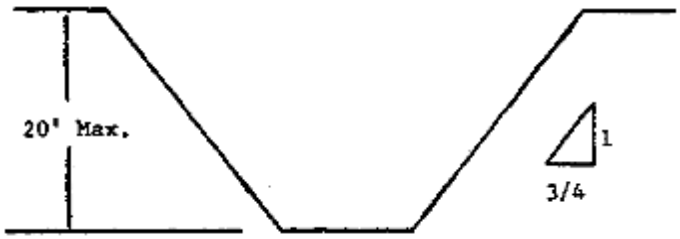
Appendix 18-C
Soil & Slope Tables

TABLE A-1 MAXIMUM ALLOWABLE SLOPES

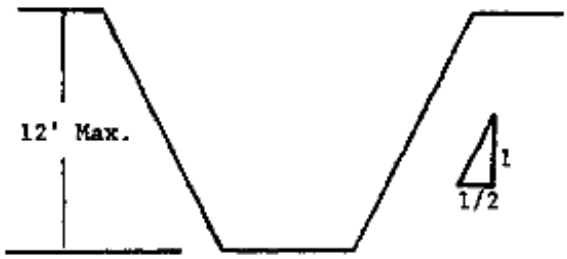
SOIL OR ROCK TYPE	MAXIMUM ALLOWABLE SLOPES FOR EXCAVATIONS LESS THAN 20 FEET DEEP
STABLE ROCK	VERTICAL (90 Degrees from the horizontal)
TYPE A	¾ to 1 (approximately 53 Degrees from the horizontal)
TYPE B	1 to 1 (45 Degrees from the horizontal)
TYPE C	1 ½ to 1 (approximately 34 Degrees from the horizontal)

Simple Slopes Made In Type A Soil:
All simple slope excavation 20 feet or less in depth will have a maximum allowable slope of ¾ to 1.



SIMPLE SLOPE (<24 hours open)

Exception: Simple slope excavations which are open 24 hours or less **(short term)** and which are 12 feet or less in depth will have a maximum allowable slope of ½ to 1.

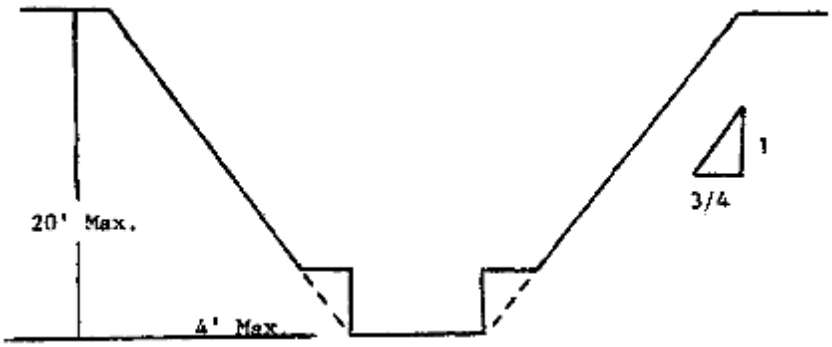


SIMPLE SLOPE - < 24 hours open

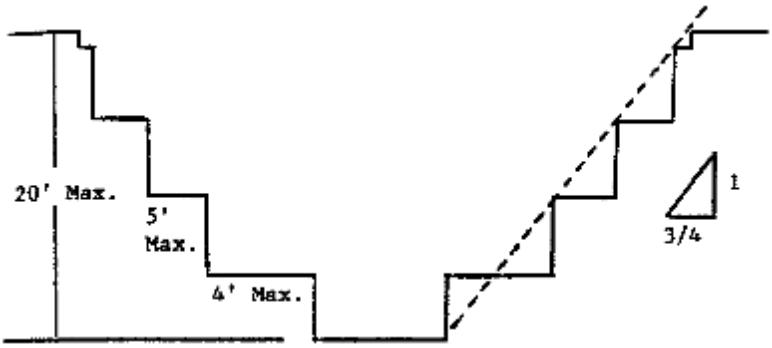
Appendix 18-C
Soil & Slope Tables

Benched Excavations Made In Type A Soil

All benched excavations 20 feet or less in depth will have a maximum allowable slope of ¾ to 1 and maximum bench dimensions as follows:



