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Proceedings, Federal Workshop on Excavation Safety, September 19 and 20, 1978

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Center for Building Technology
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December 1979

Prepared for

Occupational Safety and Health Administration
Department of Labor
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U.S. DEPARTMENT OF COMMERCE
Luther H. Hodges, Jr., *Under Secretary*
Jordan J. Baruch, *Assistant Secretary for Science and Technology*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

ABSTRACT

A two-day workshop was held at the Department of Labor in Washington, D.C., on September 19-20, 1978 to obtain opinions from knowledgeable people on tentative conclusions and recommendations of a NBS Study on excavation safety. The workshop agenda included a series of presentations on Tuesday, September 19, 1978 and a series of group discussions on Wednesday, September 20, 1978. The topic areas covered in the group discussions were:

1) Soil Classification

2) Acceptable Measures to Protect Workers Against Death or Injury by Caving of Banks in Trenches and Excavations

3) Role of the Professional Engineer and Engineering Guidelines

This report summarizes and synthesizes opinions expressed in these group discussions and presents comments provided by correspondence after the two-day workshop.

Key Words: Acceptable Work Practices, Excavation, Geotechnical Engineering; Safety; Shoring; Soil Classification; Trench; Workshop.

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SUMMARY OF FINDINGS AND RECOMMENDATIONS DISCUSSED AT THE FEDERAL WORKSHOP ON EXCAVATION SAFETY - SEPTEMBER 19-20, 1978

1.0 INTRODUCTION

A two-day workshop was held at the Department of Labor in Washington, D.C., on September 19-20, 1978, for the purpose of obtaining opinions from knowledgeable people on tentative conclusions and recommendations of a National Bureau of Standards [NBS] study on excavation safety. Sixty-one participants including contractors, labor union representatives, industry representatives, professional engineers, government officials and interested persons from the academic community attended (Appendix A). A preliminary NBS report on excavation safety (Appendix B) was provided to the workshop participants to elicit comments during the workshop.

The NBS study consisted of three parts: A field study of present practice in excavation, trenching, and shoring and of the impact of the Occupational Safety and Health Administration (OSHA) regulations as preceived by contractors, labor unions and State and Federal enforcement agencies; a study to assess the technical provisions in the present OSHA regulations and of available options for improving the soil classification system and the technical provisions for sloping and shoring of trenches; and a study of timber presently used for shoring to reasonably assess the load carrying capacity of timber shoring systems.

The workshop agenda included a series of presentations of the various phases of the NBS study on Tuesday, September 19, 1978, and a series of group discussions on Wednesday, September 20, 1978 (see Agenda, Appendix C). The topic areas covered in the group discussions were:

(1) Soil Classification

(2) Acceptable Measures to Protect Workers Against Death or Injury by Caving of Banks in Trenches and Excavations

(3) Role of the Professional Engineer and Engineering Guidelines

This report summarizes and synthesizes opinions expressed in the group discussions and presents comments provided by correspondence after the two-day workshop (Appendix D).

2.0 SUMMARY OF COMMENTS FROM THE WORKING GROUPS

2.1 <u>GENERAL</u>

On Wednesday, September 20, 1978, the three working groups met to discuss their topic area and the results were presented at a general session meeting.

A summary of the findings and recommendations of each group is presented below. The reader should refer to the preliminary NBS report on excavation safety (Appendix B) for a better understanding of the significance of these comments.

2.2 SOIL CLASSIFICATION GROUP SESSION

Jack Mickle - Chairman
David Hadden - Secretary

The points and recommendations made during this session were (refer to Appendix B):

(1) Shape of Lateral Earth Pressure Diagram. (Page B-17) The rectangular shape is satisfactory. However, the effect of mobile surcharges on the shape of this diagram should be looked into.

(2) Slopes and Adjustments (Figures 1 and 2). (Pages B-16 and B-17) The compound shape for Case III in Figure 1 of the preliminary NBS report was dropped from further consideration.

A maximum of three foot unshored subditch in a compound trench was recommended.

Shored compound trenches should have the shoring extending sufficiently above the straight sides to prevent roll in of objects or spoil.

(3) Concepts of Equivalent Weights. (Pages B-9 and B-10) The concept of equivalent weights (20, 40, 60, and 80 pcf) was accepted.

(4) Alternate Soil Classification Systems. (Pages B-24 to B-26) The matrix system of soil classification was recommended. However, footnotes or other methods should be used to draw attention to factors that may affect the soil category.

(5) Field Identification Tests. (Pages B-21 to B-24) The field identification tests (visual examination, pocket penetrometer and drying test) referred to in the preliminary NBS report were accepted as the best available methods.

2.3 ACCEPTABLE MEASURES GROUP SESSION

George Bradberry - Chairman
Roy Gurnham - Secretary

The following points and recommendations were discussed in the order listed:

1. The report and any proposed regulation should be divided into two distinct subsections, one for trenching and one for excavations.

2. The terms "trench" and "excavation" must be clearly defined.

(a) The proposed trench definition says in part that a trench is an excavation which is longer than it is wide (Page B-44 in Appendix B). The following problems arise with this definition:

1. Road cuts and building excavations would be included in the scope.
2. Trench areas widened to accomodate manholes - these should not be considered excavations.
3. This definition implies that only square excavations are not trenches.

(b) Trenching is normally a fast-moving progressive operation, and usually employed to install utility lines. Excavation is stationary construction.

(c) Do the proposed "long-term" and "short-term" definitions adequately define the problem area? Time must be considered in the regulations because long-term stresses in a cut are different from short-term stresses.

(d) The trench definition should be such that empirical data may be used when shoring is designed. Criteria should be drafted to determine when shoring is required for a range of anticipated soil conditions.

(e) The definition of a trench should not limit its depth to 20 feet.

(f) Trenches must be covered at night - this could help distinguish them from excavations.

3. The concern is employee safety. If no one will ever go into a trench then no shoring is required. OSHA'S responsibility is to protect the construction worker, not buildings nor the general public, from harm.

4. Manufactured shoring devices should be required to have a load capacity information plate. Load capacity of trench boxes should be expressed in terms of lateral pressure resistance.

5. Load capacities of timber members need to be specified.

6. The regulations should not concentrate on timber shoring. All types of shoring should be addressed. The best approach may be by specifying performance requirements of any shoring system. For those systems not specifically addressed in the code, an allowance for laboratory testing and certification should be made. An equitable certification program is needed.

7. Do not allow sloped trenches in clay. Require shoring at all times.

8. Do not use the 5' maximum depth on compound slopes. Use 36" or 42" (Page B-16 in Appendix B).

9. In the draft report, Section 1, Table 1 (Minimum Timber Shoring Requirements), change the numbers 4' and 5' in footnote 1(d) to 36" or 42" (Page B-12 in Appendix B).

10. Allow bottom 5 feet of shoring to be removed to permit compaction of lower levels of backfill.

2.4 ROLE OF THE PROFESSIONAL ENGINEER GROUP SESSION

Louis J. Thompson - Chairman
Brenda McCall - Secretary

The following points and recommendations were made during this session:

1) Engineers do not want the responsibility as "engineer of record" without using a factor of safety of 3 to 4.

2) Presently, most engineers do not take OSHA into consideration in their plans.

3) In California, engineers will be called in only for an area "out-of-norm."

4) In New Mexico, most design engineers refuse to design trench shoring because they do not want the responsibility. The contractors stated that they could not comply with OSHA and stay in buisness. (However, professionals in the utility business take all the precautions necessary.)

5) Most fatalities occur between 8 - 10 foot depths, not depths greater than 20 feet.

6) The role of the engineer should be according to "standards of practice" in an area. The designer (engineer) of the shoring or sheeting system should not be considered the "engineer of record." The contractor should have the responsibility because the contractor can require or request changes. In addition, the system may not be put in or maintained properly.

7) One engineer discussed the METRO system which has proven to be successful. The engineer explained that in this system they did the investigation, they showed criteria on the plans that the contractors had to use in the design of the shoring and they required the contractor to hire a geotechnical engineer.

8) A definition for "engineer of record" is needed. Some of the engineers stated that the engineer should not be held liable for anything above the state-of-the-art and that his whole effort is designing rather than construction. Engineers when taken to court cannot be held liable unless their designs are proven to be inadequate. There was a plea for cooperation between engineers and contractors.

9) The word "certify" raises the question of whether, for instance, a certified trench box will work under all conditions. It can be certified that it meets all legal requirements of design, but not as to how it is actually used.

10) It is traditional that the contractor bears all responsibility. This started back in the 1700's when the master builder was his own designer, engineer, builder, etc.

11) It was felt that the major issues were whether or not to require an "engineer of record" for trenches:

- (a) over 12 feet deep in soft clay
- (b) over 20 feet deep in any other material
- (c) over 5 feet deep for a long-term (over 48 hours) period.

12) It was felt that the main problems were as follows:

- (a) there are many different types of excavations and conditions
- (b) differentiating between an excavation and a trench.

13) Regarding the use of engineers for designing shoring or sheeting systems, it was felt that the rule should be: if the contractor is not in compliance with OSHA standards (or special conditions exist), an engineer must be required for cuts over 12 feet in clay or 20 feet in any other material. The contractor should be given the option to follow OSHA standards or use an engineer. NBS explained that their report was drawn up only for shallow depths - not greater than 20 feet.

2.5 ADDITIONAL COMMENTS

Following the workshop on September 19, and 20, 1978, additional comments on the preliminary NBS report were received. The additional comments were provided by:

(1) James H. Kleinfelder, ASFE, OSHA Committee.
(2) Leonard Freed, Ohio Contractors Associations.
(3) Thomas D. Searles, American Lumber Standards Committee.
(4) William L. Galligan, U.S. Dept. of Agriculture, Forest Service.
(5) Robert O. Middleton, Speed Shore Corporation.
(6) Robert G. Griffith, National Utility Contractors Association
(7) James E. Hollis, Associated Contractors of New Mexico.
(8) W. M. "Red" Cass, Big Red Safety & Production, Inc.
(9) John P. Gnaedinger, Soil Testing Services, Inc.

These correspondence are provided in Appendix D.

Appendix A

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NOTE: List of Participants was provided by OSHA in the order that the attendees registered.

Appendix B

Preliminary NBS Report on
Excavation Safety

NOTE: THE MATERIAL CONTAINED IN APPENDIX B WAS CIRCULATED TO WORKSHOP PARTICIPANTS FOR DISCUSSION PURPOSES. IT WAS NOT INTENDED FOR SUBSEQUENT USE FOLLOWING THE WORKSHOP.

SUMMARY OF FINDINGS AND RECOMMENDATIONS TO BE DISCUSSED AT THE FEDERAL WORKSHOP ON EXCAVATION SAFETY

1. Introduction

The OSHA Regulations for Excavation, Trenching and Shoring were promulgated in April 1971. In June 1976 OSHA engaged the National Bureau of Standards to study the compatibility of the technical provisions in these regulations with actual construction practice and with the state of knowledge in geotechnical and structural engineering, to review the experience accumulated since their promulgation, and recommend potential modifications that could improve their effectiveness.

The NBS study consisted of three parts: A field study of present practice in excavation, trenching and shoring and of the impact of the OSHA regulations as perceived by contractors, labor unions and State and Federal enforcement agencies; a technical study consisting of the assessment of the technical provisions in the present regulations and of available options for improving the soil classification method and the technical provisions for sloping and shoring; and a study of timber presently used for shoring in order to reasonably assess the load carrying capacity of timber shoring systems.

