allowing for the removal of the lower braces. Another layer of backfill shall be

positioned in the excavation up to the next layer of braces to be removed. Removal of shoring shall progress together with the backfill from the bottom to the top of the excavation. In unstable soil, ropes shall be used to pull out the jacks or braces from above after all employees have exited the excavation. All excavations shall be backfilled and the surface left in good condition.

1.15 Borrow Pits

1.15.1 Borrow pit boundaries (e.g., residential, industrial plants, sub-stations, highways) shall be located at the distance noted in SAES-A-111.

1.15.2 Pedestrian traffic shall be prohibited in borrow pit areas. Signs in Arabic and English shall be posted around roped-off/barricaded areas to warn personnel to stay away from borrow pits.

1.15.3 Dust concentrations, noise levels and security fencing (as applicable) associated with borrow pit operations shall be in accordance with SA requirements.

1.16 Thrust Boring

1.16.1 Site-Specific Procedure

The primary contractor shall submit to the SAPO a site-specific procedure for each thrust boring operation, which is based on the specialist contractor's general procedures and site-specific conditions. The site-specific procedure shall include, but not be limited to, plans for how the specialist contractor will address the following requirements.

1.16.2 Minimum Safety Requirements

A. The sidewalls of launching and reception pits shall be protected by steel sheet piling or be properly benched/sloped.

B. Proper means of access and egress shall be provided.

C. Work permits shall be per SA GI 2.100.

D. Excavation plans shall be submitted to the SAPO before work commences.

E. Prior to beginning excavation activities, the area shall be checked for buried pipes, cables, telephone lines and other underground services.

F. The perimeter of the pits shall be protected with solid barriers to prevent personnel or animals from falling in. The site shall be properly barricaded and warning signs posted.

G. When mobile heavy equipment is working close to the pits, substantial wooden stop logs and barricades shall be placed at the minimum approach distance (see Section 1.11).

H. Warning signs shall be placed around the work area and at all approaches to the job site.

I. Documented safety meetings with the work force shall be conducted each morning to advise them of potential hazards as the work progresses.

1.16.3 Hazardous Atmospheres

A. No hot work shall be performed if the lower explosive limit (LEL) is above 0%.

B. Welding of pipe joints shall comply with Chapter II-10, *Cutting, Welding and Brazing*.

C. Coating of pipe joints shall comply with Chapter II-9, *Painting and Coating*.

1.16.4 Emergency Rescue Equipment

A. Rescue equipment, including full-body harness with lifeline and a basket stretcher, shall be readily available and attended by a standby man outside the pit.

B. Fire extinguishers shall be placed at strategic points.

C. A safe means of access and egress shall be provided and maintained.

1.16.5 Nighttime Work

Adequate lighting in, around and at all approaches to the job site shall be provided for nighttime work.

1.16.6 Equipment

A. Cranes, sidebooms and other elevating/lifting equipment shall be SA certified.

B. Heavy equipment operators shall be SA certified.

C. Microtunnel launching and reception pits shall be large enough to accommodate a full pipe joint.

D. A concrete base shall be constructed to support hydraulic jacking equipment.

G. Rear walls shall be reinforced with a thrust plate designed to bear the thrust forces generated by the jacking operation.

H. Where necessary, a dewatering system shall be installed.

I. Bentonite slurry storage tank areas shall be barricaded to contain spillage.

J. Warning signs shall be posted near the slurry storage areas to keep personnel a safe distance from the spillage. Additional warning signs shall state that personnel shall not walk on the slurry crust.

1.16.7 Auger Boring

A. Spoil drawn back to the launch pit through the casing by a series of auger flights shall be safely removed in buckets and disposed of properly.

B. The progress of the auger head and the amount of spoil being withdrawn shall be monitored by the contractor in order to detect an open space (cavity) and the probability of a resultant road collapse.

1.16.8 Horizontal Directional Drilling

A. Any existing buried services shall be uncovered and a topography survey of the location performed by the contractor.

B. A plan shall be submitted by the contractor showing the required clearance from the proposed bore.

C. As the pilot bore commences, the operator shall ensure there is an adequate supply of mud (Bentonite) jetting from the drill head and the operator shall make any required directional adjustments as drilling progresses.

D. After the reamer has followed the rods to the machine end and the bore has reached the required diameter, the product pipe shall be carefully pulled through the bore to the required tie-in point.

E. Barricades and warning signs shall be erected to keep unauthorized personnel away from the heavy equipment and from the cable hauling the pipe.

F. Flagmen shall be present but at a safe distance from the pipe hauling cable when it is under stress.

APPENDIX A: TABLES AND FIGURES

Table 1.1 Excavation Planning and Design Responsibilities

Depth	Stable Rock	Soil Type A	Soil Type B	Soil Type C
1.2 m (4 ft) – 2.4 m (8 ft)	Excavation Competent Person	Excavation Competent Person	Excavation Competent Person	Excavation Competent Person
> 2.4 m (8 ft) – 6 m (20 ft)	Excavation Competent Person	Excavation Competent Person	Civil/Structural Engineer	Civil/Structural Engineer
> 6 m (20 ft) *	Civil/Structural Engineer	Civil/Structural Engineer	Civil/Structural Engineer	Civil/Structural Engineer

* CSD review of excavation plan is required if excavation is greater than 6 m (20 ft).

Table 1.2 Summary of Soil Types

Soil Type	Description of Soil Type
Stable Rock	Natural solid mineral matter that can be excavated with vertical sides, such as sandstone.
Type A	Previously undisturbed cohesive or cemented soil, such as clay or marl.
Type B	Less cohesive soil, such as a mix of sand, rocks and clay.
Type C	Less cohesive soil. Examples are: gravel, sand, muddy or freely seeping soils, submerged rock that is not stable, or a layered system. Previously disturbed soil is Type C soil.

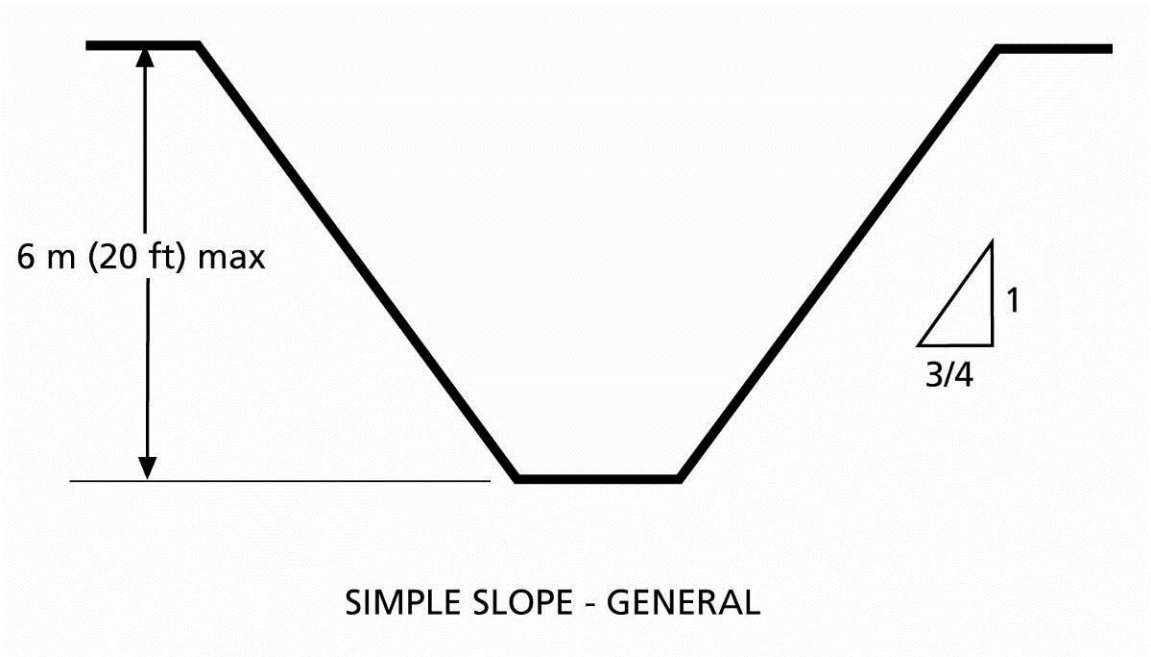
Table 1.3 Maximum Allowable Slopes

Soil Type	Maximum Allowable Slopes (H:V) for Excavations Less Than 6 m (20 ft) Deep
Stable Rock	Vertical (90°)
Type A	3/4:1 (53°)
Type B	1:1 (45°)
Type C	1-1/2:1 (34°)

Note: Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.

Figure 1.1 Sloped Excavations Made in TYPE A SOIL

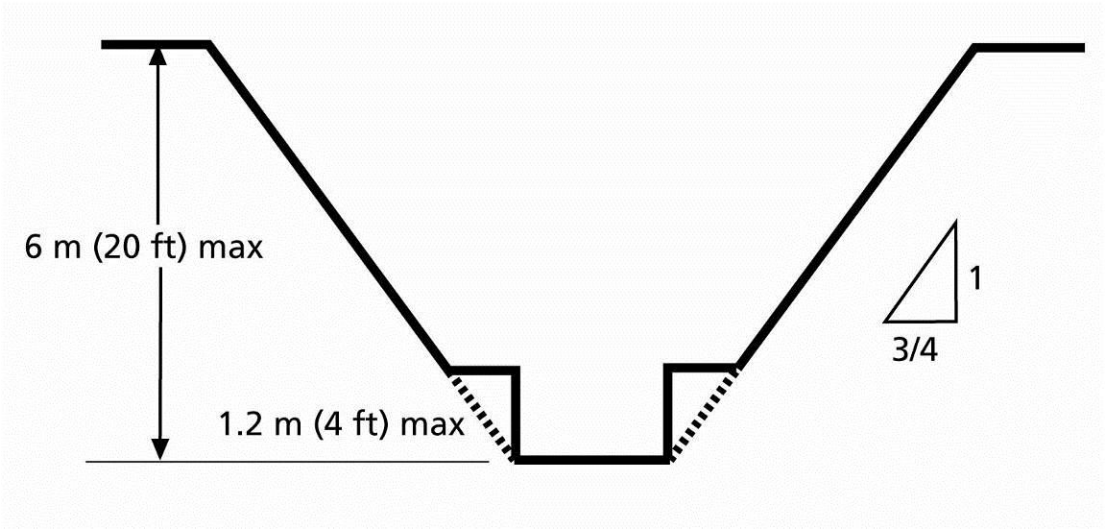
All simple slope excavations made in Type A soil that are 6 m (20 ft) or less in depth shall have a slope of not greater than 3/4 horizontal to 1 vertical.