SIMPLE BENCH

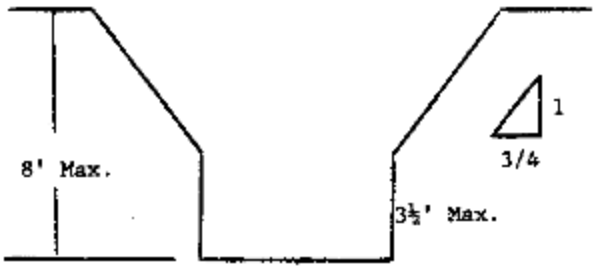


MULTIPLE BENCH

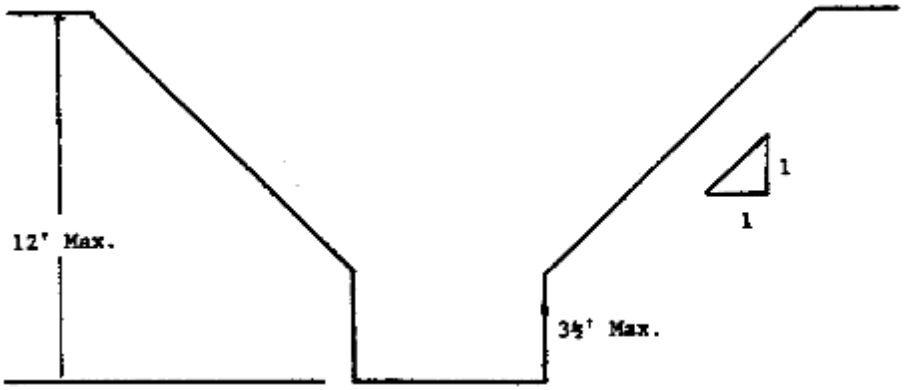
Appendix 18-C
Soil & Slope Tables

Unsupported Vertically Sided Lower Portion Made In Type A Soil

All excavations 8 feet or less in depth which have unsupported vertically sided lower portions will have a maximum vertical side of 3 1/2 feet, with the remaining upper vertical sides sloped at ¾ to 1.



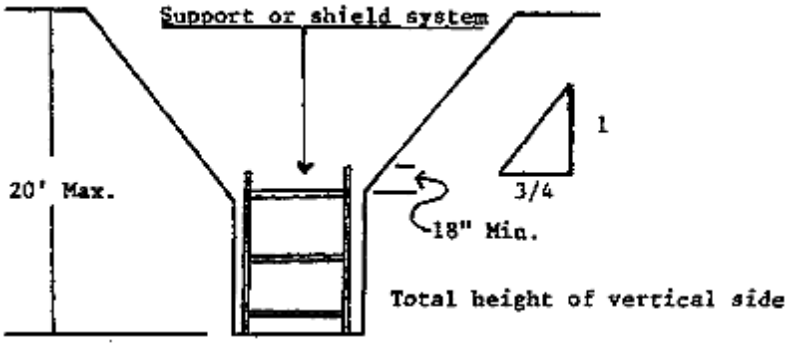
All excavations more than 8 feet but not more than 12 feet in depth with unsupported vertically sided lower portions will have a maximum allowable slope of 1 to 1 and a maximum vertical side of 3 1/2 feet.



Appendix 18-C
Soil & Slope Tables

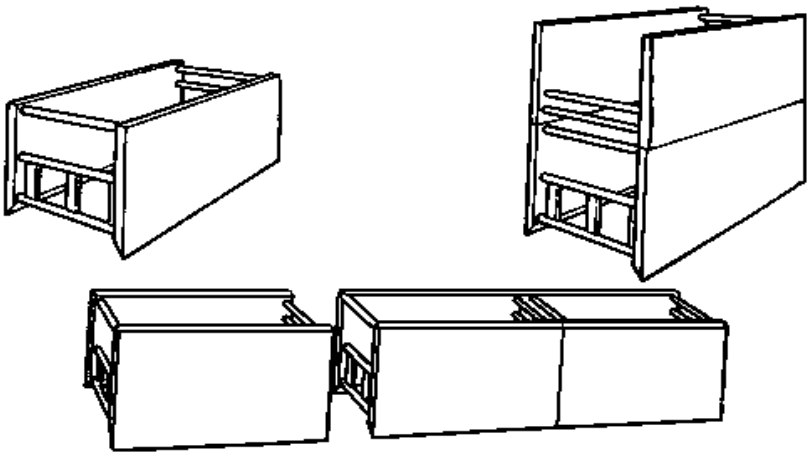
Supported Or Shielded (Vertically Sided Lower Portion) Made In Type A Soil

All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded will have a maximum allowable slope of ¾ to 1. The support or shield system must extend at least 18 inches above the top of the vertical side.



