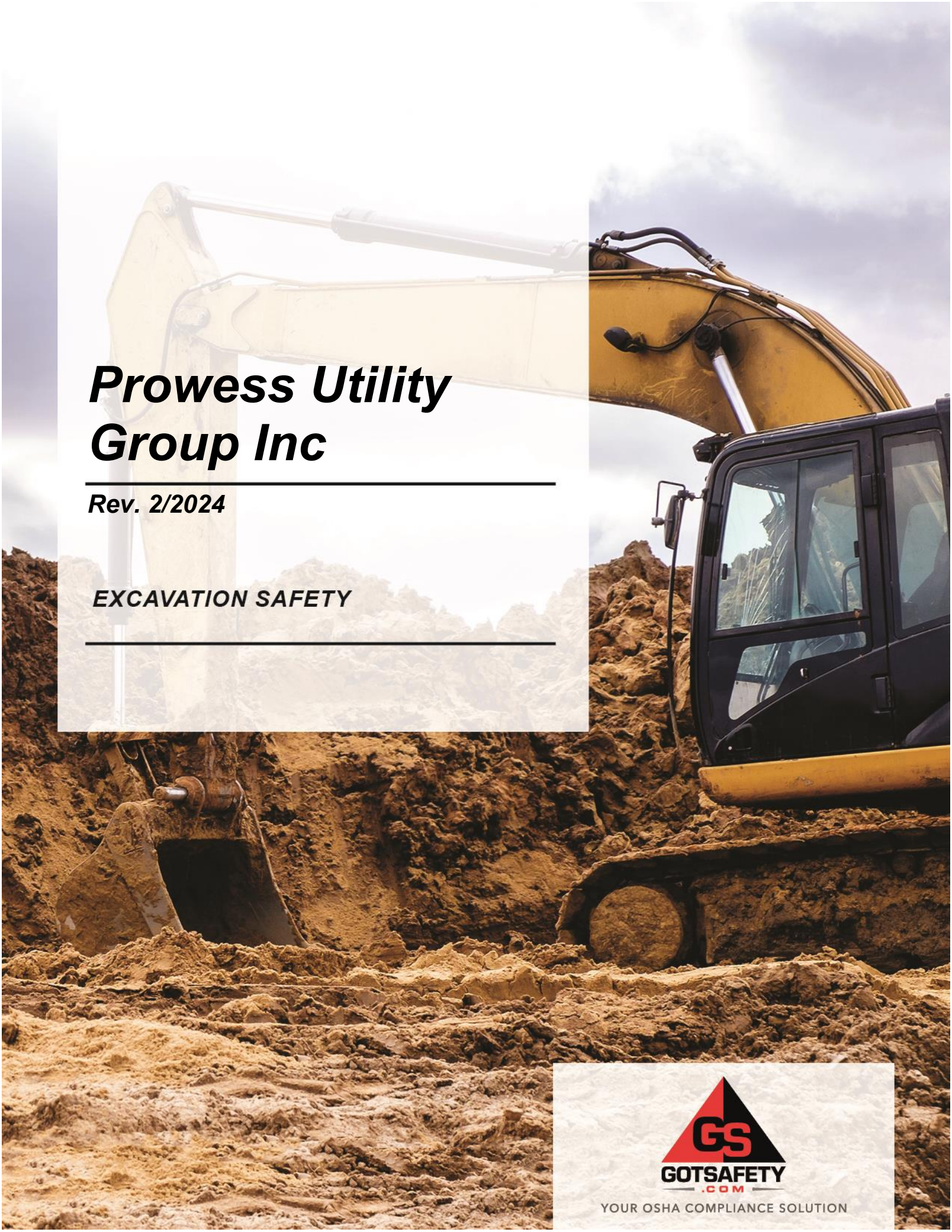

Prowess Utility Group Inc

Rev. 2/2024

EXCAVATION SAFETY

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YOUR OSHA COMPLIANCE SOLUTION

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1 OBJECTIVE

Excavating is recognized as one of the most hazardous construction operations; therefore, Prowess Utility Group Inc has adopted this Excavation Safety Program which provides Prowess Utility Group Inc and employees with the general safety standards and awareness necessary to recognize and control some of the hazards associated with trenching and excavation. The program is designed and correlated with the rules set forth under Title 8, California Code of Regulations, Sections 1540-1541.1.

2 GENERAL REQUIREMENTS

2.1 Surface Encumbrances

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

2.2 Subsurface Installations

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

a. Excavation will not commence until:
   1. The excavation area has been marked as specified in California Government Code Section 4216.2 by the excavator; and
   2. The excavator has received a positive response from all known owner/operators of subsurface installations within the boundaries of the proposed project; those responses confirm that the owner/operators have located their installations and those responses either advise the excavator of those locations or advise the excavator that the owner/operator does not operate a subsurface installation that would be affected by the proposed excavation.

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

c. Only qualified persons will perform subsurface installation locating activities, and all such activities will be performed in accordance with this section and California Government Code Sections 4216 through 4216.9. Persons who complete a training program in accordance with the

requirements of California Code of Regulations, Title 8, Section 1509, Injury and Illness Prevention Program (IIPP), that meets the minimum training guidelines and practices of the Common Ground Alliance (CGA) Best Practices, Version 3.0, published March 2006, or the standards of the National Utility Locating Contractors Association (NULCA), Standard 101: Professional Competence Standards for Locating Technicians, 2001, First Edition, which are incorporated by reference, will be deemed qualified for the purpose of this section.

d. Employees who are involved in the excavation operation and exposed to excavation operation hazards will be trained in the excavator notification and excavation practices required by this program and California Government Code Sections 4216 through 4216.9.

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

EXCEPTION: Repair work to subsurface facilities done in response to an emergency as defined in California Government Code Section 4216(d).

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

2.2.4 While the excavation is open, subsurface installations will be protected, supported or removed as necessary to safeguard employees.

2.2.5 An excavator discovering or causing damages to a subsurface installation will immediately notify the facility owner/operator or contact the Regional Notification Center to obtain subsurface installation operator contact information immediately after which the excavator will notify the facility operator. All breaks, leaks, nicks, dents, gouges, grooves or other damages to an installation's lines, conduits, coatings or cathodic protection will be reported to the subsurface installation operator. If damage to a high priority subsurface installation results in the escape of any flammable, toxic or corrosive gas or liquid or endangers life, health or property, the excavator responsible will immediately notify 9-1-1, or if 9-1-1 is unavailable, the appropriate emergency response personnel having jurisdiction. The facility owner/operator will also be contacted.

NOTE: The terms excavator and operator as used in Section 2.2 will be as defined in California Government Code Section 4216(c) and (h) respectively. The term "owner/operator" means an operator as the term "operator" is defined in California Government Code Section 4216(h).

2.3 Access and Egress

2.3.1 Structural Ramps

a. Structural ramps that are used solely by employees as a means of access or egress from excavations will be designed by a competent person. Structural ramps used for access or egress of equipment will be designed by a competent person qualified in structural design and will be constructed in accordance with the design.
b. Ramps and runways constructed of 2 or more structural members will have the structural members connected together to prevent displacement.
c. Structural members used for ramps and runways will be of uniform thickness.
d. Cleats or other appropriate means used to connect runway structural members will be attached to the bottom of the runway or will be attached in a manner to prevent tripping.
e. Structural ramps used in lieu of steps will be provided with cleats or other surface treatments to the top surface to prevent slipping.

2.3.2 Means of egress from trench excavations

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

2.4 Exposure to Vehicular Traffic

Employees exposed to public vehicular traffic will be provided with, and will wear, warning vests or other suitable garments marked with, or made of, reflectorized or high-visibility material.

2.5 Exposure to Falling Loads

No employee will be permitted underneath loads handled by lifting or digging equipment. Employees will be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles are equipped, in accordance with California Code of Regulations, Title 8, Section 1591(e), to provide adequate protection for the operator during loading and unloading operations.

2.6 Warning System for Mobile Equipment

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

2.7 Hazardous Atmospheres

2.7.1 Testing and Controls

In addition to the requirements set forth in the Construction Safety Orders and the General Industry Safety Orders to prevent exposure to harmful levels of atmospheric contaminants and to assure acceptable atmospheric conditions, the following requirements will apply:

a. Where oxygen deficiency (atmospheres containing less than 19.5% oxygen) or a hazardous atmosphere exists or could reasonably be expected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, the atmospheres in the excavation will be tested before employees enter excavations greater than 4 feet in depth.
b. Adequate precautions will be taken to prevent employee exposure to atmospheres containing less than 19.5% oxygen and other hazardous substances. These precautions include providing proper respiratory protection or ventilation.
c. Adequate precaution will be taken, such as providing ventilation, to prevent employee exposure to an atmosphere containing a concentration of a flammable gas in excess of 20% of the lower flammable limit of the gas.
d. When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, testing will be conducted as often as necessary to ensure that the atmosphere remains safe.

2.7.2 Emergency Rescue Equipment

a. Emergency rescue equipment, such as breathing apparatus, a safety harness and line, or a basket stretcher, will be readily available where hazardous atmospheric conditions exist or may reasonably be expected to develop during work in an excavation. This equipment will be attended when in use.
b. Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, will wear a harness with a lifeline securely attached to it. The lifeline will be separate from any line used to handle materials and will be individually attended at all times while the employee wearing the lifeline is in the excavation.

2.7.3 Whenever internal combustion engine-driven equipment is operated inside a shaft subject to Section 1542 of the California Code of Regulations, a ventilation system will be provided and operated in accordance with California Code of Regulations Sections 1530 and 1533(b).

NOTE: For shafts greater than 20 feet in depth and excavations unrelated to the Cal/OSHA Construction Safety Orders, refer to California Code of Regulations, Title 8, Division 1, Chapter 4, Subchapter 20, the Tunnel Safety Orders.

2.8 Protection from Hazards Associated with Water Accumulation

2.8.1 Employees will not work in excavations in which there is accumulated water, or in excavations in which water is accumulating, unless adequate

precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions necessary to protect employees adequately vary with each situation, but could include special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water or use of a safety harness and lifeline.

2.8.2 If water is controlled or prevented from accumulating by the use of water removal equipment, the water removal equipment and operations will be monitored by a competent person the ensure proper operation.

2.8.3 If excavation work interrupts the natural drainage of surface water (such as streams), diversion ditches, dikes or other suitable means will be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation. Excavations subject to runoff from heavy rains will require an inspection by a competent person and compliance with Sections 2.8.1 and 2.8.2.

2.9 Stability of Adjacent Structures

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

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

a. A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure; or
b. The excavation is in stable rock; or
c. A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.

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

2.10 Protection of Employees from Loose Rock or Soil

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

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

2.11 Inspection

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

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

2.12 Fall Protection

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

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

3 REQUIREMENTS FOR PROTECTIVE SYSTEMS

3.1 Protection of Employees in Excavations

3.1.1 Each employee in an excavation will be protected from cave-ins by an adequate protective system designed in accordance with Section 3.2 or 3.3 except when:

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

3.1.2 Protective systems will have the capacity to resist without failure all loads that are intended or could reasonably be expected to be applied or transmitted to the system.

3.2 Design of Sloping and Benching Systems

The slopes and configurations of sloping and benching systems will be selected and constructed by Prowess Utility Group Inc or designee and will be in accordance with the requirements of Section 3.2.1, 3.2.2, 3.2.3 or 3.2.4 as follows:

3.2.1 Option (1) – Allowable Configurations and Slopes

a. Excavations will be sloped at an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal), unless one of the other options listed below are used.
b. Slopes specified in 3.2.1(a) will be excavated to form configurations that are in accordance with the slopes shown for Type C soil in Appendix 3.

3.2.2 Option (2) – Determination of Slopes and Configurations using Appendices 2 and 3.

Maximum allowable slopes, and allowable configurations for sloping and benching systems, will be determined in accordance with the conditions and requirements set forth in Appendices 2 and 3.

