Trenching and Excavation - WAC 296-155: PART N

Trench and Excavation Safety for Wastewater Workers and Plumbing Contractors

Safety and Health Investment Project (SHIP)

Written by The Washington On-Site Sewage Association, Funding and Support Provided by the Washington State Department of Labor and Industries

PART N
EXCAVATION, TRENCHING, AND SHORING

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WAC 296-155-650 Scope, application, and definitions applicable to this part.

(1) **Scope and application**. This part applies to all open excavations made in the earth's surface. Excavations are defined to include trenches.

(2) **Definitions applicable to this part**.

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

Aluminum hydraulic shoring. A preengineered 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 loss of soil from under a trench shield or support system, and its sudden movement into the excavation in quantity that it could entrap, bury, injure, or immobilize a person.

Competent person. One who can identify existing or predictable hazards in the surroundings that are unsanitary, hazardous, or dangerous to employees. Also has authorization or authority by the nature of their position to take prompt corrective measures to eliminate them. The person must be knowledgeable in the requirements of this part.

Cross braces. 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 person-made cut, cavity, trench, or depression in the earth's 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. A atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

Kickouts. 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 to 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 of Washington. The registered professional engineer must comply with the Washington state department of licensing requirements, chapter 18.43 RCW.

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 WAC 296-155-657 (3)(c) or (d). 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. A 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 (4.6m). 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 (4.6 m) 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.

[Statutory Authority: RCW 49.17.010, .040, .050, and .060. 16-09-085 (Order 15-08), § 296-155-650, filed 04/19/16, effective, 05/20/16. Statutory Authority: Chapter 49.17 RCW. 94-15-096 (Order 94-07), § 296-155-650, filed 7/20/94, effective 9/20/94. Statutory Authority: Chapter 49.17 RCW and RCW 49.17.040, [49.17].050 and [49.17].060. 92-22-067 (Order 92-06), § 296-155-650, filed 10/30/92, effective 12/8/92. Statutory Authority: Chapter 49.17 RCW. 91-03-044 (Order 90-18), § 296-155-650, filed 1/10/91, effective 2/12/91. Statutory Authority: RCW 49.17.040 and 49.17.050. 86-03-074 (Order 86-14), § 296-155-650, filed 1/21/86. Statutory Authority: RCW 49.17.040, 49.17.050 and 49.17.240. 81-13-053 (Order 81-9), § 296-155-650, filed 6/17/81; Order 74-26, § 296-155-650, filed 5/7/74, effective 6/6/74.]

WAC 296-155-655 General protection requirements.

(1) **Surface encumbrances**. You must remove surface encumbrances that are located so as to create a hazard to employees supported, as necessary, to safeguard employees.

(2) **Underground installations**.

(a) You must locate utility installations, such as sewer, telephone, fuel, electric, water lines, or any other underground installations that reasonably may be expected to be encountered during excavation work, prior to opening an excavation.

(b) You must contact utility companies or owners within established or customary local response times, advised of the proposed work, and asked to locate the underground utility installation prior to the start of actual excavation.

(c) When excavation operations approach the location of underground installations, you must determine the exact location of the installations by safe and acceptable means.

(d) While the excavation is open, you must protect underground installations, supported, or removed as necessary to safeguard employees.

(3) **Access and egress**.

(a) Structural ramps.

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

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

(iii) Structural members used for ramps and runways must be of uniform thickness.

(iv) Cleats or other appropriate means used to connect runway structural members must be attached to the bottom of the runway or must be attached in a manner to prevent tripping.

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

(b) Means of egress from trench excavations. A stairway, ladder, ramp or other safe means of egress must be located in trench excavations that are 4 feet (1.22 m) or more in depth so as to require no more than 25 feet (7.62 m) of lateral travel for employees.

(4) **Exposure to vehicular traffic**. You must provide employees exposed to vehicular traffic with, and they must wear high-visibility garments meeting the requirements of WAC 296-155-200, General requirements for personal protective equipment (PPE).

(5) **Exposure to falling loads**. You must not permit any employee underneath loads handled by lifting or digging equipment. You must require employees 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 WAC 296-155-610 (2)(g), to provide adequate protection for the operator during loading and unloading operations.

(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, you must utilize a warning system such as barricades, hand or mechanical signals, or stop logs. If possible, the grade should be away from the excavation.

(7) **Hazardous atmospheres**.

(a) Testing and controls. In addition to the requirements set forth in parts B-1, C, and C-1 of this chapter (296-155 WAC) to prevent exposure to harmful levels of atmospheric contaminants and to assure acceptable atmospheric conditions, the following requirements apply:

(i) Where oxygen deficiency (atmospheres containing less than 19.5 percent oxygen) or a hazardous atmosphere exists or could reasonably be expected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, you must test the atmospheres in the excavation before employees enter excavations greater than 4 feet (1.22 m) in depth.

(ii) You must take adequate precautions to prevent employee exposure to atmospheres containing less than 19.5 percent oxygen and other hazardous atmospheres. These precautions include providing proper respiratory protection or ventilation in accordance with chapter 296-842 WAC.

(iii) You must take adequate precaution such as providing ventilation, to prevent employee exposure to an atmosphere containing a concentration of a flammable gas in excess of 10 percent of the lower flammable limit of the gas.

(iv) When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, you must conduct testing as often as necessary to ensure that the atmosphere remains safe.

(b) Emergency rescue equipment.

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

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

Note: See chapter 296-62 WAC, Part M for additional requirements applicable to confined space operations.

(8) **Protection from hazards associated with water accumulation.**

(a) Employees must 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.

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

(c) If excavation work interrupts the natural drainage of surface water (such as streams), you must use diversion ditches, dikes, or other suitable means 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 subdivisions (a) and (b) of this subsection.

(9) **Stability of adjacent structures**.

(a) Where the stability of adjoining buildings, walls, or other structures is endangered by excavation operations, you must provide support systems such as shoring, bracing, or underpinning to ensure the stability of such structures for the protection of employees.

(b) You must not permit 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 except when:

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

(ii) The excavation is in stable rock; or

(iii) A registered professional engineer has approved the determination that the structure is sufficiently removed from the excavation so as to be unaffected by the excavation activity; or

(iv) A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.

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

(10) **Protection of employees from loose rock or soil**.

(a) You must provide adequate protection to protect employees from loose rock or soil that could pose a hazard by falling or rolling from an excavation face. Such protection must 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.

(b) You must protect employees from excavated or other materials or equipment that could pose a hazard by falling or rolling into excavations. Protection must be provided by placing and keeping such materials or equipment at least two feet (.61 m) 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.

(11) **Inspections**.

(a) Daily inspections of excavations, the adjacent areas, and protective systems must 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 must be conducted by the competent person prior to the start of work and as needed throughout the shift. Inspections must also be made after every rainstorm or other hazard increasing occurrence. These inspections are only required when employee exposure can be reasonably anticipated.

(b) 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, you must remove exposed employees from the hazardous area until the necessary precautions have been taken to ensure their safety.

(12) **Fall protection**.

(a) You must provide walkways where employees or equipment are required or permitted to cross over excavations. You must provide guardrails which comply with chapter 296-155 WAC, Part C-1 where walkways are 4 feet or more above lower levels.

(b) You must provide adequate barrier physical protection at all remotely located excavations. You must barricade or cover all wells, pits, shafts, etc. Upon completion of exploration and similar operations, you must backfill temporary wells, pits, shafts, etc.

[Statutory Authority: RCW 49.17.010, .040, .050, and .060. 16-09-085 (Order 15-08), § 296-155-655, filed 04/19/16, effective, 05/20/16. Statutory Authority: RCW 49.17.010, .040, .050, and .060. 13-04-073 (Order 06-08), § 296-155-655, filed 02/04/13, effective 04/01/13. Statutory Authority: RCW 49.17.010, .040, .050, and .060. 05-03-093 (Order 04-41), § 296-155-655, filed 01/18/05, effective 03/01/05. Statutory Authority: RCW 49.17.010, .040, .050, and .060. 04-24-089 (Order 04-02), § 296-155-655, filed 12/01/04, effective 01/01/05. Statutory Authority: RCW 49.17.010, .040, .050. 99-17-094 (Order 99-01), § 296-155-655, filed 08/17/99, effective 12/1/99. Statutory Authority: RCW 49.17.010, .040, .050. 99-10 (Order 98-10), § 296-155-655, filed 05/04/99, effective 09/01/99. Statutory Authority: Chapter 49.17 RCW. 96-24-051, (Order 96-05), §296-155-655, filed 11/27/96, effective 02/01/97. 95-10-016, § 296-155-655, filed 4/25/95, effective 10/1/95. Statutory Authority: Chapter 49.17 RCW and RCW 49.17.040, [49.17].050 and [49.17].060. 92-22-067 (Order 92-06), § 296-155-655, filed 10/30/92, effective 12/8/92. Statutory Authority: Chapter 49.17 RCW. 91-03-044 (Order 90-18), § 296-155-655, filed 1/10/91, effective 2/12/91. Statutory Authority: RCW 49.17.040 and 49.17.050. 86-03-074 (Order 86-14), § 296-155-655, filed 1/21/86. Statutory Authority: RCW 49.17.040, 49.17.050 and 49.17.240. 81-13-053 (Order 81-9), § 296-155-655, filed 6/17/81; Order 76-29, § 296-155-655, filed 9/30/76; Order 74-26, § 296-155-655, filed 5/7/74, effective 6/6/74.]

WAC 296-155-657 Requirements for protective systems.

(1) **Protection of employees in excavations**.

(a) You must protect each employee in an excavation from cave-ins by an adequate protective system designed in accordance with subsections (2) or (3) of this section except when:

(i) Excavations are made entirely in stable rock; or

(ii) Excavations are less than 4 feet (1.22m) in depth and examination of the ground by a competent person provides no indication of a potential cave-in.

(b) Protective systems must 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.

(2) **Design of sloping and benching systems**. The slopes and configurations of sloping and benching systems must be selected and constructed by the employer or employer's designee and must be in accordance with the requirements of subdivision (a); or, in the alternative, subdivision (b); or, in the alternative, subdivision (c); or, in the alternative, subdivision (d), as follows:

(a) Option 1-Allowable configurations and slopes.

(i) Excavations must be sloped at an angle not steeper than 1 1/2 horizontal to one vertical (34 degrees measured from the horizontal), unless the employer uses one of the other options listed below.

(ii) Slopes specified in item (i) of this subdivision, must be excavated to form configurations that are in accordance with the slopes shown for Type C soil in Appendix B to this part.

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

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

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

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

(A) Identification of the parameters that affect the selection of a sloping or benching system drawn from such data;

(B) Identification of the limits of use of the data, to include the magnitude and configuration of slopes determined to be safe;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(iii) You must maintain at least one copy of the tabulated data which identifies the registered professional engineer who approved the data, at the job site during construction of the protective system. After that time the data may be stored off the job site, but you must make a copy of the data available to the director upon request.

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

(i) Sloping and benching systems not utilizing Option 1 or Option 2 or Option 3 under subsection (2) of this section must be approved by a registered professional engineer.

(ii) Designs must be in written form and must include at least the following:

(A) The magnitude of the slopes that were determined to be safe for the particular project;

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

(C) The identity of the registered professional engineer approving the design.

(iii) You must maintain at least one copy of the design at the job site while the slope is being constructed. After that time the design need not be at the job site, but you must maintain a copy available to the director upon request.

(3) **Design of support systems, shield systems, and other protective systems**. Designs of support systems, shield systems, and other protective systems must be selected and constructed by the employer or employer's designee and must be in accordance with the requirements of subdivision (a); or, in the alternative, subdivision (b); or, in the alternative, subdivision (c); or, in the alternative, subdivision (d) as follows:

(a) Option 1-Designs using appendices A, C, and D. Designs for timber shoring in trenches must be determined in accordance with the conditions and requirements set forth in appendices A and C to this part. Designs for aluminum hydraulic shoring must be in accordance with subdivision (b) of this subsection, but if manufacturer's tabulated data cannot be utilized, designs must be in accordance with appendix D.

(b) Option 2-Designs using manufacturer's tabulated data.

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

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

(iii) Manufacturer's specifications, recommendations, and limitations, and manufacturer's approval to deviate from the specifications, recommendations, and limitations must be in written form at the job site during construction of the protective system. After that time this data may be stored off the job site, but you must make a copy available to the director upon request.