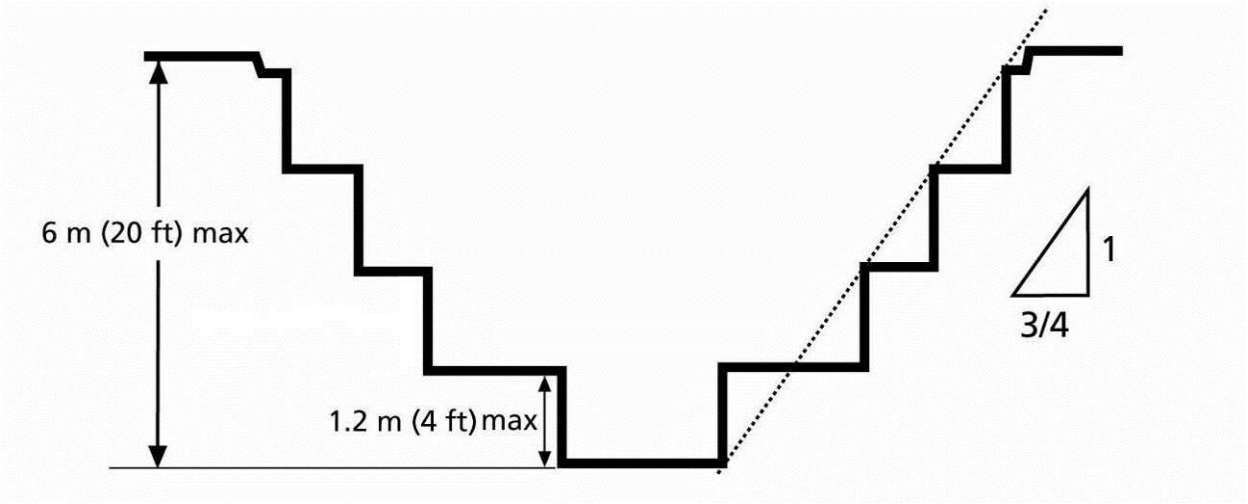
SIMPLE SLOPE - GENERAL

Figure 1.2 Benched Excavations Made in TYPE A SOIL

All benched excavations made in Type A soil that are 6 m (20 ft) or less in depth shall have a maximum allowable slope of 3/4 horizontal to 1 vertical and maximum bench dimensions as follows.



Simple Bench



Multiple Bench

Figure 1.3 Supported or Shielded Excavations Made in TYPE A SOIL

All excavations made in Type A soil that are 6 m (20 ft) or less in depth, which have vertically sided lower portions that are supported or shielded, shall have a maximum allowable slope of 3/4 to 1. The support or shield system shall extend at least 0.45 m (18 inches) above the top of the vertical side.

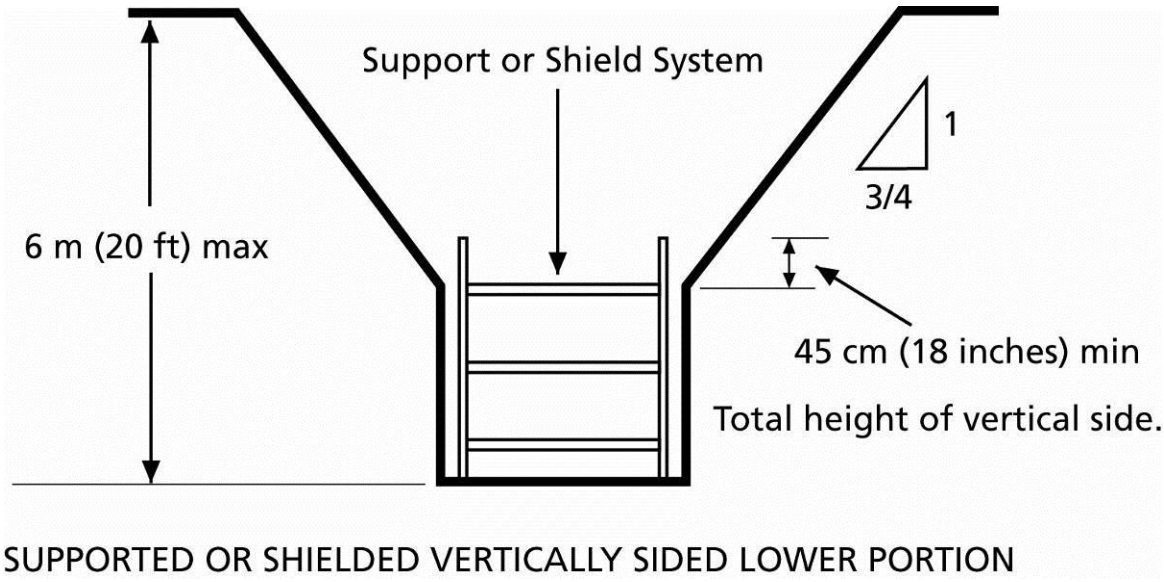


Figure 1.4 Sloped Excavations Made in TYPE B SOIL

All simple slope excavations made in Type B soil that are 6 m (20 ft) or less in depth shall have a slope of not greater than 1 horizontal to 1 vertical.

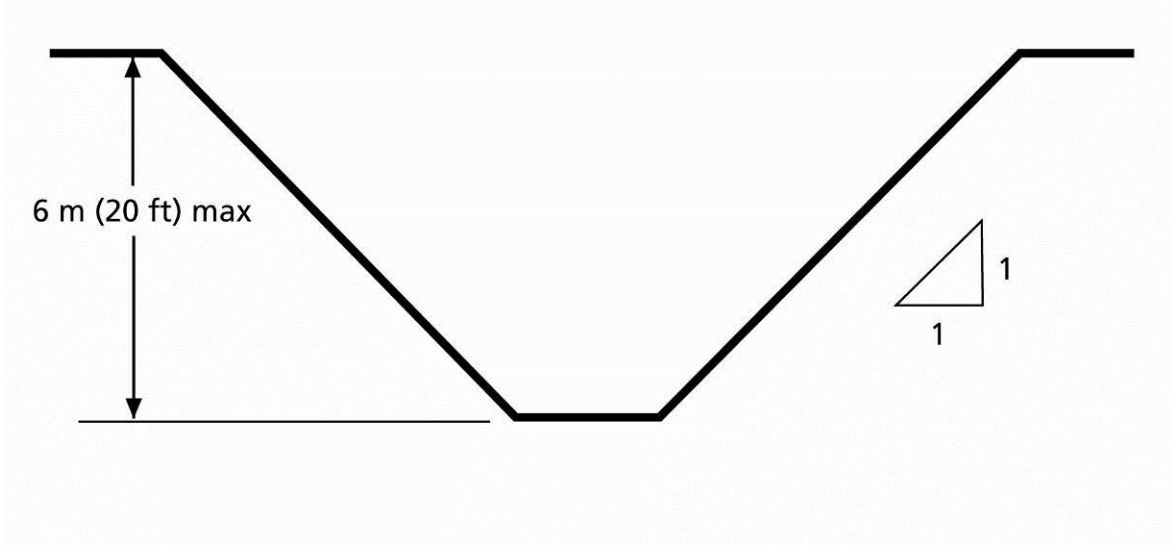
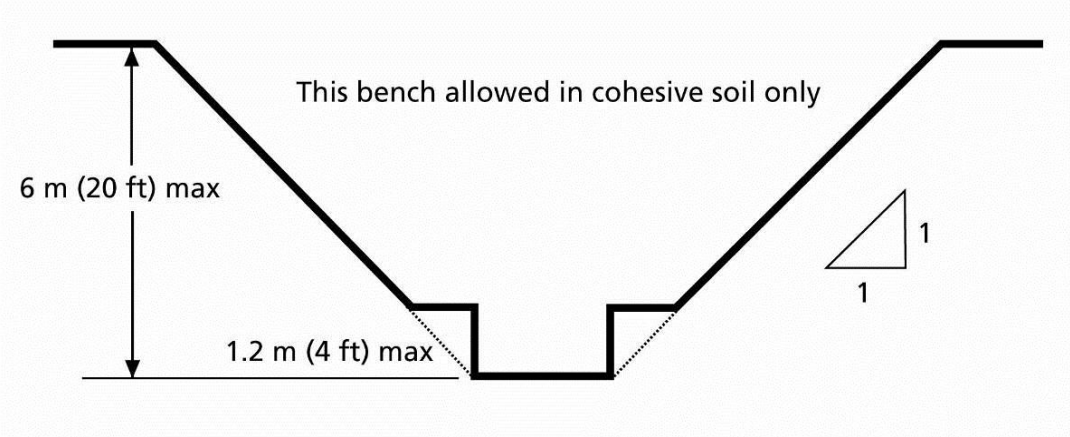
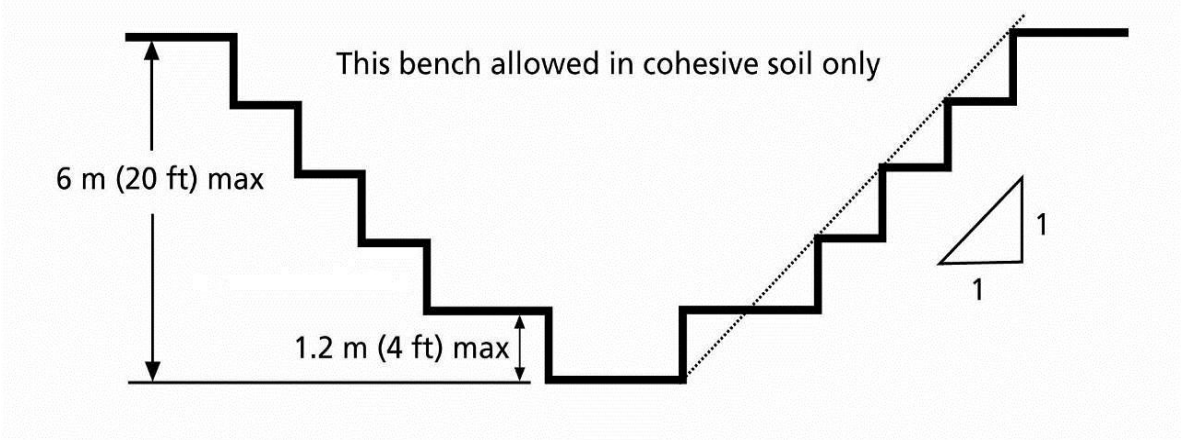


Figure 1.5 Benched Excavations Made in TYPE B SOIL

All benched excavations made in Type B soil that are 6 m (20 ft) or less in depth shall have a maximum allowable slope of 1 horizontal to 1 vertical and maximum bench dimensions as shown below. Benched excavations that are unsupported or unshielded are permitted only in cohesive soils.



Simple Bench



Multiple Bench

Figure 1.6 Supported or Shielded Excavations Made in TYPE B SOIL

All excavations made in Type B soil that are 6 m (20 ft) or less in depth that have vertically sided lower portions shall be shielded or supported to a height at least 0.45 m (18 inches) above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1:1.

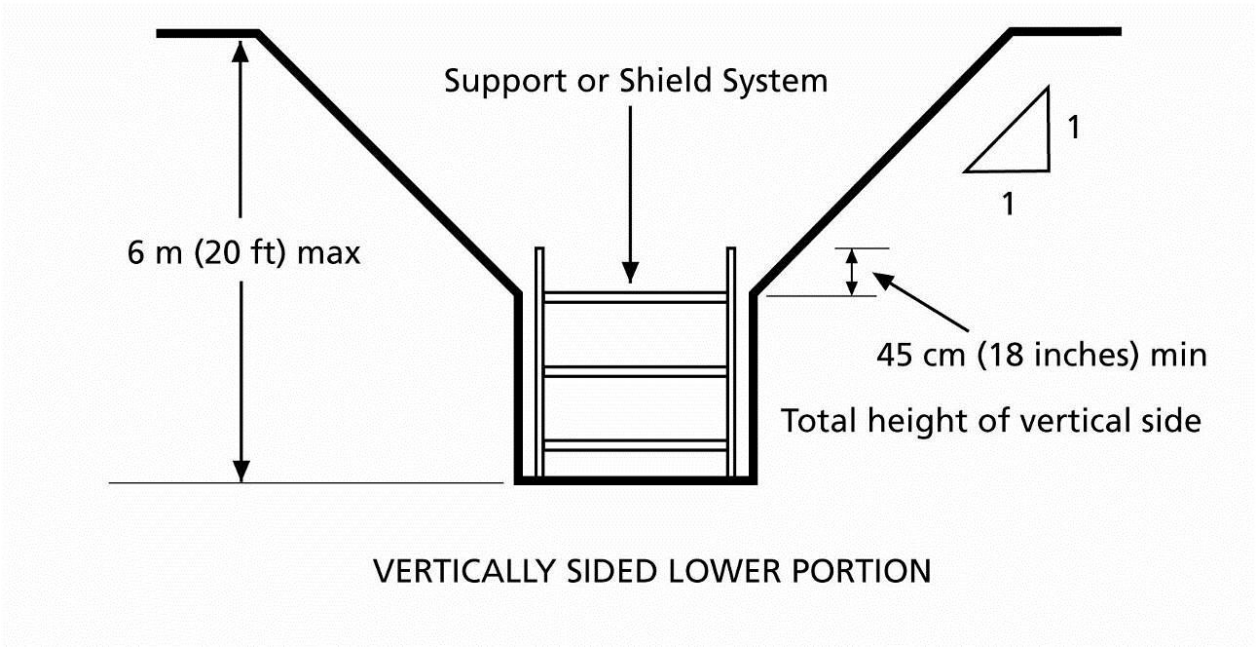


Figure 1.7 Excavations Made in TYPE C SOIL

All simple slope excavations made in Type C soil that are 6 m (20 ft) or less in depth shall have a slope of not greater than 1-1/2 horizontal to 1 vertical.