3.2.3 Option (3) – Designs Using Other Tabulated Data

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

3.2.4 Option (4) – Design by a Registered Professional Engineer

a. Sloping and benching systems not utilizing Option (1) or Option (2) or Option (3) under Section 3.2.1 will be stamped and signed by a registered professional engineer.
b. Designs will be in written form and will include at least the following:
    1. The magnitude of the slopes that were determined to be safe for the particular project;
    2. The configurations that were determined to be safe for the particular project;
    3. The identity of the registered professional engineer approving the design.
c. At least one copy of the design will be maintained at the jobsite while the slope is being constructed. After that time the design need not be at the jobsite, but a copy will be made available to the Division upon request.

3.3 Design of Support Systems, Shield Systems and Other Protective Systems

Designs of support systems, shield systems and other protective systems will be selected and constructed by Prowess Utility Group Inc or designee and will be in accordance with the requirements of Section 3.3.1; or, in the alternative, Section 3.3.2; or, in the alternative, Section 3.3.3; or, in the alternative, Section 3.3.4 as follows:

3.3.1 Option (1) – Designs using Appendices 2, 4 and 5

Designs for timber shoring in trenches will be determined in accordance with the conditions and requirements set forth in Appendices 2 and 4. Designs for aluminum hydraulic shoring will be in accordance with Section 3.3.2, but if manufacturer's tabulated data cannot be utilized, designs will be in accordance with Appendix 5.

3.3.2 Option (2) – Designs using Manufacturer's Tabulated Data

a. Design of support systems, shield systems or other protective systems that are drawn from manufacturer's tabulated data will be in accordance with all specifications, recommendations and limitations issued or made by the manufacturer.
b. Deviation from the specifications, recommendations and limitations issued or made by the manufacturer will only be allowed after the manufacturer issues specific written approval.
c. Manufacturer's specifications, recommendations and limitations, and manufacturer's approval to deviate from the specifications, recommendations and limitations will be in written form at the jobsite during construction of the protective system. After that time this data may be stored off the jobsite, but a copy will be made available to the Division upon request.

3.3.3 Option (3) – Designs using Other Tabulated Data

a. Designs of support systems, shield systems or other protective systems will be selected from, and be in accordance with, tabulated data such as tables and charts.
b. The tabulated data will be in written form and include all of the following:
    1. Identification of the parameters that affect the selection of a protective system drawn from such data;
    2. Identification of the limits of use of the data;
    3. Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.
c. At least one copy of the tabulated data, which identifies the registered professional engineer who approved the data, will be maintained at the jobsite during construction of the protective system. After that time, the data may be stored off the jobsite, but a copy of the data will be made available to the Division upon request.

3.3.4 Option (4) – Design by a Registered Professional Engineer

a. Support systems, shield systems and other protective systems not utilizing Option (1), Option (2) or Option (3) above will be approved by a registered professional engineer.
b. Designs will be in written form and will include the following:
    1. A plan indicating the sizes, types and configurations of the materials to be used in the protective system; and
    2. The identity of the registered professional engineer approving the design.
c. At least 1 copy of the design will be maintained at the jobsite during construction of the protective system. After that time, the design may be stored off the jobsite, but a copy of the design will be made available to the Division upon request.

3.4 Materials and Equipment

3.4.1 Materials and equipment used for protective systems will be free from damage or defects that might impair their proper function.

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

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

3.5 Installation and Removal of Supports

3.5.1 General

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

f. Backfilling will progress together with the removal of support systems from excavations.

3.5.2 Additional requirements for support systems for trench excavations

a. Excavation of material to a level no greater than 2 feet below the bottom of the members of a support system will be permitted, but only if the system is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the support system.
b. Installation of a support system will be closely coordinated with the excavation of trenches.

3.6 Sloping and Benching Systems

Employees will not be permitted to work on the faces of sloped or benched excavations at levels above other employees except when employees at the lower levels are adequately protected from the hazard of falling, rolling or sliding material or equipment.

3.7 Shield Systems

3.7.1 General

a. Shield systems will not be subjected to loads exceeding those which the system was designed to withstand.
b. Shields will be installed in a manner to restrict lateral or other hazardous movement of the shield in the even of the application of sudden lateral loads.
c. Employees will be protected from the hazard of cave-ins when entering or exiting the areas protected by shields.
d. Employees will not be allowed in shields when shields are being installed, removed or moved vertically.

3.7.2 Additional requirements for shield systems used in trench excavations

The sides of the shield will extend a minimum of 18 inches above the vertical walls of compound excavations as shown in Appendix 3, figures B-1, B-1.2 and B-1.3. On vertically-cut trenches, the shield will extend to at least the catch point of the trench. Excavations of earth material to a level not greater than 2 feet below the bottom of a shield will be permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the shield.

3.8 Uprights

Uprights will extend to the top of the trench with the lower end of the upright not more than 2 feet from the bottom of the trench.

4 SHAFTS

4.1 General

4.1.1 All wells or shafts over 5 feet in depth into which employees are permitted to enter will be retained with lagging, spiling or casing.

EXCEPTION: Exploration shafts; see California Code of Regulations, Section 1542(d).

4.1.2 The lagging, spiling or casing will extend at least one foot above ground level and will be provided the full depth of the shaft or at least 5 feet into solid rock, if possible.

4.1.3 All wells, pits, shafts, caissons, etc. will be barricaded or securely covered.

4.1.4 Upon completion of exploration and similar operations, temporary wells, pits, shafts, etc. will be backfilled.

4.2 Small Shafts in Hard Compact Soil

Two-inch (nominal) cribbing may be used in square shafts not over 4 feet square in hard compact soil. Each member will be cut 1/2 way through the width of the member and dovetailed into position so each member will act as a shore as well as lagging. Strips will be nailed in each corner to prevent the boards from dropping down.

4.3 Shafts in Other Than Hard Compact Soil

4.3.1 A system of lagging supported by braces and corner posts will be used for square or rectangular shafts. Corner posts of 4-inch by 4-inch material are normally acceptable in shafts 4-feet square, or smaller, if they are braced in each direction with horizontal 4-inch by 4-inch members at intervals not exceeding 4 feet. Braces and corner posts in larger shafts will be correspondingly larger as determined by a civil engineer.

4.3.2 Round shafts will be completely lagged with 2-inch material which is supported at intervals not greater than 4 feet by means of adjustable rings of metal or timber that are designed to resist the collapsing force, or cased in a manner that provides equivalent protection.

4.4 Exploration Shafts

Only a geotechnical specialist will be permitted to enter an exploration shaft without lagging, spiling or casing for the purpose of subsurface investigations under the following conditions:

4.4.1 Initial Inspection
The type of materials and stability characteristics of the exploration shaft will be personally observed and recorded by the geotechnical specialist during

the drilling operation. Potentially unsafe explorations shafts will not be entered.

4.4.2 Surface Casing

The upper portion of the exploration shaft will be equipped with a surface ring-collar to provide casing support of the material within the upper 4 feet of the exploration shaft. The ring-collar will extend at least 1-foot above the ground surface.

4.4.3 Gas Tests

Prior to entry into exploration shafts, tests and/or procedures will be instituted to assure that the atmosphere within the shaft does not contain dangerous air contamination or oxygen deficiency. These tests and/or procedures will be maintained while working within the shaft to assure that dangerous air contamination or oxygen deficiency will not occur.

4.4.4 Unstable Local Conditions

The geotechnical specialist will not descend below any portion of any exploration shaft where caving or groundwater seepage is noted or suspected.

4.4.5 Ladder and Cable Descents

A ladder may be used to inspect exploration shafts 20 feet or less in depth. In deeper exploration shafts, properly-maintained mechanical hoisting devices with a safety factor of at least 6 will be provided and used. Such devices will be under positive control of the operator being positive powered up and down with fail-safe brakes.

4.4.6 Emergency Standby Employee

An emergency standby employee will be positioned at the surface near the exploration shaft opening whenever a geotechnical specialist is inside the shaft.

4.4.7 Communication

A two-way, electrically-operated communication system will be in operation between the standby employee and the geotechnical specialist whenever boring inspections are being made in exploration shafts over 20 feet in depth or when ambient noise levels make communication difficult.

4.4.8 Safety Equipment

The following safety equipment will be used to protect the geotechnical specialist:

a. An approved safety harness which will suspend a person upright and that is securely attached to the hoist cable.
b. A 12-inch to 18-inch diameter steel coneshaped headguard/deflector that is attached to the hoist cable above the harness.
c. A hoist cable having a minimum diameter of 5/16 inches.
d. Approved head protection.

4.4.9 Electrical Devices
All electrical devices used within the exploration shaft by the geotechnical specialist will be approved for hazardous locations.

4.4.10 Surface Hazards
The storage and use of flammable or other dangerous materials will be controlled at the surface to prevent them from entering the exploration shaft.

5 COFFERDAMS

5.1 If overtopping of the cofferdam by high waters is possible, means will be provided for controlled flooding of the work area.

5.2 Warning signs for evacuation of employees in case of emergency will be developed and posted.

5.3 Cofferdam walkways, bridges or ramps with at least 2 means of exit will be provided with guardrails as specified in California Code of Regulations, Title 8, Section 1620.

5.4 Cofferdams located close to navigable shipping channels will be protected from vessels in transit, where possible.

APPENDIX 1 – DEFINITIONS

Accepted engineering practices – Those requirements which are compatible with standards of practice required by a registered professional engineer.

Aluminum hydraulic shoring – A pre-engineered shoring system comprised of aluminum hydraulic cylinders (crossbraces) used in conjunction with vertical rails (uprights) or horizontal rails (walers). Such system is designed specifically to support the sidewalls of an excavation and prevent cave-ins.

Bell-bottom pier hole – A type of shaft or footing excavation, the bottom of which is made larger than the cross section above to form a belled shape.

Benching (benching system) – A method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

Cave-in – The separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury or otherwise injure and immobilize a person.

Crossbraces – The horizontal members of a shoring system installed perpendicular to the sides of the excavation, the ends of which bear against either uprights or wales.

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

Faces or sides – The vertical or inclined earth surfaces formed as a result of excavation work.

Failure – The breakage, displacement or permanent deformation of a structural member or connection so as to reduce its structural integrity and its supportive capabilities.

Hazardous atmosphere – An atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irrigating, oxygen deficient, toxic or otherwise harmful, may cause death, illness or injury.

Kickout – The accidental release or failure of a cross brace.

Protective system – A method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems and other systems that provide the necessary protection.

Ramp – An inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood.

Registered professional engineer – A person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a "registered professional engineer" within the meaning of this standard when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

Sheeting – The members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.

Shield (shield system) – A structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either premanufactured or job-built in accordance with Section 3.3.3 or 3.3.4. Shields used in trenches are usually referred to as "trench boxes" or "trench shields."

Shoring (shoring system) – A structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation and which is designed to prevent cave-ins.

Sides – see "Faces"

Sloping (sloping system) – A method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure and application of surcharge loads.

Stable rock – Natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.

Structural ramp – A ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock are not considered structural ramps.

Support system – A structure such as underpinning, bracing or shoring, which provides support to an adjacent structure, underground installation or the sides of an excavation.

Tabulated data – Tables and charts approved by a registered professional engineer and used to design and construct a protective system.

Trench (trench excavation) – A narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet. If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet or less, (measured at the bottom of the excavation), the excavation is also considered to be a trench.

Trench box – See "Shield."

Trench shield – See "Shield."

Uprights – The vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other. Uprights placed so that individual members are closely spaced, in contact with or interconnected to each other, are often called “sheeting.”

Wales – Horizontal members of a shoring system placed parallel to the excavation face whose sides bear against the vertical members of the shoring system or earth.