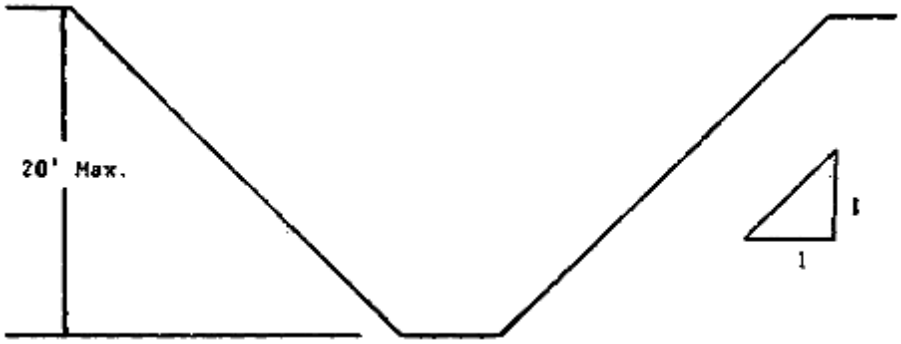
SUPPORTED OR SHIELDED VERTICALLY SIDED LOWER PORTION

Trench Shield (Trench Box) Configurations

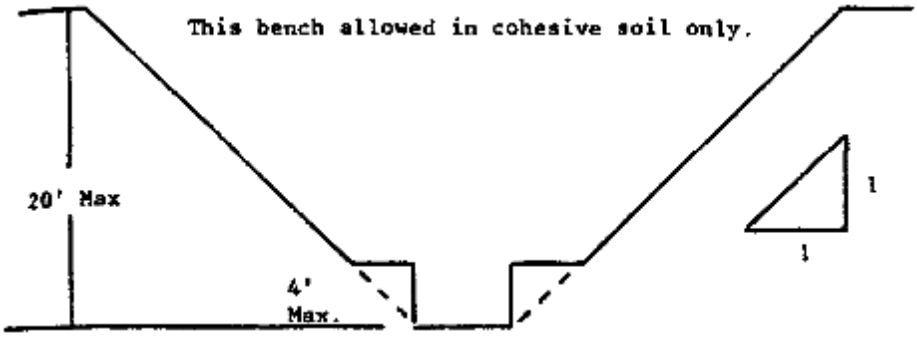


Appendix 18-C
Soil & Slope Tables

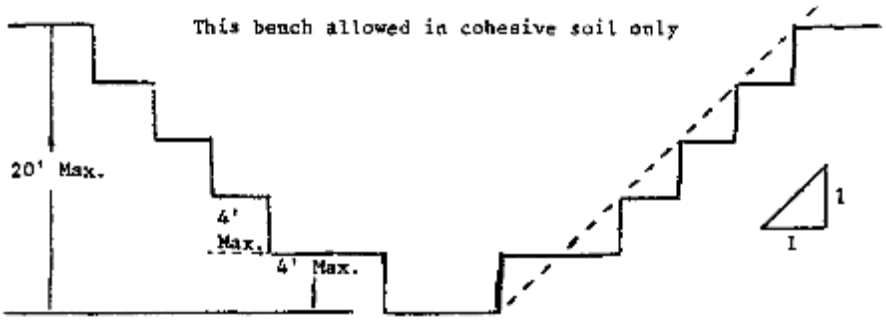
Simple Slopes Made In Type B Soil
All simple slope excavations 20 feet or less in depth will have a maximum allowable slope of 1 to 1.



Benched Excavations Made In Type B Soil
All benched excavations 20 feet or less in depth will have a maximum allowable slope of 1 to 1 and maximum bench dimensions as follows (but only in cohesive soil):