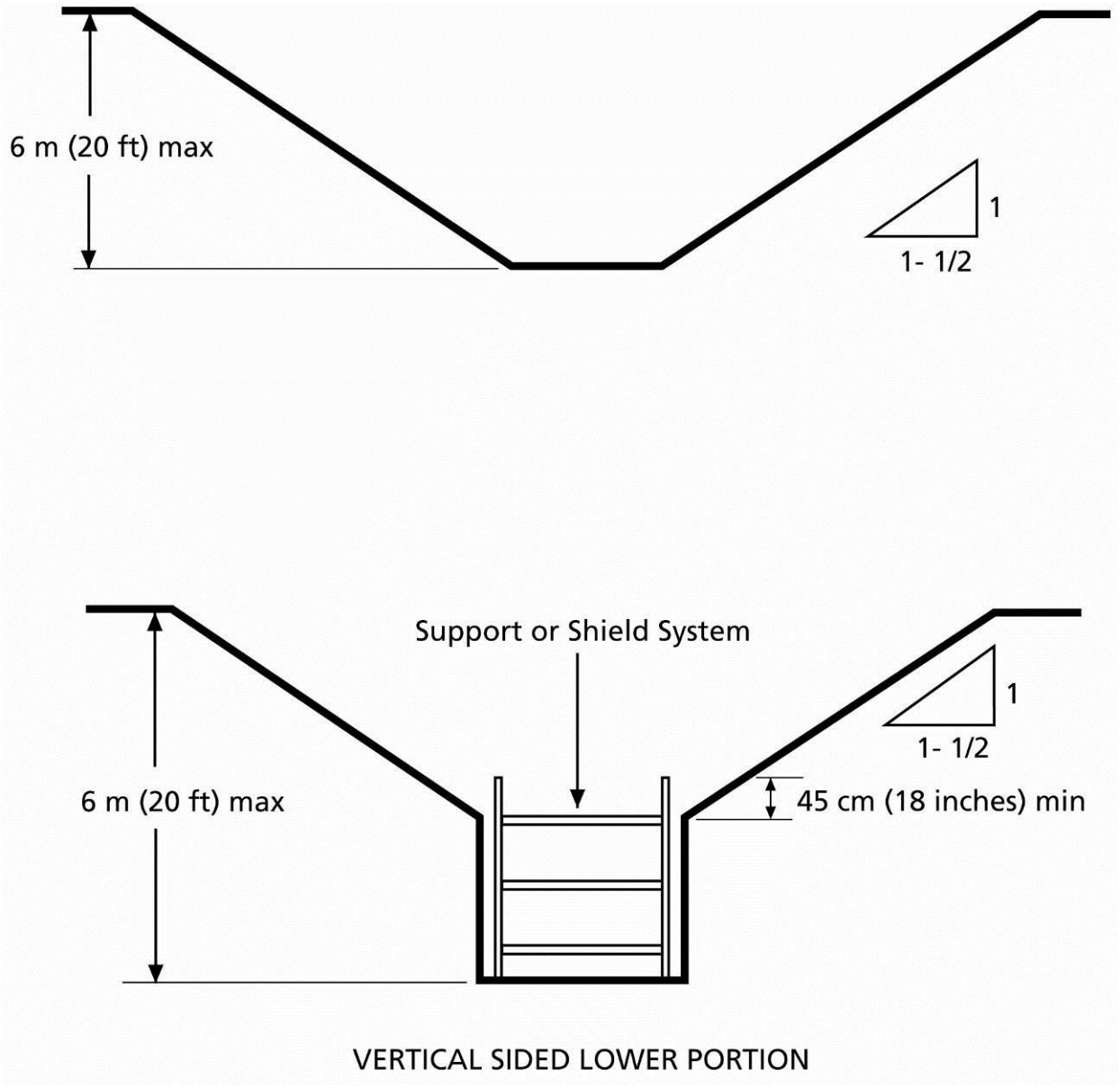


Figure 1.8 Excavations Made in Layered Soils

All excavations made in layered soils that are 6 m (20 ft) or less in depth shall have a maximum allowable slope for each layer as set forth below.

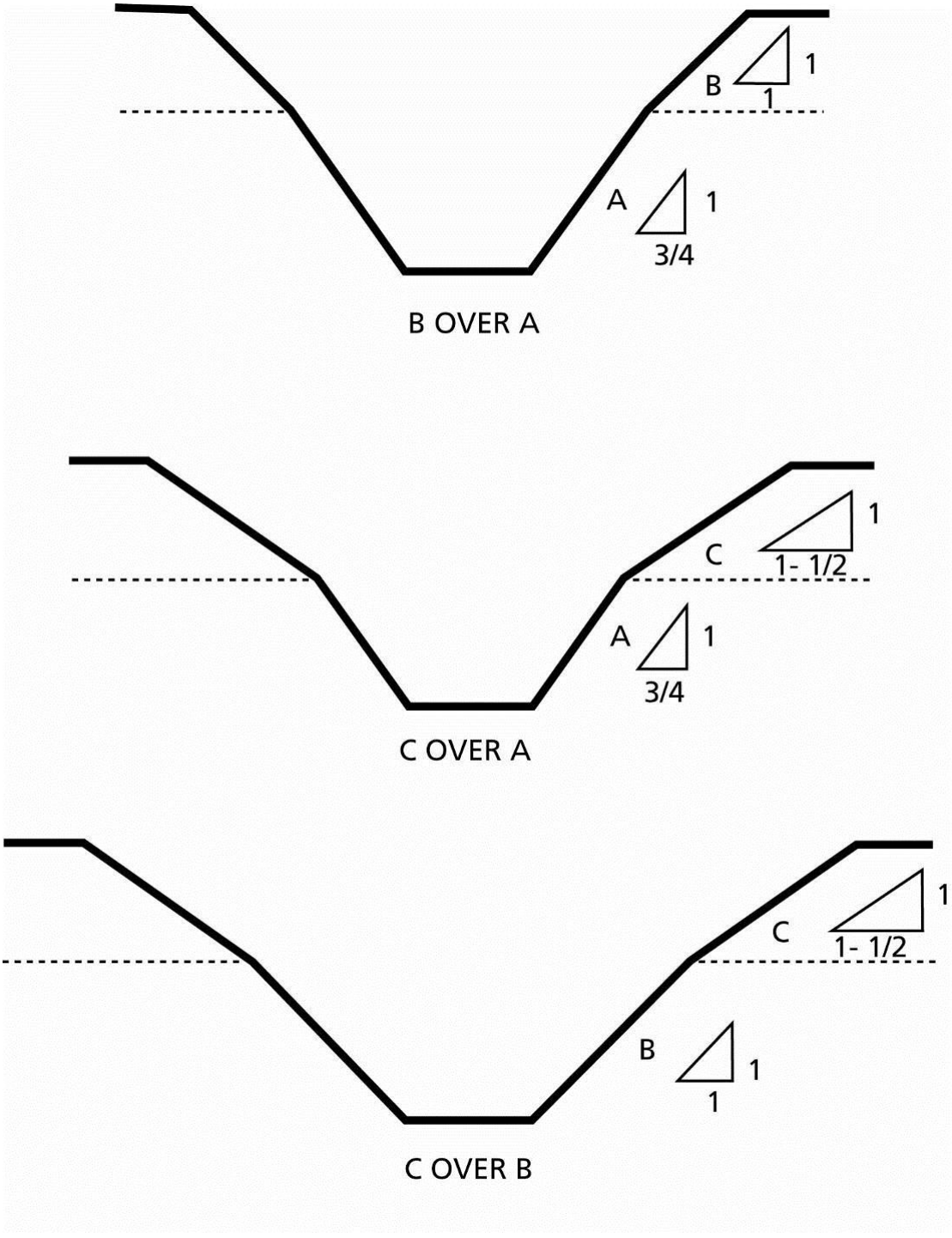
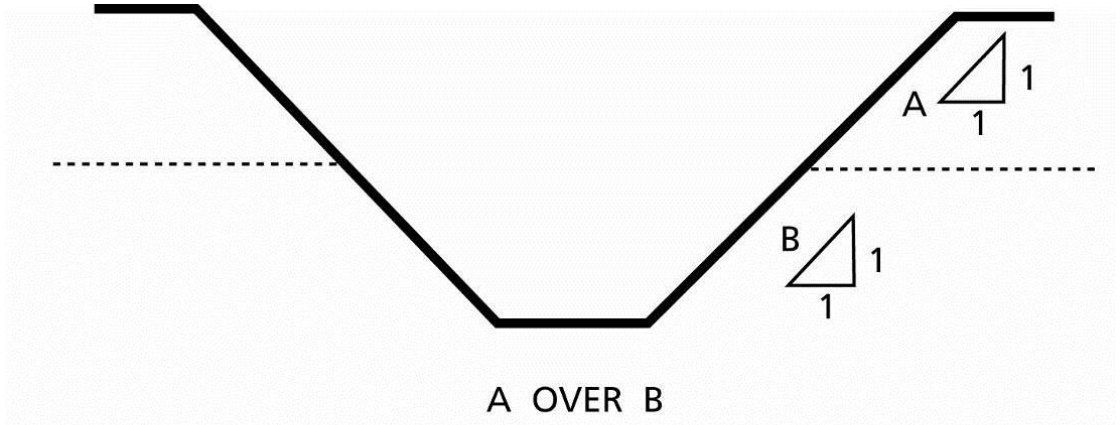
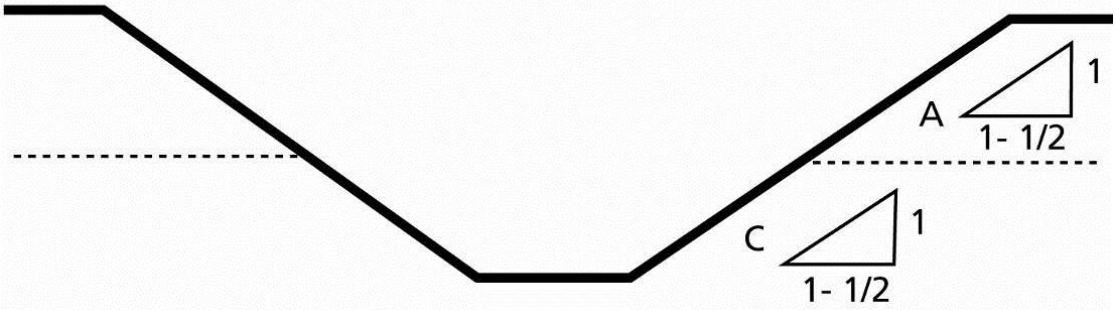