APPENDIX 2 – REQUIREMENTS FOR PROTECTIVE SYSTEMS (SOIL CLASSIFICATION)

a. Scope and Application

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

2. Application
This appendix applies when a sloping or benching system is designed in accordance with the requirements set forth in Section 3.2.2 as a method of protection for employees from cave-ins. This appendix also applies when timber shoring for excavations is designed as a method of protection from cave-ins in accordance with Appendix 4 and when aluminum hydraulic shoring is designed in accordance with Appendix 5. This appendix also applies if other protective systems are designed and selected for use from data prepared in accordance with the requirements set forth in Section 3.3 and the use of the data is predicated on the use of the soil classification system set forth in this appendix.

b. Definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Type B soil:

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

Type C soil:

1. Cohesive soil with an unconfined compressive strength of 0.5 tsf or less; or
2. Granular soils including gravel, sand and loamy sand; or
3. Submerged soil or soil from which water is freely seeping; or
4. Submerged rock that is not stable; or
5. Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper.

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

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

c. Requirements

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

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

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

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

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

d. Acceptable Visual and Manual Tests

1. Visual Tests
Visual analysis is conducted to determine qualitative information regarding the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the open excavation, and the soil taken as samples from excavated materials.
   a. Observe samples of soil that are excavated and soil in the sides of the excavation. Estimate the range of particle sizes and the relative amounts of the particle sizes. Soil that is primarily composed of fine-grained material is cohesive

material. Soil composed primarily of coarse-grained sand or gravel is granular material.

b. Observe soil as it is excavated. Soil that remains in clumps when excavated is cohesive. Soil that breaks up easily and does not stay in clumps is granular.
c. Observe the side of the opened excavation and the surface area adjacent to the excavation. Crack-like openings such as tension cracks could indicate fissured material. If chunks of soil spall off a vertical side, the soil could be fissured. Small spalls are evidence of moving ground and are indications of potentially hazardous situations.
d. Observe the area adjacent to the excavation and the excavation itself for evidence of existing utility and other underground structures, and to identify previously disturbed soil.
e. Observe the opened side of the excavation to identify layered systems. Examine layered systems to identify if the layers slope toward the excavation. Estimate the degree of slope of the layers.
f. Observe the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation or the location of the level of the water table.
g. Observe the area adjacent to the excavation and the area within the excavation for sources of vibration that may affect the stability of the excavation face.

2. Manual Tests

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

a. Plasticity – Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as 1/8-inch in diameter. Cohesive material can be successfully rolled into threads without crumbling. For example, if at least a 2-inch length of 1/8-inch thread can be held on one end without tearing, the soil is cohesive.
b. Dry strength – If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it is granular (any combination of gravel, sand or silt). If the soil is dry and falls into clumps which break up into smaller clumps, but the smaller clumps can only be broken up with difficulty, it may be clay in any combination with gravel, sand or silt. If the dry soil breaks into clumps which do not break up into small clumps and which can only be broken with difficulty, and there is no visual indication he soil is fissured, the soil may be considered unfissured.
c. Thumb penetration – The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb, and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a minimum the effects of exposure to drying influences (rain, flooding), the classification of the soil must be changed accordingly.
d. Other strength tests – Estimates of unconfined compressive strength of soils can also be obtained by use of a pocket penetrometer or by using a hand-operated shearvane.

e. Drying test – The basic purpose of the drying test is to differentiate between cohesive material with fissures, unfissured cohesive material and granular material. The procedure for the drying test involves drying a sample of soil that is approximately one inch thick and 6 inches in diameter until it is thoroughly dry:
   1. If the sample develops cracks as it dries, significant fissures are indicated.
   2. Samples that dry without cracking are to be broken by hand. If considerable force is necessary to break a sample, the soil has significant cohesive material content. The soil can be classified as an unfissured cohesive material and the unconfined compressive strength should be determined.
   3. If a sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

APPENDIX 3 – REQUIREMENTS FOR PROTECTIVE SYSTEMS (SLOPING AND BENCHING)

a. Scope and Application

This appendix contains specifications for sloping and benching when used as methods of protecting employees working in excavations from cave-ins. The requirements of this appendix apply when the design of sloping and benching protective systems is to be performed in accordance with the requirements set forth in Section 3.2.

b. Definitions

Actual slope – The slope to which an excavation face is excavated.

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

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

Short term exposure – A period of time less than, or equal to, 24 hours that an excavation is open.

c. Requirements

1. Soil classification
   Soil and rock deposits will be classified in accordance with Appendix 2 to Section 2.

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

3. Actual slope
   a. The actual slope will not be steeper than the maximum allowable slope.
   b. The actual slope will be less steep than the maximum allowable slope when there are signs of distress. If that situation occurs, the slope will be cut back to an actual slope which is at least 1/2 horizontal to one vertical (1/2H:1V) less steep than the maximum allowable slope.
   c. When surcharge loads from stored material or equipment, operating equipment or traffic are present, a competent person will determine the degree to which the actual slope must be reduced below the maximum allowable slope and will assure that such reduction is achieved. Surcharge loads from adjacent structures will be evaluated in accordance with Section 2.9.

4. Configurations
Configurations of sloping and benching systems will be in accordance with Figure B-1.

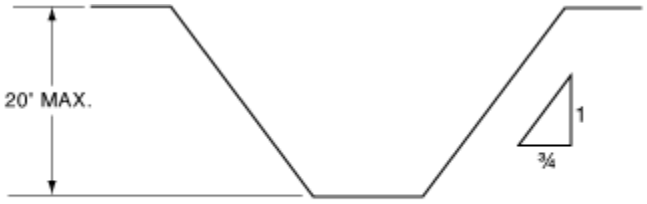
Table B-1 Maximum Allowable Slopes	
Soil or Rock Type	**Maximum Allowable Slopes (H:V) (1) for Excavations Less than 20 Feet Deep (3)**
Stable Rock	Vertical (90 Deg.)
Type A (2)	3/4:1 (53 Deg.)
Type B	1:1 (45 Deg.)
Type C	1 1/2:1 (34 Deg.)

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

Figure B-1
Slope Configurations

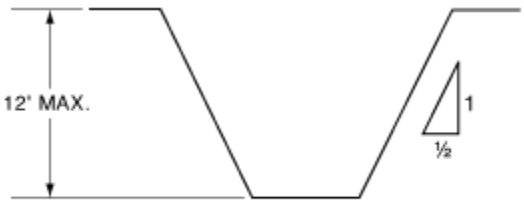
(All slopes stated below are in the horizontal to vertical ratio)
B-1.1 Excavations made in Type A soil

1. All simple slope excavations 20 feet or less in depth will give a maximum allowable slope of 3/4:1.



SIMPLE SLOPE - GENERAL

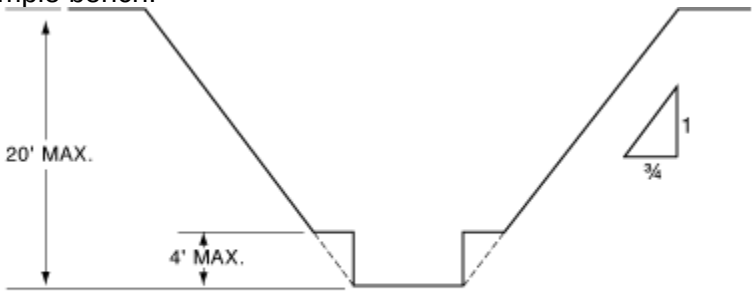
EXCEPTION: Simple slope excavations which are open 24 hours or less (short term) and which are 12 feet or less in depth will have a maximum allowable slope of 1/2:1.



SIMPLE SLOPE - SHORT TERM

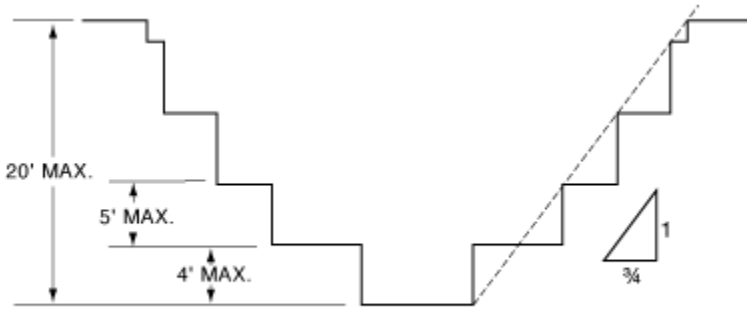
2. All benched excavations 20 feet or less in depth will have a maximum allowable slope of 3/4 to 1 and maximum bench dimensions as follows:

Simple bench:



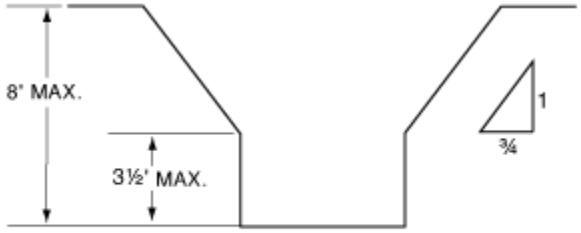
SIMPLE BENCH

Multiple bench:



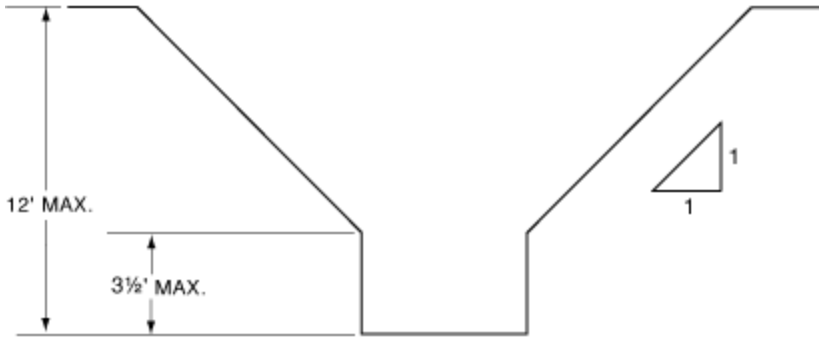
MULTIPLE BENCH

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



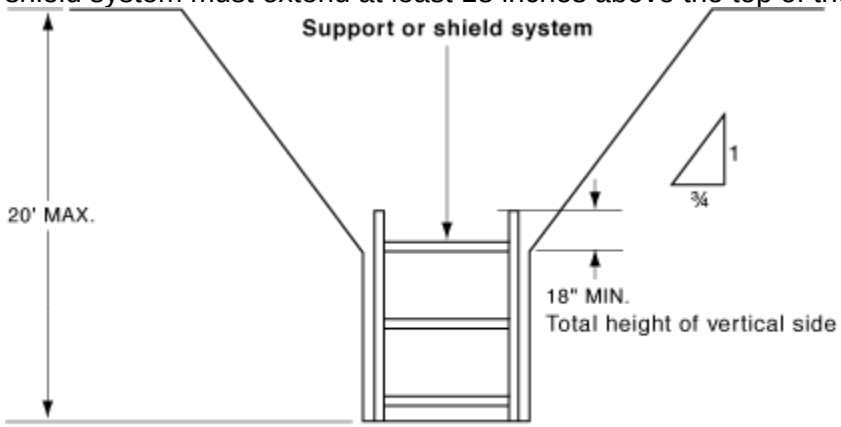
UNSUPPORTED VERTICALLY SIDED LOWER PORTION MAXIMUM 8 FEET IN DEPTH

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



**UNSUPPORTED VERTICALLY SIDED LOWER PORTION
MAXIMUM 12 FEET IN DEPTH**

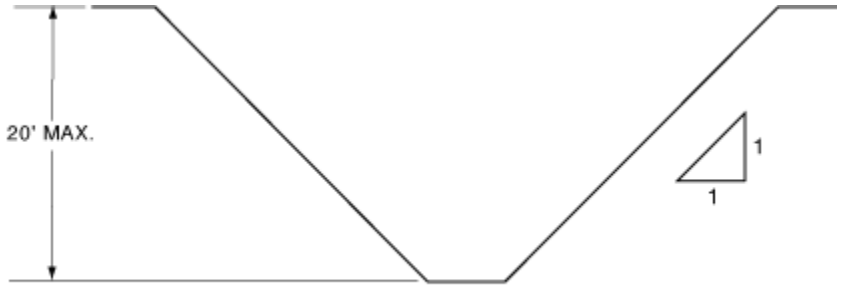
All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded will have a maximum allowable slope of 3/4:1. The support or shield system must extend at least 18 inches above the top of the vertical side.