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

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

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

(A) Identification of the parameters that affect the selection of a protective system drawn from such data;

(B) Identification of the limits of use of the data;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(iii) You must maintain at least one copy of the tabulated data, which identifies the registered professional engineer who approved the data, at the job site during construction of the protective system. After that time the data may be stored off the job site, but you must make a copy of the data available to the director upon request.

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

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

(ii) Designs must be in written form and must include the following:

(A) A plan indicating the sizes, types, and configurations of the materials to be used in the protective system; and

(B) The identity of the registered professional engineer approving the design.

(iii) You must maintain at least one copy of the design at the job site during construction of the protective system. After that time, the design may be stored off the job site, but you must maintain a copy of the design available to the director upon request.

(4) **Materials and equipment.**

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

(b) You must use and maintain manufactured materials and equipment used for protective systems in a manner that is consistent with the recommendations of the manufacturer, and in a manner that will prevent employee exposure to hazards.

(c) When material or equipment that is used for protective systems is damaged, a competent person must 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 you must remove such material or equipment from service, and it must be evaluated and approved by a registered professional engineer before being returned to service.

(5) **Installation and removal of support.**

(a) General.

(i) Members of support systems must be securely connected together to prevent sliding, falling, kickouts, or other predictable failure.

(ii) You must install and remove support systems in a manner that protects employees from cave-ins, structural collapses, or from being struck by members of the support system.

(iii) You must not subject individual members of support systems to loads exceeding those which those members were designed to withstand.

(iv) Before temporary removal of individual members begins, you must take additional precautions to ensure the safety of employees, such as installing other structural members to carry the loads imposed on the support system.

(v) Removal must begin at, and progress from, the bottom of the excavation. You must release members 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.

(vi) Backfilling must progress together with the removal of support systems from excavations.

(b) Additional requirements for support systems for trench excavations.

(i) Excavation of material to a level no greater than two feet (.61 m) below the bottom of the members of a support system is 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.

(ii) Installation of a support system must be closely coordinated with the excavation of trenches.

(6) **Sloping and benching systems**. You must not permit employees 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.

(7) **Shield systems.**

(a) General.

(i) You must not subject shield systems to loads exceeding those which the system was designed to withstand.

(ii) You must install shields in a manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads.

(iii) You must protect employees from the hazard of cave-ins when entering or exiting the areas protected by shields.

(iv) You must not allow employees in shields when shields are being installed, removed, or moved vertically.

(b) Additional requirement for shield systems used in trench excavations. Excavations of earth material to a level not greater than two feet (.61 m) below the bottom of a shield is 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.

[Statutory Authority: RCW 49.17.010, .040, .050, and .060. 16-09-085 (Order 15-08), § 296-155-657, filed 04/19/16, effective, 05/20/16. Statutory Authority: Chapter 49.17 RCW and RCW 49.17.040, [49.17].050 and [49.17].060. 92-22-067 (Order 92-06), § 296-155-657, filed 10/30/92, effective 12/8/92. Statutory Authority: Chapter 49.17 RCW. 91-03-044 (Order 90-18), § 296-155-657, filed 1/10/91, effective 2/12/91.]

WAC 296-155-66103 Reserved.

[Statutory Authority: Chapter 49.17 RCW and RCW 49.17.040, [49.17].050 and [49.17].060. 92-22-067 (Order 92-06), § 296-155-66103, filed 10/30/92, effective 12/8/92. Statutory Authority: Chapter 49.17 RCW. 91-03-044 (Order 90-18), § 296-155-66103, filed 1/10/91, effective 2/12/91.]

WAC 296-155-66105 Reserved.

[Statutory Authority: Chapter 49.17 RCW and RCW 49.17.040, [49.17].050 and [49.17].060. 92-22-067 (Order 92-06), § 296-155-66105, filed 10/30/92, effective 12/8/92. Statutory Authority: Chapter 49.17 RCW. 91-03-044 (Order 90-18), § 296-155-66105, filed 1/10/91, effective 2/12/91.]

WAC 296-155-66109 Reserved.

[Statutory Authority: Chapter 49.17 RCW and RCW 49.17.040, [49.17].050 and [49.17].060. 92-22-067 (Order 92-06), § 296-155-66109, filed 10/30/92, effective 12/8/92. Statutory Authority: Chapter 49.17 RCW. 91-03-044 (Order 90-18), § 296-155-66109, filed 1/10/91, effective 2/12/91.]

WAC 296-155-664 Appendices.

[Statutory Authority: Chapter 49.17 RCW and RCW 49.17.040, [49.17].050 and [49.17].060. 92-22-067 (Order 92-06), § 296-155-664, filed 10/30/92, effective 12/8/92. Statutory Authority: Chapter 49.17 RCW. 91-03-044 (Order 90-18), § 296-155-664, filed 1/10/91, effective 2/12/91.]

WAC 296-155-66401 Appendix A-Soil classification.

(1) **Scope and application.**

(a) 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.

(b) Application. This appendix applies when a sloping or benching system is designed in accordance with the requirements set forth in WAC 296-155-657 (2)(b) as a method of protection for employees from cave-ins. This appendix also applies when timber shoring for excavations is designed as a method of protection from cave-ins in accordance with appendix C to part N of this chapter, and when aluminum hydraulic shoring is designed in accordance with appendix D. This Appendix also applies if other protective systems are designed and selected for use from data prepared in accordance with the requirements set forth in WAC 296-155-657(3), and the use of the data is predicated on the use of the soil classification system set forth in this appendix.

(2) **Definitions.**

The definitions and examples given below are based on, in whole or in part, the following; American Society for Testing Materials (ASTM) Standards D653-85 and D2488; The Unified Soils Classification System, The U.S. Department of Agriculture (USDA) Textural Classification Scheme; and The National Bureau of Standards Report BSS-121.

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 sideslopes, and is plastic when moist. Cohesive soil is hard to break up when dry, and exhibits significant cohesion when submerged. Cohesive soils include clayey silt, sandy clay, silty clay, clay and organic clay.

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

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

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

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

Moist soil. A condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before 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. For the purpose of this part, 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. Cohesive soils with an unconfined compressive strength of 1.5 ton per square foot (tsf) (144 kPa) 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. No soil is Type A if:

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

Type B.

- Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa): or
- 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.
- Previously disturbed soils except those which would otherwise be classed as Type C soil.
- Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration: or
- Dry rock that is not stable: or
- Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than 4 horizontal to 1 vertical (4H.1V), but only if the material would otherwise be classified as Type B.

Type C.

- Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less: or
- Granular soils including gravel, sand, and loamy sand: or
- Submerged soil or soil from which water is freely seeping: or
- Submerged rock that is not stable, or
- Material in a sloped, layered system where the layers dip into the excavation or a slope of 4 horizontal to 1 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.

(3) **Requirements**.

(a) Classification of soil and rock deposits. Each soil and rock deposit must be classified by a competent person as Stable Rock, Type A, Type B, or Type C in accordance with the definitions set forth in subsection (2) of this section.

(b) Basis of classification. The classification of the deposits shall be made based on the results of at least one visual and at least one manual analysis. Such analyses must be conducted by a competent person using tests in subsection (4) of this section or in other recognized 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.

(c) Visual and manual analyses. The visual and manual analyses, such as those noted as being acceptable in subsection (4) of this section, must 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.

(d) Layered systems. In a layered system, the system must 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.

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

(4) **Acceptable visual and manual tests.**

(a) Visual tests. Visual analysis is conducted to determine qualitative information regarding the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the open excavation, and the soil taken as samples from excavated material.

(i) 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.

(ii) 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.

(iii) 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.

(iv) 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.

(v) 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.

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

(vii) 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.

(b) 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.

(i) Plasticity. Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as 1/8-inch in diameter. Cohesive material can be successfully rolled into threads without crumbling. For example, if at least a two inch (50 mm) length of 1/8-inch thread can be held on one end without tearing, the soil is cohesive.

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

(iii) Thumb penetration. The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. (This test is based on the thumb penetration test described in American Society for Testing and Materials (ASTM) Standard designation D2488-"Standard Recommended Practice for Description of Soils (Visual-Manual Procedure).") Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be and 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. If the excavation is later exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly.

(iv) 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 shear vane.

(v) 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 1 inch thick (2.54 cm) and 6 inches (15.24 cm) in diameter until it is thoroughly dry:

(A) If the sample develops cracks as it dries, significant fissures are indicated.

(B) 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 a unfissured cohesive material and the unconfined compressive strength should be determined.

(C) 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.

[Statutory Authority: RCW 49.17.010, .040, .050, and .060. 16-09-085 (Order 15-08), § 296-155-66401, filed 04/19/16, effective, 05/20/16. Statutory Authority: Chapter 49.17 RCW and RCW 49.17.040, [49.17].050 and [49.17].060. 92-22-067 (Order 92-06), § 296-155-66401, filed 10/30/92, effective 12/8/92.]

WAC 296-155-66403 Appendix B-Sloping and benching.

(1) **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 WAC 296-155-657 (2)(b).

(2) **Definitions.**

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

Distress. Soil that 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 ravelling, 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).

(3) **Requirements.**

(a) Soil classification. Soil and rock deposits must be classified in accordance with appendix A of this Part.

(b) Maximum allowable slope. The maximum allowable slope for a soil or rock deposit must be determined from Table N-1 of this appendix.

(c) Actual slope.

(i) The actual slope must not be steeper than the maximum allowable slope.

(ii) The actual slope must be less steep than the maximum allowable slope, when there are signs of distress. If that situation occurs, the slope must 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.

(iii) When surcharge loads from stored material or equipment, operating equipment, or traffic are present, a competent person must determine the degree to which the actual slope must be reduced below the maximum allowable slope, and must ensure that such reduction is achieved. Surcharge loads from adjacent structures shall be evaluated in accordance with WAC 296-155-655(9).

(d) Configurations. Configurations of sloping and benching systems must be in accordance with Figures N-1 through N-18.

Table N-1

SOIL OR ROCK TYPE	MAXIMUM ALLOWABLE SLOPES (H:V) [1] FOR EXCAVATIONS LESS THAN 20 FEET DEEP [2]
STABLE ROCK TYPE A TYPE B TYPE C	VERTICAL (90°) 3/4:1 (53°) 1:1 (45°) 1 1/2:1 (34°)

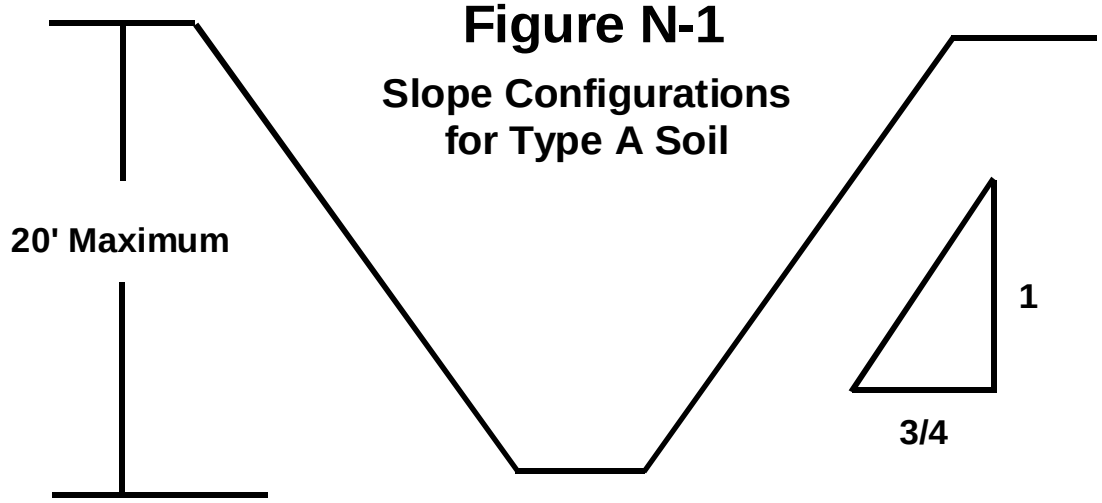
NOTES

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

[2]: Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer.