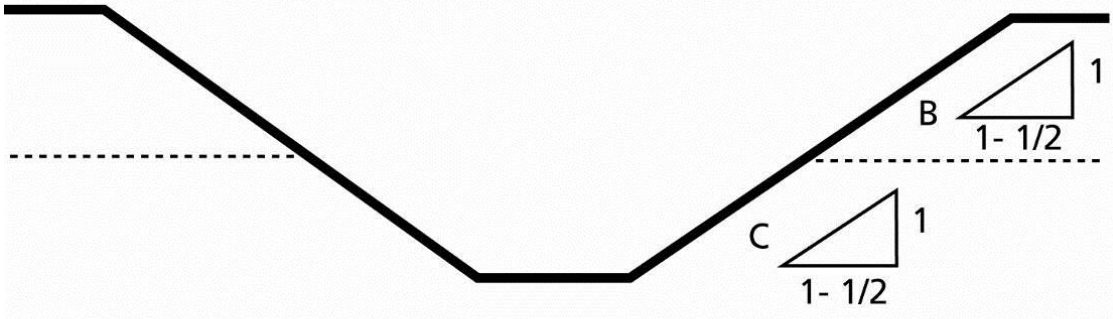
Figure 1.8 (Continued) Excavations Made in Layered Soils



A OVER B



A OVER C



B OVER C

Figure 1.9 Examples of Trench Shields

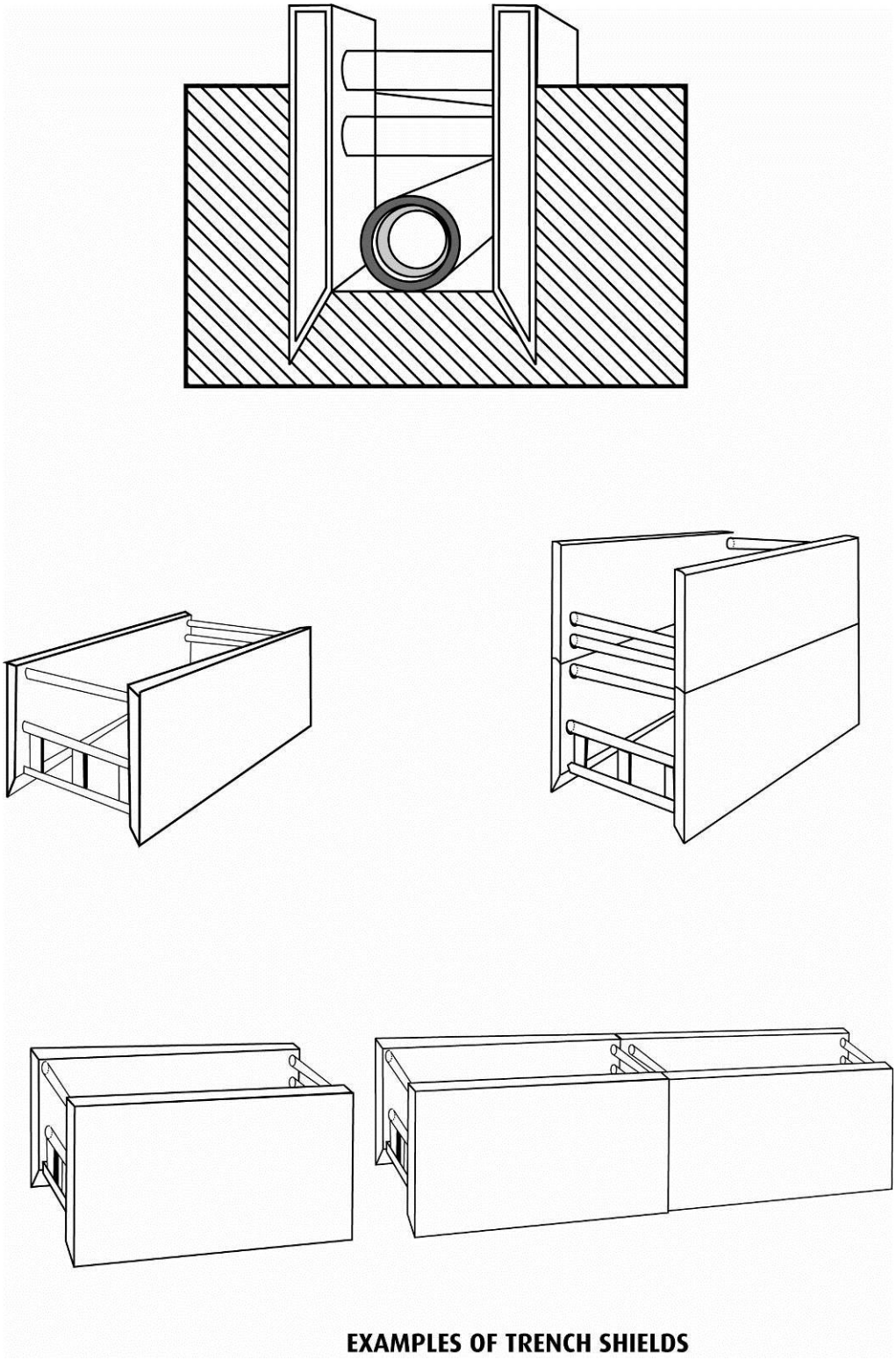


Figure 1.10 Safe Distance Back from Top of Slope for Storage of Materials or Placing Equipment (TYPE A SOIL)