**SUPPORTED OR SHIELDED VERTICALLY
SIDED LOWER PORTION**

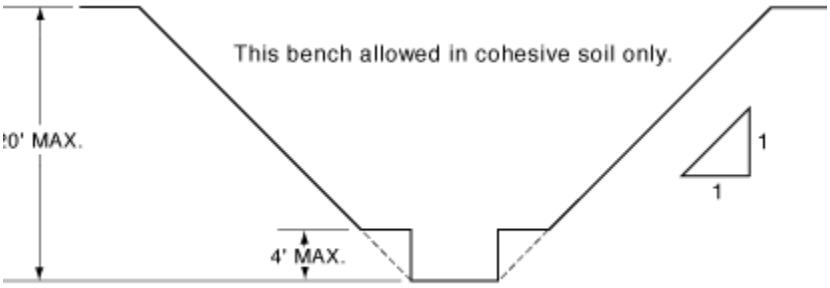
Figure B-1.2
Excavations Made in Type B Soil

1. All simple slope excavations 20 feet or less in depth will have a maximum allowable slope of 1:1.

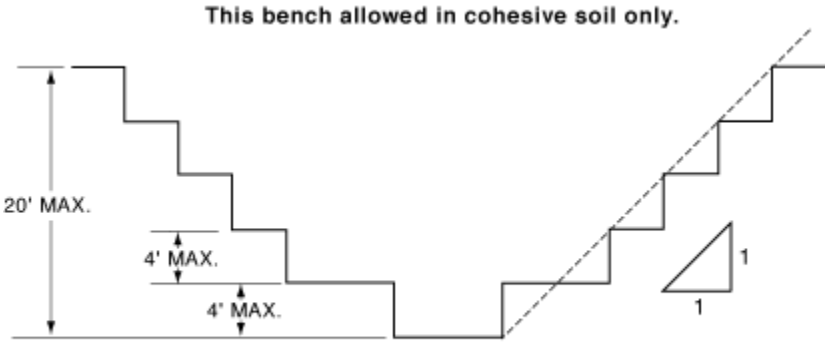


SIMPLE SLOPE

2. All benched excavations 20 feet or less in depth will have a maximum allowable slope of 1:1 and maximum bench dimensions as follows:

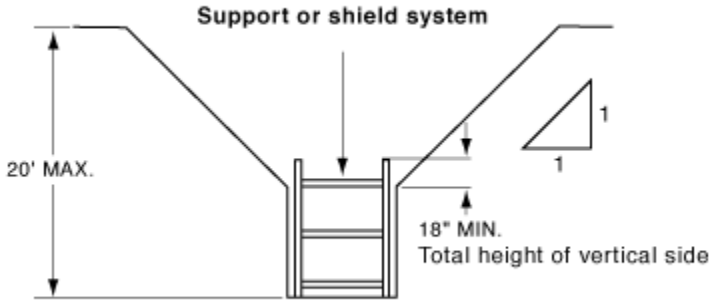


SINGLE BENCH



MULTIPLE BENCH

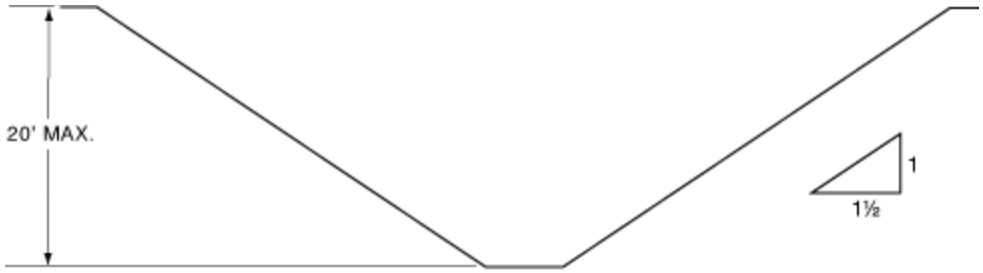
3. All excavations 20 feet or less in depth which have vertically sided lower portions will be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations will have a maximum allowable slope of 1:1.



VERTICALLY SIDED LOWER PORTION

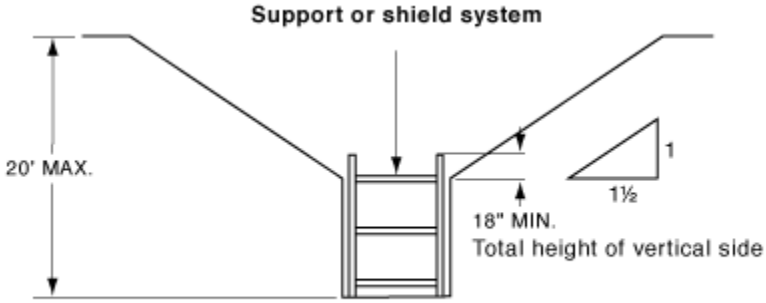
Figure B-1.3
Excavations Made in Type C Soil

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



SIMPLE SLOPE

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

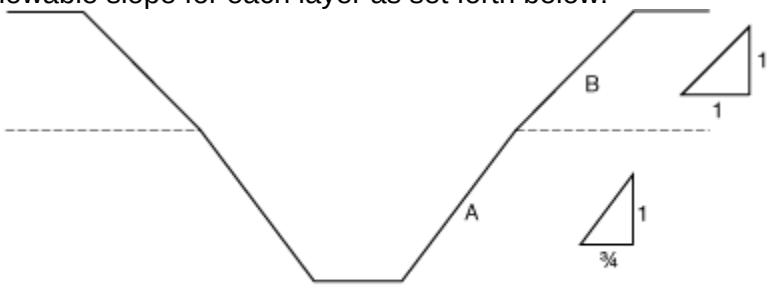


VERTICALLY SIDED LOWER PORTION

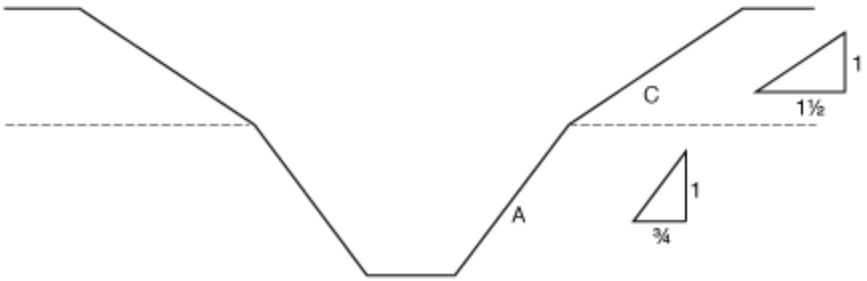
3. All other sloped excavations will be in accordance with the other options permitted in Section 3.2.2.

Figure B-1.4
Excavations Made in Layered Soil

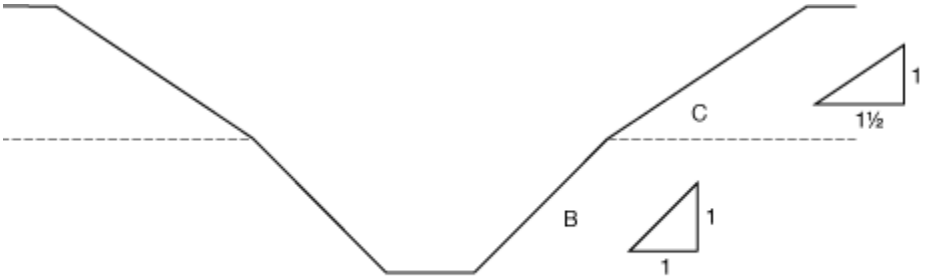
1. All excavations 20 feet or less in depth made in layered soils will have a maximum allowable slope for each layer as set forth below:



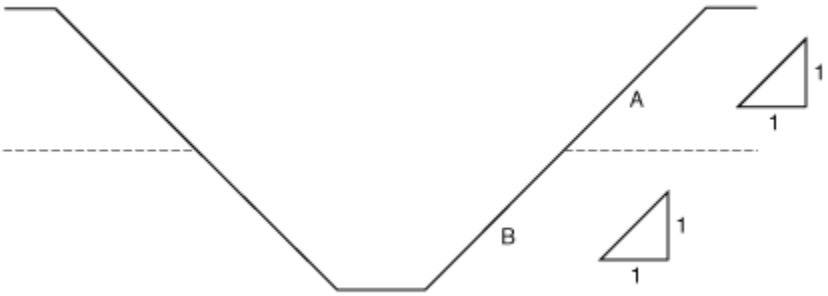
B OVER A



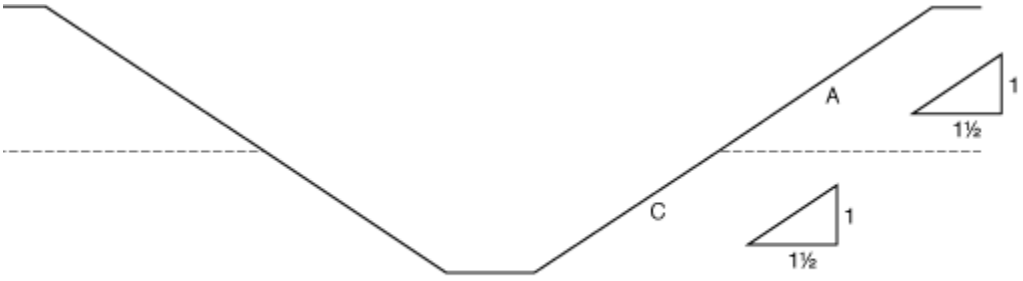
C OVER A



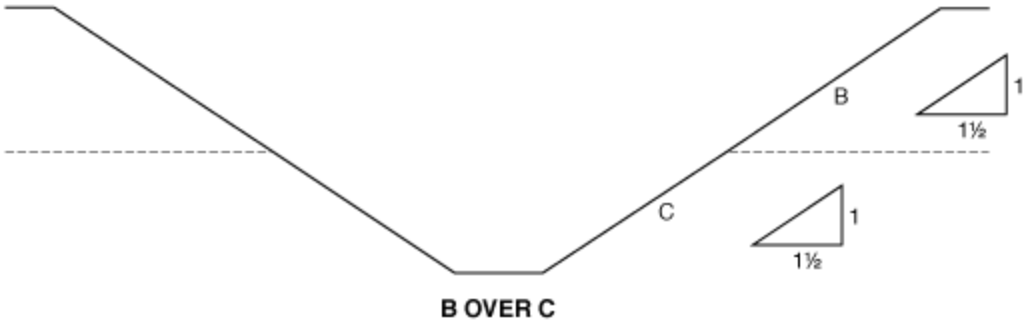
C OVER B



A OVER B



A OVER C



B OVER C

2. All other sloped excavations will be in accordance with the other options permitted in Section 3.2.2.

APPENDIX 4 – TIMBER SHORING FOR TRENCHES

a. Scope

This appendix contains information that can be used when timber shoring is provided as a method of protection from cave-ins in trenches that do not exceed 20 feet in depth. This appendix must be used when design of timber shoring protective systems is to be performed in accordance with Section 3.3.1. Other timber shoring configurations; other systems of support such as hydraulic and pneumatic systems; and other protective systems such as sloping, benching, shielding and freezing systems must be designed in accordance with the requirements set forth in Section 3.2 and 3.3.

b. Soil Classification

In order to use the data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in California Code of Regulations, Title 8, Article 6.

c. Presentation of Information

Information is presented in several forms as follows:

1. Information is presented in tabular form in Tables C-1.1, C-1.2 and C-1.3 and Tables C-2.1, C-2.2 and C-2.3 following Section (g) of Appendix 4. Each table presents the minimum sizes of timber members to use in a shoring system, and each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. The data are arranged to allow the user the flexibility to select from among several acceptable configurations of members based on varying the horizontal spacing of the crossbraces. Stable rock is exempt from shoring requirements and therefore, no data are presented for this condition.
2. Information concerning the basis of the tabular data and the limitations of the data is presented in Section (d) of this appendix, and on the tables themselves.
3. Information explaining the use of the tabular data is presented in Section (e) of this appendix.
4. Information illustrating the use of the tabular data is presented in Section (f) of this appendix.
5. Miscellaneous notations regarding Tables C-1.1 through C-1.3 and Tables C-2.1 through C-2.3 are presented in Section (g) of this appendix.

d. Basis and Limitations of the Data

1. Dimensions of timber members
   A. The sizes of the timber members listed in Tables C-1.1 through C-1.3 are taken from the National Bureau of Standards (NBS) report, “Recommended Technical Provisions for Construction Practice in Shoring and Sloping of Trenches and Excavations.” In addition, where NBS did not recommend specific sizes of members, member sizes are based on an analysis of the sizes required for use by existing codes and on empirical practice.
   B. The required dimensions of the members listed in Tables C-1.1 through C-1.3 refer to actual dimensions and not nominal dimensions of the timber. Employers wanting to use nominal size shoring are directed to Tables C-2.1 through C-2.3 or have this choice under Section 3.3.3.
2. Limitation of application
   A. It is not intended that the timber shoring specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice.