Figure N-1

Slope Configurations for Type A Soil



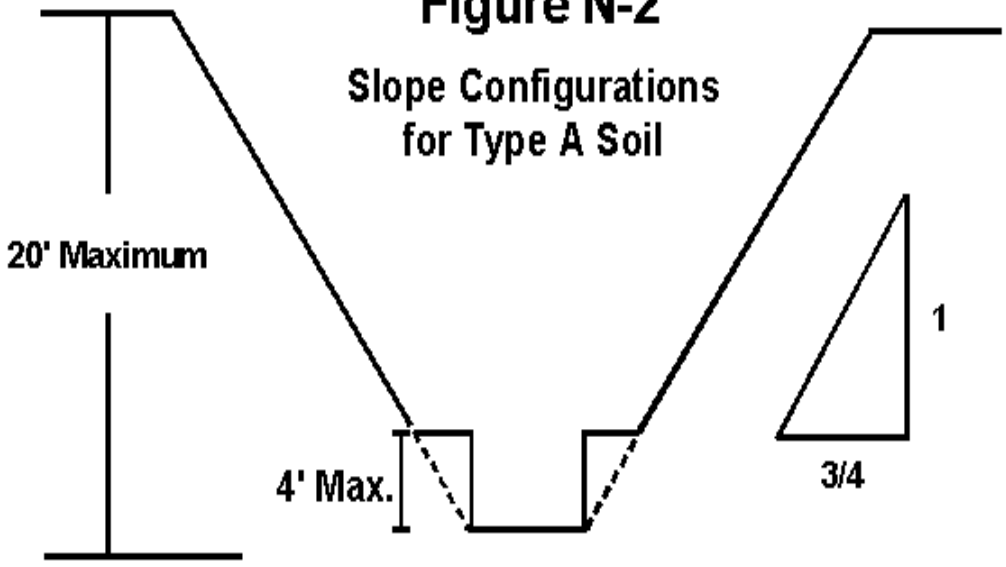
Simple Slope - General

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

WAC 296-155-66403 (Cont.)

Figure N-2

Slope Configurations for Type A Soil

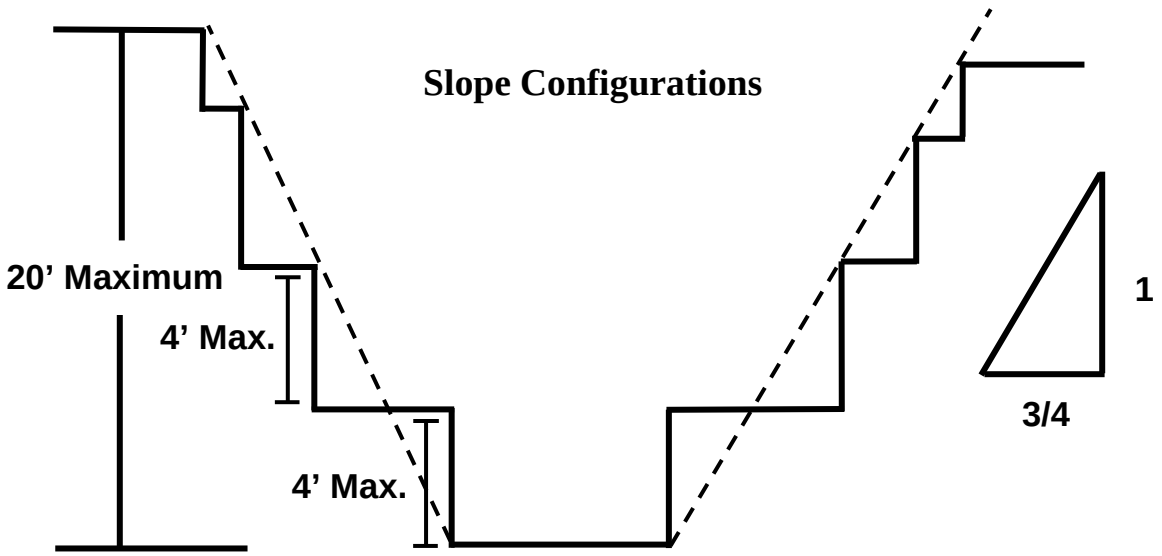


Simple Bench

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

Figure N-3

Slope Configurations

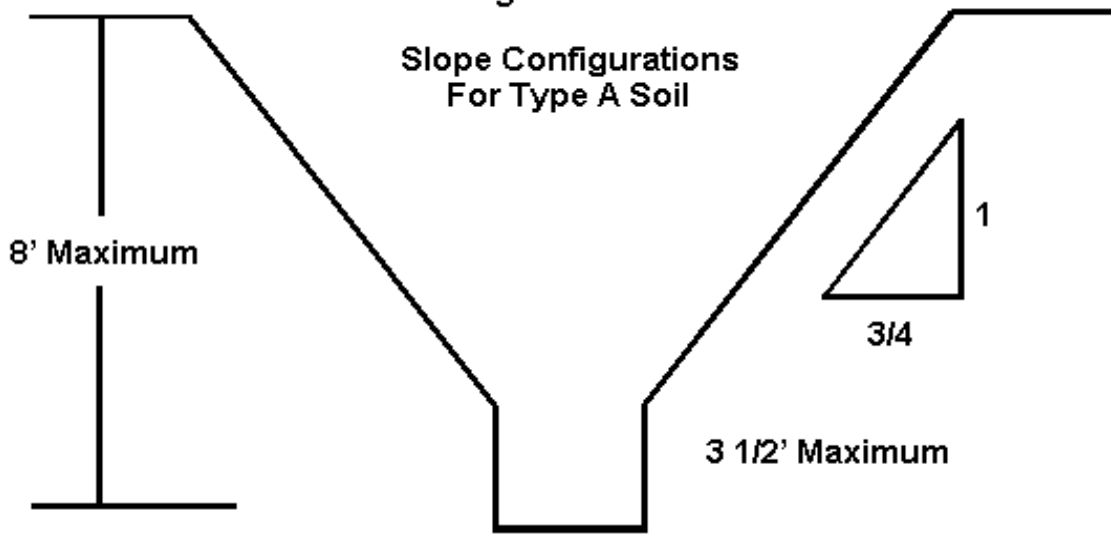


Multiple Bench

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

WAC 296-155-66403 (Cont.)

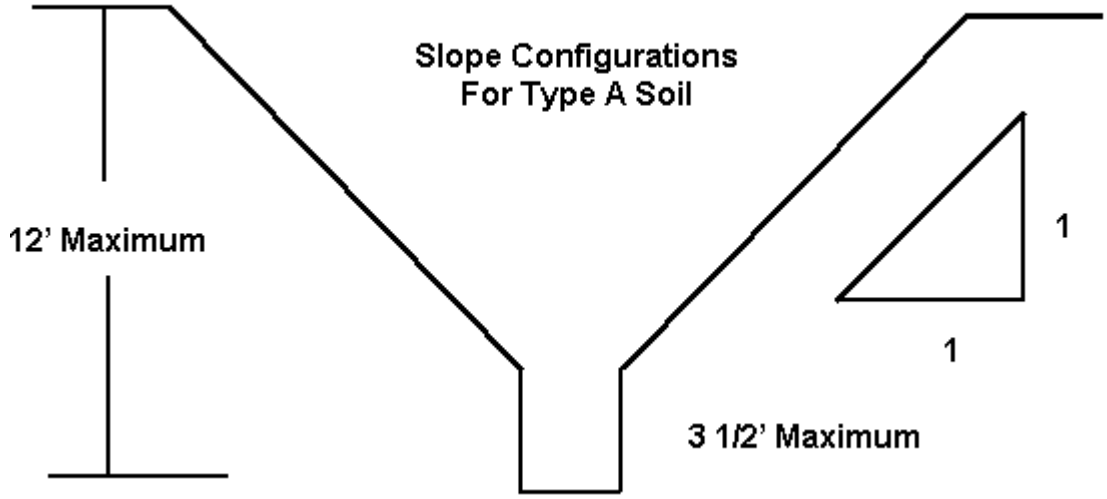
Figure N-4



**Unsupported Vertically Sided Lower Portion
Maximum 8 Feet in Depth**

All excavations 8 feet or less in depth which have unsupported vertically sided lower portions must have a maximum vertical side of 3 ½ feet.

Figure N-5

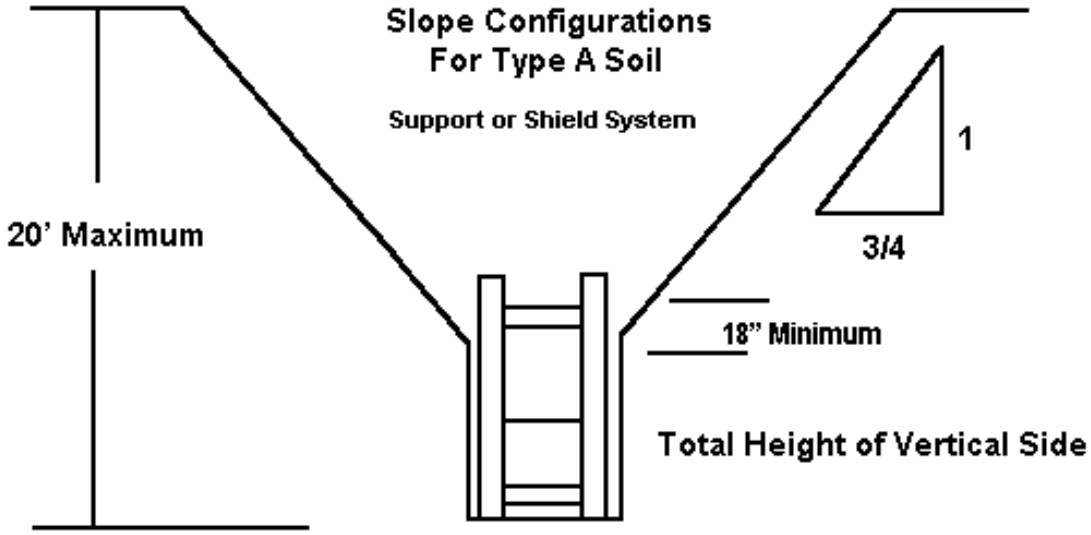


**Unsupported Vertically Sided Lower Portion
Maximum 12 Feet in Depth**

All excavations more than 8 feet but not more than 12 feet in depth which have unsupported vertically sided lower portions shall have a maximum allowable slope of 1:1 and vertical side of 3 ½ feet.

WAC 296-155-66403 (Cont.)

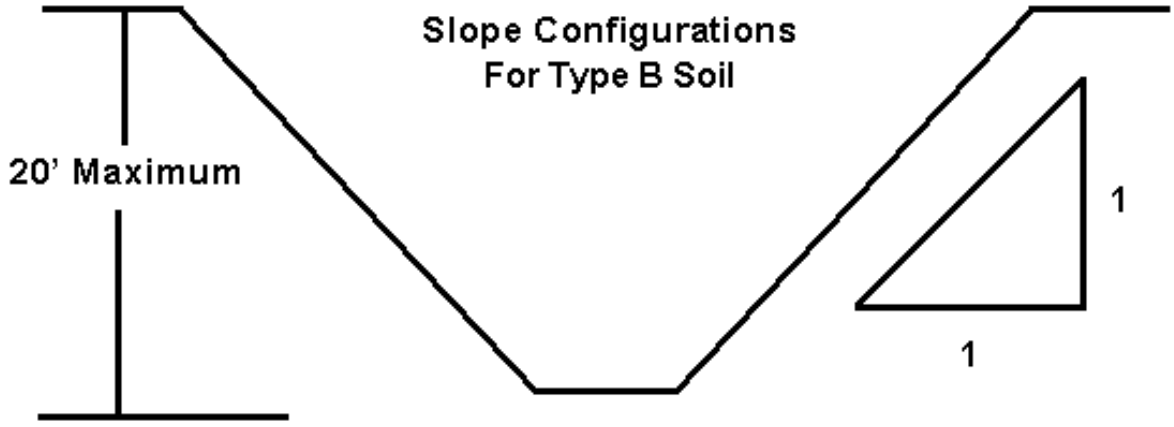
Figure N-6



Unsupported Vertically Sided Lower Portion
Maximum 20 Feet in Depth

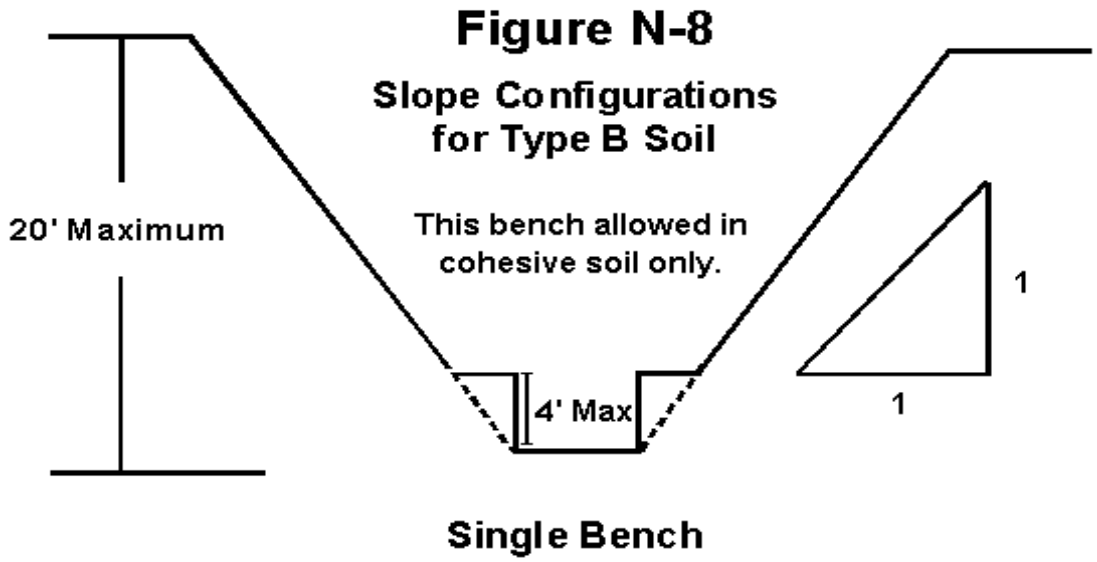
All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded shall have a maximum allowable slope of 3/4:1. The support or shield system must extend at least 18 inches above the top of the vertical side. All other simple slope, compound slope and vertically sided lower portion excavations must be in accordance with options permitted under WAC 296-155-657(2).