SINGLE BENCH

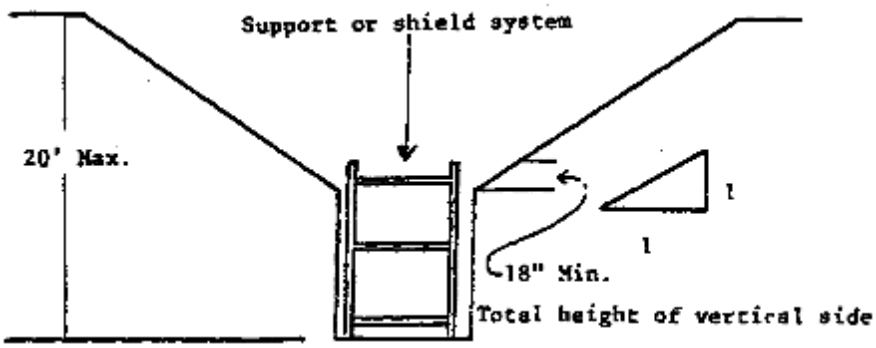


MULTIPLE BENCH

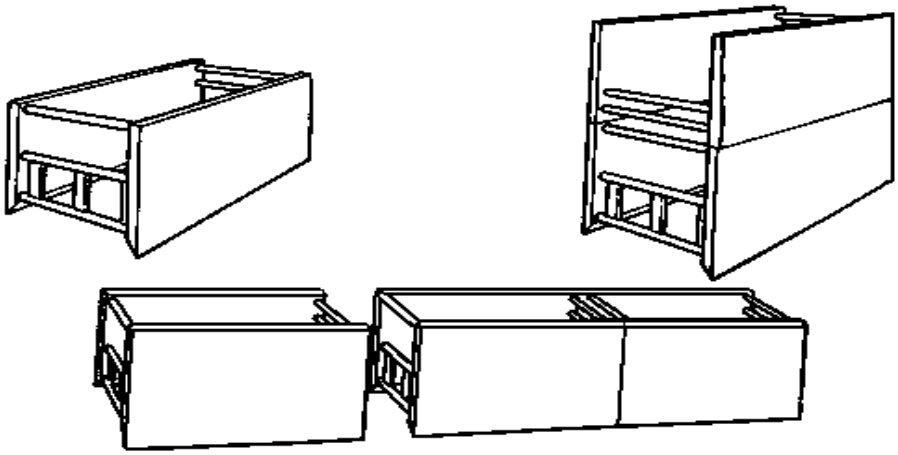
Appendix 18-C
Soil & Slope Tables

Vertically Sided Lower Portion Made In Type B Soil

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



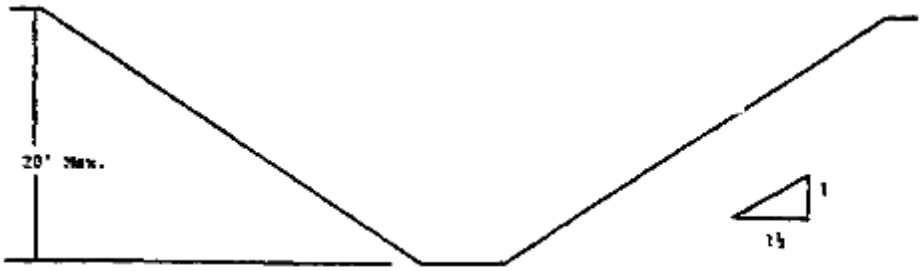
Trench Shield (Trench Box) Configurations



Appendix 18-C
Soil & Slope Tables

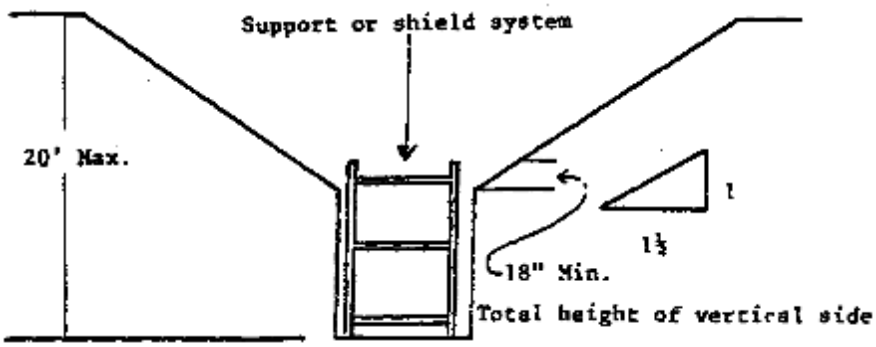
Excavations made in Type C soil.

Simple Slope Made In Type C Soil
All simple slope excavations 20 feet to/including 4 feet in depth will have a maximum allowable slope of 1 ½ to 1.

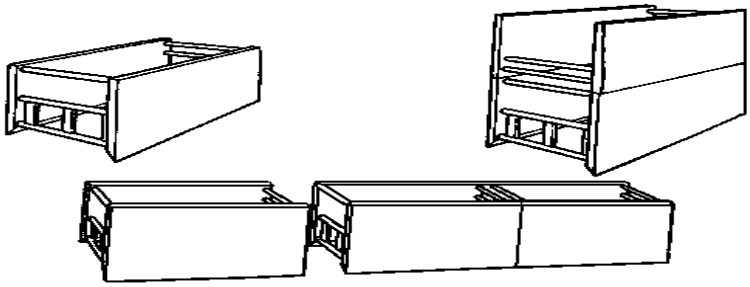


SIMPLE SLOPE

All excavations 20 feet or less in depth which have vertically sided lower portions will be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations will have a maximum allowable slope of 1 ½ to 1.



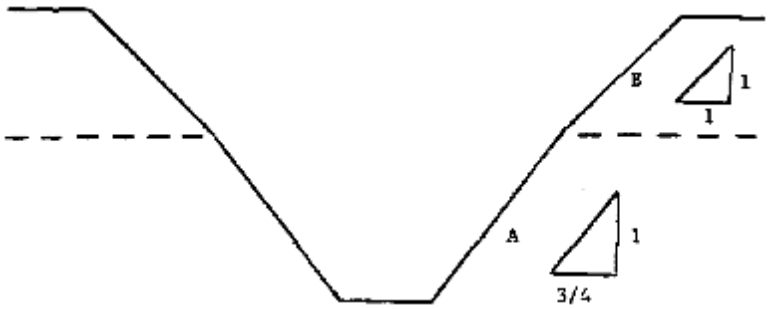
Trench Shield (Trench Box) Configurations