Shoring systems for use in situations that are not covered by the data in this appendix must be designed as specified in Section 3.3.

B. When any of the following conditions are present, the members specified in the tables are not considered adequate. Either an alternate timber shoring system must be designed or another type of protective system designed in accordance with Section 3.
   i. When loads imposed by structures or by stored material adjacent to the trench weigh in excess of the load imposed by a 2-foot soil surcharge. The term "adjacent" as used here means the area within a horizontal distance from the edge of the trench equal to the depth of the trench.
   ii. When vertical loads imposed on crossbraces exceed a 240-pound gravity load distributed on a one-foot section of the center of the crossbrace.
   iii. When surcharge loads are present from equipment weighing in excess of 20,000 pounds.
   iv. When only the lower portion of a trench is shored and the remaining portion of the trench is sloped or benched unless: the sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

e. Use of Tables

The members of the shoring system that are to be selected using this information are the crossbraces, the uprights and the wales, where wales are required. Minimum sizes of members are specified for use in different types of soil. There are six tables of information, two for each soil type. The soil type must first be determined in accordance with the soil classification system described in Appendix 2. Using the appropriate table, the selection fo the size and spacing of the members is then made. The selection is based on the depth and width of the trench where the members are to be installed and, in most instances, the selection is also based on the horizontal spacing of the crossbraces. Instances where a choice of horizontal spacing of crossbracing is available, the horizontal spacing of the crossbraces must be chosen by the user before the size of any member can be determined. When the soil type, the width and depth of the trench, and the horizontal spacing of the crossbraces, the size and vertical spacing of the crossbraces are known, the size and vertical spacing of the crossbraces, the size and vertical spacing of the wales and the size and horizontal spacing of the uprights can be read from the appropriate table.

f. Examples to Illustrate the Use of Tables C-1.1 through C-1.3

1. Example 1

A trench dug in Type A soil is 13 feet deep and 5 feet wide. From Table C-1.1, 4 acceptable arrangements of timber can be used.

Arrangement #1

Space 4x4 crossbraces at 6 feet horizontally and 4 feet vertically. Wales are not required.

Space 3x8 uprights at 6 feet horizontally. This arrangement is commonly called "skip shoring."

Arrangement #2
Space 4x6 crossbraces at 8 feet horizontally and 4 feet vertically.
Space 8x8 wales at 4 feet vertically.
Space 2x6 uprights at 4 feet horizontally.

Arrangement #3
Space 6x6 crossbraces at 10 feet horizontally and 4 feet vertically.
Space 8x10 wales at 4 feet vertically.
Space 2x6 uprights at 5 feet horizontally.

Arrangement #4
Space 6x6 crossbraces at 12 feet horizontally and 4 feet vertically.
Space 10x10 wales at 4 feet vertically.
Space 3x8 uprights at 6 feet horizontally.

2. Example 2
A trench dug in Type B soil is 13 feet deep and 5 feet wide. From Table C-1.2 three acceptable arrangements of members are listed.

Arrangement #1
Space 6x6 crossbraces at 6 feet horizontally and 5 feet vertically.
Space 8x8 wales at 5 feet vertically.
Space 2x6 uprights at 2 feet horizontally.

Arrangement #2
Space 6x8 crossbraces at 8 feet horizontally and 5 feet vertically.
Space 10x10 wales at 5 feet vertically.
Space 2x6 uprights at 2 feet horizontally.

Arrangement #3
Space 8x8 crossbraces at 10 feet horizontally and 5 feet vertically.
Space 10x12 wales at 5 feet vertically.
Space 2x6 uprights at 2 feet vertically.

3. Example 3
A trench dug in Type C soil is 13 feet deep and 5 feet wide. From Table C-1.3 two acceptable arrangements of members can be used.

Arrangement #1
Space 8x8 crossbraces at 6 feet horizontally and 5 feet vertically.
Space 10x12 wales at 5 feet vertically.
Position 2x6 uprights as closely together as possible.
If water must be retained, use special tongue and groove uprights to form tight sheeting.

Arrangement #2
Space 8x10 crossbraces at 8 feet horizontally and 5 feet vertically.
Space 12x12 wales at 5 feet vertically.
Position 2x6 uprights in a close sheeting configuration unless water pressure must be resisted. Tight sheeting must be used where water must be retained.

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

   Space 8x10 crossbraces at 6 feet horizontally and 5 feet vertically.
   Space 12x12 wales at 5 feet vertically.
   Use 3x6 tightsheeting.
   Use of Tables C-2.1 through C-2.3 would follow the same procedures.

g. Notes for all Tables

1. Members sizes at spacings other than indicated are to be determined as Specified in Section 3.3, “Design of Protective Systems.”

2. When conditions are saturated or submerged use Tight Sheeting. Tight Sheeting refers to the use of specially-edged timber planks (e.g., tongue and groove) at least 3 inches thick, steel sheet piling or similar construction that, when driven or placed in position, provide a tight wall to resist the lateral pressure of water and to prevent the loss of backfill material. Close Sheeting refers to the placement of planks side-by-side allowing as little space as possible between them.

3. All spacing indicated is measured center to center.

4. Wales to be installed with greater dimension horizontal.

5. If the vertical distance from the center of the lowest crossbrace to the bottom of the trench exceeds 2 and 1/2 feet, uprights will be firmly embedded or a mudsill will be used. Where uprights are embedded, the vertical distance from the center of the lowest crossbrace to the bottom of the trench will not exceed 36 inches. When mudsills are used, the vertical distance will not exceed 42 inches. Mudsills are wales that are installed at the toe of the trench side.

6. Trench jacks may be used in lieu of, or in combination with, timber crossbraces.

7. Placement of crossbraces
   When the vertical spacing of crossbraces is 4 feet, place the top crossbrace no more than 2 feet below the top of the trench. When the vertical spacing of crossbraces is 5 feet, place the top crossbrace no more than 2.5 feet below the top of the trench.

Table C-1.1 Timber Trench Shoring – Minimum Timber Requirements* Soil Type A P(a) – 24 x H + 72 psf (2 ft surcharge)							
Depth of Trench (feet)	Size (Actual) and Spaceing of Members**						
	Horiz. Spacing (feet)	Width of Trench (Feet)					Vert. Spacing (feet)
		Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	
5 to 10	Up to 6	4x4	4x4	4x6	6x6	6x6	4
	Up to 8	4x4	4x4	4x6	6x6	6x6	4
	Up to 10	4x6	4x6	4x6	6x6	6x6	4
	Up to 12	4x6	4x6	6x6	6x6	6x6	4
10 to 15	Up to 6	4x4	4x4	4x6	6x6	6x6	4
	Up to 8	4x6	4x6	6x6	6x6	6x6	4
	Up to 10	6x6	6x6	6x6	6x8	6x8	4
	Up to 12	6x6	6x6	6x6	6x8	6x8	4
15 to 20	Up to 6	6x6	6x6	6x6	6x8	6x8	4
	Up to 8	6x6	6x6	6x6	6x8	6x8	4
	Up to 10	8x8	8x8	8x8	8x8	8x10	4
	Up to 12	8x8	8x8	8x8	8x8	8x10	4
Over 20	See Note 1						

Table C-1.1 Timber Trench Shoring – Minimum Timber Requirements* Soil Type A P(a) = 25 x H + 72 psf (2 ft surcharge) (continued)							
Depth of Trench (feet)	Size (Actual) and Spacing of Members**						
	Wales		Uprights				
	Size (in)	Vert. Spacing (feet)	Maximum Allowable Horizontal Spacing (feet)				
			Close	4	5	6	8
5 to 10	Not Req'd	---				2x6	
	Not Req'd	---					2x8
	8x8	4			2x6		
	8x8	4				2x6	
10 to 15	Not Req'd	---				3x8	
	8x8	4		2x6			
	8x10	4			2x6		
	10x10	4				3x8	
15 to 20	6x8	4	3x6				
	8x8	4	3x6				
	8x10	4	3x6				
	10x10	4	3x6				
Over 20	See Note 1						

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

** Manufactured members of equivalent strength may be substituted for wood.

Table C-1.2 Timber Trench Shoring – Minimum Timber Requirements* Soil Type B P(a) = 45 x H + 72 psf (2 ft surcharge)							
Depth of Trench (feet)	Size (actual) and Spacing of Members**						
	Cross Braces						
	Horiz. Spacing (feet)	Width of Trench (feet)					Vert. Spacing (feet)
		Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	
5 to 10	Up to 6	4x6	4x6	6x6	6x6	6x6	5
	Up to 8	6x6	6x6	6x6	6x8	6x8	5
	Up to 10	6x6	6x6	6x6	6x8	6x8	5
	See Note 1						
10 to 15	Up to 6	6x6	6x6	6x6	6x8	6x8	5
	Up to 8	6x8	6x8	6x8	8x8	8x8	5
	Up to 10	8x8	8x8	8x8	8x8	8x10	5
	See Note 1						
15 to 20	Up to 6	6x8	6x8	6x8	8x8	8x8	5
	Up to 8	8x8	8x8	8x8	8x8	8x10	5
	Up to 10	8x10	8x10	8x10	8x10	10x10	5
	See Note 1						
Over 20	See Note 1						

Table C-1.2 Timber Trench Shoring – Minimum Timber Requirements*							
Depth of Trench (Feet)	Size (Actual) and Spacing of Members**						
	Wales		Uprights				
	Size (in)	Vert. Spacing (feet)	Maximum Allowable Horizontal Spacing (Feet)				
			Close	2	3		
5 to 10	6x8	5			2x6		
	8x10	5			2x6		
	10x10	5			2x6		
10 to 15	8x8	5		2x6			
	10x10	5		2x6			
	10x12	5		2x6			
15 to 20	8x10	5	3x6				
	10x12	5	3x6				
	12x12	5	3x6				
Over 20	See Note 1						

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

** Manufactured members of equivalent strength may be substituted for wood.

Table C-1.3 Timber Trench Shoring – Minimum Timber Requirements* Soil Type C P(a) = 80 x H + 72 psf (2 ft Surcharge)							
Depth of Trench (feet)	**Size (Actual) and Spacing of Members****						
	Cross Braces						
	Horiz. Spacing (feet)	**Width of Trench (feet)**					**Vert. Spacing (feet)**
		Up to 4	**Up to 6**	**Up to 9**	**Up to 12**	**Up to 15**	
5 to 10	Up to 6	6x8	6x8	6x8	8x8	8x8	5
	Up to 8	8x8	8x8	8x8	8x8	8x10	5
	Up to 10	8x10	8x10	8x10	8x10	10x10	5
	See Note 1						
10 to 15	Up to 6	8x8	8x8	8x8	8x8	8x10	5
	Up to 8	8x10	8x10	8x10	8x10	10x10	5
	See Note 1						
	See Note 1						
15 to 20	Up to 6	8x10	8x10	8x10	8x10	10x10	5
	See Note 1						
	See Note 1						
	See Note 1						
Over 20	See Note 1						