Figure N-7

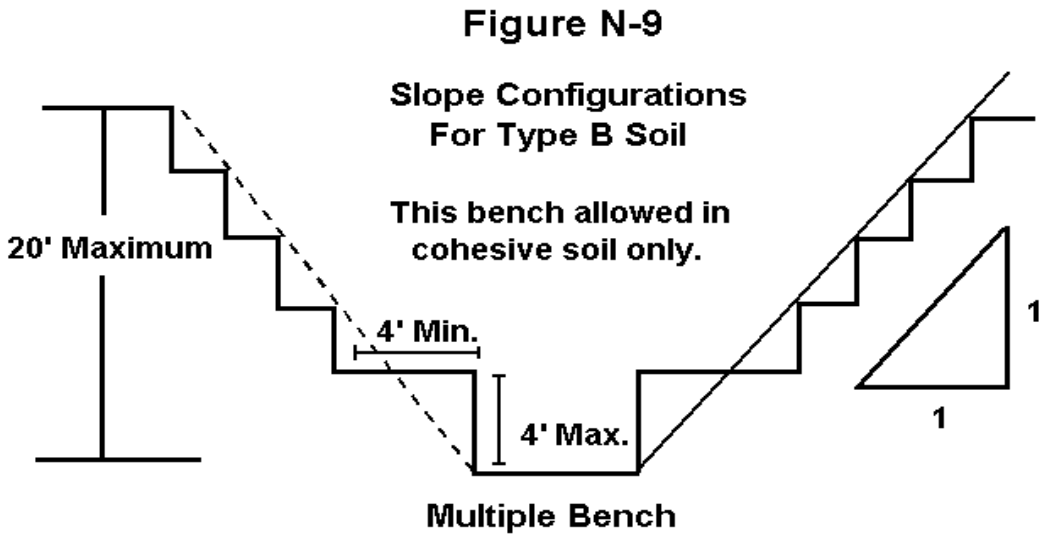


Simple slope

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

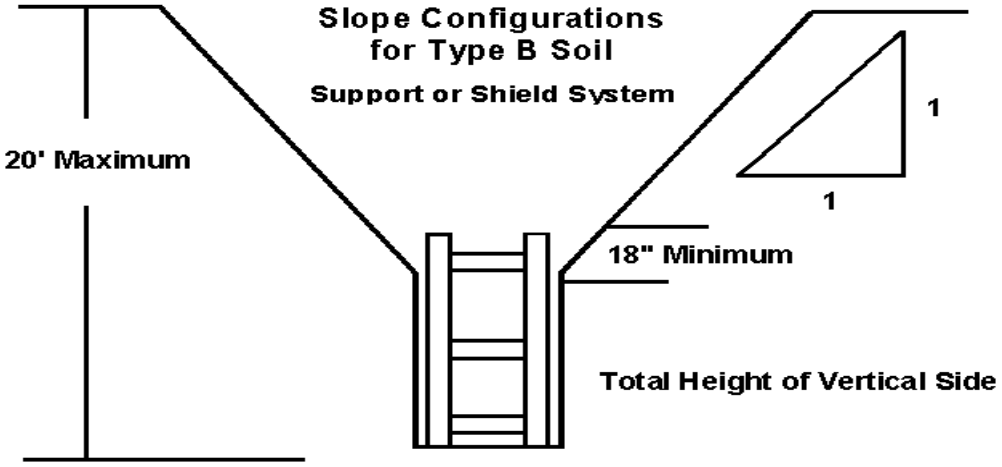


All excavations 20 feet or less in depth must have a maximum allowable slope of 1:1 and maximum bench dimensions of 4 feet.



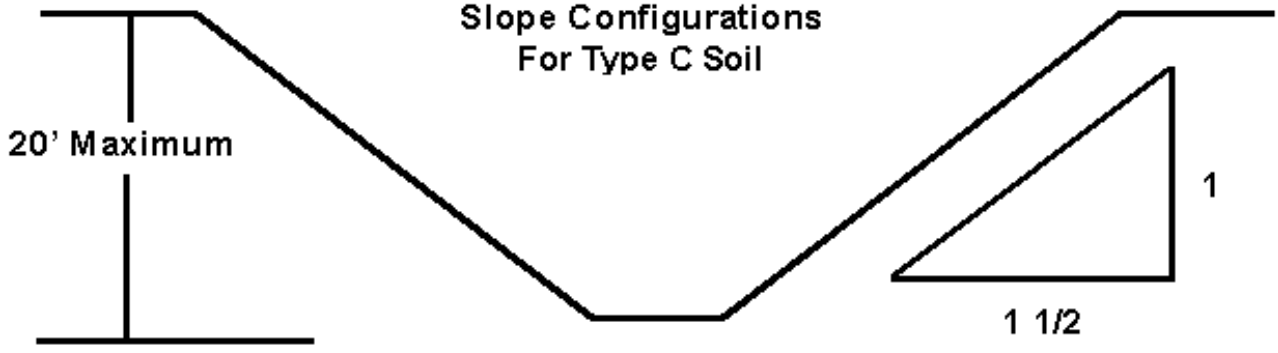
All excavations 20 feet or less in depth must have a maximum allowable slope of 1:1 and maximum bench dimensions of 4 feet.

Figure N-10



All excavations 20 feet or less in depth which have vertically sided lower portions must be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations must have a maximum allowable slope of 1:1. All other simple slope, compound slope and vertically sided lower portion excavations must be in accordance with options permitted under WAC 296-155-657(2).

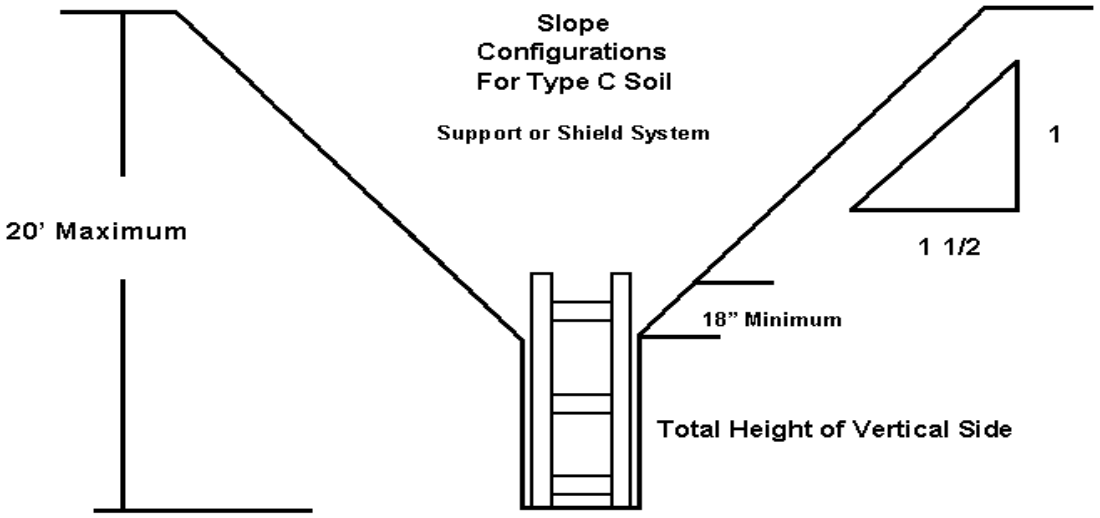
Figure N-11



Simple Slope

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

Figure N-12



Vertically Sided Lower Portion

All excavations 20 feet or less in depth which have vertically sided lower portions must be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations must have a maximum allowable slope of 1 1/2:1. All other simple slope, compound slope and vertically sided lower portion excavations must be in accordance with options permitted under WAC 296-155-657(2).