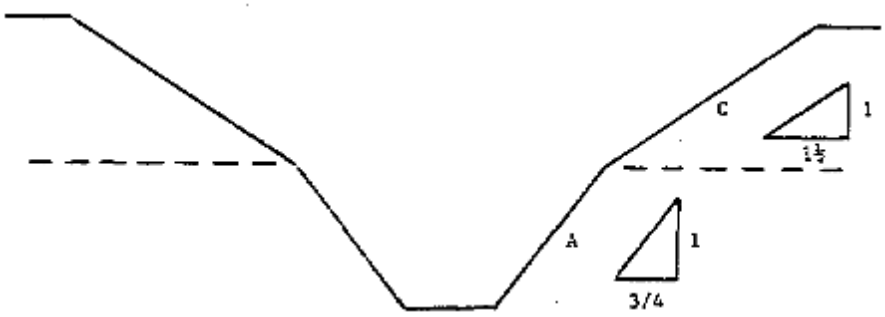
Appendix 18-C
Soil & Slope Tables

Excavations made in Type B layered soils.

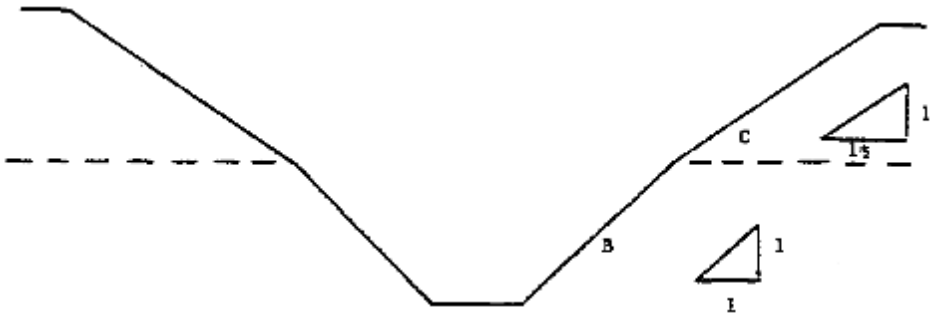
Sloped Excavations Made In Layered Soils.
All excavations 20 feet or less in depth made in layered soils will have a maximum allowable slope for each layer as set forth below.



TYPE B (1 to 1 slope) OVER TYPE A (3/4 to 1 slope)

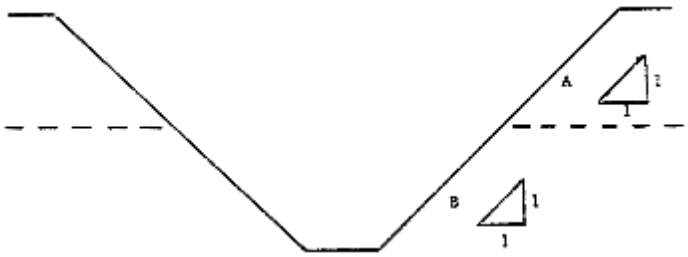


TYPE C (1 ½ to 1 slope) OVER TYPE A (3/4 to 1 slope)

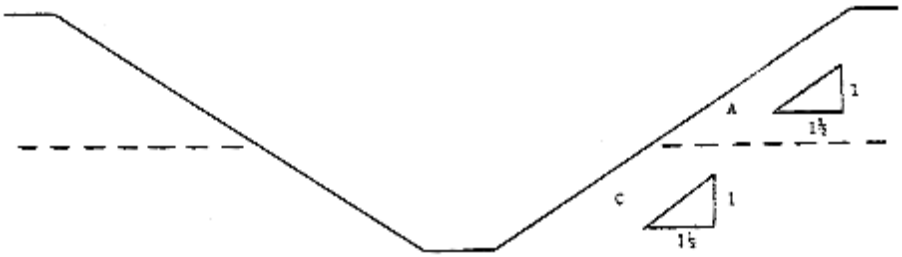


TYPE C (1 ½ to 1 slope) OVER TYPE B (1 to 1 slope)

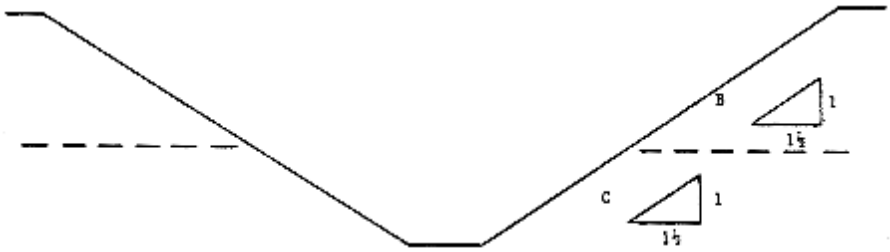
Appendix 18-C
Soil & Slope Tables



TYPE A OVER TYPE B (both 1 to 1 slopes)