Findings and preliminary recommendations of the NBS study are briefly summarized herein.

2. Scope

The material in this summary is presented in four sections: Section 1 contains recommended options for improving the technical provisions. It contains a summary of recommended acceptable practice. Guidelines for the determination of compliance with acceptable practice by licensed engineers are given in the Appendix.

Section 2 contains recommended options for a soil classification system.

Section 3 contains recommended allowable stresses and specifications for timber.

Section 4 contains a summary of the field survey.

The material is presented to elicit critical comments which can be discussed in detail in the workshop.

SECTION 1. Options for Improving the Technical Provisions in the Regulations for Trenching and Shoring. (Summary of recommended acceptable practice)

1. <u>General Definition</u>:

Protective measures are deemed acceptable if they meet the minimum requirements stipulated by OSHA. Acceptability does not necessarily insure that the measures are adequate under all circumstances.

2. <u>Sloped Excavations</u>:

Sloped short-term excavations are acceptable if they comply <u>either</u> with Condition 1 <u>or</u> with Condition 2.

Condition 1: The excavation is designed by a licensed engineer in accordance with proposed guidelines (see Appendix).

Condition 2: The slopes are no steeper than the stable slope under the prevailing condition[1/] and do not exceed the following allowable maximum slopes:

Option 1:[2/] 3/4 horizontal in 1 vertical (intact rock is exempt from any maximum sloping provision).

1/ If there is any indication of general or local instability slopes shall be cut back by at least 1/4 hor: 1 vert.

2/ Option 1 is predicated on a simple soil classification scheme and on the premise that maximum <u>allowable</u> slopes, like maximum speed limits, are not necessarily safe in all conditions.

Option 2.

Soil Category[3/]	Max. Slope, hor:vert.*
I	1/2:1
II	3/4:1
III	1:1
IV	2:1

* If significant vibration is present and/or trench is to be left open for more than 4 hours add 1/4 to horizontal portion of I and II and 1/2 to horizontal portion of III and IV.

Compound slopes shall comply with Fig. 1.

3. Shored Excavations

The following excavations shall be shored: All excavations deeper than 5 ft which do not comply with the provisions for sloped excavations except that unshored excavations deeper than 5 ft are acceptable in sound unfractured bedrock.

The following shoring systems are acceptable:

1. Shoring systems designed by a licensed engineer in accordance with proposed guidelines (see Appendix).

2. Timber shoring complying with Tables 1 and 2 and with the specifications for trenching timber (see Section 3).

3. Shoring systems "designed to resist" the working loads specified under the simplified procedure in 3(b).

3/ See Section 2 for Soil Classification.

The term "designed to resist" shall be interpreted as follows:

(1) All structural members are designed by a licensed engineer to resist the stipulated working load in accordance with proposed Guidelines (See Appendix).

or (2) Structural members are rated to resist allowable working loads equal to or greater than those caused by the vertical and lateral loads stipulated in 3(b).

or (3) Shoring systems or protective devices are rated for use under pre-defined conditions.

3(a) Rating

Rating of Structural Components or Assemblies which are Part of the Shoring System.

Pre-fabricated components or sub-assemblies forming part of the shoring system may be rated by a licensed engineer and subsequently used to resist working loads equal to or smaller than those for which they are rated.

Rating shall be as follows: Struts shall be rated for their allowable compressive load. If struts are extendable, the rating shall reflect the effect of length on load capacity. Wales supported at given length intervals shall be rated for allowable lateral load per linear length of wale. For strut-wale assemblies, the wale shall be designed to resist moments and shears not less than 80 percent of those resulting from a load per linear foot equal to the sum of the tributary allowable strut loads divided by the length of the wale.

Rating may be accomplished by engineering analysis or testing in accordance with the Engineering Guidelines (See Appendix). Rating of struts shall include consideration of the 240 lb vertical downward load (See 3(b)). Rating shall be valid for the period of time stipulated by the licensed engineer or for one year, whichever is less, and shall be renewed after inspection and, where necessary, re-testing. The rating and its effective date shall be permanently marked on the member or assembly.

Hydraulic shores shall be tested at least once a year to 1.25 times their allowable working load, and the load shall be maintained for 5 minutes without any pressure drop.

Rating of Shoring Systems and Protective Devices

Repetitively-used shoring systems or protective devices such as trench boxes shall be rated by a licensed engineer for allowable working loads or for predetermined conditions of use.

Rating for conditions of use shall include designation of maximum allowable depth and maximum w_e value (See 3(b)). Rating for allowable working load shall include the designation of the allowable horizontal load per unit area. Thus a trench box that can be used in a 10 ft deep trench in soft clay may be rated as follows:

H_e = 10 ft (see 3(b) for symbols)
w_e = 80 lb/ft^3

Alternatively this trench box could be rated for an allowable lateral pressure of 960 lb/ft^2.

Rating of trench boxes and other protective devices shall also consider loads other than lateral loads attributable to construction and installation methods.

Trench boxes used at the bottom of sloped excavations shall be rated for the full equivalent height or the depth from the bottom of the excavations to level ground whichever is less, and shall protrude not less than 1 ft above the sideslope of the excavation.

Rating shall be certified by a licensed engineer in accordance with proposed Guidelines (see Appendix) and shall be valid for a period not to exceed 1 year. The rating and its effective date shall be permanently marked on the protective device.

3(b) Working loads to be used in the simplified design procedure.

The following loads shall be resisted simultaneously:

(1) a gravity load of 240 lb distributed over any 1 ft length of any crossbrace.

(2) the lateral pressure p_e, distributed uniformly over the entire surface area of the supported bank from the bottom of the excavation to the top of the supported portion of the bank (see Fig. 2).

<u>Calculation of p_e</u> (see also Figs. 2-4).

$p_e = w_e (H_e + 2)$ or $w_e (H_e + H_q + H_w)$ whichever is <u>greater</u> (eq. 1)

(the second equation will only govern if very heavy equipment is used) (see Fig. 3)

$H_e = H (1 + 0.04 \beta)$ where β = angle of slope with horizontal in degrees (eq. 2)

or $H_e = H [1 + 2:(h/v)]$ (See Fig. 2) (eq. 3)

$H_e = H$ when level ground is retained by shoring

H_e need not exceed height from bottom of trench to level ground surface.

w_e is determined as follows:

Option 1.

Under the water table or in soft clay: use $w_e = 80\ lb/ft^3$

Special condition for soft clay: All short term excavations deeper than 12 ft and all long term excavations deeper than 5 ft shall be designed by a licensed engineer.

For short term excavations in hard intact (unfissured) cohesive soils: use $w_e = 20\ lb/ft^3$.

in all other soils use $w_e = 40\ lb/ft^3$

Option 2:

Soil Category	w_e*
I	20
II	40
III	60
IV	80

*If significant vibration is present and/or trench left open more than 4 hours increase w_e by 25%.

Loads tributary to members of the shoring system.

The following portion of the lateral loads caused by p_e shall be assumed to act on members of the shoring system: 100 percent of the tributary load shall be assumed to act on all struts, 80 percent of the tributary load shall be assumed to act on wales (vertical members directly supported by struts shall be designed as wales), 67 percent of the tributary load shall be assumed to act on sheeting. Tributary loads shall be calculated in accordance with Figure 4.

TABLE 1

MINIMUM REQUIREMENTS FOR TIMBER SHORING OF TRENCHES [1/]

Trench Depth (ft)	Soil Type [2/]	Minimum Strut and Wale Size: Horizontal Center-to-Center Strut Spacing (ft) 6	8	10	12	14	16	20	Maximum Center-to-Center Vertical Wale Spacing (ft)	Minimum Sheeting Thickness (in)
5–10	Type I	4 x 6	6 x 6	6 x 6	8 x 8	8 x 8	10 x 10	10 x 10	5	2
5–10	Type II	6 x 6	6 x 8	8 x 8	8 x 10	10 x 10	10 x 12	12 x 12	5	3
10–15	Type I	6 x 6	6 x 8	8 x 8	8 x 10	10 x 10	10 x 12	—	5	2
10–15	Type II	6 x 8	8 x 8	8 x 10	10 x 10	10 x 12	12 x 12	—	5	3
15–20	Type I	6 x 8	8 x 8	8 x 10	10 x 10	10 x 12	12 x 12	—	5	3
15–20	Type II	8 x 8	8 x 10	10 x 10	10 x 12	12 x 12	—	—	5	3

1/ (a) All lumber dimensions are actual.

(b) Strut sizes are for 4 ft trench width. For wider trenches, use Table 1-A.

(c) For spacing greater than 10 ft, insert intermediate struts before workers enter trench.

(d) If vertical distance from the center of the lowest strut to the bottom of the trench exceeds 2 1/2 ft, sheeting shall be firmly embedded or mudsill shall be used. The vertical distance from the center of the lowest strut to the bottom of the trench shall not exceed 4 ft, or 5 ft if mudsill is used.

(e) For skip bracing or clearance between sheeting in excess of 2 ft, see Table 2.

2/ Type I Soil Conditions: Bottom of excavation above the groundwater table. Soft clays are under Type II conditions.

Type II Conditions: Bottom of excavation below the groundwater table or excavations in soft clay.

Special Condition for Soft Clay: All trenches deeper than 12 ft shall be designed by a licensed professional engineer with geotechnical expertise.

TABLE 1-A

ADJUSTMENT OF STRUT SIZE FOR TRENCH WIDTH

Trench Width (ft)	Strut Sizes (Read Down for Equivalent Size)								
4	4 x 4	4 x 6	6 x 6	6 x 8	8 x 8	8 x 10	10 x 10	10 x 12	12 x 12
6	4 x 6	6 x 6	6 x 8	6 x 8	8 x 8	8 x 10	10 x 10	10 x 12	12 x 12
9	6 x 6	6 x 6	6 x 8	8 x 8	8 x 8	8 x 10	10 x 10	10 x 12	12 x 12
12	6 x 6	6 x 8	8 x 8	8 x 8	8 x 10	10 x 10	10 x 12	12 x 12	12 x 12
15	6 x 8	8 x 8	8 x 8	8 x 10	10 x 10	10 x 10	10 x 12	12 x 12	—

TABLE 2

MINIMUM REQUIREMENTS FOR TIMBER SKIP BRACING 1/

Trench Depth (ft)	Soil Type	Minimum Strut Size — Horizontal Center-to-Center Strut Spacing: 4 ft	6 ft	8 ft	Minimum Size of Upright — Horizontal Center-to-Center Spacing of Uprights: 2 ft	3 ft	4 ft	6 ft	8 ft	Minimum Wale Size
5-10	Hard, Compact		4 x 4					2 x 6		None Required
5-10	Hard, Compact			4 x 4					2 x 8	None Required
10-15	Hard, Compact	4 x 4					2 x 6			None Required
10-15	Hard, Compact		4 x 4					3 x 8		None Required
5-10	Likely to Crack		4 x 4			2 x 6				4 x 4
10-15	Likely to Crack	4 x 4	4 x 6		2 x 6					4 x 6

1/ (a) All lumber dimensions are actual.