Figure N-13

EXCAVATIONS MADE IN LAYERED SOILS

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

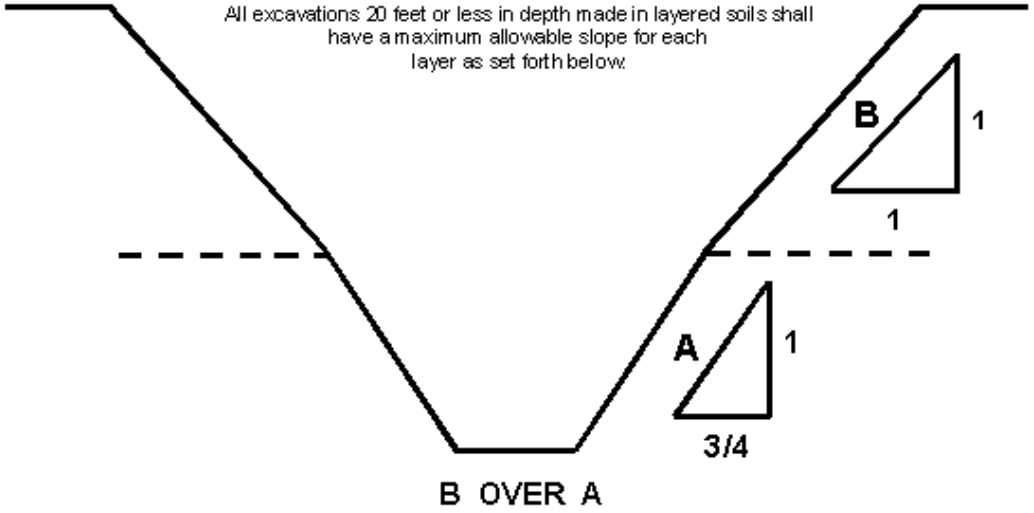
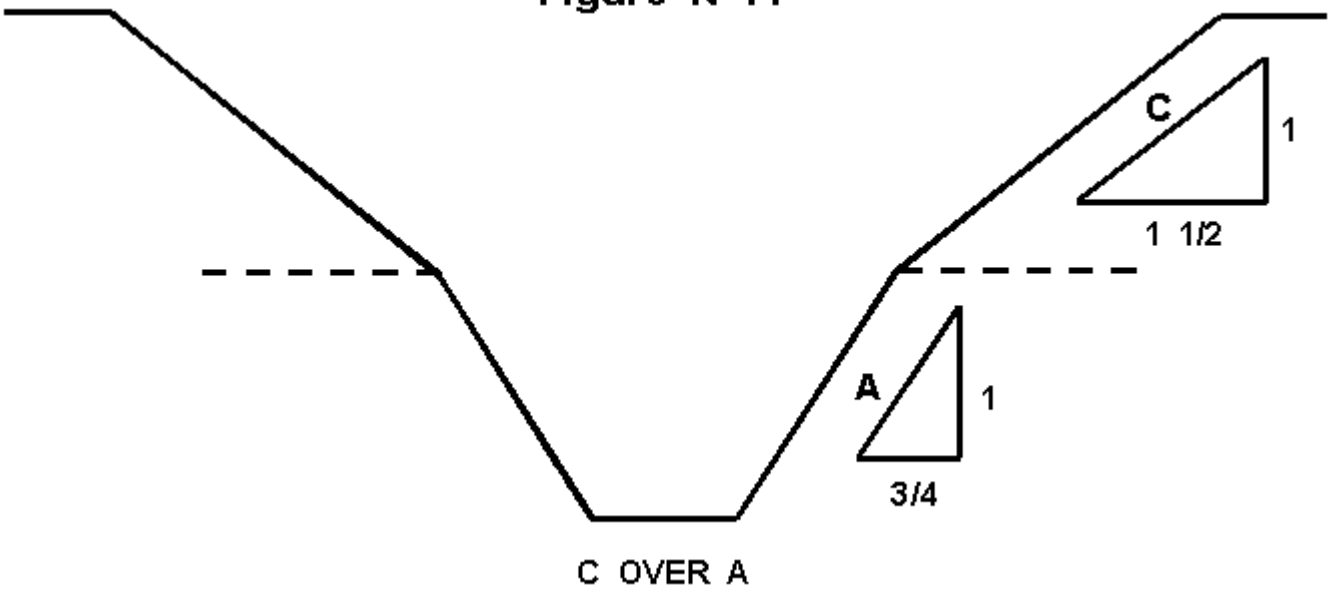
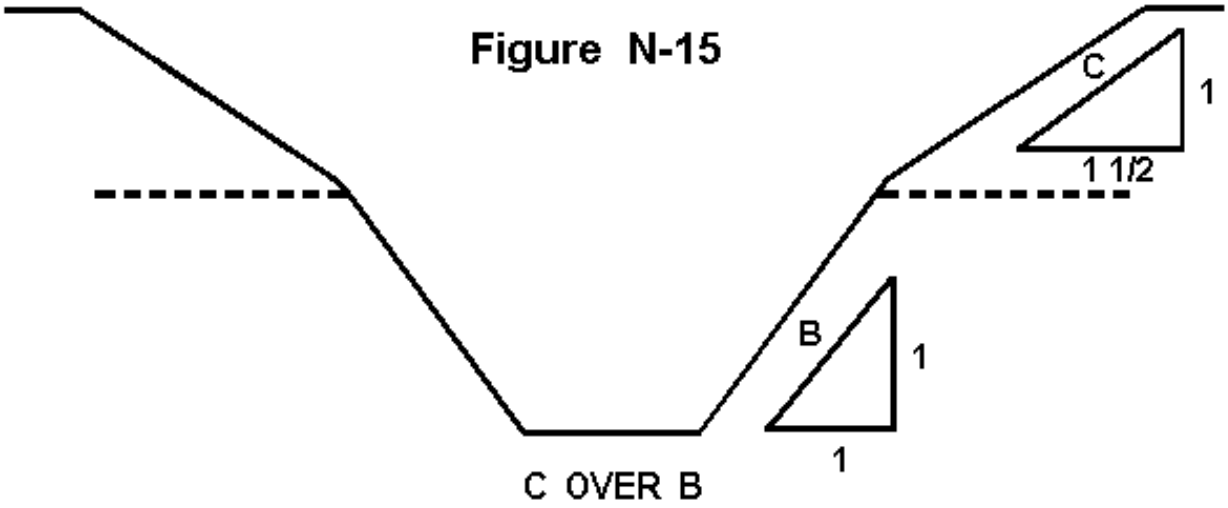


Figure N-14



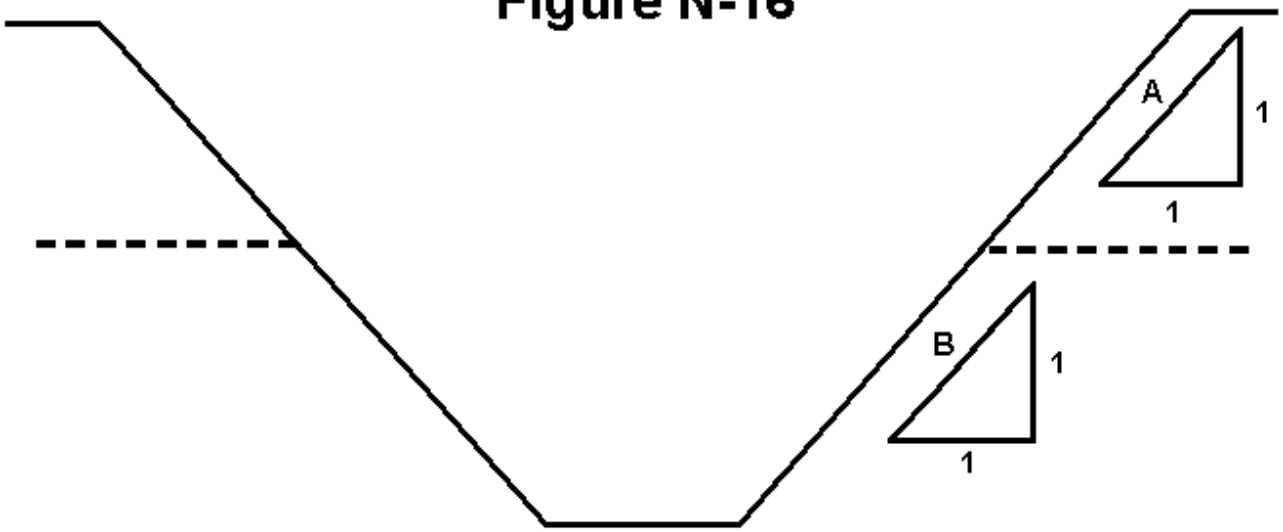
C OVER A

Figure N-15



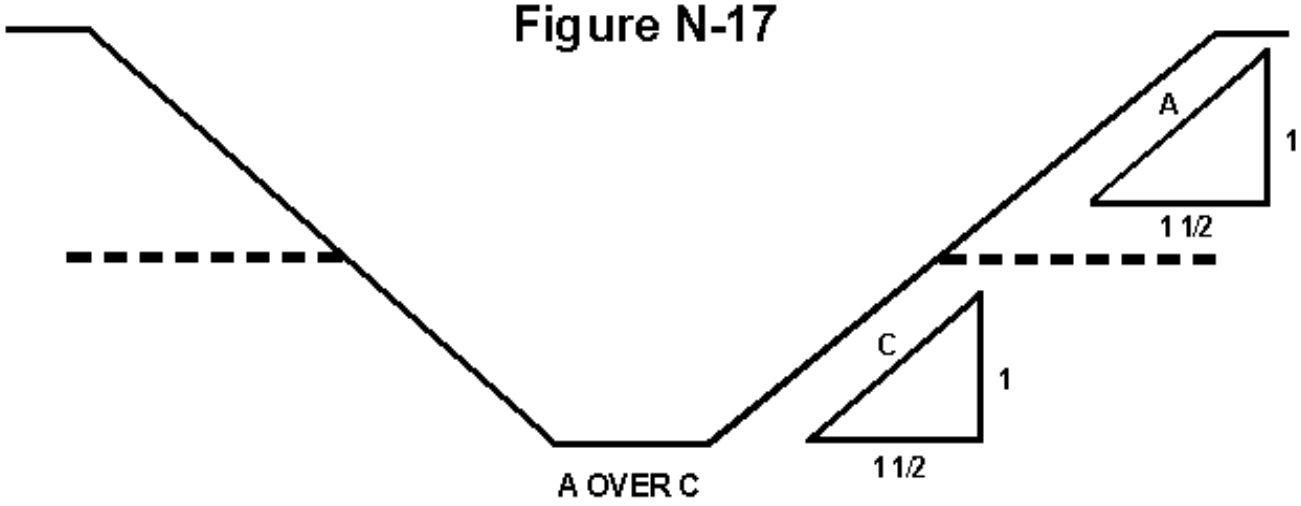
C OVER B

Figure N-16



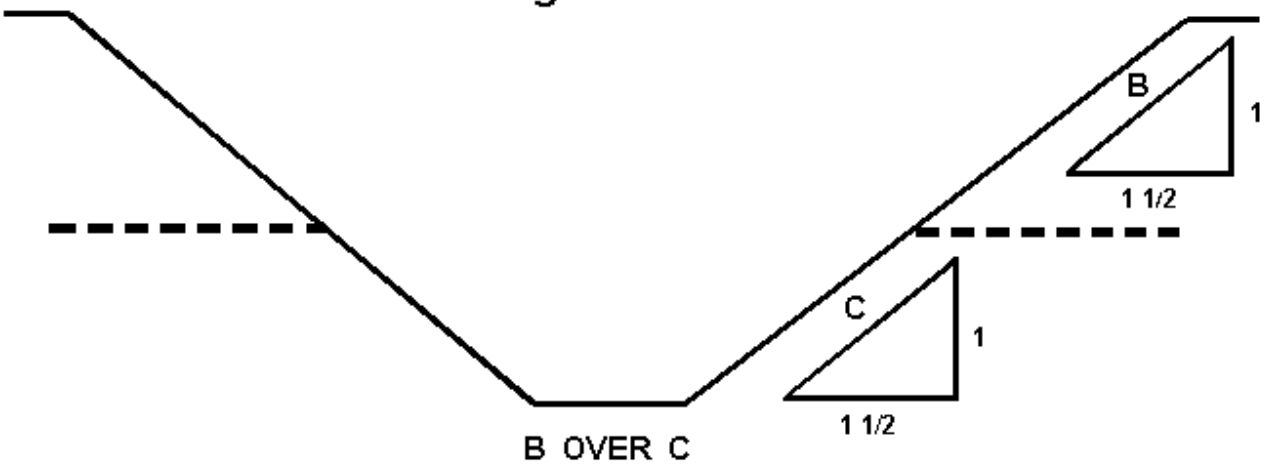
A OVER B

Figure N-17



A OVER C

Figure N-18



[Statutory Authority: RCW 49.17.010, .040, .050, and .060. 16-09-085 (Order 15-08), § 296-155-66403 filed 04/19/16, effective, 05/20/16. Statutory Authority: RCW 49.17.010, .040, .050. 99-17-094 (Order 99-01), § 296-155-66403, filed 08/17/99, effective 12/01/99. Statutory Authority: Chapter 49.17 RCW and RCW 49.17.040, [49.17].050 and [49.17].060. 92-22-067 (Order 92-06), § 296-155-66403, filed 10/30/92, effective 2/8/92.]

WAC 296-155-66405 Appendix C-Timber shoring for trenches.

(1) **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 (6.1 m) in depth. This appendix must be used when design of timber shoring protective systems is to be performed in accordance with WAC 296-155-657 (3)(a). 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 WAC 296-155-657 (2) and (3).

(2) **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 appendix A of this part.

(3) **Presentation of information**. Information is presented in several forms as follows:

(a) Information is presented in tabular form in Tables N-2 through N-7 following subsection (7) of this appendix. 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.

(b) Information concerning the basis of the tabular data and the limitations of the data is presented in subsection (4) of this appendix, and on the tables themselves.

(c) Information explaining the use of the tabular data is presented in subsection (5) of this appendix.

(d) Information illustrating the use of the tabular data is presented in subsection (6) of this appendix.

(e) Miscellaneous notations regarding Tables N-2 through N-7 are presented in subsection (7) of this Appendix.

(4) **Basis and limitations of the data.**

(a) Dimensions of timber members.

(i) The sizes of the timber members listed in Tables N-2 through N-7 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.

(ii) The required dimensions of the members listed in Tables N-2, N-3, and N-4 refer to actual dimensions and not nominal dimensions of the timber. Employers wanting to use nominal size shoring are directed to Tables N-5, N-6, and N-7, or have this choice under WAC 296-155-657 (3)(c), and are referred to The Corps of Engineers, The Bureau of Reclamation or data from other acceptable sources.

(b) Limitation of application.

(i) 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 WAC 296-155-657(3).

(ii) 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 WAC 296-155-657.

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

(B) When vertical loads imposed on cross braces exceed a 240-pound gravity load distributed on a one-foot section of the center of the crossbrace.

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

(D) 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.