TYPE A OVER TYPE C (both 1 ½ to 1 slopes)



TYPE B OVER TYPE C (both 1 ½ to 1 slopes)

Appendix 18-C
Soil & Slope Tables

TABLE B - 1 ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES
FOR SOIL TYPE A

DEPTH OF TRENCH (feet)	HYDRAULIC CYLINDERS				
	MAXIMUM HORIZONTAL SPACING (center to center in feet)	MAXIMUM VERTICAL SPACING (center to center in feet)	WIDTH OF TRENCH (feet)		
			UP TO 8	OVER 8 UP TO 12	OVER 12 UP TO 15
over 5 up to 10	8	4	2 INCH DIAMETER*	2 INCH DIAMETER*	3 INCH DIAMETER*
over 10 up to15	8				
over 15 up to 20	7				
OVER 20	Designed by Registered Professional Engineer				

* Safe working capacity of a 2 inch diameter cylinder must be at least 18,000 pounds; safe working capacity of a 3 inch diameter cylinder must be at least 30,000 pounds; vertical shoring rails will have a minimum section modulus of 0.40 inch; when vertical shores are used, there must be a minimum of three shores spaced equally, horizontally, in a group.

Appendix 18-C
Soil & Slope Tables

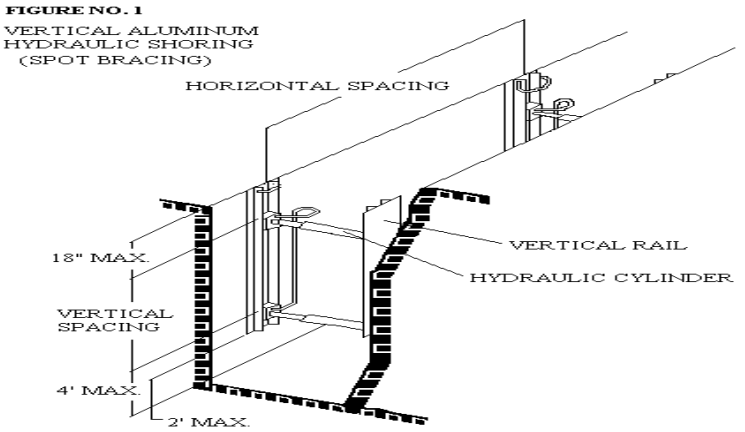
TABLE B - 1 ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES
FOR SOIL TYPE B

DEPTH OF TRENCH (feet)	HYDRAULIC CYLINDERS				
	MAXIMUM HORIZONTAL SPACING (center to center in feet)	MAXIMUM VERTICAL SPACING (center to center in feet)	WIDTH OF TRENCH (feet)		
			UP TO 8	OVER 8 UP TO 12	OVER 12 UP TO 15
over 5 up to10	8	4	2 INCH DIAMETER*	2 INCH DIAMETER*	3 INCH DIAMETER*
over 10 up to 15	6.5				
over 15 up to 20	5.5				
OVER 20	Designed by Registered Professional Engineer				

* Safe working capacity of a 2 inch diameter cylinder must be at least 18,000 pounds; safe working capacity of a 3 inch diameter cylinder must be at least 30,000 pounds; vertical shoring rails will have a minimum section modulus of 0.40 inch; when vertical shores are used, there must be a minimum of three shores spaced equally, horizontally, in a group.

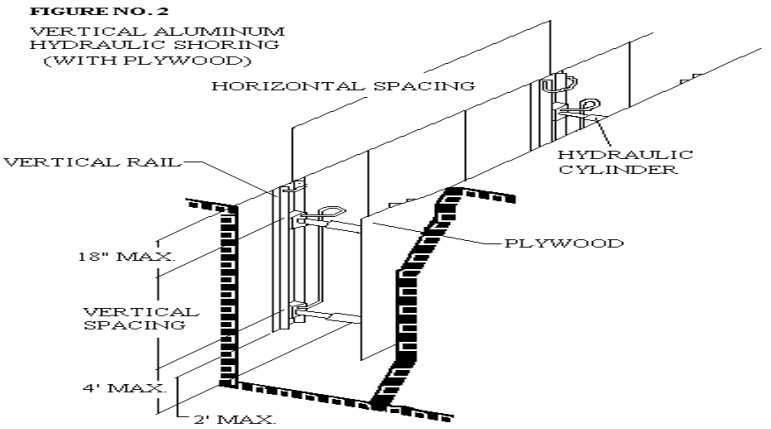
Appendix 18-C
Soil & Slope Tables

Vertical aluminum hydraulic shoring (spot bracing)