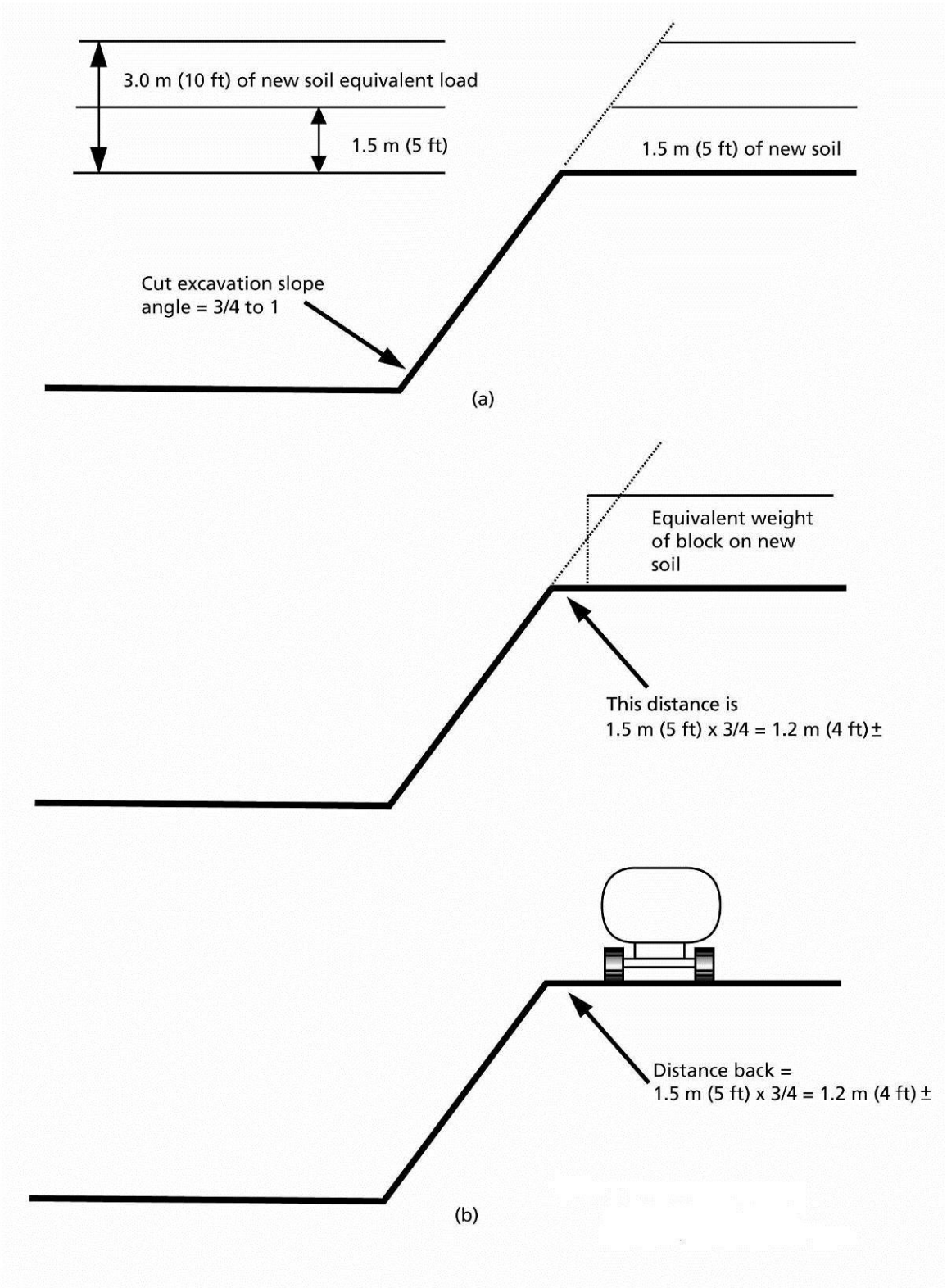


Figure 1.11 Excavation Screw Jacks

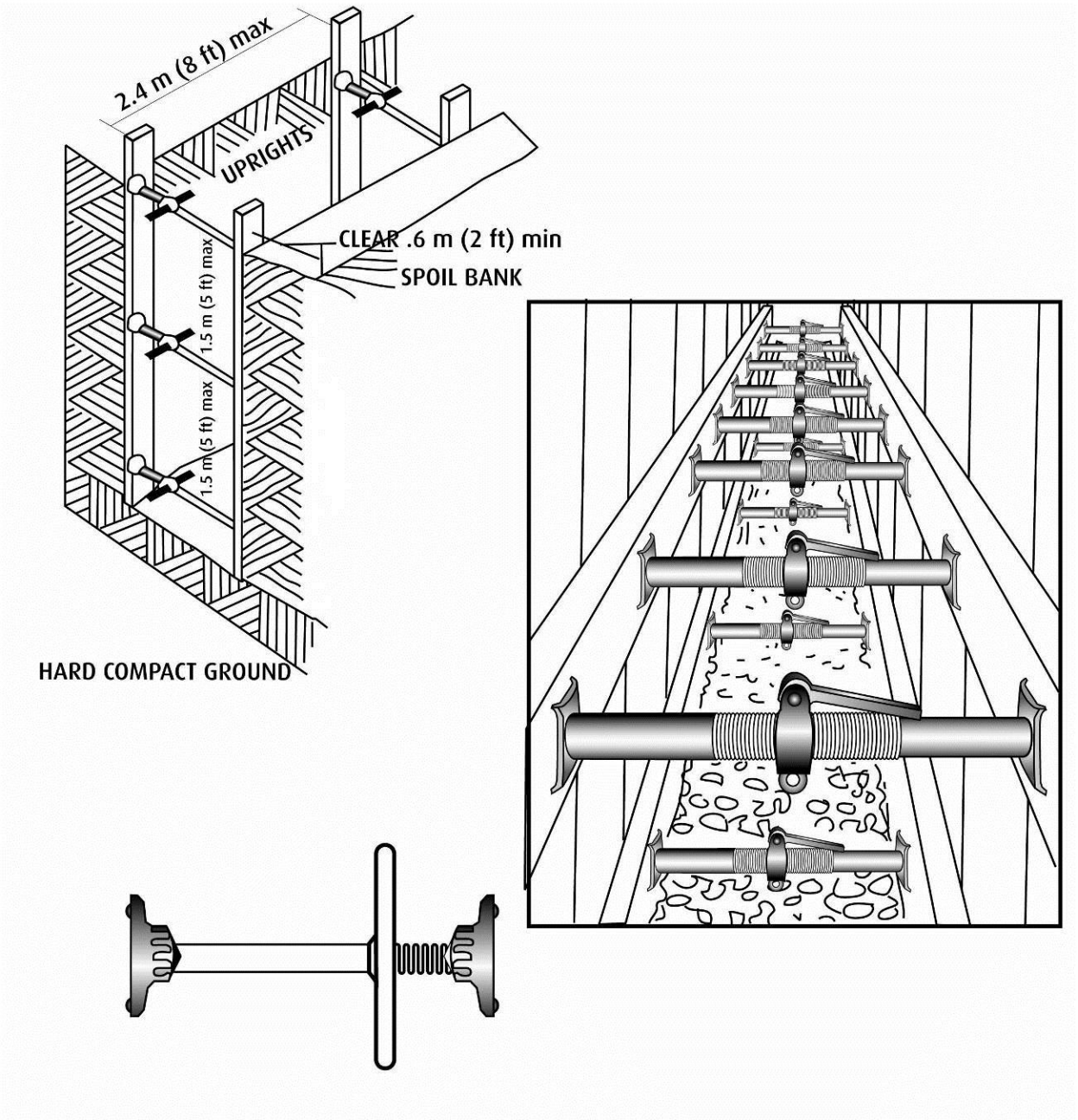


Figure 1.12 Aluminum Hydraulic Shoring: Typical Installations

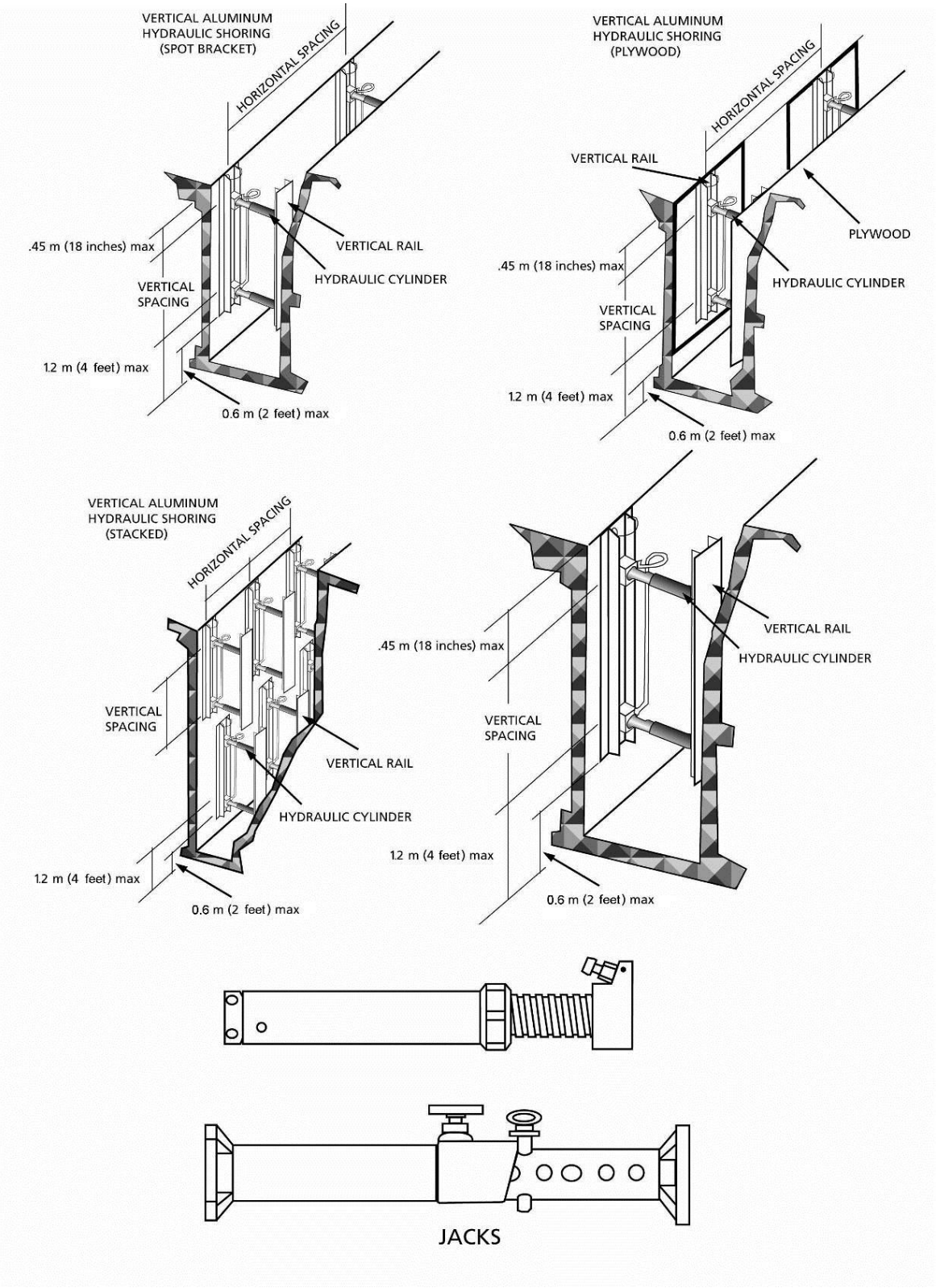


Table 1.4 Aluminum Hydraulic Shoring, Vertical Shores for TYPE A SOIL

	Hydraulic Cylinders				
			Width of Excavation		
Depth of Excavation (ft)	Maximum Horizontal Spacing (ft)	Maximum Vertical Spacing (ft)	Up to 8 ft	Over 8 up to 12 ft	Over 12 up to 15 ft
Over 5 up to 10	8	4	2 inches diameter	2 inches diameter	3 inches diameter
Over 10 up to 15	8	4	2 inches diameter	2 inches diameter	3 inches diameter
Over 15 up to 20	7	4	2 inches diameter	2 inches diameter	3 inches diameter
Over 20	Excavation plan shall be prepared by a degreed civil/structural engineer and reviewed by CSD				

Table 1.5 Aluminum Hydraulic Shoring, Vertical Shores for TYPE B SOIL

	Hydraulic Cylinders				
			Width of Excavation		
Depth of Excavation (ft)	Maximum Horizontal Spacing (ft)	Maximum Vertical Spacing (ft)	Up to 8 ft	Over 8 up to 12 ft	Over 12 up to 15 ft
Over 5 up to 10	8	4	2 inches diameter	2 inches diameter	3 inches diameter
Over 10 up to 15	6.5	4	2 inches diameter	2 inches diameter	3 inches diameter
Over 15 up to 20	5.5	4	2 inches diameter	2 inches diameter	3 inches diameter
Over 20	Excavation plan shall be prepared by a degreed civil/structural engineer and reviewed by CSD				

Figure 1.13 Aluminum Hydraulic Shoring Waler Systems

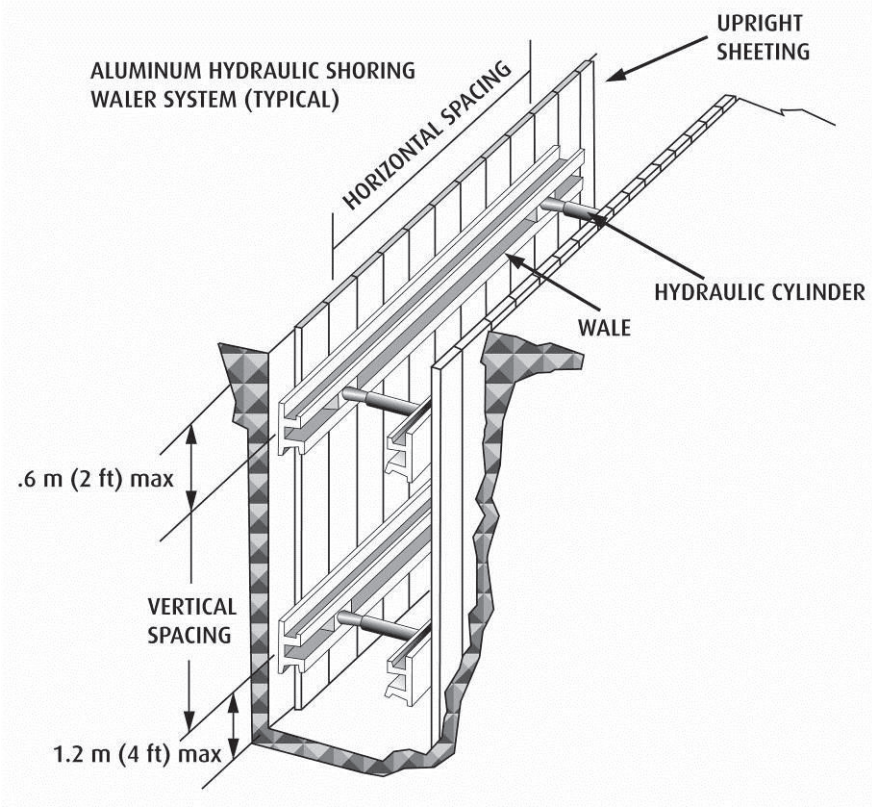


Table 1.6 Aluminum Hydraulic Shoring Waler Systems for TYPE B SOIL

Depth of excavation (ft)	Wales		Hydraulic Cylinders								
	Vertical Spacing (ft)	Section Modulus (inch³)	Width of Excavation (ft)						Maximum Horizontal spacing (on center)		
			Up to 8		Over 8 up to 12		Over 12 up to 15		Solid Sheet	2 ft	3 ft
			Horiz. Spacing (ft)	Cylinder Diameter (inches)	Horiz. Spacing (ft)	Cylinder Diameter (inches)	Horiz. Spacing (ft)	Cylinder Diameter (inches)			
Over 5 up to 10	4	3.5	8.0	2	8.0	2	8.0	3	---	---	3 x 12
		7.0	9.0	2	9.0	2	9.0	3			
		14.0	12.0	3	12.0	3	12.0	3			
Over 10 up to 15	4	3.5	6.0	2	6.0	2	6.0	3	---	3 x 12	—
		7.0	8.0	3	8.0	3	8.0	3			
		14.0	10.0	3	10.0	3	10.0	3			
Over 15 up to 20	4	3.5	5.5	2	5.5	2	5.5	3	3 x 12	---	—
		7.0	6.0	3	6.0	3	6.0	3			
		14.0	9.0	3	9.0	3	9.0	3			
Over 20	Excavation plan shall be prepared by a degreed civil/structural engineer and reviewed by CSD										

Figure 1.14 Example of a Timber Shoring Protective System

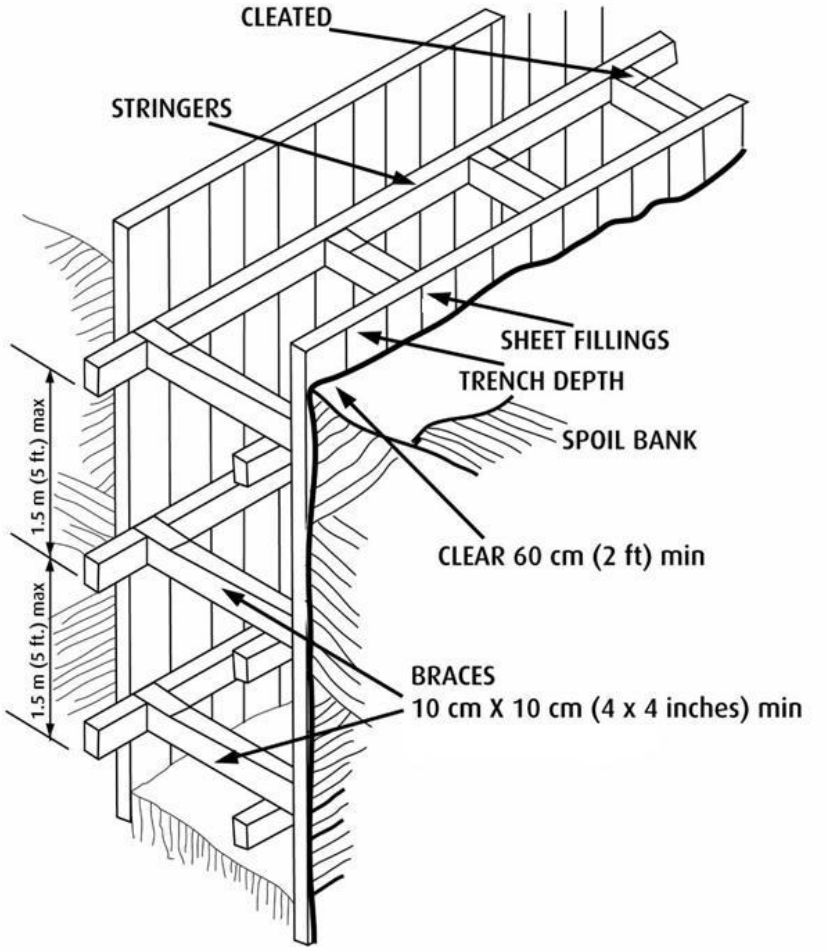


Figure 1.15 Personnel Clearance Requirements When Vehicles or Heavy Equipment are Near the Edge of the Excavation