Table C-1.3 Timber Trench Shoring – Minimum Timber Requirements* Soil Type C P(a) = 80 x H + 72 psf (2 ft Surcharge) (Continued)							
Depth of Trench (feet)	**Size (Actual) and Spacing of Members****						
	Wales		**Uprights**				
	Size (in)	**Vert. Spacing (feet)**	**Maximum Allowable Horizontal Spacing (feet)**				
			Close				
5 to 10	8x10	5	2x6				
	10x10	5	2x6				
	12x12	5	2x6				
10 to 15	10x12	5	2x6				
	12x12	5	2x6				
15 to 20	12x12	5	3x6				
Over 20	See Note 1						

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

** Manufactured members of equivalent strength may be substituted for wood.

Table C-2.1 Timber Trench Shoring – Minimum Timber Requirements* Soil Type A P(a) = 25 x H + 72 psf (2 ft Surcharge)							
Depth of Trench (feet)	Size (S4S) and Spacing of Members**						
	Cross Braces						
	Horiz. Spacing (feet)	Width of Trench (feet)					Vert. Spacing (feet)
		Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	
5 to 10	Up to 6	4x4	4x4	4x4	4x4	4x6	4
	Up to 8	4x4	4x4	4x4	4x6	4x6	4
	Up to 10	4x6	4x6	4x6	6x6	6x6	4
	Up to 12	4x6	4x6	4x6	6x6	6x6	4
10 to 15	Up to 6	4x4	4x4	4x4	6x6	6x6	4
	Up to 8	4x6	4x6	4x6	6x6	6x6	4
	Up to 10	6x6	6x6	6x6	6x6	6x6	4
	Up to 12	6x6	6x6	6x6	6x6	6x6	4
15 to 20	Up to 6	6x6	6x6	6x6	6x6	6x6	4
	Up to 8	6x6	6x6	6x6	6x6	6x6	4
	Up to 10	6x6	6x6	6x6	6x6	6x8	4
	Up to 12	6x6	6x6	6x6	6x8	6x8	4
Over 20	See Note 1						

Table C-2.1 Timber Trench Shoring – Minimum Timber Requirements* Soil Type A P(a) = 25 x H + 72 psf (2 ft Surcharge) (Continued)							
Depth of Trench (feet)	Size (S4S) and Spacing of Members**						
	Wales		Uprights				
	Size (in)	Vert. Spacing (feet)	Maximum Allowable Horizontal Spacing (feet)				
			Close	4	5	6	8
5 to 10	Not Req'd	Not Req'd				4x6	
	Not Req'd	Not Req'd					4x8
	8x8	4			4x6		
	8x8	4				4x6	
10 to 15	Not Req'd	Not Req'd				4x10	
	6x8	4		4x6			
	8x8	4			4x8		
	8x10	4		4x6		4x10	
15 to 20	6x8	4	3x6				
	8x8	4	3x6	4x12			
	8x10	4	3x6				
	8x12	4	3x6	4x12			
Over 20	See Note 1						

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

** Manufactured members of equivalent strength may be substituted for wood.

Table C-2.2 Timber Trench Shoring – Minimum Timber Requirements* Soil Type B P(a) = 45 x H + 72 psf (2 ft Surcharge)							
Depth of Trench (feet)	Size (S4S) and Spacing of Members**						
	Cross Braces						
	Horiz. Spacing (feet)	Width of Trench (feet)					Vert. Spacing (feet)
		Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	
5 to 10	Up to 6	4x6	4x6	4x6	6x6	6x6	5
	Up to 8	4x6	4x6	6x6	6x6	6x6	5
	Up to 10	4x6	4x6	6x6	6x6	6x8	5
	See Note 1						
10 to 15	Up to 8	6x8	6x8	6x8	8x8	8x8	5
	Up to 10	6x8	6x8	8x8	8x8	8x8	5
	See Note 1						
15 to 20	Up to 6	6x8	6x8	6x8	6x8	8x8	5
	Up to 8	6x8	6x8	6x8	8x8	8x8	5
	Up to 10	8x8	8x8	8x8	8x8	8x8	5
	See Note 1						
Over 20	See Note 1						

Table C-2.2 Timber Trench Shoring – Minimum Timber Requirements* Soil Type B P(a) = 45 x H + 72 psf (2 ft Surcharge) (Continued)							
Depth of Trench (feet)	Size (S4S) and Spacing of Members**						
	Wales		Uprights				
	Size (in)	Vert. Spacing (feet)	Maximum Allowable Horizontal Spacing (feet)				
			Close	2	3		
5 to 10	6x8	5			3x12 4x8		4x12
	8x8	5		3x8		4x8	
	8x10	5			4x8		
10 to 15	8x8	5	3x6	4x10			
	10x10	5	3x6	4x10			
	10x12	5	3x6	4x10			
15 to 20	8x10	5	4x6				
	10x12	5	4x6				
	12x12	5	4x6				
Over 20	See Note 1						

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

** Manufactured members of equivalent strength may be substituted for wood.

Table C-2.3 Timber Trench Shoring – Minimum Timber Requirements* Soil Type C P(a) = 80 x H + 72 psf (2 ft Surcharge)							
Depth of Trench (feet)	Size (S4S) and Spacing of Members**						
	Cross Braces						
	Horiz. Spacing (feet)	Width of Trench (feet)					Vert. Spacing (feet)
		Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	
5 to 10	Up to 6	6x6	6x6	6x6	6x6	8x8	5
	Up to 8	6x6	6x6	6x6	8x8	8x8	5
	Up to 10	6x6	6x6	8x8	8x8	8x8	5
	See Note 1						
	See Note 1						
10 to 15	Up to 6	6x8	6x8	6x8	8x8	8x8	5
	Up to 8	8x8	8x8	8x8	8x8	8x8	5
	See Note 1						
	See Note 1						
15 to 20	Up to 6	8x8	8x8	8x8	8x10	8x10	5
	See Note 1						
	See Note 1						
	See Note 1						
Over 20	See Note 1						

Table C-2.3 Timber Trench Shoring – Minimum Timber Requirements* Soil Type C P(a) = 80 x H + 72 psf (2 ft Surcharge) (Continued)							
Depth of Trench (feet)	Size (S4S) and Spacing of Members						
	Wales		Uprights				
	Size (in)	Vert. Spacing (feet)	Maximum Allowable Horizontal Spacing (feet)				
			Close				
5 to 10	8x8	5	3x6				
	10x10	5	3x6				
	10x12	5	3x6				
10 to 15	10x10	5	4x6				
	12x12	5	4x6				
15 to 20	10x12	5	4x6				
Over 20	See Note 1						

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

** Manufactured members of equivalent strength may be substituted for wood.

APPENDIX 5 – REQUIREMENTS FOR PROTECTIVE SYSTEMS (ALUMINUM HYDRAULIC SHORING FOR TRENCHES)

a. Scope

This appendix contains information that can be used when aluminum hydraulic shoring is provided as a method of protection against cave-ins in trenches that do not exceed 20 feet in depth. This appendix will be used when design of the aluminum hydraulic protection system cannot be performed in accordance with Section 3.3.2.

b. Soil Classification

In order to use data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in Appendix 2.

c. Presentation of Information

Information is presented in several forms as follows:

1. Information is presented in tabular form in Tables D-1.1, D-1.2, D-1.3 and D-1.4. Each table presents the maximum vertical and horizontal spacings that may be used with various aluminum member sizes and various hydraulic cylinder sizes. Each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. Tables D-1.1 and D-1.2 are for vertical shores in Types A and B soil. Tables D-1.3 and D-1.4 are for horizontal waler systems in Types B and C soil.
2. Information concerning the basis of the tabular data and the limitations of the data is presented in Section (d) of this appendix.
3. Information explaining the use of the tabular data is presented in Section (e) of this appendix.
4. Information illustrating the use of the tabular data is presented in Section (f) of this appendix.
5. Miscellaneous notations (footnotes) regarding Table D-1.1 through D-1.4 are presented in Section (g) of this appendix.
6. Figures, illustrating type installations of hydraulic shoring, are included just prior to the Tables. The illustrations page is entitled “Aluminum Hydraulic Shoring: Typical Installations.”

d. Basis and Limitations of the Data

1. Vertical shore rails and horizontal wales are those that meet the Section Modulus requirements in the D-a tables. Aluminum material is 6061-T6 or material of equivalent strength and properties.
2. Hydraulic cylinders specifications
   A. 2-inch cylinders will be a minimum 2-inch inside diameter with a minimum safe working capacity of no less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.
   B. 3-inch cylinders will be minimum 3-inch inside diameter with a safe working capacity of not less than 30,000 pounds axial compressive load at extensions as recommended by product manufacturer.
3. Limitation of application
   A. It is not intended that the aluminum hydraulic specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current

trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be otherwise designed as specified in Section 3.3.

B. When any of the following conditions are present, the members specified in the Tables are not considered adequate. In this case, an alternative aluminum hydraulic shoring system or other type of protective system must be designed in accordance with Section 3.
   i. When vertical loads are imposed on crossbraces exceed a 100 pound gravity load distributed on a one foot section of the center of the hydraulic cylinder.
   ii. When surcharge loads are present from equipment weighing in excess of 20,000 pounds.
   iii. When only the lower portion of a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than 3 horizontal to 1 vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

e. Use of Tables D-1.1, D-1.2, D-1.3 and D-1.4

The members of the shoring system that are to be selected using this information are the hydraulic cylinders, and either the vertical shores or the horizontal wales. When a waler system is used the vertical timber sheeting to be used is also selected from these tables. The Tables D-1.1 and D-1.2 for vertical shores are used in Type A and B soils that do not require sheeting. Type B soils that may require sheeting, and Type C soils that always require sheeting, are found in the horizontal wale Tables D-1.3 and D-1.4. The soil type must first be determined in accordance with the soil classification system described in Appendix 2. Using the appropriate table, the selection of the size and spacing of the members is made. The selection is based on the depth and width of the trench where the members are to be installed. In these tables, the vertical spacing is held constant at 4 feet on center. The tables show the maximum horizontal spacing of cylinders allowed for each size of wale in the waler system tables, and in the vertical shore tables, the hydraulic cylinder horizontal spacing is the same as the vertical shore spacing.

f. Example to Illustrate the Use of the Tables

1. Example 1
   A trench dug in Type A soil is 6 feet deep and 3 feet wide. From Table D-1.1: Find vertical shores and 2 inch diameter cylinders spaced 8 feet on center (o.c.) horizontally and 4 feet on center (o.c.) vertically. (See Figures 1 & 3 for typical installations.)
2. Example 2
   A trench is dug in Type B soil that does not require sheeting, 13 feet deep and 5 feet wide. From Table D-1.2: Find vertical shores and 2 inch diameter cylinders spaced 6.5 feet o.c. horizontally and 4 feet o.c. vertically. (See Figures 1 & 3 for typical installations.)
3. Example 3
   A trench is dug in Type B soil that does not require sheeting, but does experience some minor raveling of the trench face. The trench is 16 feet deep and 9 feet wide. From Table D-1.2: Find vertical shores and 2 inch diameter cylinder (with special oversleeves as designated by footnote #2) spaced 5.5 feet o.c. horizontally and 4 feet o.c. vertically. Plywood (per footnote (g)(7) to the D-1 Table) should be used behind the shores. (See Figures 2 & 3 for typical installations.)