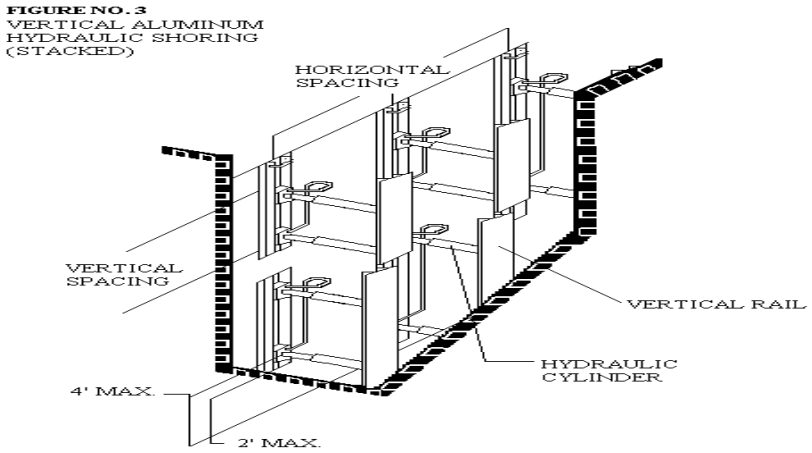


Vertical aluminum hydraulic shoring (with plywood)

Plywood shall be 1.125 inch thick softwood or equivalent.



Vertical aluminum hydraulic shoring (stacked)



Appendix 18-C
Soil & Slope Tables

TABLE B - 1 ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL TYPE B

DEPTH OF TRENCH (feet)	WALES		HYDRAULIC CYLINDERS			
			WIDTH OF TRENCH (feet)			
	VERTICAL SPACING (feet)	SECTION MODULUS (IN (3))	UP TO 8		OVER 8 UP TO 12	
			HORIZ SPACING	CYLINDER DIAMETER	HORIZ SPACING	CYLINDER DIAMETER
over 5 up to 10	4	3.5	88.0	2 IN	8.0	2 IN*
		7.0	9.0	2 IN	9.0	2 IN*
		14.0	12.0	3 IN	12.0	3 IN*
over 10 up to 15	4	3.5	6.0	2 IN	6.0	2 IN*
		7.0	8.0	3 IN	8.0	3 IN*
		14.0	10.0	3 IN	10.0	3 IN*
over 15 up to 20	4	3.5	5.5	2 IN	53.5	2 IN*
		7.0	6.0	3 IN	6.0	3 IN*
		14.0	9.0	3 IN	9.0	3 IN*
OVER 20	Designed by Registered Professional Engineer					

* Safe working capacity of a 2 inch diameter cylinder must be at least 18,000 pounds; safe working capacity of a 3 inch diameter cylinder must be at least 30,000 pounds; when vertical shores are used, there must be a minimum of three shores spaced equally, horizontally, in a group.

Appendix 18-C
Soil & Slope Tables

TABLE B - 1 ALUMINUM HYDRAULIC SHORING

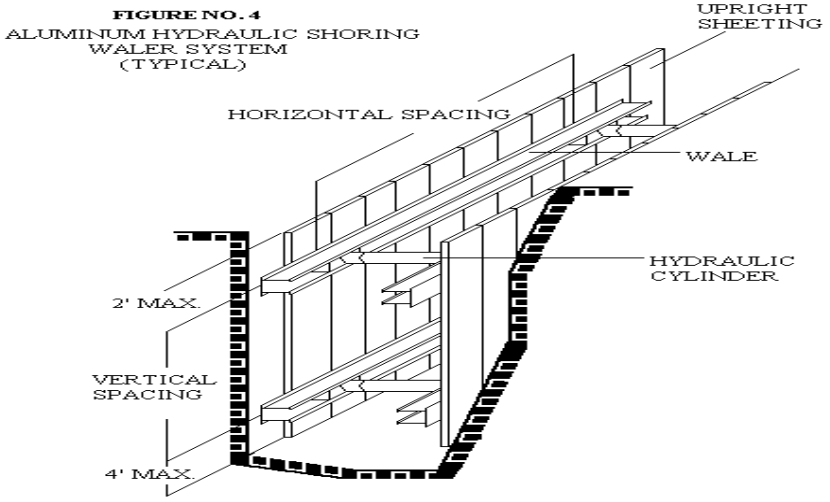
WALER SYSTEMS (using Timber uprights)

FOR SOIL TYPE B

DEPTH OF TRENCH (feet)	WALES		HYDRAULIC CYLINDERS		TIMBER UPRIGHTS		
	VERTICAL SPACING (feet)	SECTION MODULUS (IN (3))	WIDTH OF TRENCH (feet)		MAX. HORIZ SPACING (ON CENTER)		
			OVER 12 UP TO 15		SOLID SHEET	2 FT	3 FT
			HORIZ SPACING	CYLINDER DIAMETER			
over 5 up to 10	4	3.5*	8.0	3 IN*	-----	-----	3X12
		7.0*	9.0	3 IN*			
		14.0*	12.0	3 IN*			
over 10 up to 15	4	3.5*	6.0	3 IN*	-----	3X12	-----
		7.0*	8.0	3 IN*			
		14.0*	10.0	3 IN*			
over 15 up to 20	4	3.5*	5.5	3 IN*	3X12	-----	-----
		7.0*	6.0	3 IN*			
		14.0*	9.0	3 IN*			
OVER 20	Designed by Registered Professional Engineer						

* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales; safe working capacity of a 3 inch diameter cylinder must be at least 30,000 pounds; when vertical shores are used, there must be a minimum of three shores spaced equally, horizontally, in a group.