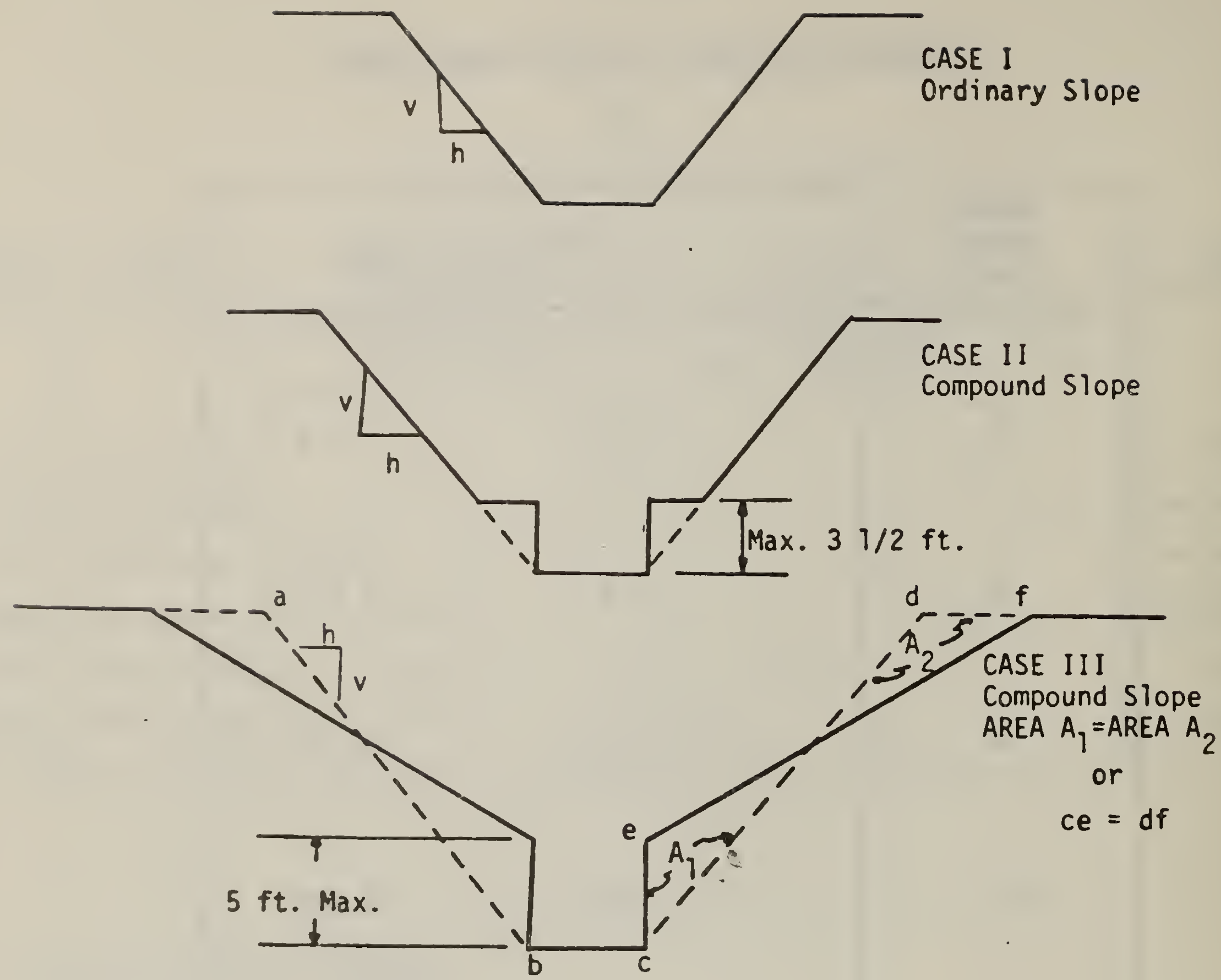
(b) Strut sizes are for 4 ft trench width. For wider trenches, see Table 2-A.

(c) Vertical center-to-center spacing of struts and wales shall not exceed 4 ft.

TABLE 2-A

ADJUSTMENT OF STRUT SIZE FOR TRENCH WIDTH

Trench Width (ft)	Minimum Strut Size	
4	4 x 4	4 x 6
6	4 x 6	6 x 6
9	6 x 6	6 x 6
12	6 x 6	6 x 8
15	6 x 8	8 x 8



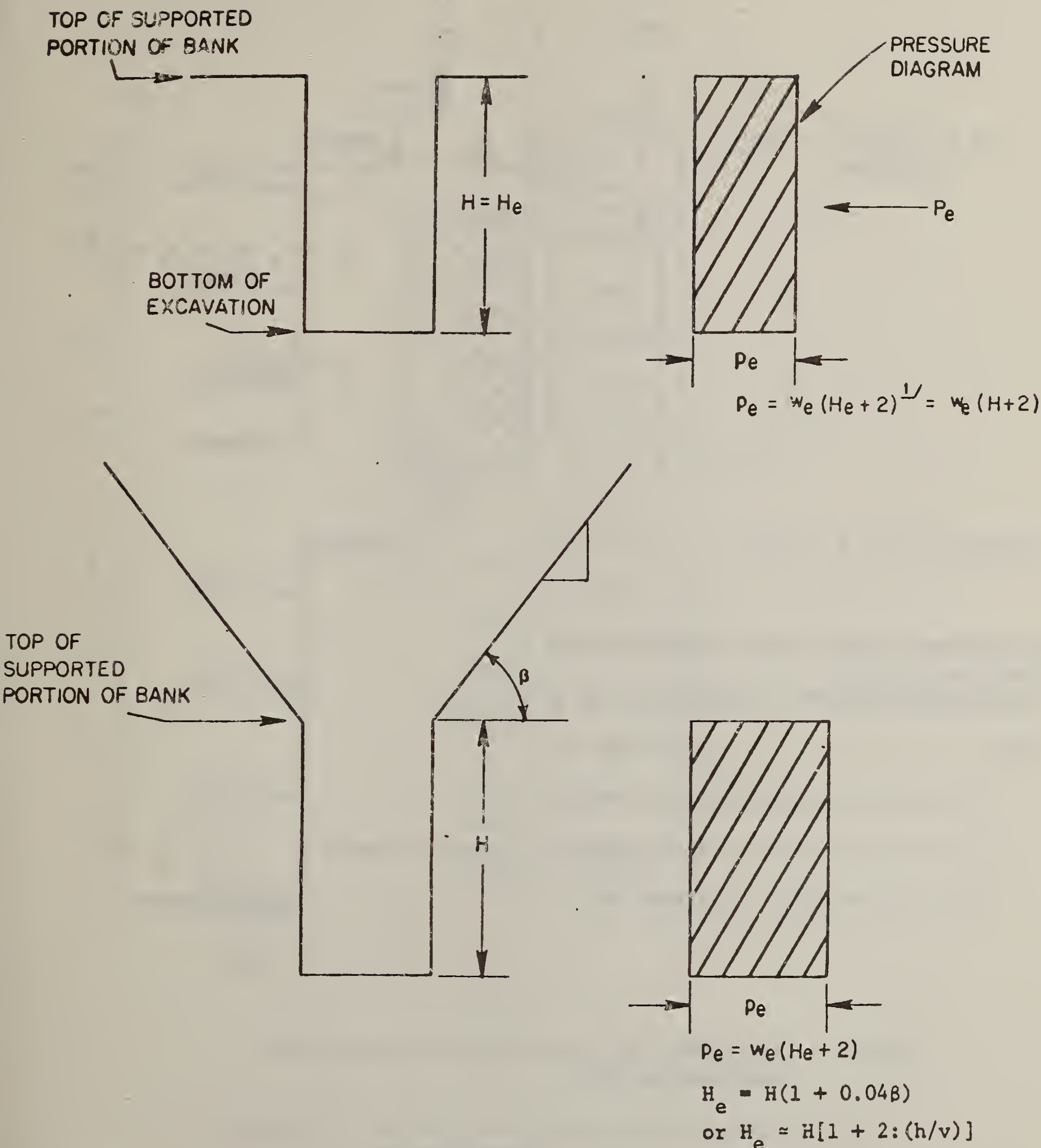
Ratio h/v to be greater than the minimum allowable

CASE I - Ordinary slope

CASE II - Compound slope. Only the configuration shown is acceptable.

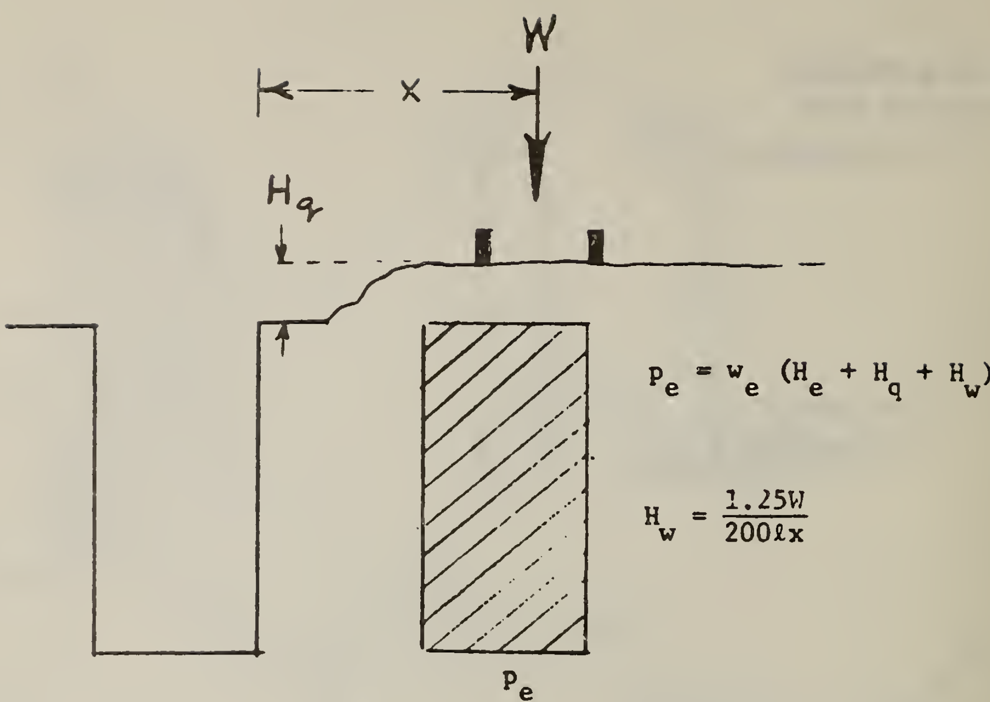
CASE III - Compound slope. Any configuration is acceptable provided that:
(1) No vertical bank exceeds 5 feet.
(2) The vertical distance must be compensated by an equivalent area of excavated material.
(3) The cross sectional area of the excavation must at least equal area abcd.

Figure 1. Minimum Recommended Provisions for Sloped Excavations.



1/ W_e = Equivalent lateral pressure coefficient (lb/ft^3) depending on soil conditions.

Figure 2. Acceptable lateral working loads



H = actual height of surcharge (if any)

H_w = height increase allowance for heavy equipment

where

ℓ = length of wheelbase, of vehicle

x = distance from center of vehicle to side of trench

W = gross weight of vehicle, lb

Figure 3. Acceptable Lateral Working Loads When Heavy Equipment is Used.