4. Example 4
   A trench is dug in previously disturbed Type B soil, with characteristics of a Type C soil, and will require sheeting. The trench is 18 feet deep and 12 feet wide. 8 foot horizontal spacing between cylinders is desired for working space. From Table D-1.3: Find horizontal wale with a section modulus of 14.0 spaced at 4 feet o.c. vertically and 3 inch diameter cylinder spaced at 9 feet maximum o.c. horizontally, 3 x 12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)
5. Example 5
   A trench is dug in Type C soil, 9 feet deep and 4 feet wide. Horizontal cylinder spacing in excess of 6 feet is desired for working space. From Table D-1.4: Find horizontal wale with a section modulus of 7.0 and 2 inch diameter cylinders spaced at 6.5 feet o.c. horizontally. Or, find horizontal wale with a 14.0 section modulus and 3 inch diameter cylinder spaced at 10 feet o.c. horizontally. Both wales are spaced 4 feet o.c. vertically, 2x12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

g. Footnotes, and general notes, for Tables D-1.1, D-1.2, D-1.3 and D-1.4
   1. For applications other than those listed in the tables, refer to Section 3.3.2 for use of manufacturer's tabulated data. For trench depths in excess of 20 feet, refer to Section 3.3.2 and 3.3.3.
   2. 2-inch diameter cylinders, at this width, will have structural steel tube (3.5 x 3.5 x 0.1875) oversleeves, or structural oversleeves of manufacturer's specification, extending the full, collapsed length.
   3. Hydraulic cylinders capacities
      A. 2-inch cylinders will be a minimum 2-inch inside diameter with a safe working capacity of not less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.
      B. 3-inch cylinders will be a minimum 3-inch inside diameter with a safe work capacity of not less than 30,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.
   4. All spacing indicated is measured center to center.
   5. Vertical shoring rails will have a minimum section modulus of 0.40 inch.
   6. When vertical shores are used, there must be a minimum of 3 shores spaced equally, horizontally, in a group.
   7. Plywood will be 1.125 inches thick of wood or 0.75 inch thick, 14 ply, arctic white birch (Finland form). Please note that plywood is not intended as a structural member, but only for prevention of local raveling (sloughing of the trench face) between shores. Equivalent material may be used if it has been approved in accordance with California Code of Regulations, Title 8, Section 1505(a).
   8. See Appendix 4 for timber specifications.
   9. Wales are calculated for simple span conditions.
   10. See Appendix 5, Section (d), for basis and limitations of the data.

ALUMINUM HYDRAULIC SHORING
TYPICAL INSTALLATIONS

FIGURE NO. 1

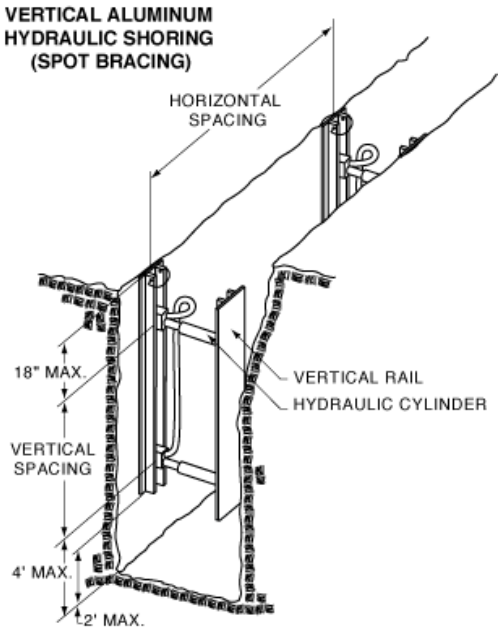


FIGURE NO. 2

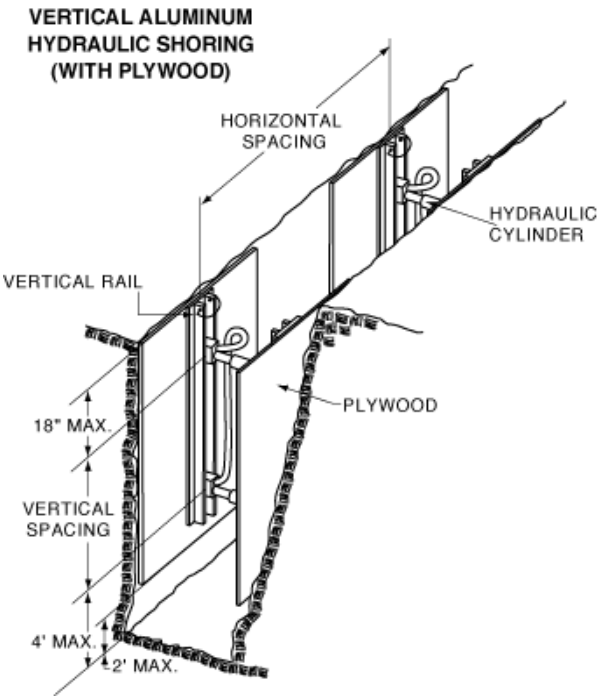


FIGURE NO. 3

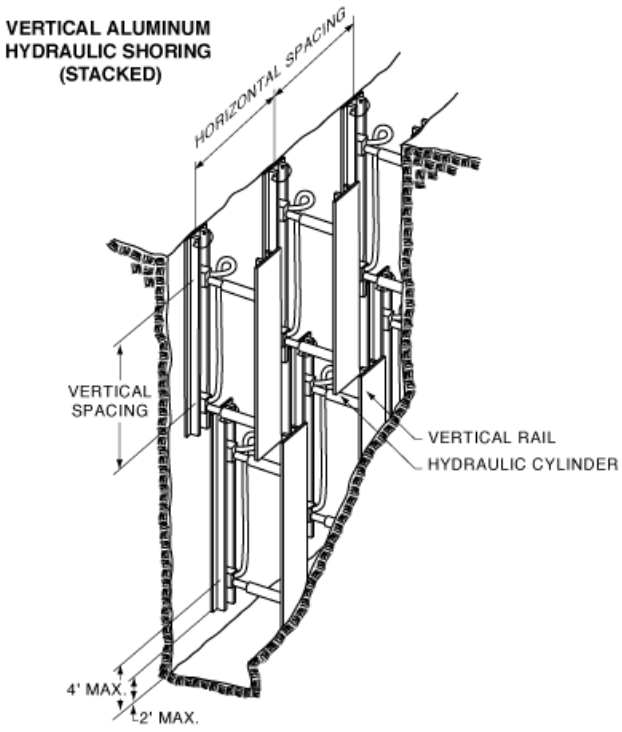


FIGURE NO. 4

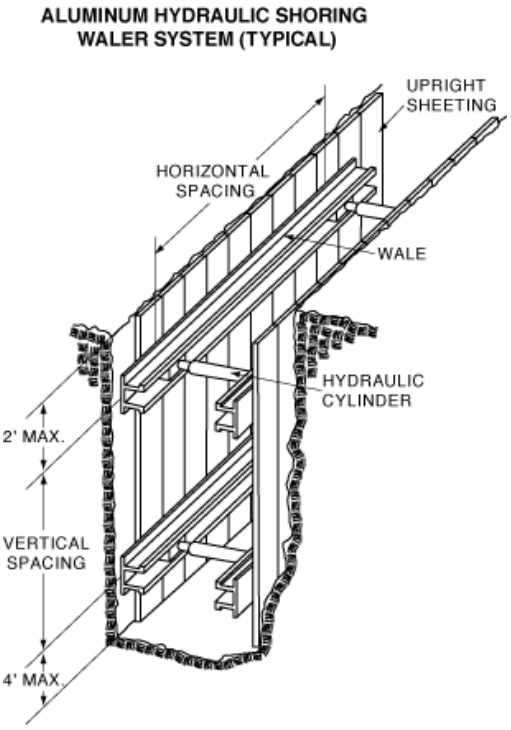


Table D-1.1 Aluminum Hydraulic Shoring Vertical Shores For Soil Type A					
Depth of Trench (feet)	Hydraulic Cylinders				
	Maximum Horizontal Spacing (feet)	Maximum Vertical Spacing (feet)	Width of Trench (feet)		
			Up to 8	Over 8 Up to 12	Over 12 Up to 15
Over 5 Up to 10	8	4	2 inch diameter	2 inch diameter Note (2)	3 inch diameter
Over 10 Up to 15	8				
Over 15 Up to 20	7				
Over 20	Note (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix 5, Item (g)
Note (1): See Appendix 5, Item (g)(1)
Note (2): See Appendix 5, Item (g)(2)

Table D-1.2 Aluminum Hydraulic Shoring Vertical Shores For Soil Type B					
Depth of Trench (feet)	Hydraulic Cylinders				
	Maximum Horizontal Spacing (feet)	Maximum Vertical Spacing (feet)	Width of Trench (feet)		
			Up to 8	Over 8 Up to 12	Over 12 Up to 15
Over 5 Up to 10	8	4	2 inch diameter	2 inch diameter Note (2)	3 inch diameter
Over 10 Up to 15	6.5				
Over 15 Up to 20	5.5				
Over 20	Note (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix 5, Item (g)
Note (1): See Appendix 5, Item (g)(1)
Note (2): See Appendix 5, Item (g)(2)

Table D-1.3 Aluminum Hydraulic Shoring Waler Systems For Soil Type B						
Depth of Trench (feet)	Wales		Width of Trench (feet)			
	Vertical Spacing (feet)	Section Modulus (in(3))	Up to 8		Over 8 up to 12	
			Horiz. Spacing	Cylinder Diameter	Horiz. Spacing	Cylinder Diameter
Over 5 Up to 10	4	3.5	8.0	2 in	8.2	2 in Note (2)
		7.0	9.0	2 in	9.0	2 in Note (2)
		14.0	12.0	3 in	12.0	3 in
Over 10 Up to 15	4	3.5	6.0	2 in	6.0	2 in Note (20
		7.0	8.0	3 in	8.0	3 in
		14.0	10.0	3 in	10.0	3 in
Over 15 Up to 20	4	3.5	5.5	2 in	5.5	2 in Note (2)
		7.0	6.0	3 in	6.0	3 in
		14.0	9.0	3 in	9.0	3 in
Over 20	Note (1)					

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix 5, Item (g)
Note (1): See Appendix 5, Item (g)(1)
Note (2): See Appendix 5, Item (g)(2)
* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.
** Douglas fir or equivalent with a bending strength not less than 1500 psi.

Table D-1.3 Aluminum Hydraulic Shoring Waler Systems For Soil Type B (continued)							
Depth of Trench (feet)	Wales		Hydraulic Cylinders		Timber Uprights		
	Vertical Spacing (feet)	Section Modulus (in(3))	Width of Trench (feet)		Max. Horiz Spacing (on center)		
			Over 12 Up to 15		Solid Sheet	2 ft	3 ft
			Horiz Spacing	Cylinder Diameter			
Over 5 Up to 10	4	3.5	8.0	3 in	---	---	3x12
		7.0	9.0	3 in			
		14.0	12.0	3 in			
Over 10 Up to 15	4	3.5	6.0	3 in	---	3x12	---
		7.0	8.0	3 in			
		14.0	10.0	3 in			
Over 15 Up to 20	4	3.5	5.5	3 in	3x12	---	---
		7.0	6.0	3 in			
		14.0	9.0	3 in			
Over 20	Note (1)						

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix 5, Item (g)
Note (1): See Appendix 5, Item (g)(1)
Note (2): See Appendix 5, Item (g)(2)
* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.
** Douglas fir or equivalent with a bending strength not less than 1500 psi.

Table D-1.4 Aluminum Hydraulic Shoring Waler Systems For Soil Type C						
Depth of Trench (feet)	Wales		Hydraulic Cylinders			
	Vertical Spacing (feet)	* Section Modulus (in(3))	Width of Trench (feet)			
			Up to 8		Over 8 Up to 12	
			Horiz Spacing	Cylinder Diameter	Horiz Spacing	Cylinder Diameter
Over 5 Up to 10	4	3.5	6.0	2 in	6.0	2 in Note (2)
		7.0	6.5	2 in	6.5	2 in Note (2)
		14.0	10.0	3 in	10.0	3 in
Over 10 Up to 15	4	3.5	4.0	2 in	4.0	2 in Note (2)
		7.0	5.5	3 in	5.5	3 in
		14.0	8.0	3 in	8.0	3 in
Over 15 Up to 20	4	3.5	3.5	2 in	3.5	2 in Note (2)
		7.0	5.0	3 in	5.0	3 in
		14.0	6.0	3 in	6.0	3 in
Over 20	Note (1)					

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix 5, Item (g)
Note (1): See Appendix 5, Item (g)(1)
Note (2): See Appendix 5, Item (g)(2)
* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.
** Douglas fir or equivalent with a bending strength not less than 1500 psi.