(5) **Use of Tables**. The members of the shoring system that are to be selected using this information are the cross braces, the uprights, and the wales, where wales are required. Minimum sizes of members are specified for use in different types of soil. There are 6 tables of information, two for each soil type. The soil type must first be determined in accordance with the soil classification system described in appendix A of this Part. Using the appropriate table, the selection of the size and spacing of the members is then made. The selection is based on the depth and width of the trench where the members are to be installed and, in most instances, the selection is also based on the horizontal spacing of the crossbraces. Instances where a choice of horizontal spacing of crossbracing is available, the horizontal spacing of the crossbraces must be chosen by the user before the size of any member can be determined. When the soil type, the width and depth of the trench, and the horizontal spacing of the crossbraces 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.

(6) **Examples to illustrate the use of Tables N-2 through N-4.**

(a) Example 1.

A trench dug in Type A soil is 13 feet deep and 5 feet wide.
From Table N-2, for acceptable arrangements of timber can be used.

Arrangement #1

Space 4x4 crossbraces at six 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 four 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.

(b) Example 2.

A trench dug in Type B soil in 13 feet deep and 5 feet wide.
From Table N-3 three acceptable arrangements of members are listed.

Arrangement #1

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

(c) Example 3.

A trench dug Type C soil is 13 feet deep and 5 feet wide.
From Table N-4 two acceptable arrangements of members can be used.

Arrangement #1

Space 8x8 crossbraces at six 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.

(d) 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 N-4. 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 tight sheeting.
Use of Tables N-5, N-6, and N-7 would follow the same procedures.

(7) **Notes for all tables.**

(a) Member sizes at spacings other than indicated are to be determined as specified in WAC 296-155-657(3). "Design of Protective Systems."

(b) 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.

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

(d) Wales to be installed with greater dimension horizontal.

(e) If the vertical distance from the center of the lowest crossbrace to the bottom of the trench exceeds 2 1/2 feet, you must firmly embed uprights or use a mudsill. Where uprights are embedded, the vertical distance from the center of the lowest crossbrace to the bottom of the trench must not exceed 36 inches. When mudsills are used, the vertical distance shall not exceed 42 inches. Mudsills are wales that are installed at the toe of the trench side.

(f) Trench jacks may be used in lieu of or in combination with timber crossbraces.

(g) Placement of crossbraces. When the vertical spacing of crossbraces is 4 feet, place the top crossbrace no more than two 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 N-2

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS*
SOIL TYPE A P_a - 25 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **												
	CROSS BRACES						WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)				VERT. SPACING (FEET)	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15			CLOSE	4	5	6	7
4 TO 10	UP TO 6	4 X 4	4 X 4	4 X 6	6 X 6	6 X 6	4	Not Req'd	---				2 X 6	
	UP TO 8	4 X 4	4 X 4	4 X 6	6 X 6	6 X 6	4	Not Req'd	---					2 X 8
	UP TO 10	4 X 6	4 X 6	4 X 6	6 X 6	6 X 6	4	8 X 8	4			2 X 6		
	UP TO 12	4 X 6	4 X 6	4 X 6	6 X 6	6 X 6	4	8 X 8	4				2 X 6	
10 TO 15	UP TO 6	4 X 4	4 X 4	4 X 4	6 X 6	6 X 6	4	Not Req'd	---				3 X 8	
	UP TO 8	4 X 6	4 X 6	4 X 6	6 X 6	6 X 6	4	8 X 8	4		2 X 6			
	UP TO 10	6 X 6	6 X 6	6 X 6	6 X 8	6 X 8	4	8 X 10	4			2 X 6		
	UP TO 12	6 X 6	6 X 6	6 X 6	6 X 8	6 X 8	4	10 X 10	4				3 X 8	
15 TO 20	UP TO 6	6 X 6	6 X 6	6 X 6	6 X 8	6 X 8	4	6 X 8	4	3 X 6				
	UP TO 8	6 X 6	6 X 6	6 X 6	6 X 8	6 X 8	4	8 X 8	4	3 X 6				
	UP TO 10	8 X 8	8 X 8	8 X 8	8 X 8	8 X 10	4	8 X 10	4	3 X 6				
	UP TO 12	8 X 8	8 X 8	8 X 8	8 X 8	8 X 10	4	10 X 10	4	3 X 6				
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufacturered members of equivalent strength may be substituted for wood.

TABLE N-3

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							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3		
4 TO 10	UP TO 6	4 X 4	4 X 4	6 X 6	6 X 6	6 X 6	5	6 X 8	5			2 X 6		
	UP TO 8	4 X 4	4 X 4	6 X 6	6 X 8	6 X 8	5	8 X 10	5			2 X 6		
	UP TO 10	4 X 6	4 X 6	6 X 6	6 X 8	6 X 8	5	8 X 8	5			2 X 6		
	See Note 1													
10 TO 15	UP TO 6	4 X 4	4 X 4	6 X 6	6 X 8	6 X 8	5	8 X 8	5		2 X 6			
	UP TO 8	4 X 6	4 X 6	6 X 8	8 X 8	8 X 8	5	10 X 10	5		2 X 6			
	UP TO 10	6 X 6	6 X 6	8 X 8	8 X 8	8 X 10	5	10 X 12	5		2 X 6			
	See Note 1													
15 TO 20	UP TO 6	6 X 8	6 X 8	6 X 8	8 X 8	8 X 8	5	8 X 10	5	3 X 6				
	UP TO 8	8 X 8	8 X 8	8 X 8	8 X 8	8 X 10	5	10 X 10	5	3 X 6				
	UP TO 10	8 X 10	8 X 10	8 X 10	8 X 10	10 X 10	5	10 X 12	5	3 X 6				
	See Note 1													
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufacturered members of equivalent strength may be substituted for wood.

TABLE N-4

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							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE				
4 TO 10	UP TO 6	6 X 8	6 X 8	6 X 8	8 X 8	8 X 8	5	8 X 10	5	2 X 6				
	UP TO 8	8 X 8	8 X 8	8 X 8	8 X 8	8 X 10	5	10 X 12	5	2 X 6				
	UP TO 10	8 X 10	8 X 10	8 X 10	8 X 10	10 X 10	5	12 X 12	5	2 X 6				
	See Note 1													
10 TO 15	UP TO 6	8 X 8	8 X 8	8 X 8	8 X 8	8 X 10	5	10 X 12	5	2 X 6				
	UP TO 8	8 X 10	8 X 10	8 X 10	8 X 10	10 X 10	5	12 X 12	5	2 X 6				
	See Note 1													
	See Note 1													
15 TO 20	UP TO 6	8 X 10	8 X 10	8 X 10	8 X 10	10 X 10	5	12 X 12	5	3 X 6				
	See Note 1													
	See Note 1													
	See Note 1													
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufacturered members of equivalent strength may be substituted for wood.

Table N-5

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							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3		
4 TO 10	UP TO 6	4 X 4	4 X 4	6 X 6	6 X 6	6 X 6	5	6 X 8	5			2 X 6		
	UP TO 8	4 X 4	4 X 4	6 X 6	6 X 8	6 X 8	5	8 X 10	5			2 X 6		
	UP TO 10	4 X 6	4 X 6	6 X 6	6 X 8	6 X 8	5	8 X 8	5			2 X 6		
	See Note 1													
10 TO 15	UP TO 6	4 X 4	4 X 4	6 X 6	6 X 8	6 X 8	5	8 X 8	5		2 X 6			
	UP TO 8	4 X 6	4 X 6	6 X 8	8 X 8	8 X 8	5	10 X 10	5		2 X 6			
	UP TO 10	6 X 6	6 X 6	8 X 8	8 X 8	8 X 10	5	10 X 12	5		2 X 6			
	See Note 1													
15 TO 20	UP TO 6	6 X 8	6 X 8	6 X 8	8 X 8	8 X 8	5	8 X 10	5	3 X 6				
	UP TO 8	8 X 8	8 X 8	8 X 8	8 X 8	8 X 10	5	10 X 10	5	3 X 6				
	UP TO 10	8 X 10	8 X 10	8 X 10	8 X 10	10 X 10	5	10 X 12	5	3 X 6				
	See Note 1													
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufacturered members of equivalent strength may be substituted for wood.

TABLE N-6

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							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3	4	6
4 TO 10	UP TO 6	4 X 6	4 X 6	4 X 6	6 X 6	6 X 6	5	6 X 8	5			3 X 12 4 X 8		4 X 12
	UP TO 8	4 X 6	4 X 6	6 X 6	6 X 6	6 X 6	5	8 X 8	5		3 X 8		4 X 8	
	UP TO 10	4 X 6	4 X 6	6 X 6	6 X 6	6 X 8	5	8 X 10	5			4 X 8		
	See Note 1													
10 TO 15	UP TO 6	6 X 6	6 X 6	6 X 6	6 X 8	6 X 8	5	8 X 8	5	3 X 6	4 X 10			
	UP TO 8	6 X 6	6 X 8	6 X 8	8 X 8	8 X 8	5	10 X 10	5	3 X 6	4 X 10			
	UP TO 10	6 X 8	6 X 8	8 X 8	8 X 8	8 X 8	5	10 X 12	5	3 X 6	4 X 10			
	See Note 1													
15 TO 20	UP TO 6	6 X 8	6 X 8	6 X 8	6 X 8	8 X 8	5	8 X 10	5	4 X 6				
	UP TO 8	6 X 8	6 X 8	6 X 8	8 X 8	8 X 8	5	10 X 12	5	4 X 6				
	UP TO 10	8 X 8	8 X 8	8 X 8	8 X 8	8 X 8	5	12 X 12	5	4 X 6				
	See Note 1													
OVER 20	SEE NOTE 1													

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

TABLE N-7

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							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE				
4 TO 10	UP TO 6	6 X 6	6 X 6	6 X 6	6 X 6	8 X 8	5	8 X 8	5	3 X 6				
	UP TO 8	6 X 6	6 X 6	6 X 6	8 X 8	8 X 8	5	10 X 10	5	3 X 6				
	UP TO 10	6 X 6	6 X 6	8 X 8	8 X 8	8 X 8	5	10 X 12	5	3 X 6				
	See Note 1													
10 TO 15	UP TO 6	6 X 8	6 X 8	6 X 8	8 X 8	8 X 8	5	10 X 10	5	4 X 6				
	UP TO 8	8 X 8	8 X 8	8 X 8	8 X 8	8 X 8	5	12 X 12	5	4 X 6				
	See Note 1													
	See Note 1													
15 TO 20	UP TO 6	8 X 8	8 X 8	8 X 8	8 X 10	8 X 10	5	10 X 12	5	4 X 6				
	See Note 1													
	See Note 1													
	See Note 1													
OVER 20	SEE NOTE 1													

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

[Statutory Authority: Chapter 49.17 RCW and RCW 49.17.040, [49.17].050 and [49.17].060. 92-22-067 (Order 92-06), § 296-155-66405, filed 10/30/92, effective 12/8/92.]

WAC 296-155-66407 Appendix D-Aluminum hydraulic shoring for trenches.

(1) **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 (6.1m) in depth. This appendix must be used when design of the aluminum hydraulic protective system cannot be performed in accordance with WAC 296-155-657 (3)(b).

(2) **Soil Classification**. In order to use data presented in this appendix, you must first determine the soil type or types in which the excavation is made using the soil classification method set forth in appendix A of this Part.

(3) **Presentation of information**. Information is presented in several forms as follows:

(a) Information is presented in tabular form in Tables N-8 through N-11. 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 N-8 and N-9 are for vertical shores in Types A and B soil. Tables N-10 and N-11 are for horizontal waler systems in Types B and C soil.

(b) Information concerning the basis of the tabular data and the limitations of the data is presented in subsection (4) of this appendix.

(c) Information explaining the use of the tabular data is presented in subsection (5) of this appendix.

(d) Information illustrating the use of the tabular data is presented in subsection (6) of this appendix.

(e) Miscellaneous notations (footnotes) regarding Table N-8 through N-11 are presented in subsection (7) of this appendix.

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

(4) **Basis and limitations of the data.**

(a) Vertical shore rails and horizontal wales are those that meet the Section Modulus requirements in Tables N-8 through N-10. Aluminum material is 6061-T6 or material of equivalent strength and properties.

(b) Hydraulic cylinders specifications.

(i) two-inch cylinders must be a minimum two-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.

(ii) 3-inch cylinders must be a 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.

(c) Limitation of application.

(i) 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 WAC 296-155-657(3).

(ii) 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 WAC 296-155-657.

(A) When vertical loads imposed on cross braces exceed a 100 Pound gravity load distributed on a one foot section of the center of the hydraulic cylinder.