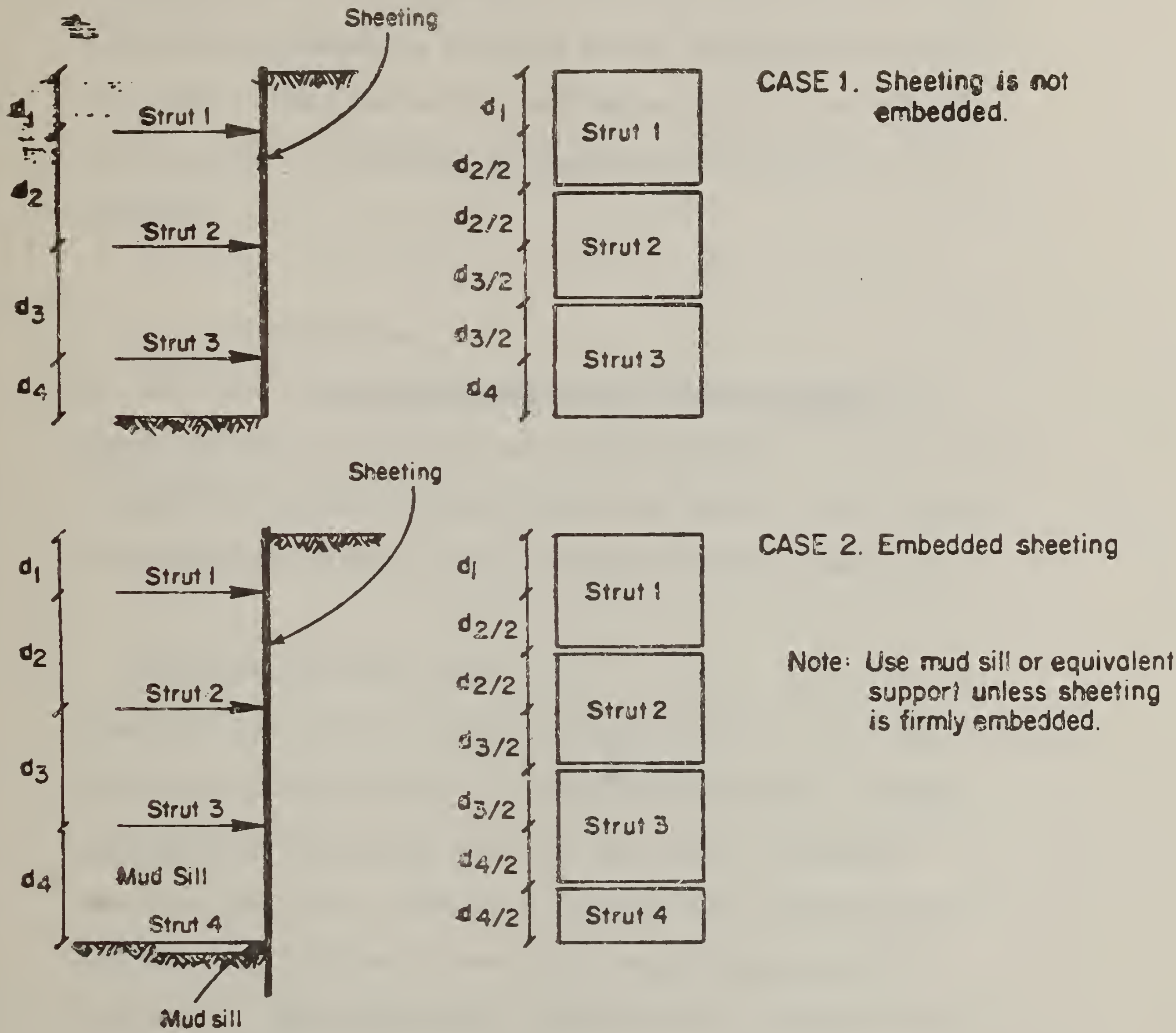


Figure 4 - Lateral Loads Tributary to Members of the Shoring System.

SECTION 2. Soil Classification System

1. Introduction

For brevity, most of the detail is omitted in this synopsis. The following information is presented mostly in the form of charts and tables. These are mostly self-explanatory, but may require interpretation. Additional information will be given at the Workshop.

2. Soil Classifications

Two alternate classification systems are proposed. The first, termed the Matrix Classification System is shown in Tables 1 and 2. A simplified alternate system is given in Table 3. Both systems are based upon the field identification tests discussed in 3.

3. Field Identification Tests

Three primary tests are considered necessary for routine identification and classification of soils as trench work progresses. Visual examination can determine extensive qualitative information regarding soil type, presence of fractures and discontinuities, influence and location of water, and surrounding geographical influences. Penetration tests, even crude ones, provide quantitative estimates of soil strengths, Drying tests are necessary to differentiate between granular (non-cohesive) and cohesive materials and to identify fissured materials.

3.1 Visual Examination

A visual examination should be continuously conducted as trenching progresses. The visual examination will identify changes in soil through color variations, moisture variations, bedding planes, fractures or joints, apparent texture and approximate strength information. The presence of water in the trench is quite important. In particular, sections of open trench should be studied to observe surface cracking or revelling, which will indicate fractures and fissures in cohesive materials. Samples of an apparently cohesive soil in a relatively dry state will likely break along fissures or fracture lines into clumps.

3.2 Pocket Penetrometer Test

A crude approximation of the unconfined compression strength of a soil can be obtained by use of a pocket penetrometer. The pocket penetrometer should be utilized in place, preferably in the sides of a freshly opened trench. Tests should be made at locations no further apart than 10 feet horizontally along the trench. At each location, at least 2 tests should be made on each side of the trench. Tests should be at the approximate one-third points on both sides.

In lieu of a pocket penetrometer it is recommended that the "Thumb Imprint" test be utilized (ASTM D2488). Soils in which thumb penetration requires a major effort are considered stiff. Conversely, soils which can be penetrated to the knuckle with ease shall be considered soft. All other soils, where penetration is obtained with moderate force, shall be considered as medium strength.

3.3 Drying Test

The basic purpose of the drying test is to differentiate between granular, cohesive materials with fissures, and intact cohesive materials. The test must be conducted on undisturbed samples, perhaps taken with an ordinary shovel, since they will identify fractures, fissures and slicken-sides in cohesive soils as well as the coarse-grained component of other materials.

The procedure for the drying test involves drying a sample of soil approximately one-half to one inch thick and six inches in diameter. The sample can be dried in an oven (ASTM D2216), by placing on a hot engine exhaust manifold for about an hour, or by baking in the sun for a few hours during hot weather. If significant fissures exist, they will become apparent upon drying as the sample will crack along the weak fissures or joints. If the sample dries to a hardened state intact, it should be broken by hand as described in the following paragraph.

After drying, the sample is grasped between the thumb and forefinger of one hand and lifted so that a length of at least 5 inches is cantilevering beyond the forefinger. If the sample can be lifted intact without breaking, the soil has a significant clay content and should be classified as a soft, medium or stiff clay based upon its penetration test results. If the sample breaks upon lifting, it is either a fissured clay or a granular material. Distinction between a fissured clay and a granular material can be made by attempting to pulverize the resulting dried clumps of material. A simple means would be to squeeze them together in one hand. (Even stepping on them is all right). If they pulverize into very small fragments, the material is granular. If the clumps do not pulverize easily, the material is a fissured clay.

4. Alternate Classification Systems

4.1 Matrix Classification System

Table 1 Soil Categories

Primary Soil Classification	Water in Trench?			
	No		Yes	
	Fissures &/or Joints?		Fissures &/or Joints?	
	No	Yes	No	Yes
Rock	I	II	II	III
Granular Soils	II	II	III	III
Stiff Clay	I	II	III	III
Medium Clay	II	III	III	IV
Soft Soils	IV	IV	IV	IV

Notes:

1. Inclined layered systems. Layered systems shall be considered inclined when angle of dip is 4:1 (approximately 15°) or larger. Weak side is side where layers dip into the trench, and will be classified as a Category IV material regardless of type of soil and site conditions. The strong side, dipping away from the trench face, shall be classified using Table 1.

2. Horizontally-bedded, layered soils (dip less than 4:1 or approximately 15°). w_e and slope factors shall be interpolated directly, based on the proportional thickness of the layers making up the trench bank, except in the case where an extensive layer of weak material is overlain by stronger material. In those cases where a layer of weak material two feet or more thick is overlain by stronger material, the w_e and slope of the overlaying stronger material shall be taken to the same as those of the underlying extensive layer of weaker material.

3. Disturbed material. All fill materials shall be treated as <u>Granular</u> Soils.

Table 2 Minimum Acceptable Stability Requirements

Soil Category	w_e [1]	Max. Slope[2] Horiz:Vertical
I	20	1/2:1
II	40	3/4:1
III	60	1:1
IV	80	2:1

Notes:

1. If significant vibration is present, and/or trench is to be left open for more than 4 hours, increase w_e factor by 25%.

2. If significant vibration is present, and/or trench is to be left open for more than 4 hours, add 1/4 to the horizontal portion for I and II soils. Add 1/2 to the horizontal portion for III and IV soils.

4.2 Table 3 Simplified Classification System

Category	Type	w_e, lb/ft^2	Max. Slope Horiz:Vert
A	Intact Hard Soils	20	3/4:1
B	Medium Soils	40	3/4:1
C	Soft Clay and Submerged Soils	80	--

Notes:

1. Intact hard soils are hard clays, tills and cemented gravels above the groundwater table which have no fissures or inclined layers which dip into the trench.

2. Soft clays have an unconfined compressive strength of less than 1,000 psf and can be identified by penetrometer tests, Torvane tests or laboratory tests.

3. Medium soils are all soils which do not fall in category A or C.

4. Fractured rock falls in category B if it is dry and in category C if it is submerged. Note that unless rock excavation is by pre-splitting or equivalent means rock will be normally fractured.

SECTION 3. Findings, Conclusions, and Recommendations of Trenching Lumber Study

1. Summary

In certain areas of the United States lumber is used extensively to brace trenches against collapse. The life and safety of the men working in these trenches depends on the adequacy of the lumber bracing used to prevent the trench from collapsing. NBS conducted a field study of trenching lumber and found that either ungraded hardwood or graded softwood is used. For graded softwood, allowable stresses and other properties are established. The hardwood, however, is ungraded and there are no guidelines for allowable stresses and other properties. The NBS statistical analysis of the hardwood grades based on the field study indicated that 80 percent of the pieces are a No. 2 grade or higher; 60 percent of the pieces are a No. 1 grade or higher. These percentages do not reflect the effects of wane and decay, which are additional problems. NBS therefore recommended that allowable stresses and other properties be based on a No. 2 minimum grade. It is also possible to base allowable stresses etc., on a No. 1 minimum grade, dependent on the level of quality control. In either case, quality control is necessary and can be implemented in two steps.

Step 1. A specification, which is part of the OSHA regulation stipulating minimum quality, such as limits on wane, decay, and defects and exclusion of weak species, based on a traditional strength ratio and consistent with the stress level chosen.

Step 2. Introduction of a voluntary grading system by industry, which would insure the Step 1. specification for trenching lumber.

2. Scope

The study was performed in three steps:

(1) identification and investigation of properties and characteristics of trenching lumber

(2) a field investigation at selected trenching lumber distribtuion sites in Washington, D.C., Houston, Texas, and Los Angeles, California.

(3) development of recommendations concerning allowable stresses and minimum requirements and conditions of use for trenching lumber.