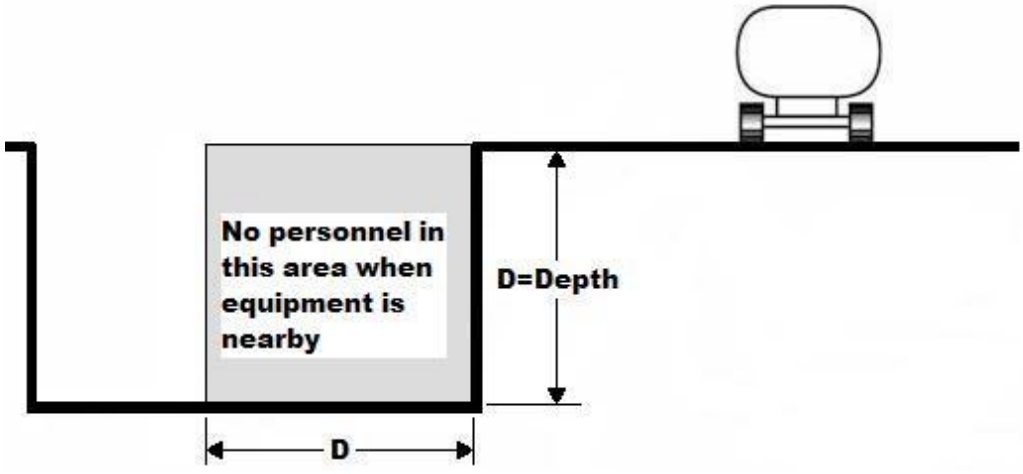


Table 1.7 Timber Excavation Shoring, Minimum Timber Requirements*
TYPE A SOIL

Depth of Excavation (ft)	Size (Actual) and Spacing of Members**												
	Cross Braces						Stringers		Uprights				
	Horizontal Spacing (ft)	Width of Excavation (ft)					Vertical Spacing (ft)	Size (inches)	Vertical Spacing (ft)	Maximum Allowable Horizontal Spacing (ft)			
		Up to 4	Up to 6	Up to 9	Up to 12	Up to 15				Close	4	5	6	8
5 to 10	Up to 6	4 x 4	4 x 4	4 x 6	6 x 6	6 x 6	4	Not Req'd	---				2 x 6	
	Up to 8	4 x 4	4 x 4	4 x 6	6 x 6	6 x 6	4	Not Req'd	---					2 x 8
	Up to 10	4 x 6	4 x 6	4 x 6	6 x 6	6 x 6	4	8 x 8	4			2 x 6		
	Up to 12	4 x 6	4 x 6	6 x 6	6 x 6	6 x 6	4	8 x 8	4				2 x 6	
10 to 20	Up to 6	4 x 4	4 x 4	4 x 6	6 x 6	6 x 6	4	Not Req'd	---				3 x 8	
	Up to 8	4 x 6	4 x 6	6 x 6	6 x 6	6 x 6	4	8 x 8	4		2 x 6			
	Up to 10	6 x 6	6 x 5	6 x 6	6 x 8	6 x 8	4	8 x 10	4			2 x 6		
	Up to 12	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	4	10 x 10	4				3 x 8	
15 to 20	Up to 6	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	4	6 x 8	4	3 x 6				
	Up to 8	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	4	8 x 8	4	3 x 6				
	Up to 10	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	4	8 x 10	4	3 x 6				
	Up to 12	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	4	10 x 10	4	3 x 6				
Over 20	Excavation plan shall be prepared by a degreed civil/structural engineer and reviewed by CSD													

* Mixed oak or equivalent with a bending strength of not less than 850 psi.

** Timber sizes shown are actual (not nominal) sizes. Manufactured members of equivalent strength may be substituted for wood.

Note: Maximum spoils height is 0.6 m (2 ft) within a horizontal distance away from the edge of the excavation equal to the depth of the excavation.

Table 1.8 Timber Excavation Shoring, Minimum Timber Requirements*
TYPE B SOIL

Depth of Excavation (ft)	Size (Actual) and Spacing of Members**										
		Cross Braces						Stringers		Uprights		
	Horizontal Spacing (ft)	Width of Excavation (ft)					Vertical Spacing (ft)	Size (inches)	Vertical Spacing (ft)	Maximum Allowable Horizontal 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			
	Up to 8	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	5	8 x 10	5			
	Up to 10	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	5	10 x 10	5			
	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 6	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 6	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	Excavation plan shall be prepared by a degreed civil/structural engineer and reviewed by CSD											

* Mixed oak or equivalent with a bending strength of not less than 850 psi.

** Timber sizes shown are actual (not nominal) sizes. Manufactured members of equivalent strength may be substituted for wood.

Notes:

1. Maximum spoils height is 0.6 m (2 feet) within a horizontal distance away from the edge of the excavation equal to the depth of the excavation.

2. Member sizes at spacings other than indicated requires an excavation plan to be prepared by a degreed civil/structural engineer and reviewed by CSD.

Table 1.9 Timber Excavation Shoring, Minimum Timber Requirements*
TYPE C SOIL

Depth of Excavation (ft)	Size (Actual) and Spacing of Members **									
	Cross Braces							Stringers		Uprights
	Horizontal Spacing (ft)	Width of Excavation (ft)					Vertical Spacing (ft)	Size (inches)	Vertical Spacing (ft)	Maximum Allowable Horizontal Spacing (ft)
		Up to 4	Up to 6	Up to 9	Up to 12	Up to 15				Close
5 to 10	Up to 6	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	8 x 10	5	2 x 6
	Up to 8	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	5	10 x12	5	2 x 6
	Up to 10	8 x 10	8 x 10	8 x 10	8 x 10	10x10	5	12x12	5	2 x 6
	See Note 1									
10 to 15	Up to 6	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	5	10x12	5	2 x 6
	Up to 8	8 x 10	8 x 10	8 x 10	8 x 10	10x10	5	12x12	5	2 x 6
	See Note 1									
15 to 20	Up to 6	8 x 10	8 x 10	8 x 10	8 x 10	10x10	5	12x12	5	3 x 6
	See Note 1									
Over 20	Excavation plan shall be prepared by a degreed civil/structural engineer and reviewed by CSD									

* Mixed oak or equivalent with a bending strength of not less than 850 psi.

** Timber sizes shown are actual (not nominal) sizes. Manufactured members of equivalent strength may be substituted for wood.

Notes:

1. Maximum spoils height is 0.6 m (2 ft) within a horizontal distance away from the edge of the excavation equal to the depth of the excavation.

2. Member sizes at spacings other than indicated requires an excavation plan to be prepared by a degreed civil/structural engineer and reviewed by CSD.