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

(C) When only the lower portion of a trench is shored and the remaining portion of the trench is sloped or benched unless: The slope 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.

(5) **Use of Tables N-8 through N-11**. 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 N-8 and N-9 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 N-10 and N-11. The soil type must first be determined in accordance with the soil classification system described in appendix A of this Part. 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.

(6) **Example to Illustrate the Use of the Tables:**

(a) Example 1: A trench dug in Type A soil is 6 feet deep and 3 feet wide. From Table N-8: Find vertical shores and two inch diameter cylinders spaced 8 feet on center (o.c.) horizontally and 4 feet on center (o.c.) vertically. (See Figures N-23 & N-25 for typical installations.)

(b) Example 2: A trench is dug in Type B soil that does not require sheeting, 13 feet deep and 5 feet wide. From Table N-9: Find vertical shores and two inch diameter cylinders spaced 6.5 feet o.c. horizontally and 4 feet o.c. vertically. (See Figures N-23 & N-25 for typical installations.)

(c) 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 N-9: Find vertical shores and two inch diameter cylinder (with special oversleeves as designated by subdivision (7)(b)) spaced 5.5 feet o.c. horizontally and 4 feet o.c. vertically, plywood (per subdivision (7)(g) to the N-8 through N-11 Tables) should be used behind the shores. (See Figures N-24 & N-25 for typical installations.)

(d) 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 N-10: 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, 3x12 timber sheeting is required at close spacing vertically. (See Figure N-26 for typical installation.)

(e) 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 N-11: Find horizontal wale with a section modulus of 7.0 and two inch diameter cylinders spaced at 6.5 feet o.c. horizontally. Or, find horizontal wale with a 14.0 section modulus and 3 inch diameter cylinder spaced at 10 feet o.c. horizontally. Both wales are spaced 4 feet o.c. vertically. 3x12 timber sheeting is required at close spacing vertically. (See Figure N-26 for typical installation.)

(7) **Footnotes, and general notes, for Tables N-8 through N-11.**

(a) For applications other than those listed in the tables, refer to WAC 296-155-657 (3)(b) for use of manufacturer's tabulated data. For trench depths in excess of 20 feet, refer to WAC 296-155-657 (3)(b) and (c).

(b) Two-inch diameter cylinders, at this width, shall have structural steel tube (3.5x3.5x0.1875) oversleeves, or structural oversleeves of manufacturer's specification, extending the full, collapsed length.

(c) Hydraulic cylinders capacities.

(i) Two-inch cylinders must 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.

(ii) 3-inch cylinders must 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.

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

(e) Vertical shoring rails must have a minimum section modulus of 0.40 inch.

(f) When vertical shores are used, there must be a minimum of 3 shores spaced equally, horizontally, in a group.

(g) Plywood must be 1.125 in. thick softwood 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.

(h) See appendix C for timber specifications.

(i) Wales are calculated for simple span conditions.

(j) See subsection (4) of this appendix, for basis and limitations of the data.

FIGURE N-19
VERTICAL ALUMINUM
HYDRAULIC SHORING
(SPOT BRACING)

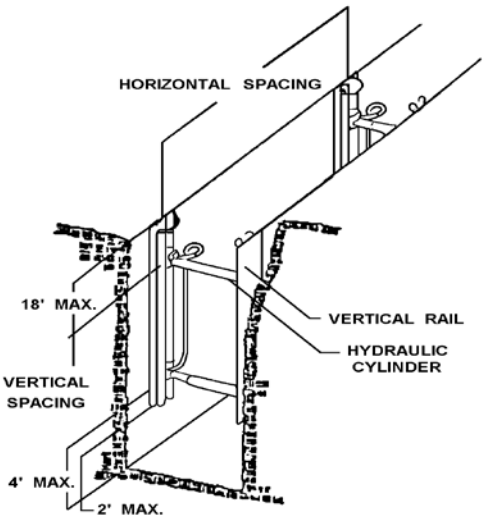


FIGURE N-20
VERTICAL ALUMINUM
HYDRAULIC SHORING
(WITH PLYWOOD)

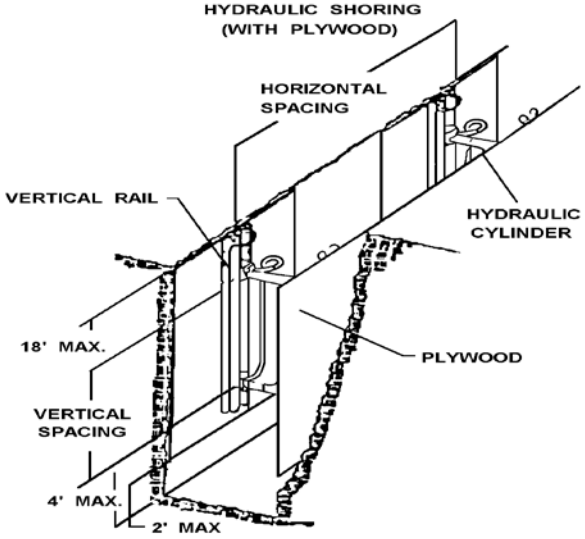


FIGURE N-21
ALUMINUM HYDRAULIC
WALER SYSTEM
(TYPICAL)

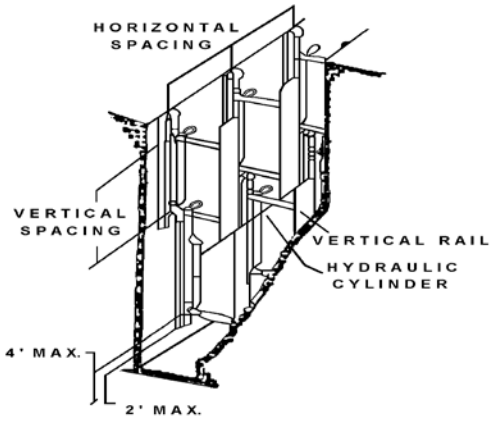


FIGURE N-22
ALUMINUM HYDRAULIC
WALER SYSTEM
(TYPICAL)

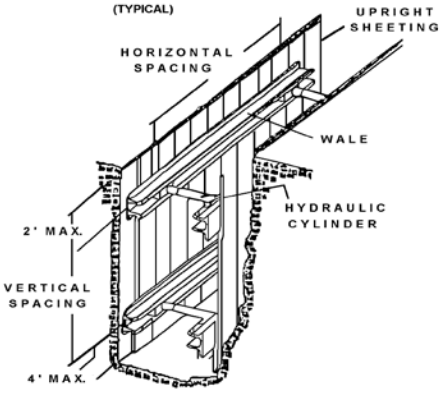


TABLE N-8
ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES
FOR SOIL *TYPE A*

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 4 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 D, WAC 296-155-66407(7)
Note (1), See Appendix D, WAC 296-155-66407(7)(a)
Note (2), See Appendix D, WAC 296-155-66407(7)(b)

TABLE N-9
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 4 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 D, WAC 296-155-66407(7)
Note (1), See Appendix D, WAC 296-155-66407(7)(a)
Note (2), See Appendix D, WAC 296-155-66407(7)(b)

TABLE N-10
ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL *TYPE B*

Depth of Trench (Feet)	Wales		Hydraulic Cylinders						Timber Uprights		
			Width of Trench (Feet)						Max. Horizontal Spacing (on Center)		
			Up to 8		Over 8 Up to 12		Over 12 Up to 15				
	Vertical Spacing (Feet)	Section* Modulus (In^3)	Horiz. Spacing	Cylinder Diameter	Horiz. Spacing	Cylinder Diameter	Horiz. Spacing	Cylinder Diameter	Solid Sheet	2 Feet	3 Feet
Over 4 Up to 10	4	3.5	8.0	2 IN	8.0	2 IN Note (2)	8.0	3 IN	—	—	3 X 12
		7.0	9.0	2 IN	9.0	2 IN Note (2)	9.0	3 IN			
		14.0	12.0	3 IN	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 (2)	6.0	3 IN	—	3 X 12	—
		7.0	8.0	3 IN	8.0	3 IN	8.0	3 IN			
		14.0	10.0	3 IN	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)	5.5	3 IN	3 X 12	—	—
		7.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
		14.0	9.0	3 IN	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 D, WAC 296-155-66407(7)
Note (1), See Appendix D, WAC 296-155-66407(7)(a)
Note (2), See Appendix D, WAC 296-155-66407(7)(b)
***Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.**

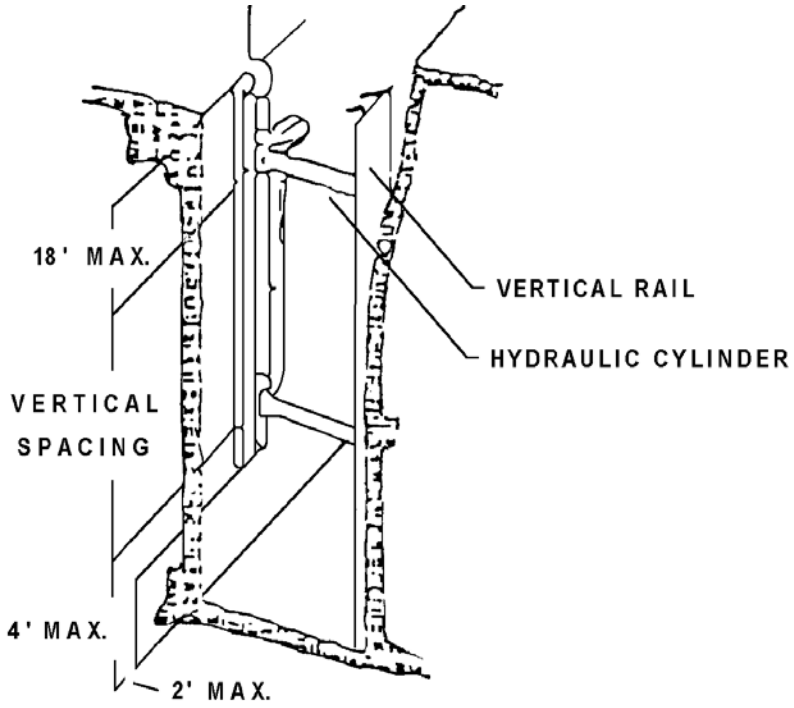
TABLE N-11
ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL *TYPE C*

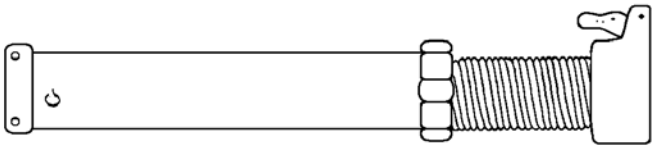
Depth of Trench (Feet)	Wales		Hydraulic Cylinders						Timber Uprights		
			Width of Trench (Feet)						Max. Horizontal Spacing (on Center)		
			Up to 8		Over 8 Up to 12		Over 12 Up to 15				
	Vertical Spacing (Feet)	Section* Modulus (In^3)	Horiz. Spacing	Cylinder Diameter	Horiz. Spacing	Cylinder Diameter	Horiz. Spacing	Cylinder Diameter	Solid Sheet	2 Feet	3 Feet
Over 4 Up to 10	4	3.5	6.0	2 IN	6.0	2 IN Note (2)	6.0	3 IN	3 X 12	—	—
		7.0	6.5	2 IN	6.5	2 IN Note (2)	6.5	3 IN			
		14.0	10.0	3 IN	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)	4.0	3 IN	3 X 12	—	—
		7.0	5.5	3 IN	5.5	3 IN	5.5	3 IN			
		14.0	8.0	3 IN	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)	3.5	3 IN	3 X 12	—	—
		7.0	5.0	3 IN	5.0	3 IN	5.0	3 IN			
		14.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
Over 20	NOTE (1)										

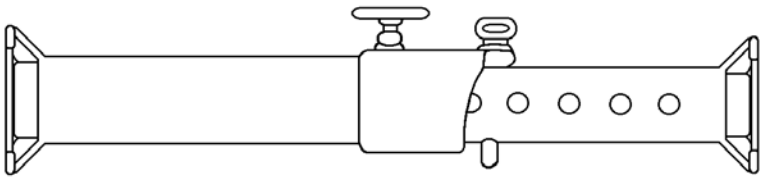
Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, WAC 296-155-66407(7)
Note (1), See Appendix D, WAC 296-155-66407(7)(a)
Note (2), See Appendix D, WAC 296-155-66407(7)(b)
***Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.**

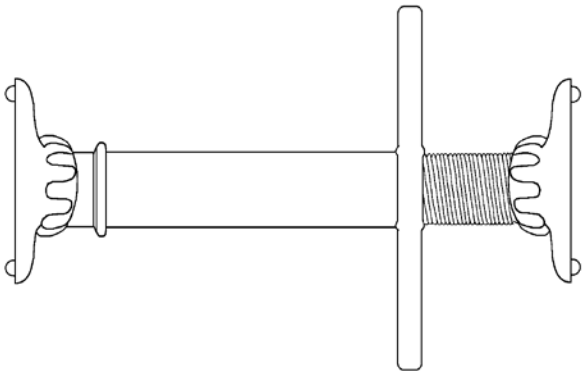
[Statutory Authority: RCW 49.17.010, .040, .050, and .060. 16-09-085 (Order 15-08), § 296-155-66407, filed 04/19/16, effective, 05/20/16. Statutory Authority: Chapter 49.17 RCW and RCW 49.17.040, [49.17].050 and [49.17].060. 92-22-067 (Order 92-06), § 296-155-66407, filed 10/30/92, effective 12/8/92.]