3. Findings, Conclusions, and Recommendations

3.1 Critical Properties and Characteristics

- most of the hardwood and softwood lumber used is rough sawn and green
- the hardwood is ungraded (mill run) and consists of a variety of species, with a high frequency of oak.
- much of the hardwood wales and sheeting are left in place (not reused);
- some softwood is used in Los Angeles, San Francisco, New York City, and Chicago.
- the softwood used in the West Coast is stress graded Douglas Fir. Southern Pine and Douglas Fir are sometimes used in New York and and Chicago.
- for solid sheeting, wales cause the most difficulty for contractors from a structural standpoint, struts next, and sheeting the least difficulty.

3.2 Field Investigation

(a) Lumber Grade Disregarding Wane, Damage, and Decay - The most important grade taken was a basic strength grade, called G, in which the effects of wane, damage and decay were disregarded.

Table 1 shows the major findings for the G grade.

(b) Upgrading - Wales were attempted to be upgraded by assigning a G grade to a partial length since the maximum bending stress occurs in a partial length of a full length wale. The percent of wales that could be upgraded ranged from about 15% - 40%.

(c) Wane - The frequency, severity and economic impact of wane were shown to be significant for hardwood wales. Wane did not appear to be a problem for the softwood wales. 42% of the hardwood wales and struts were reduced by an average of 2 grades. 8% of the softwood wales and struts were reduced by an average of 1 grade.

(d) Decay - About 10% of the hardwood wales and struts were downgraded from their G grade, due to decay; on the average, wales and struts were reduced at least 1 grade due to decay.

(e) Trimming - About 28% of the members in D.C., 15% in Houston, and 14% in Los Angeles could be upgraded by trimming.

(f) Damage - About 2% of the hardwood and 4% of the softwood wales, struts, and sheeting were downgraded due to damage.

(g) Species - At least 50% of the hardwood wales, struts, and sheeting were either red or white oak. The softwood in Los Angeles was Douglas Fir.

Slope of Grain - About 95% of the hardwood wales, struts, and sheeting had a slope of grain of 1:20 or less.

Moisture Content - Almost all the lumber sampled was green.

3.3 Allowable Properties

(a) Hardwood Allowable Properties - Because formally approved lumber stresses do not exist for most hardwood species, applicable ASTM standards (D 2555, D245) were followed in conformance with procedures recognized under the American Lumber Standard PS 20-70 to develop allowable stresses and other properties (Table 2).

(b) Softwood Allowable Properties - A minimum grade of No. 2 is recommended for softwood wales and struts. Allowable stresses for species and grade combinations are given in the National Design Specifications for Wood Construction, National Forest Products Association, June 1977. The same wane limitations which apply to hardwood (3.3(c)) are recommended for softwood.

(c) Tentative specification for area loss by wane

(a) Performance specification

(1) For the middle 1/3 of the length of the member the moment of inertia in any direction and the cross-sectional area shall not be reduced by more than 10 percent.

(2) For the rest of the length of the member the moment of inertia shall not be reduced by more than 25 percent and the cross sectional area shall not be reduced by more than 10 percent.

(b) Prescriptive Specification

(1) For the middle third: The sum of any two adjacent sides must be at least 3/4 of the sum of their specified nominal lengths with the following exception: if wane is confined to one corner only, the sum of the two adjacent sides must be at least 2/3 of their specified nominal lengths.

(2) For the rest of the length of the member: The sum of any two adjacent sides must be at least 2/3 of the sum of their specified nominal lengths with the following exception: if wane is confined to one corner only, the sum of the two adjacent sides must be at least 1/2 of their specified nominal lengths.

3.4 Use Recommendations

Use recommendations covering duration of load, damage, bark, decay, insect attack, inspectability, exposure, and storage for various aspects of trenching lumber applications were developed. The development assumes a severe environment, possible reuse of structural members, and the need for structural integrity related to safety of both life and property, for finite periods of time.

Table 1. Summary of Findings for G Grade for Wales, Struts, and Sheeting

		(1) Sample Size N	(2) Percent of Pieces With a No. 2 Grade or Higher	(3) Percent of Pieces With a No. 1 Grade or Higher	(4) Average Strength Ratio,* SR, Based on No. 2 or Higher Grades	(5) Coefficient of Variation of Strength Ratio
Hard-wood	Wales, Struts	241	80	63	57	19%
	Sheeting	83	85	60	56	16%
Soft-wood	Wales, Struts	37	100	83	58	19%
	Sheeting	65	74	52	55	16%

* The strength ratio, SR, is defined in ASTM D245 as the hypothetical ratio of a member's strength to that it would have if no weakening defects (e.g., knots) were present. For example, a member with an SR of 45 would be expected to have at least 45 percent of the strength of an equally sized member which is free of any defects. The grades and corresponding SR values are given in Table 1a. Note that only grades of No. 2 and higher could be assigned SR values; thus average SR values are based only on grades of No. 2 and higher.

Table 1a. Strength Ratio (SR) Values in Terms of Grade

Strength Ratio	Grade
86	Industrial 86
72	Industrial 72
65	Industrial 65
65	Select Structural
55	No. 1
45	No. 2
Not assigned	No. 3
Not assigned	None

Table 2

Allowable Unit Stresses for Hardwood Trenching Lumber[1/]

Hardwood group[2/]	F_b	F_t	$F_{c\parallel}$	F_v	$F_{c\perp}$	E
2 TO 4 IN. THICK, 2 TO 14 IN. WIDE						
White oak[3/]	875	575	550	105	355	800,000
Mixed oak[4/]	850	550	500	80	355	800,000
Mixed hardwoods I[5/]	725	475	375	65	165	800,000
Mixed hardwoods II[6/]	600	400	350	50	115	800,000
5 IN. AND THICKER, 5 TO 20 IN. WIDE						
White oak[3/]	975	650	525	120	355	800,000
Mixed oak[4/]	925	625	475	90	355	800,000
Mixed hardwoods I[5/]	800	550	350	75	165	800,000
Mixed hardwoods II[6/]	675	450	325	60	115	800,000

1/ Ref. Southern Pine Inspection Bureau Grading Rules, 1977 edition, for general grade description as follows:

Grade	Paragraph	Size
No. 2	313	2 to 4 in. thick, 2 to 4 in. wide
No. 2	343	2 to 4 in. thick, 5 to 14 in. wide
No. 2 SR	406	5 in. and thicker, 5 to 20 in. wide

Assumes 10-yr. load duration basis. For new (first use) lumber, adjustments for load duration may be made: for 1-yr. duration multiply by 1.1; for 1 wk., multiply by 1.25 for 2 days, multiply by 1.30. Load duration adjustments for used trenching lumber are not recommended. For hardwood trenching lumber, requirements are waived for manufacture, compression wood, firm knots, skips, stain, and warp. Holes limited as knots; wane limited as 3.3(c).

2/ Hardwood species defined per ASTM D 1165.

3/ White oak: The following white oaks--bur, chestnut, live, overcup, post, swamp chestnut, swamp white, white.

4/ Mixed oak: Red oak (black, cherry bark, laurel, northern red, pin, scarlet, southern red, water, willow); white oak (footnote 3).

5/ Mixed hardwoods I: Ash (black, blue, green, Oregon); beech; birch (sweet, yellow); cherry; elm (American, rock, slippery); hackberry; hickory (mockernut, pignut, shagbark, shellbark); locust (black, honeylocust); magnolia (cucumber, southern, sweetbay); maple (bigleaf, black, red, silver, sugar); mixed oak (footnote 4); pecan (bitternut hickory, nutmeg hickory, pecan, water hickory); red alder; sassafrass; sugarberry; sweetgum; sycamore; tanoak; tupelo (black, water); yellow poplar. Excludes all cottonwood, all aspen, basswood, and balsam poplar.

6/ Mixed hardwoods II: All hardwoods in Mixed hardwoods I (footnote 5) plus black and eastern cottonwood; quaking and bigtooth aspen; basswood. Excludes balsam poplar.

SECTION 4. Summary of Field Study

1. Scope

One hundred meetings were held with top management of contracting firms in 9 metropolitan areas. Most of the meetings included field visits. Additional information was obtained from trade associations. The information sought was in three areas:

Technical aspects of excavation work and associated hazards

Assessment of OSHA standards and suggested changes

Company characteristics and management practices affecting safety

2. Summary of Information

<u>Trench Configurations</u>

Most trenches are less than 15 ft deep, but few, other than waterlines are less than 5 ft deep. A typical trench may be no wider than 3 ft and the length of open trench behind the backhoe is generally less than 50 ft. The soil type encountered is an important factor causing variations in work methods.

<u>Shoring Types</u>

Types of shoring systems vary considerably between contractors, even in similar soil conditions. Various types of shoring are used, including timber shoring (solid sheeting and skeleton), hydraulic shores, trench boxes and trench shield. The majority of trenches are not shored by traditional timber shoring. Provisions for the removal of wood shoring when the trench is filled vary among local governments and range from provisions to leave shoring in place to provisions requiring removal of shores. Several contractors indicated that timber shoring may be used repeatedly.

Slope Determination

A majority of contractors rely on their experience and judgment

Determination of Required Shoring

Most contractors rely on experience and accepted local empirical practice. A few firms use enlngeering design. In a few instances (California, Wisconsin, N. Y. City) Contractors derive satisfactory guidance from state or Municipal regulations.

Soil Investigation

Contractors generally use test pits and borings. Although the majority of contractors have in house engineers, many occasionally hire geotechnical consultants for the soils exploration, using the in house engineers to design the shoring systems.

Hazards

Running sand is generally identified as the worst soil conditions. Other hazards identified were areas which were previously excavated (sometimes this condition is not known in advance), intersecting trenches and groundwater. Causes of cave in include poor or unexpected soil conditions, excessive groundwater, incorrect assessment of soil conditions. Failure to shore properly or failure to shore were most frequently cited.

OSHA Provisions

The majority of contractors stated that Table P-1 of the OSHA provisions was not helpful. With some exceptions contractors were also not satisfied with Table P-2.

OSHA Inspection

Most contractors had at least one site inspection. Most felt that OSHA regulation had generally an adverse effect by increasing production cost. Most contractors were critical of inspection, citing a lack of common sense as the key obstacle to meaningful inspection.

Assistance from Other Agencies

Much safety assistance is received from insurance carriers. Routine advice is provided by equipment suppliers (hydraulic shores, etc.) and by trade associations (NUCA, AGC).

Industry Characteristics

Utility contractors tend to be small (less than $5 million annual volume), and specialize in only trenchwork. Their operations are generally confined to a 50-mile radius. Most companies have less than 50 employees and a home office staff of no more than 4.

Safety Programs

Most contractors hold weekly "toolbox meetings." The rank of the presiding individual may range from company president to foreman. Many contractors do not seem convinced that the meetings have merit, however, there is some disagreement on this point.

Safety Training

Company safety officers generally visit the jobsite frequently. Normally these officers have also line duties. Sometimes this function is performed by company presidents or owners. Safety training to foremen is frequently provided by OSHA classes and first aide seminars.

Company Practices

Injury frequency is affected by some management practices and policies. Practices which have beneficial effects are: to provide foremen with little production cost information; not to have a dogmatic approach to worker conflicts (consider worker complaints even if foreman is implicated); to help new foremen who have supervisor problems rather than demoting them; to limit the authority of foremen to fire workers.

Company Size

Smaller companies tend to have smaller injury frequencies. Parameters affecting safety are familiarity with work area; specialization in trench work; management control of field operation; and personnel.