Figure 1.16 Layout of Trenches 1.2 to 2.4 m (4 to 8 ft) Deep

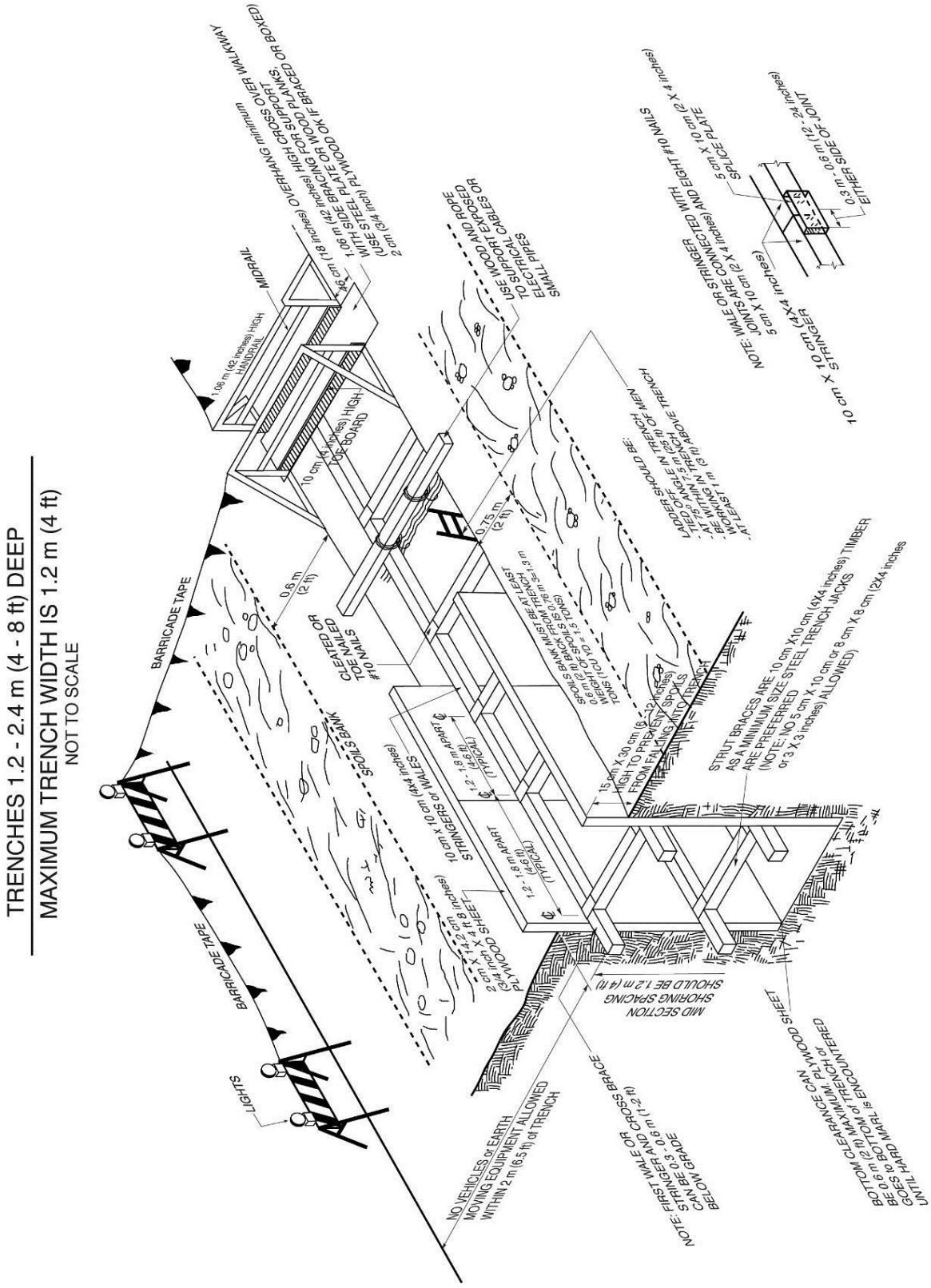
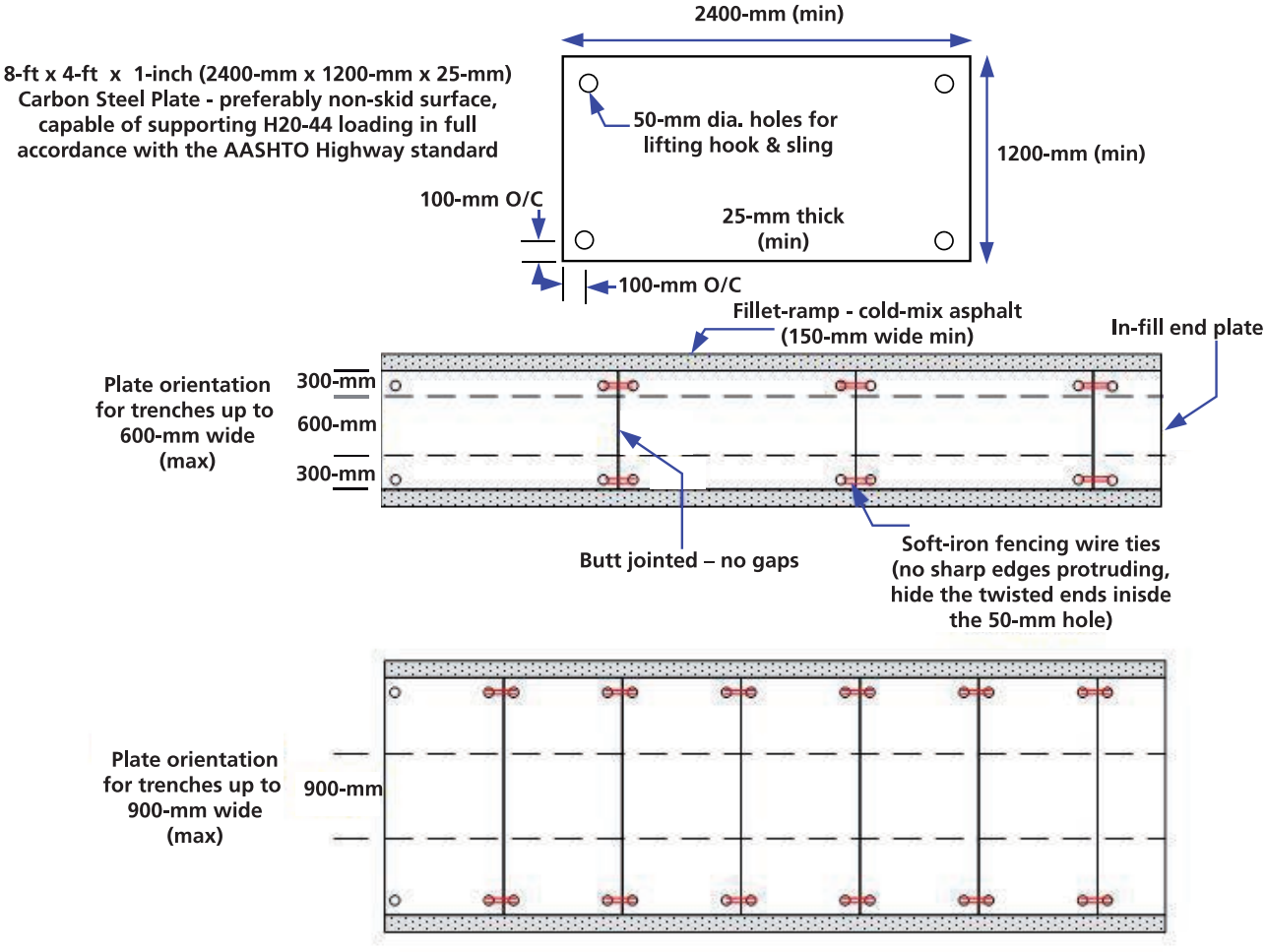


Figure 1.17 Typical Cover Plates for Road Trenches



Notes

1. Road surface shall be level, adjust level using cold-mix asphalt as required. Plates shall be fully supported around the perimeter to prevent wobbling or rocking.
2. No protruding edges on the plates No nails or screws. Deflected or damaged plates shall not be used.
3. Minimum 300-mm overlap between the edge of the plate and the edge of the trench.
4. Warning sign "Slow -Ramp Ahead" must be placed 30-meters before the trench on each side of the road.
5. Trenches over 900-mm wide, or > 15-m long, required an engineered design solution.
6. Plate protection for road trenches must be included in the work permit and HIP.
7. The trench shoring shall be in accordance with Section 1.7 of this Chapter.
8. Open road trenches shall have warning lights during darkness hours.
9. All road work shall be in accordance with Saudi Aramco Engineering Standards requirements and road crossings shall be completed in an expeditious manner to minimize duration for use of trench cover plates.

Figure 1.18 Typical Cover Plates for Road Trenches

Alternate Plate Jointing Method
[temporary welds]

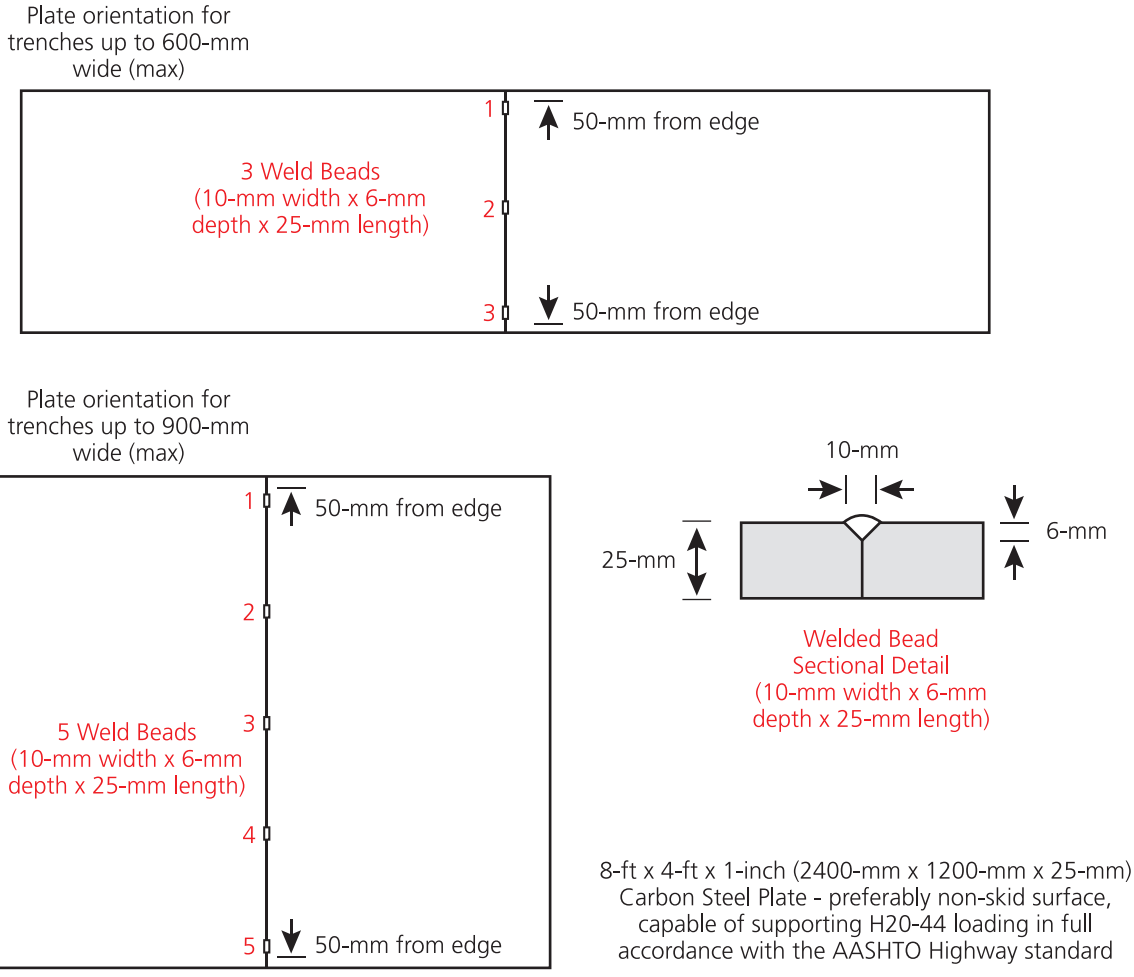


Figure 1.19 Typical Cover Plates for Road Trenches

Road Trench
Flush Fitting Option
[wire ties or temporary welds]

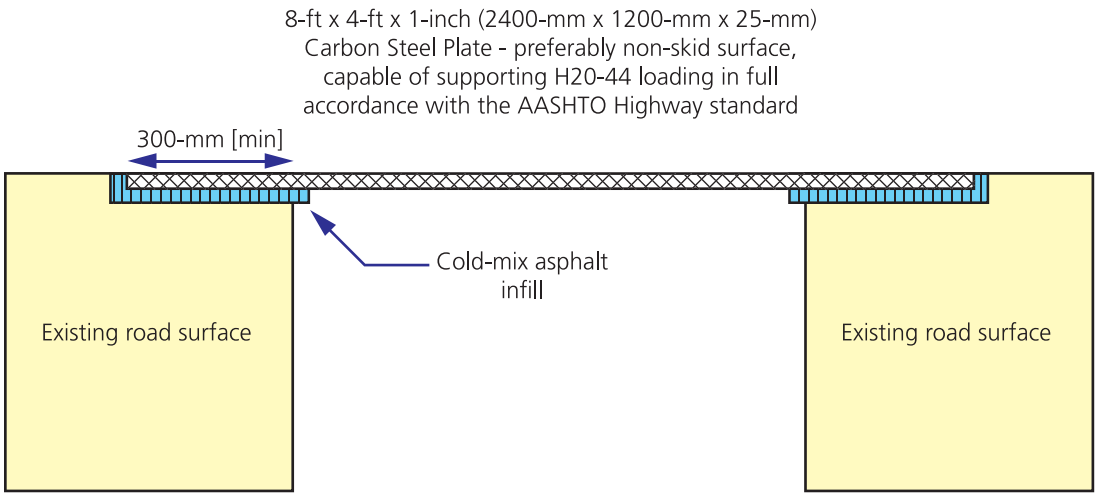


Figure 1.20 Typical Cover Plates for Road Trenches

Road Trench
Surface Installation
[wire ties or temporary welds]