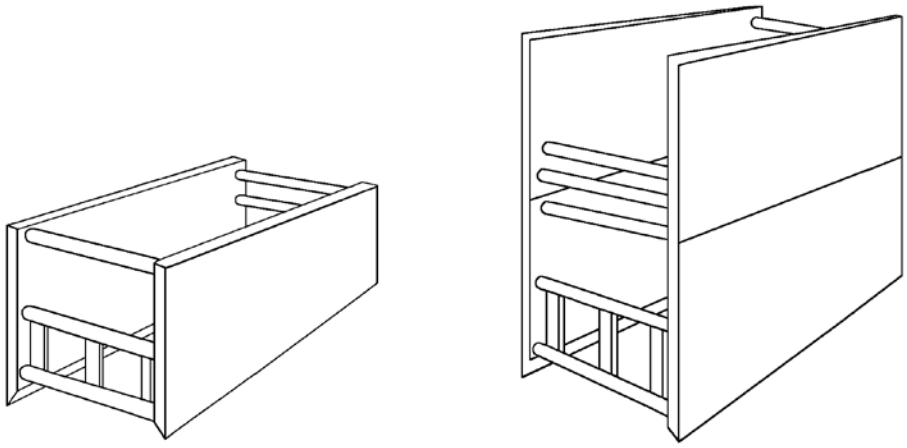
55-66409 Appendix E--Alternatives to timber shoring.

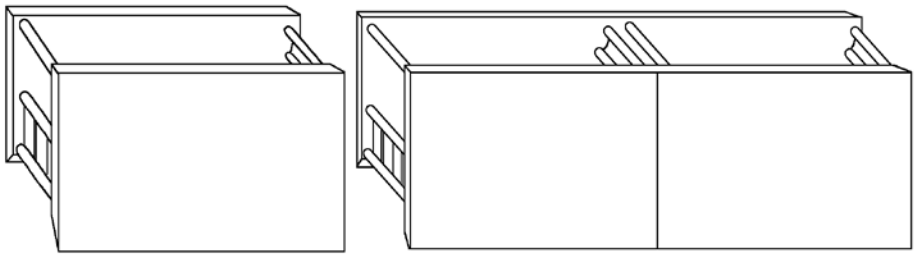












[Statutory Authority: Chapter 49.17 RCW and RCW 49.17.040, [49.17].050 and [49.17].060. 92-22-067 (Order 92-06), § 296-155-66409, filed 10/30/92, effective 12/8/92.]

WAC 296-155-66411 Appendix F--Selection of protective systems.

The following figures are a graphic summary of the requirements contained in Part N 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 WAC 296-155-657 (2) and (3).

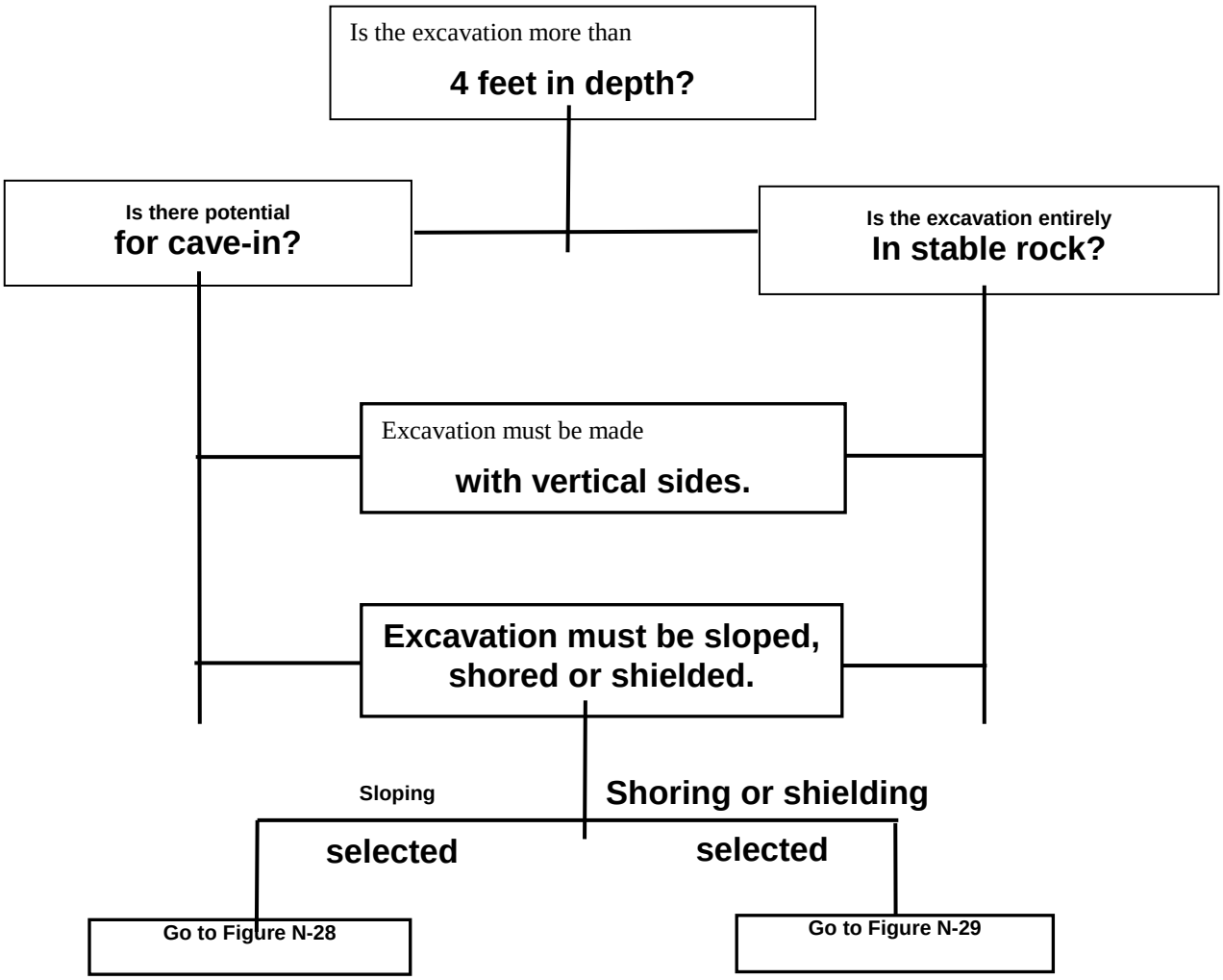


Figure N-27 - PRELIMINARY DECISIONS

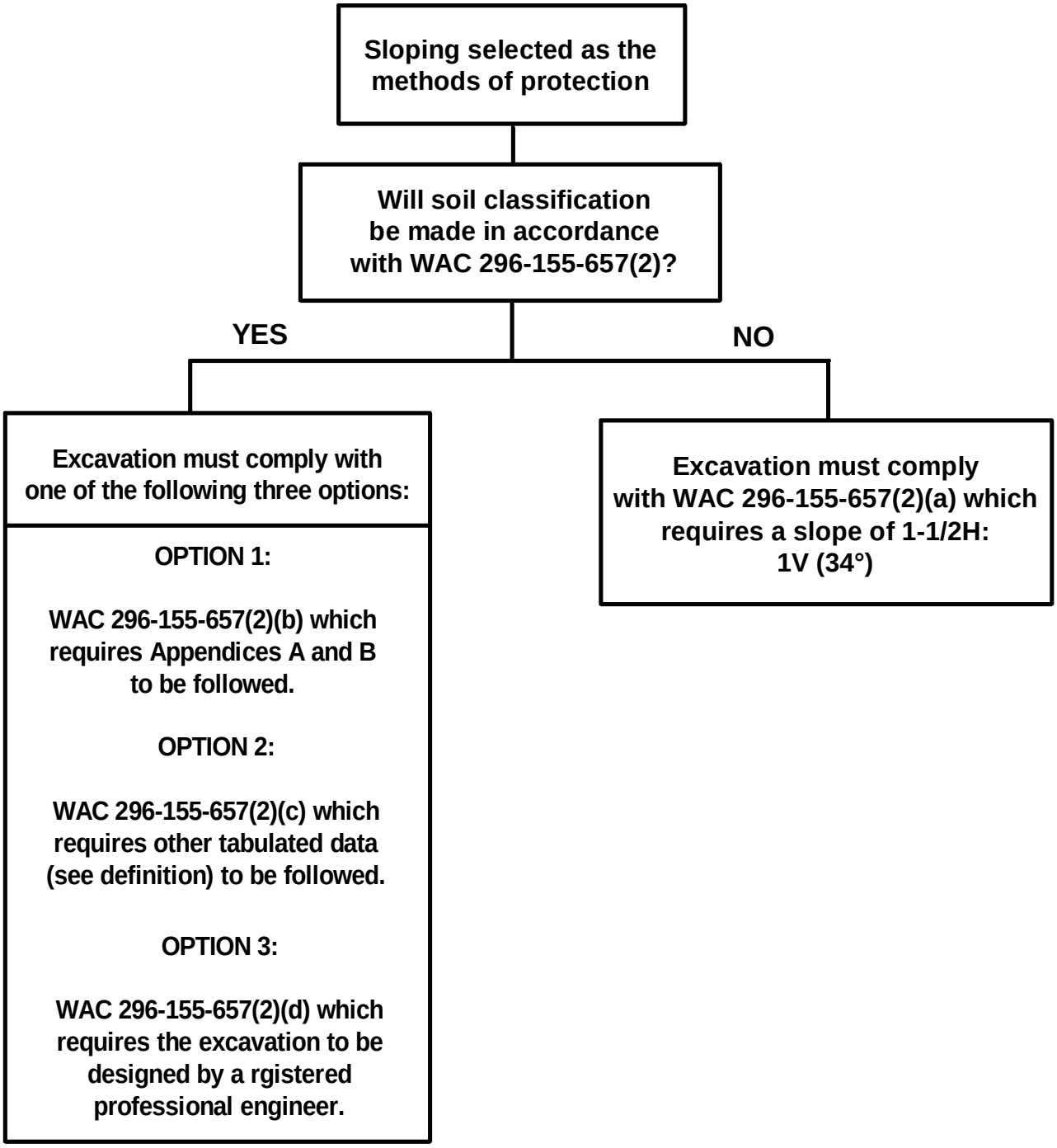


FIGURE N-28 - SLOPING OPTIONS

Shoring or shielding selected as the method of protection.

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

OPTION 1:

WAC 296-155-657(3)(a) which requires Appendices A and C to be followed (e.g., timber shoring)

OPTION 2:

WAC 296-155-657(3)(b) which requires manufacturers data to be followed (e.g., hydraulic shoring, trench jacks, air shores, shields)

OPTION 3:

WAC 296-155-657(3)(c) which requires tabulated data (see definition) to be followed (e.g., any system as per the tabulated data).

OPTION 4:

WAC 296-155-657(3)(d) which requires the excavation to be designed by a registered professional engineer (e.g., any designed system).

FIGURE N-29 - SHORING AND SHIELDING OPTIONS

[Statutory Authority: Chapter 49.17 RCW and RCW 49.17.040, [49.17].050 and [49.17].060. 92-22-067 (Order 92-06), § 296-155-66411, filed 10/30/92, effective 12/8/92.]