Shoring Methods

More injuries occur when workers have to handle materials and equipment manually rather than by machines.

APPENDIX

ENGINEERING GUIDELINES FOR THE DESIGN OF SHORING SYSTEMS AND OTHER MEANS TO PROTECT WORKERS IN TRENCHES AND EXCAVATION

1. INTRODUCTION

When workers are required to enter any excavation deeper than 5 feet, protective measures must be taken in compliance with the OSHA Regulations for Excavations, Trenching and Shoring. OSHA recognizes that in the case of shallow trenches, where there is rapid progress of work, it is in many instances unrealistic to require that a licensed engineer be in responsible charge of the design of the shoring for all the portions of the excavation. It is also noted that even if an engineer designs the shoring under these conditions on the basis of soil exploration data, he has no knowledge of the subsurface conditions between borings. OSHA therefore stipulated protective measures which are deemed acceptable. These include the following: a maximum permissible slope in sloped excavations; empirical provisions for timber shoring; shoring systems designed to resist pre-defined lateral pressures which OSHA deems acceptable for a wide range of conditions; pre-fabricated shoring systems and protective devices such as hydraulic shores or trench boxes which are rated for maximum allowable loads they may be used to support or maximum depths to which they can be used under certain pre-determined subsurface conditions.

In the following instances a licensed engineer must be in responsible charge of the design of shoring systems or other protective measures.

(1) Whenever the depth of the trench or excavation exceeds 20 ft in all soils, or 12 ft in soft clays.

(2) Whenever there is a deviation from the protective measures which are deemed acceptable by OSHA.

(3) For all excavations defined herein as long-term excavations.

Furthermore, a licensed engineer will have to certify the rating of pre-fabricated shoring systems or trench boxes.

In some exceptional cases, it will be possible to modify the OSHA stipulations for acceptability on a regional basis, when a well documented case can be made by a licensed engineer on the basis of readily identifiable regional conditions and substantial past experience.

These guidelines are for professional engineers who design shoring systems or other means to protect workers in excavations. The guidelines are not meant to be a standard from which a professional engineer cannot deviate. Rather, they convey minimum design loads and safety margins which OSHA considers appropriate and design limit states which should be considered. It is recognized that the design of shoring systems, the stability analysis of slopes, and the assessment of soil conditions are not an exact science which can be approached with a set of rigid rules, but rather an art which requires judgment, experience and recognition of unique local conditions. Thus these guidelines can neither be imposed as mandatory rules, nor can a professional engineer forego his responsibility to determine in each instance whether the stated guidelines provide adequate protection.

2. Scope

The guidelines contain recommended minimum requirements for the protection of workers in excavations against death and injury. They do not cover other important parameters which an engineer must consider, such as protection of adjacent structures, utilities and improvements against damaging settlements, or effects of ground water fluctuations on adjacent properties.

Three methods of protection are considered in the guidelines.

Sloping of the banks of excavations;
Shoring;
Shielding of the work space by protective devices.

Other methods could also be used such as soil stabilization by freezing or grouting.

The guidelines do not apply to excavations whose collapse does not endanger workers.

3. Definitions

Allowable Stresses are stresses which should not be exceeded under the most critical combination of design loads.

Design loads are loads or load combinations used for design.

Load Capacity of a structural component of a shoring system is the failure load which is expected to be equaled or exceeded by 95 percent of all such components. Thus if a number of components are tested the load capacity is determined as $S = \bar{S}(1 - 1.65\ v)$ where:

$\bar{S}$ = average load capacity

v = coefficient of variation

S = load capacity

Long term excavations are all excavations which are open for more than 48 hours. (24 hours were suggested)

Safety margin is the ratio between load capacity and the effect of the most critical combination of design loads. In the case of stability a safety margin is the ratio between driving forces and resisting forces. For excavation slope stability the safety margin can be taken as the ratio between critical height and actual height.

Shoring Systems are structural systems supporting the bank of an excavation. The components of shoring systems are defined in Figure 1.

Short term excavations are excavations which are open for less than 48 hours. (24 hours?)

Trenches are short term excavations in which the bottom length exceeds the bottom width, the bottom width is less than 15 feet and the depth is less than 20 feet.

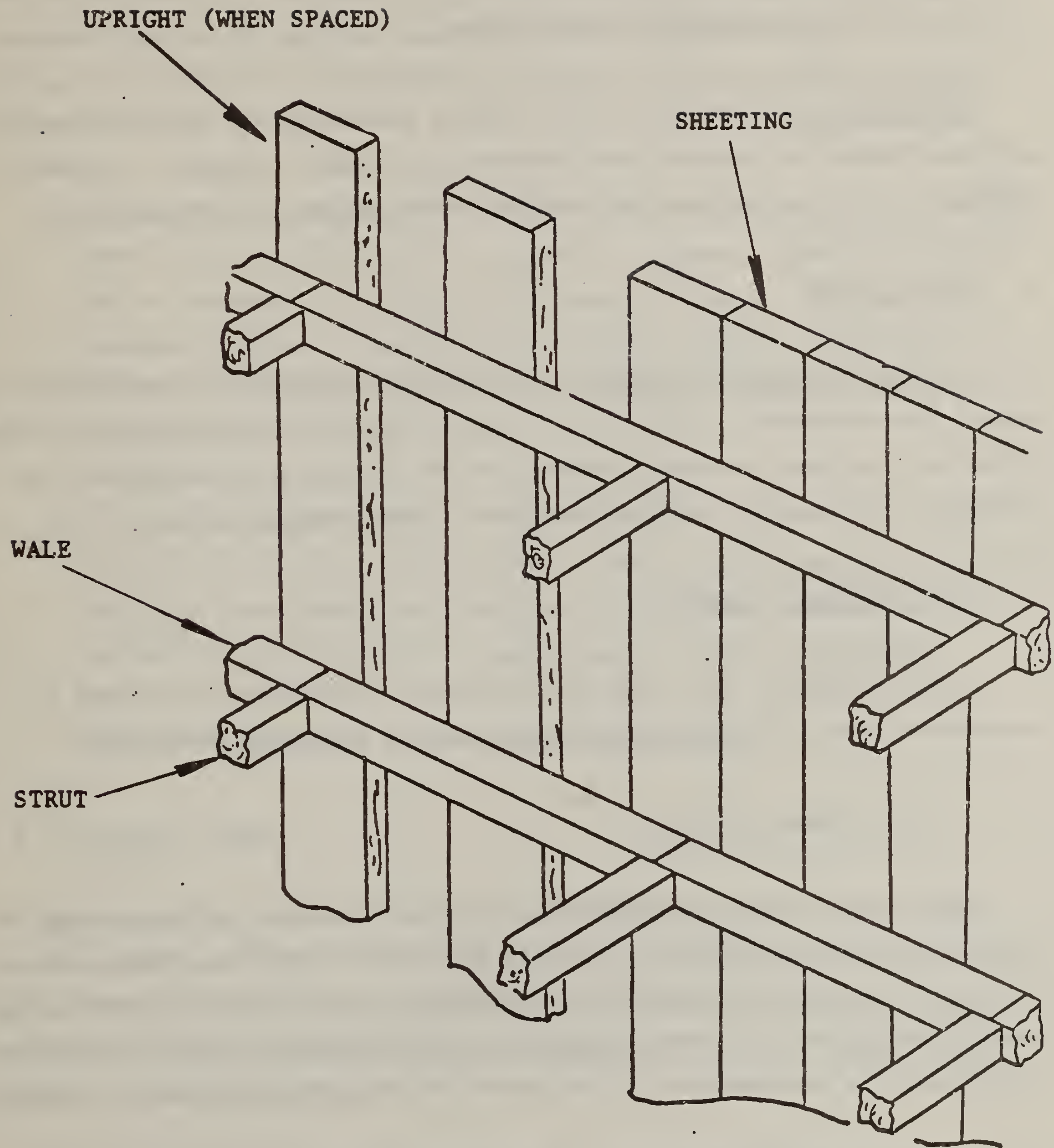


FIGURE 1 COMPONENTS OF THE SHORING SYSTEM

Ultimate loads are working loads multiplied by the following factors:

1.7 for long term excavations
1.3 for short term excavations

Working Loads are loads which should reasonable be anticipated and which must be resisted with appropriate safety margins. All loads defined in the guidelines are working loads, unless otherwise noted.

4. Design Loads

All the design loads listed, but not necessarily only the listed loads should be considered. Unless specifically stated otherwise in the design criteria, the most critical combination of design loads should be considered. The design loads defined herein are working loads.

4.1 Soil and Water Loads

Loads caused by soil and water pressures should be calculated in accordance with accepted engineering practice and these guidelines.

4.1.1 Loads Caused by Water

Hydrostatic loads, hydrodynamic loads and seepage forces should be considered where applicable. Special attention should be given to the effects of potential groundwater fluctuations, saturation of previously drained deposits, and water penetration into fissures. The following conditions are recommended as the basis for determining critical loads:

For long-term excavations: conditions caused by the 5-year flood.

For short-term excavation: conditions caused by the 1-year flood or alternatively the most severe condition which will not cause interruption of work and evacuation of workers from the excavation.

4.1.2 Soil Loads

Soil loads should be determined in accordance with the state of the art in geotechnical engineering. Special attention should be given to fissures, planes of weakness and previously excavated soils. The following conditions are recommended as a basis for determining critical loads.

For long-term excavations: Drained as well as undrained conditions need to be considered if applicable. Apparent cohesion should not be assumed to contribute to shear strength. Effects of exposure, lateral expansion, desiccation cracks, freezing, erosion, and change in confining pressures should be taken into account.

For short-term excavations: In most instances only undrained conditions need to be considered. Short term strength characteristics could be considered, provided that an adequate assessment is made of conditions that could lead to loss of strength.

Further information is provided in Appendix A.

4.2 Surcharge Loads

Surcharge loads should be determined on the basis of actual anticipated working conditions. Consideration should be given to: the amount and location of accumulated spoil material; stored construction material; construction equipment; vehicular and human traffic; and foundations adjacent to the excavation.

In no case shall the surcharge load be assumed less than 200 lb/ft^2 distributed over the entire area or the equivalent of an additional 2 ft depth of material excavated on the site (using average unit weight of soil deposits), whichever is more.

4.3 Operational Loads

All loads caused by the anticipated excavations work must be considered. These include excavated or construction material supported by portions of the shoring system and workers climbing on the shoring system. The following minimum load should be used for design: A gravity load of 240 lb, distributed over any 1 ft long portion of any strut.

4.4 Dynamic Loads

Dynamic loads caused by pile driving, blasting, traffic and construction equipment should be considered.

4.5 Restraint loads. Restraint loads caused by temperature, moisture, shrinkage, swelling or other dimensional changes in structural members of the shoring system should be considered when applicable. In general it can be assumed that the empirically-based lateral loads that can be calculated in accordance with these guidelines contain a reasonable allowance for temperature effects on struts.

5. Design Criteria

5.1 Sloped Excavations

5.1.1 Design Limit States:

1. Slope stability failure (part or all of the embankment)
2. Sloughing

5.1.2 Design Criteria

5.1.2.1 Long-term Excavations

Granular soils (no cohesion)
slope angle should not exceed angle of internal friction.

Cohesive Soils

The safety margin against stability failure should be greater than 1.5.