Aluminum hydraulic shoring - Waler System (using timber uprights)



Appendix 18-C
Soil & Slope Tables

TABLE B - 1 ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL TYPE C

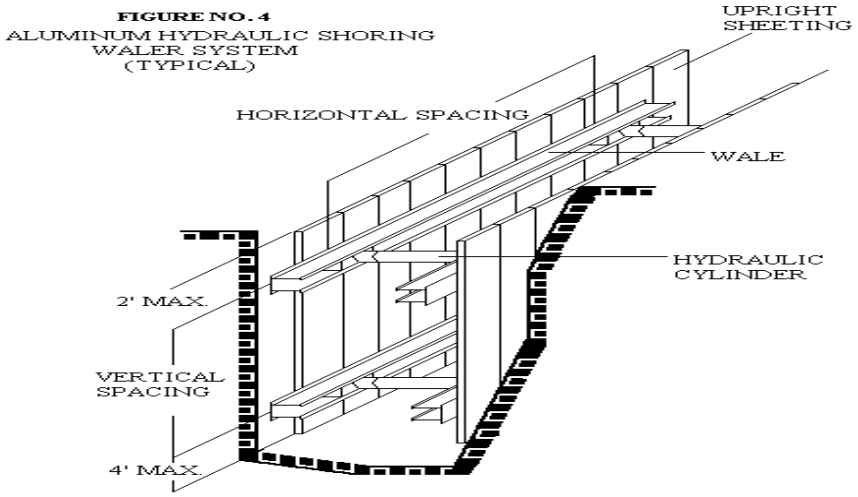
DEPTH OF TRENCH (feet)	WALES		HYDRAULIC CYLINDERS			
			WIDTH OF TRENCH (feet)			
			UP TO 8		OVER 8 UP TO 12	
	VERTICAL SPACING (feet)	SECTION MODULUS (IN (3))	HORIZ SPACING	CYLINDER DIAMETER	HORIZ SPACING	CYLINDER DIAMETER
over 5 up to 10	4	3.5*	6.0	2*	6.0	2 IN*
		7.0*	6.5	2*	6.5	2 IN*
		14.0*	10.0	3*	10.0	3 IN*
over 10 up to 15	4	3.5*	4.0	2*	4.0	2 IN*
		7.0*	5.5	3*	5.5	3 IN*
		14.0*	8.0	3*	8.0	3 IN*
over 15 up to 20	4	3.5*	3.5	2*	3.5	2 IN*
		7.0*	5.0	3*	5.0	3 IN*
		14.0*	6.0	3*	6.0	3 IN*
OVER 20	Designed by Registered Professional Engineer					

* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales; Safe working capacity of a 2 inch diameter cylinder must be at least 18,000 pounds ; safe working capacity of a 3 inch diameter cylinder must be at least 30,000 pounds; when vertical shores are used, there must be a minimum of three shores spaced equally, horizontally, in a group.

Appendix 18-C
Soil & Slope Tables

TABLE B - 1 ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS (using timber uprights)
FOR SOIL TYPE C

DEPTH OF TRENCH (feet)	WALES		HYDRAULIC CYLINDERS		TIMBER UPRIGHTS		
	VERTICAL SPACING (feet)	SECTION MODULUS (IN (3))	WIDTH OF TRENCH (FEET) OVER 12 UP TO 15		MAX. HORIZ SPACING (ON CENTER)		
			HORIZ SPACING	CYLINDER DIAMETER	SOLID SHEET	2 FT	3 FT
OVER 5 UP TO 10	4	3.5*	6.0	3 IN*	3X12	-----	-----
		7.0*	6.5	3 IN*			
		14.0*	10.0	3 IN*			
OVER 10 UP TO 15	4	3.5*	4.0	3 IN*	3X12	-----	-----
		7.0*	5.5	3 IN*			
		14.0*	8.0	3 IN*			
OVER 15 UP TO 20	4	3.5*	3.5	3 IN*	3X12	-----	-----
		7.0*	5.0	3 IN*			
		14.0*	6.0	3 IN*			
OVER 20							

* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales; safe working capacity of a 3 inch diameter cylinder must be at least 30,000 pounds; when vertical shores are used, there must be a minimum of three shores spaced equally, horizontally, in a group.

Aluminum hydraulic shoring - Waler System (using timber uprights)