Table D-1.4 Aluminum Hydraulic Shoring Waler Systems For Soil Type C (continued)							
Depth of Trench (feet)	Wales		Hydraulic Cylinders		Timber Uprights		
	Vertical Spacing (feet)	* Section Modulus (in(3))	Width of Trench (feet)		Max. Horiz Spacing (on center)		
			Over 12 Up to 15		Solid Sheet	2 ft	3 ft
			Horiz Spacing	Cylinder Diameter			
Over 5 Up to 10	4	3.5	6.0	3 in	3x12	---	---
		7.0	6.5	3 in			
		14.0	10.0	3 in			
Over 10 Up to 15	4	3.5	4.0	3 in	3x12	---	---
		7.0	5.5	3 in			
		14.0	8.0	3 in			
Over 15 Up to 20	4	3.5	3.5	3 in	3x12	---	---
		7.0	5.0	3 in			
		14.0	6.0	3 in			
Over 20	Note (1)						

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix 5, Item (g)
Note (1): See Appendix 5, Item (g)(1)
Note (2): See Appendix 5, Item (g)(2)
* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.
** Douglas fir or equivalent with a bending strength not less than 1500 psi.

APPENDIX 6 – ALTERNATIVES TO TIMBER SHORING

Figure 1 – Aluminum Hydraulic Shoring

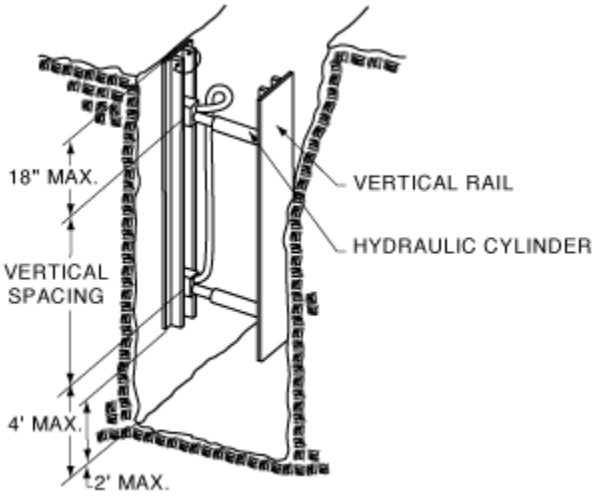


Figure 2 – Pneumatic/Hydraulic Shoring

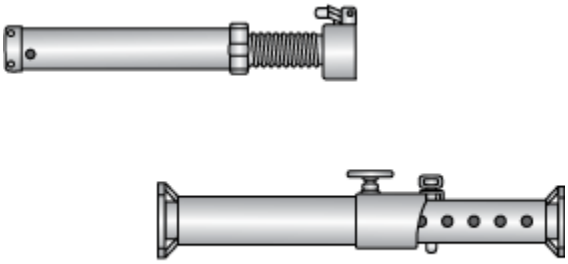


Figure 3 – Trench Kacks (Screw Jacks)

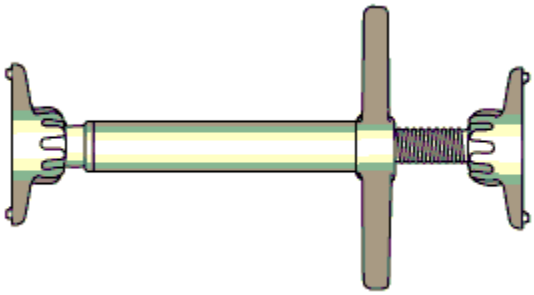
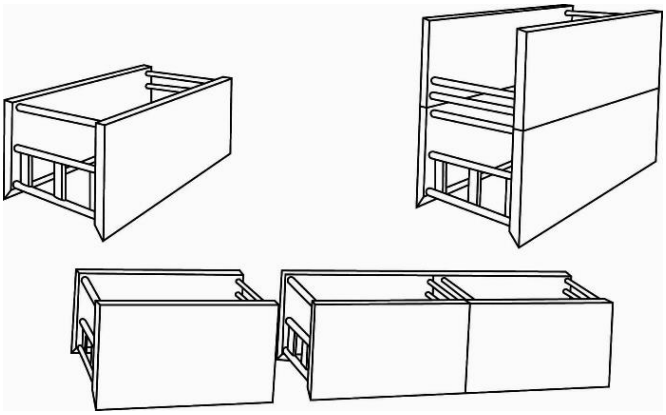


Figure 4 – Trench Shields



APPENDIX 7 – REQUIREMENTS FOR PROTECTIVE SYSTEMS

The following figures are a graphic summary of the requirements contained in California Code of Regulations, Title 8, Article 6 for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer in accordance with Section 3.2 and 3.3.

Figure 1 – Preliminary Decisions

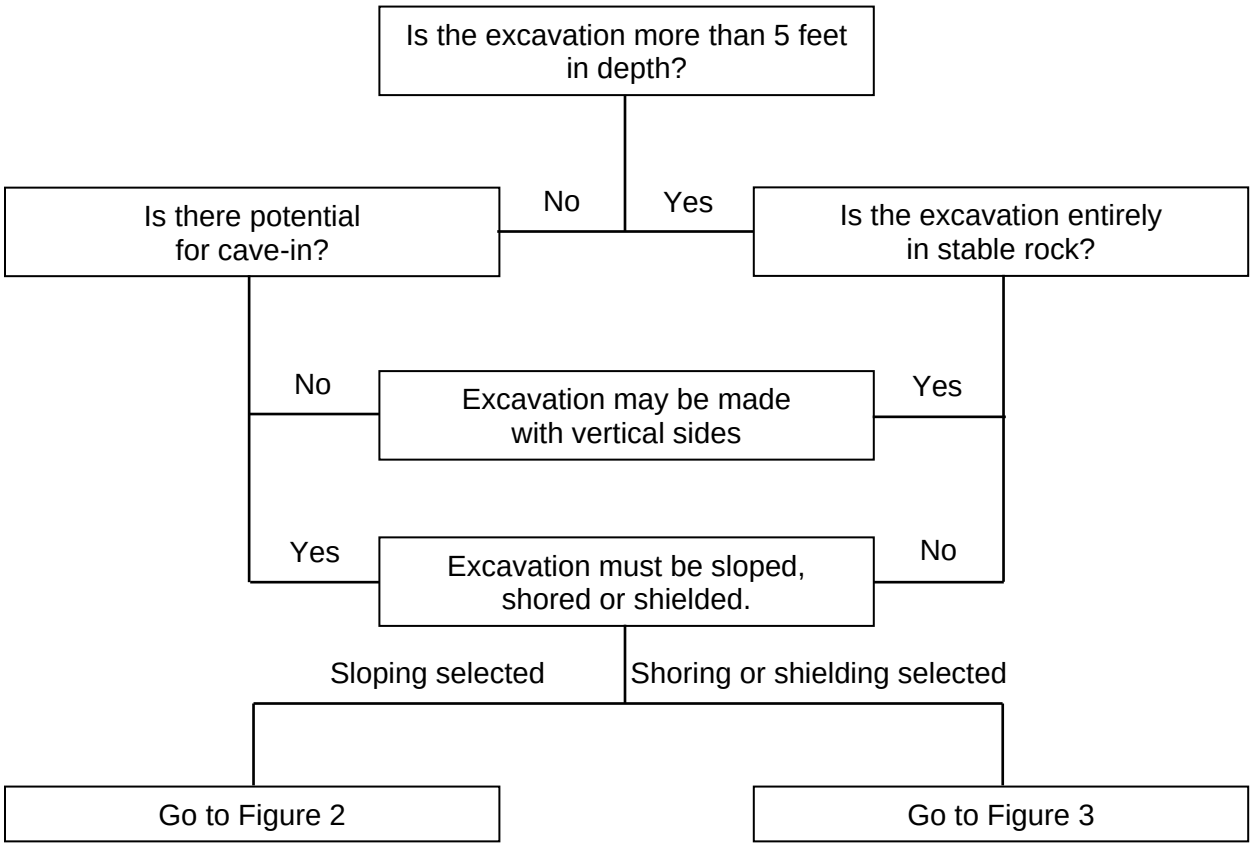


Figure 2 – Sloping Options

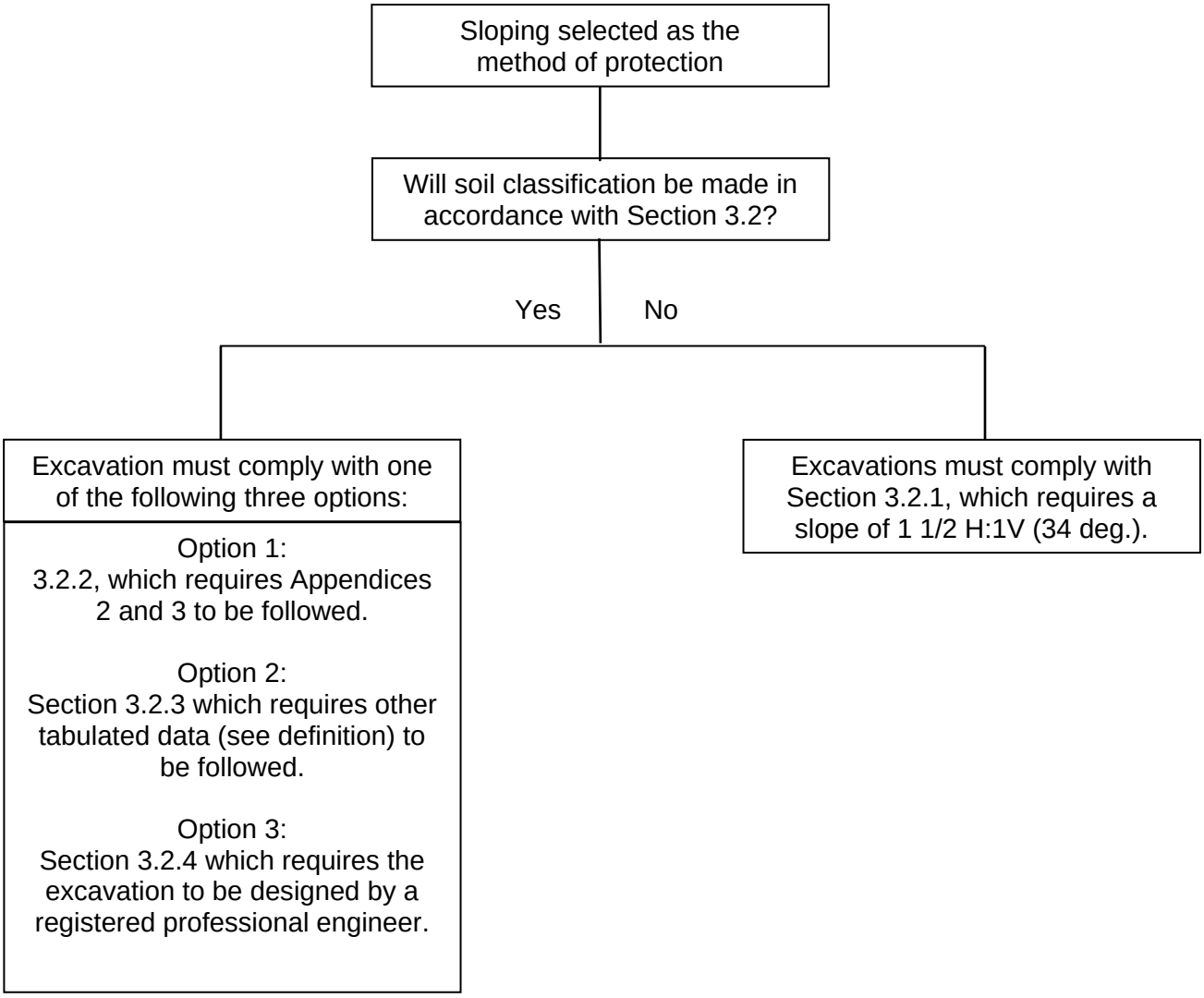


Figure 3 – Shoring and Shielding Options