Suitable surface and subsurface drainage should be provided to prevent stability failures or sloughing induced by seepage or erosion.

For deep excavations

6 ft wide benches should be provided at vertical intervals not exceeding 30 ft.

Maximum unbraced height of vertical bank:

5 ft for all soils or fractured rock. No limitation for sound unfractured rock.

5.1.2.2 Short-term Excavations

The safety margin against stability failure should exceed 1.5 except that for dry cohesionless soils a slope angle equal to the angle of repose may be maintained. Short term strength properties could be utilized, provided that there are adequate safeguards against conditions which could cause strength degradation.

Maximum unbraced vertical bank: For intact hard clays the unbraced height could exceed 5 ft provided that there is substantial empirical evidence that the risk is not excessive. For all other soils, including fractured rock, the maximum unbraced height should not exceed 5 ft. There are no limitations for sound rock.

5.2 Braced Excavations

5.2.1 Design Limit States

(1) Stability failure of the bank
(2) Base instability
(3) Partial caving or sloughing of the bank between spaced vertical or horizontal supports.

(4) Failure of the soil supporting struts anchors or soldier piles.

(5) Failure of structural components of the shoring system.

5.2.2 Design Criteria

5.2.2.1 Stability of the Bank

A stability failure of the bank is the collapse of all or part of the bank caused by sliding of a soil mass along a failure surface. The failure surface may lie outside the support points of structural members of the shoring system (supports of raker braces, soil anchors or the bottom of soldier piles or cantilever sheeting) and thus render the shoring ineffective, or it may be caused by the structural failure of members of the shoring system.

The safety margin against any stability failure of the bank shall exceed 1.5.

5.2.2.2 Base Stability

Base instability leads to heaving of the base of the excavation, which in turn can cause dislocation and collapse of the shoring system. The safety margin against base instability should exceed 1.5. Potential effects of uplift resulting from artesian pressure in confined aquifers should be considered. Dewatering should be adequate to prevent piping (quick condition) caused by seepage of groundwater into the base of the excavation. In deep clay deposits, base instability should be considered a problem whenever N_b exceed the following values: $N_b \geq 6$ for trenches where $\frac{H}{B} \geq 3$; $N_b \geq 5.14$ for very wide excavations; intermediate values for $0 < \frac{H}{B} < 3$

where $N_b = \frac{\gamma H}{c_b}$ = stability number for base failure

γ = unit weight of soil, lb/ft^3

H = depth of excavation, ft.

B = width of excavation, ft.

c_b = undrained shear strength below excavation base, lb/ft^2

5.2.2.3 Soil Stability Between Spaced Supports

There is no generally accepted theoretical approach by which the ability of a soil to arch between successive supports can be evaluated or correlated with strength properties of the soil. There is empirical evidence that short-term supports can be spaced up to 8 ft on center in hard clay, very stiff sandy clays or glacial tills and 4 to 6 ft on center in slightly fissured stiff clays. Guidance can be derived on a regional basis from empirical evidence.

5.2.2.4 Soil Support for Struts, Anchors or Soldier Piles

A minimum safety margin of 3 is recommended against bearing failures of members of the shoring systems such as raker braces.

A safety margin of not less than 1.5 should be used when passive earth pressure is relied upon to support embedded portions of soldier piles and sheeting or deadmen.

All soil anchors should be proof load tested to 1.33 times their working load. If the load capacity of soil anchors is determined by tests, it should be not less than 1.5 times the working load for anchor inclinations of 1 vertical in 2 horizontals or less, and increase to 2.0 times their working load for inclinations of 1 horizontal in 2 verticals. When anchor capacity is determined by analysis the margin of safety should not be less than 3. Soil anchors subjected to the working load should not show measurable creep when the load is sustained for 15 minutes.

5.2.2.5 Design of Structural Components of the Shoring System

5.2.2.5.1 Applicable Standards

Structural members should be designed in accordance with the following standards:

Steel: Specifications for the Design, Fabrication and Erection of Structural Steel Construction, American Institute of Steel Construction, New York, N. Y., Feb. 1969.

Concrete: Building Code Requirements for Reinforced Concrete, (ACI 318-71), American Concrete Institute, Detroit, Michigan, November 1971.

Aluminum: Specifications for Aluminum Structures, The Aluminum Association, New York, N. Y., November 1967.

Wood: National Design Specifications for Wood Construction, National Forest Products Association, June 1977, for softwood lumber stresses.

Because formally approved lumber stresses do not exist for most hardwood species, applicable ASTM Standards may be followed in conformance with procedures recognized under the American Lumber Standard, PS70/70. (For allowable stresses refer to Section 3 Table 2)

5.2.2.5.2 Allowable Stresses

Allowable stresses should be determined in accordance with the applicable standard. In long-term excavations allowable stresses should not be exceeded under any applicable combination of working loads. In short-term excavations allowable stresses in structural members may be exceeded by up to 33 percent, however, allowable stresses should not be exceeded in connections between structural members.

5.2.2.5.3 Ultimate Strength Design

Ultimate strength, rather than working stress design may be used whenever such a procedure is stipulated in the applicable standard. Ultimate loads should be taken as 1.7 times the working load for long-term excavations and 1.3 times the working load for short-term excavations.

5.2.2.5.4 Determination of Load Capacity by Test

If the load capacity of a structural component of the shoring system is determined by test, the following minimum requirements are recommended:

1. Strength variability should be considered in accordance with the definition of load capacity.

2. Under no circumstances should the allowable working load of struts exceed 67 percent of mean failure load in temporary excavations or 50 percent of the failure load in permanent excavations.

3. For cross braces (struts) the test load should be applied with an eccentricity of not less than 1/3 the thickness of the strut with respect to any one of the principal axes (but not simultaneously with respect to both axes), or with the eccentricity producing an end moment equal to the center-span moment caused by a concentrated load of 340 lb applied at the center of the strut, whichever is greater.

4. For wood members the provision of ASTM D2915 should serve as a guideline.

APPENDIX A

A.1 List of Symbols

B - Width of excavation

c - Cohesion (undrained shear strength) of material in bank in lb/ft^2

c_b - Undrained shear strength of material below bottom of excavation in lb/ft^2.

d - 0.707 x bottom width of excavation or depth from bottom of excavation to firmer soil stratum, whichever is less, in feet.

H - Depth of Excavation, in feet.

k_a - Coefficient of active earth pressure, as defined by pertinent equations listed.

Δk_a - Additional increment of k_a as defined by Henkel (1971).

m - Coefficient in lateral force equation as defined by Peck (1969).

$N = \frac{\gamma H}{S}$ Stability number, based on shear strength and weight of material in the bank.

$N_b = \frac{\gamma H}{S_b}$ Stability number, based on shear strength of material below bottom of excavation and weight of material in bank.

$\overline{N}$ - Blowcount in standard penetration test using traditional U. S. methods rope and cathead) in blows per foot.

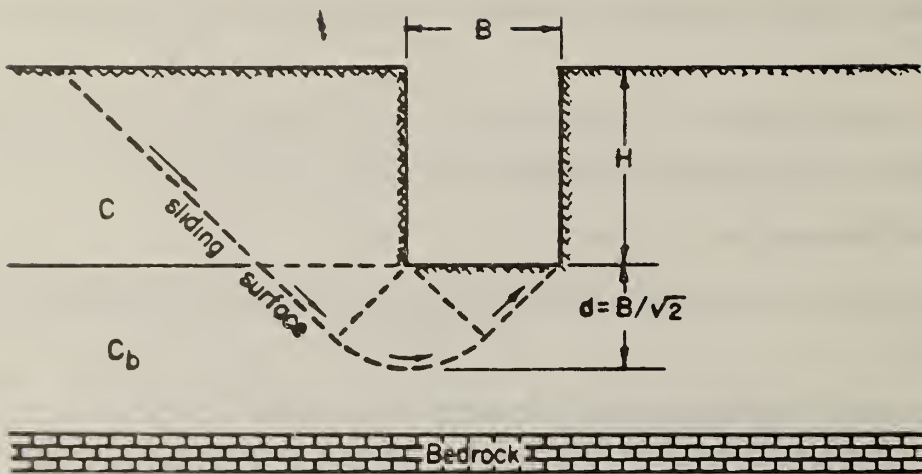
γ - Unit weight of soil (in natural condition or as assumed for worst case) in lb/ft^3.

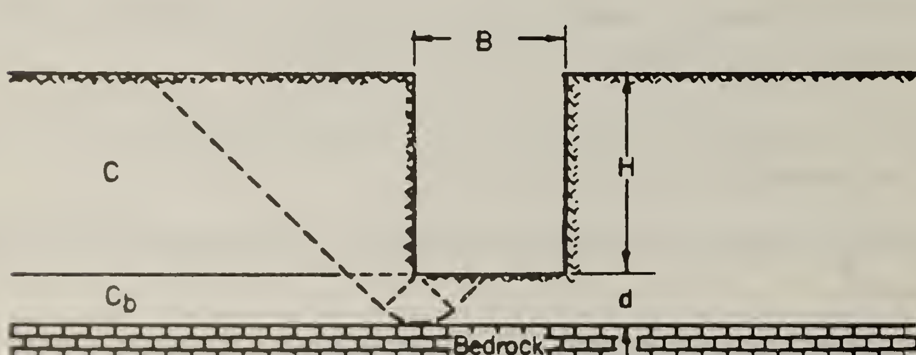
γ_{sat} - Unit weight of saturated soil, in lb/ft^3.

γ_{sub} - Unit weight of submerged soil in lb/ft^3.

γ_w - Unit weight of water in lb/ft^3.

ϕ - Angle of internal friction, in degrees.


B
H
C
sliding
surface
d=B/√2
Cb
Bedrock


B
H
C
Cb
d
Bedrock

A.2 References

The following references provide guidance which is considered adequate. Lateral loads calculated in accordance with these references are considered to be working loads.

(1) Peck, R. B., "Deep Excavations and Tunneling in Soft Ground," State-of-the-Art Report, Proceedings 7th International Conference on Soil Mechanic's and Foundation Engineering, State-of-the-Art Volume, pp. 225-250, Mexico, City (1969).

(2) Peck, R. B., Hanson, W. E., Thurnburn, T. H., Foundation Engineering, Chapter 27, John Wiley and Sons, New York, N. Y., Jan. 1974.

(3) Goldberg, D. T., Jaworski, W. E., and Gordon, M. D., Lateral Support Systems and Underpinning, Report No. FHWA-RD-75-129, Vol. II, Federal Highway Administration, Office of Research and Development, Washington, D.C. April, 1976.

(4) Department of the Navy, "Soil Mechanics, Foundations and Earth Structures, NAVFAC DM-7, Chapter 10, U.S. Naval Publications and Forms Center, Philadelphia, Pa., September 1971.

(5) United States Steel Company, "Steel Sheet Piling Design Manual," U.S. Steel, Pittsburgh, PA., July, 1975.

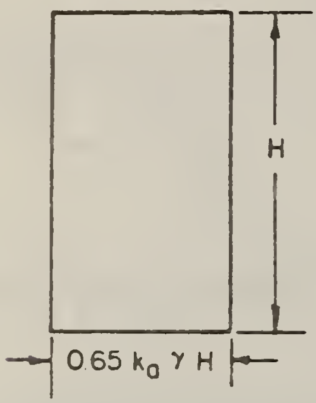
The preceding references contain design approaches which are not necessarily identical. However, all these approaches are widely used and are considered to be adequately conservative.