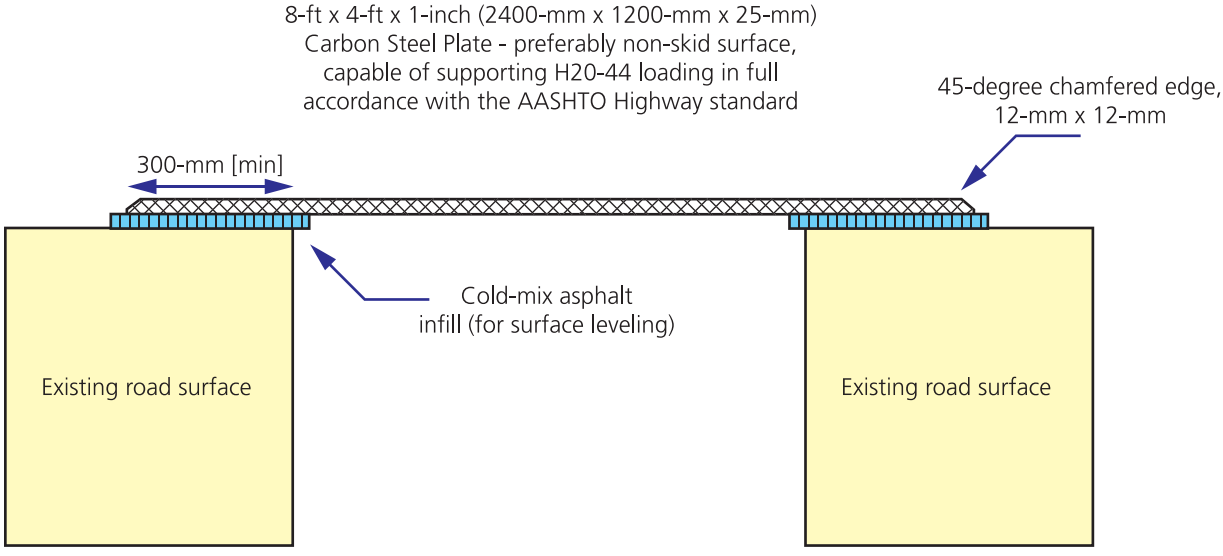
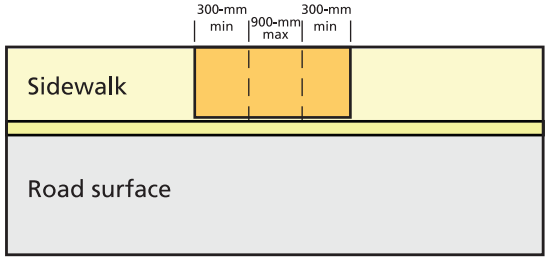


Figure 1.21 Typical Sidewalk Trench Protection

8-ft x 4-ft x ¾-inch (2400-mm x 1200-mm x 20-mm)
Shuttering or Shoring Plywood - non-skid surface

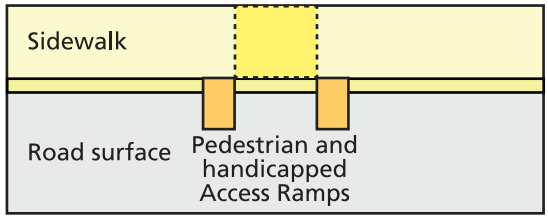
Non-Barricaded
Open Trench

Protection for open trenches up to 900-mm wide (max), in a sidewalk without barricades

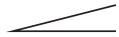


Barricaded
Open Trench

Protection for open trenches any width in a sidewalk with barricades



Pedestrian and Handicapped
Access Ramp



30˚ slope (max)

¾-inch thick (20-mm)
Shuttering or Shoring Plywood, non-skid surface, nailed construction with 2-inch (50-mm) x 2-inch (50-mm) frame, 31-inches (800-mm) wide minimum.

The pedestrian and handicapped access ramp shall be protected with traffic cones placed at 2-ft (600-mm) intervals on the road aligned to the length of the ramp, to a distance of 30-ft (10-m) either side.

1. Secure plywood by masonry nails or screws to the concrete or asphalt substrate, no protruding heads.

2. Minimum 300-mm overlap between the edge of the plywood and the edge of the sidewalk trench.

3. Open sidewalk trenches shall have warning lights during darkness hours.

4. Sidewalk trenches over 900-mm wide, or > 15-m long, require an engineered design solution.

5. Plywood protection for sidewalk trenches must be included in the work permit and HIP.

6. The trench shoring shall be in accorrdance with Section 1.7 of this Chapter.

7. Open trenches shall have wooden barricades on all sides,¾-inch thick (20-mm) Shuttering or Shoring Plywood,nailed construction with 2-inch (50-mm) x 2-inch (50-mm) frame, sanded finish (no splinters) and painted.

PRE-EXCAVATION CHECKLIST

PROJECT OR WORK ORDER NUMBER		EXCAVATION LOCATION	

	ACTIONS	REMARKS	DONE	INITIALS
SPONSORING ORGANIZATION (e.g., Project Management,	• Arrange and review excavation drawing	_____	☐	_____
	• Arrange demarcation of excavation site	_____	☐	_____
	• Survey site with proponent operation's rep.	_____	☐	_____
	• Arrange sign-off of this checklist by all parties	_____	☐	_____
	• Provide Work Permit (WP) Issuer's organization with this checklist and excavation drawing	_____ _____	☐ ☐	_____ _____
	• Provide notifications as required			
	SPONSORING ORGANIZATION'S REPRESENTATIVE			
	(Name, phone, signature & date) _____			
PROPONENT ENGINEERING/TECHNICAL (specify Division)	• Determine location of underground (U/G) utilities, including contacting Government Affairs if off site	_____	☐	_____
	• Verify operational status and operating condition of U/G utilities	_____ _____	☐ ☐	_____ _____
	• Arrange cable/pipe detection to locate utilities not shown on drawings and unmarked in the field			
	PROPONENT'S ENGINEERING / TECHNICAL SERVICES REPRESENTATIVE			
	(Name, phone, signature & date) _____			
PROPONENT OPERATIONS (specify Division)	• Survey site with sponsoring organization's rep.	_____	☐	_____
	• Review excavation drawing	_____	☐	_____
	• De-energize cables and isolate piping, if possible	_____	☐	_____
	• Advise WP Issuer about precautions required	_____	☐	_____
	PROPONENT OPERATION'S REPRESENTATIVE			
	(Name, phone, signature & date) _____			
ORGANIZATION OF WP RECEIVER (specify)	Review Saudi Aramco's excavation safety requirements and implement applicable measures	_____	☐	_____
	• Double-check area for unknown U/G utilities with cable/metal detector in presence of WP Issuer	_____	☐	_____
	• Provide WP Issuer with this fully signed Pre-Excavation Checklist and excavation drawing	_____	☐	_____
	WORK PERMIT RECEIVER ORGANIZATION'S REPRESENTATIVE			
	(Name, phone, signature & date) _____			

EXCAVATION INSPECTION CHECKLIST

Project or WO # _____ Excavation Location _____

This checklist shall be completed and posted on site by the excavation competent person. Inspections shall be performed before workers are initially allowed to enter the excavation, after a change in site conditions (e.g., rain storm, groundwater, sidewall deterioration or adjacent ground fissuring) and daily for excavations greater than 2.4 m (8 ft) deep. At the end of the workday, this checklist shall be given to the contractor's safety supervisor for review and filing. The contractor's safety supervisor shall maintain a consolidated list of all excavations and conduct random inspections of excavations during the course of the workday. All of Saudi Aramco's safety requirements shall be complied with at all times. The excavation competent person shall be knowledgeable of Saudi Aramco's safety requirements and have the necessary training and experience to ensure the work is performed safely.

Depth of excavation: _____ meters / feet	**Width of excavation: _____ meters / feet**

	YES	NO	N/A
Has a Pre-Excavation Checklist been completed prior to digging?			
Have all relevant departments been notified prior to digging?			
Are underground utilities, cables and pipelines located and marked prior to digging?			
Is a work permit required, issued and available on site?			
Is a Confined Space Entry Permit required, issued and available on site?			
Is gas testing required and performed; e.g., excavations deeper than 1.2 m (4 ft)?			
Is a Stand-by Man and/or Fire Watch required and available on site?			
Are pedestrian crossovers required and provided (with guardrails)?			
Is access to plant/process equipment maintained?			
If excavation is near a roadway are flagmen with bright orange vests present?			
Is the shoring/sloping/benching acceptable to prevent sidewall cave-in?			
Is shoring material in sound condition and free of damage/defects?			
Is shoring installed/maintained by qualified personnel?			
Are adequate ladders provided within a travel distance of 7.5 m (25 ft)?			
Are ladders properly secured and do they extend 1 m (3 ft) above the surface?			
Is the excavation free of tension cracks or other evidence of sidewall failure?			
Is the excavation free of water, hydrocarbons, or other toxic substances?			
Are materials and spoils set back at least 0.6 m (2 ft) from the excavation's edge?			
Are underground utilities and piping located, marked and protected from damage?			
Are pedestrian barricades/lights placed at least 1 m (3 ft) from excavation's edge?			
Are hard barricades for vehicles placed at least 2 m (6.5 ft) from excavation's edge?			
Are cranes not closer than the depth of excavation to the edge of the excavation?			
Are scaffolds erected no closer than 1.5 times the depth of excavation from its edge?			
Are overall conditions acceptable and safe for work?			

All deficiencies will be corrected immediately.

_____ _____ _____

Competent Person's Signature ***Date*** ***Verified by (Proponent/PMT)***

EXCAVATION SAFETY POCKET CARD

Use this safety inspection pocket card when planning, constructing, entering and/or restoring excavations and trenches over 1.2 m (4 ft) deep or excavations where buried utilities, pipelines, or cables may be present.

PLANNING
Has a Pre-Excavation Checklist been completed & on site?
Have all relevant departments been notified?
Are utilities, cables and pipelines located and marked?
Was an excavation plan (calculations & drawing) prepared by a civil engineer if excavation > 6 m (20 ft) deep?
Has the soil type (see back) been determined by a soil analysis or by a "Competent Person"?
Is a Confined Space Entry Permit required and on site?
CONSTRUCTION
Is only excavating/backfilling equipment allowed within 2 m (6.5 ft) of the excavation and are the following clearances maintained (unless properly designed shoring is used): • Vehicles/cranes/heavy equipment more than the depth of excavation away from excavation (2 m [6.5 ft] min.), • Scaffold posts > 1.5 times depth of excavation away?
Has one or more of the following methods of protection against sidewall cave-in been used and has it been done per the excavation drawing? • Benching • Sloping (see back) • Shoring (including trench shields, etc.)
Are spoil piles placed > 0.6 m (2 ft) away from excavation?
Are pedestrian barricades erected > 1 m (3 ft) away?
Are blinking warning lights installed and used?
Is a documented inspection performed daily by a "Competent Person"?
PERSONNEL ENTRY
Do only authorized personnel enter the excavation?
Is any water in the excavation controlled by pumping?
Are gas tests conducted (e.g., low oxygen, toxic gases)?
Is a ladder or other access available within 7.5 m (25 ft) travel distance (e.g., ladders spaced < 15 m [50 ft] apart)?
Is emergency rescue equipment available?
RESTORATION
Has the work area been restored?
Are the walking surfaces level?

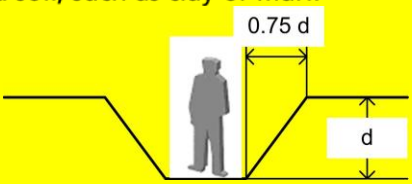
SUMMARY OF SOIL TYPES AND MAXIMUM ALLOWABLE SLOPES

A "Competent Person" is a person properly trained to identify existing and potential hazards, soil conditions, and proper design (i.e., benching, shoring, and sloping).

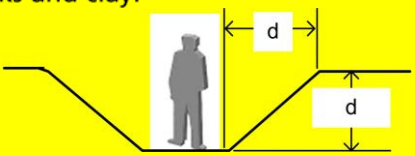
For sloping when excavation depth < 6 m (20 ft), use the following maximum allowable sidewall slopes for the type of soil, where "d" is the depth of the excavation.

- **Stable Rock** - Natural solid mineral matter that can be excavated with vertical sides, such as sandstone.

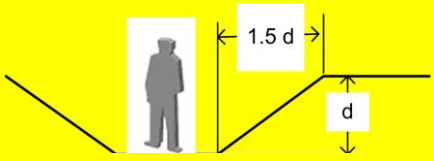
- **Type A Soil** - Previously undisturbed cohesive or cemented soil, such as clay or marl.



- **Type B Soil** - Less cohesive soil, such as a mix of sand, rocks and clay.



- **Type C Soil** - Least cohesive soil. Examples are: gravel, sand, muddy or freely seeping soils, submerged rock that is not stable or a layered system. Previously disturbed soil is Type C soil.



Front **Back**