A.3 Summary of Information

Hereafter is a brief summary of information derived from the references listed in A.2. The suggested pressure envelopes are not intended as an endorsement of one single approach to the problem, but rather as a summary of commonly used approaches which are considered adequately conservative.

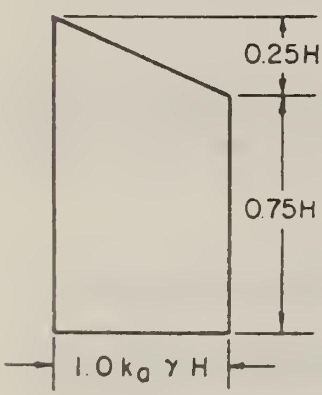
A.3.1 Lateral Pressures

(1) Sands (Ref A.2-1)



$$k_a = \tan^2 (45 - \phi/2)$$

(2) Soft to Medium Clays, when N > 6 (if pressures calculated under (3) using 0.4 γH are larger, use (3)).



$$N = \frac{\gamma H}{c}$$

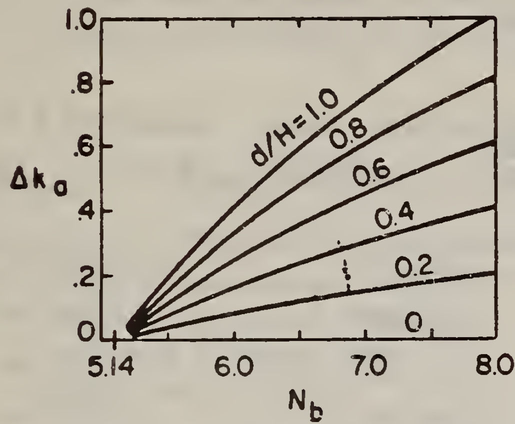
$$k_a = 1 - m \frac{4}{N}$$

When cut is underlain by deep, soft, normally consolidated clays: m = 0.4
All other cases: m = 1.0

Alternate approach after Henkel (1971)[1/]

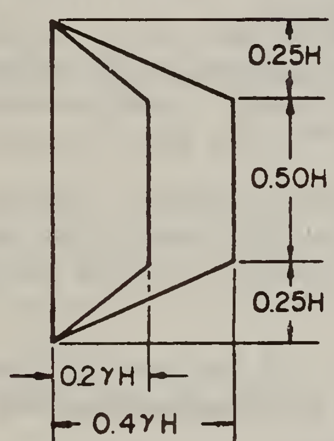
1/ Henkel, D. J., The Calculation of Earth Pressure in Open Cuts in Soft Clays, The Arup Journal, Vol. 6 No. 4, (1971).

$$k_a = (1 - \frac{4}{N}) + \frac{2.83d}{H}(1 - \frac{5.1H}{N_b}) = k_a + \Delta k_a \; ; \; N_b = \frac{\gamma H}{c_b} \; ;$$



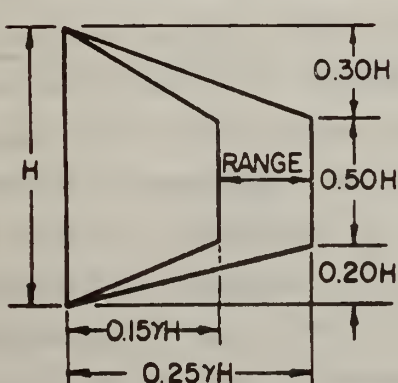
plot of Δk_a Vs. N_b after Henkel (1971)

(3) Stiff Clays, whenever $N < 4$. (if $4 < N < 6$ use (2) or (3), whichever gives larger pressures)

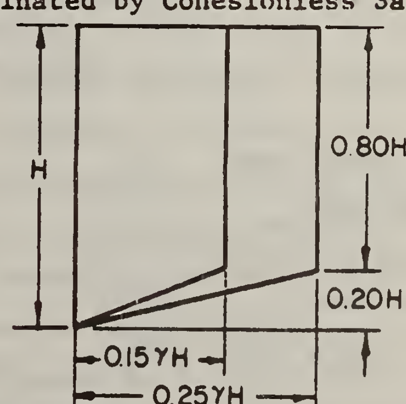


(4) Dense cohesive sands, very stiff sandy clays.[2/]

Relatively Uniform



Upper Third of Cut Dominated by Cohesionless Sands



[2/] Diagram recommended by Goldberg et.al. (1976).

Table A.1 Typical Values of Unit Weight

Soil Type	Moist U.W. Above W.T., γ(lbf/ft^3)	Saturated U.W. Below W.T., γ_{sat}(lbf/ft^3)
Poorly graded sand	105-115	115-125
Clean well graded sands	115-125	125-130
Silty or clayey sands	120-130	125-135
Silty or clayey sands & gravel	125-135	130-145
Soft to medium clay	100-115	100-115
Stiff to very stiff clay	110-125	110-125
Organic silt or clay	90-100	90-100

$\gamma_{sub} = \gamma_{sat} - \gamma_w$

$\gamma_w = 62.4$ lb/ft^3

Table A.2 Relationship between Properties of Cohesionless Soil and Standard Penetration Test Results

Soil Type	SPT, $\bar{N}$ blows/ft.	Relative Density D_r%	ϕ (after Peck)	k_a
Very loose sand	<4	0-15	29°	>0.35
Loose sand	4-10	15-35	29°-30°	0.35-0.33
Medium dense sand	10-30	35-65	30°-36°	0.33-0.26
Dense sand	30-50	65-85	36°-41°	0.26-0.21
Very dense sand	>50	85-100	>41°	<0.21

Table A.3 Properties of Cohesive Soil and Standard Penetration Test Results (Goldberg, et al., 1976)

Clay Consistency	Identification	SPT, $\overline{N}$ blows/ft.	Undrained Shear Str. lbf/ft^2	Unconfined Comp. Str. lbf/ft^2
Very soft	Easily penetrated several inches by fist. Exudes between fingers when squeezed in hand.	<2	250	<500
Soft	Easily penetrated several inches by thumb. Molded by light finger pressure	2-4	250-500	500-1000
Medium	Can be penetrated several inches by thumb with moderate effort. Molded by strong finger pressure	4-8	500-1000	1000-2000
Stiff	Readily idented by thumb but penetrated only with great effort. Idented by thumb	8-15	1000-2000	2000-4000
Very stiff	Readily indented by thumbnail	15-30	2000-4000	4000-8000
Hard	Indented with difficulty	>30	>4000	>8000

The correlation between $\overline{N}$ values and soil properties for clays can be regarded as no more than a crude approximation, but for sands it is often reliable enough to permit the use of $\overline{N}$ values in design. Unconfirmed compression tests or triaxial tests are more reliable for clays. It should also be noted that the value of $\overline{N}$ can be influenced by numerous factors such as: the depth at which the test is made; the location of the water table; presence of boulders in the deposits; irregularities in performing the test; etc. In general, $\overline{N}$ values used here are representative of those obtained by the traditional U. S. (rope and cathead) method. If other methods are used, a correction for delivered energy is desirable.

Appendix C

AGENDA

WORKSHOP

OSHA/NBS TRENCHING AND EXCAVATION RESEARCH
Department of Labor Auditorium
Washington, D.C.

AGENDA

Tuesday, September 19, 1978

8:30 A.M. - Registration
9:15 A.M. - Welcome . . . . A. Martin
9:20 A.M. - Industry Remarks . . . . T. Seymour
9:35 A.M. - Purpose of Workshop . . . . J. Bryson
9:50 A.M. - Overview of Excavation Project . . . . F. Yokel
10:30 A.M. - Coffee
10:50 A.M. - Tentative Recommendations . . . . F. Yokel
11:30 A.M. - Discussion
12:00 - Lunch
1:30 P.M. - Soil Classification System . . . . R. Tucker
2:00 P.M. - Discussion of Soil Classification Options
2:30 P.M. - Timber Study . . . . L. Knab and W. Galligan
3:00 P.M. - Discussion of Timber Recommendations
3:30 P.M. - Field Study . . . . J. Hinze
4:00 P.M. - Discussion of Field Study
4:30 P.M. - Form Working Groups
Suggest three working groups:

1. Soil Classification
2. Acceptable Measures
3. Trenching Timber

4:45 P.M. - Adjourn

WORKSHOP

OSHA/NBS TRENCHING AND EXCAVATION RESEARCH
Department of Labor Auditorium
Washington, D.C.

AGENDA

Wednesday, September 20, 1978

9:00 A.M.	Working Groups meet
11:00 A.M.	Report of Working Groups and Discussion
12:00	Adjourn

Appendix D

Comments Provided by Correspondence after Completion of the Two-day Workshop

ASFE
ASSOCIATION OF SOIL AND FOUNDATION ENGINEERS

October 16, 1978

The National Bureau of Standards
Room 168, Building 226
Washington, D. C. 20324

Attention: Mr. Felix Yokel

Dear Felix:

Enclosed is a copy of your draft on the technical provisions of trenching and excavations for OSHA with our committee's comments. I have asterisked the upper right-hand corner of all pages which contain our recommended rewording. Some of the changes made in the rough draft are made without comment. Comments and discussions on the main items are listed below.

Section One

Under the heading "Rating of Shoring Systems and Protective Devices," we would recommend that you change the word "Certified by Licensed Engineer" to "Based on a professional opinion of a Licensed Engineer." We recommend this wording change because of the inherent legal exposure attached to the word "Certify."

Section Two

We recommend that the matrix soil classification system be used rather than the more simplified soil classification system, even though we recognize that training of contractors and foremen will be required. In addition, the committee felt that the rock classification system be reviewed.

Appendix

We recommend that the title of the Appendix be changed to "Engineering Guidelines for the Design of Shoring Systems and Other Means to Minimize Mass Soil and Rock Movements". The purpose of this rewording is to inform everyone of exactly what the Design Engineer will do. We do not see the Engineer or Engineering Geologist being involved in anything except mass soil and rock movement. The term "Other Protective Measures" could refer to all trench or excavation safety. Along this

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same line, we believe a comment should be put into the introduction of this section stating that the contractor is responsible for trench safety. I believe the construction industry is in agreement with this.

Part 3 - Ultimate Loads

There was some question as to how the factors of 1.7 and 1.3 were derived. This did not seem to be a critical item, however.

Part 4.4 - Dynamic Loads

The wording was changed again because of legal ramifications.

Part 5.1.2.1 - Long-Term Excavations

It was felt that the safety margin could be reduced to below 1.5 if the excavation was monitored by instrumentation or other means. The thinking being that stability factors of 1.5 are commonly used in earth dams and this stability factor can be reduced to 1.3 under the case of rapid drawdown, and 1.1 in the case of partial drawdown and seismic loads.

Under "Rock Excavations"

We have added the phrase "No limitations for sound rock as determined by a competent Geotechnical Engineer or Engineering Geologist." This wording was added because of the questions that arose regarding your definition of sound unfractured rock.

Under Part 5.2.2.4 - Soils Support for Struts, Anchors or Soldier Piles

A minimum safety margin of 2 in lieu of the 3 shown is recommended.

Appendix A - Under Part A.2 - References

We thought it would be desirable to add Joe DeSalvo's paper to the reference list if possible.

We trust that you find the work of our committee beneficial and I would appreciate being kept abreast of the progress of the OSHA regulations, particularly if regional meetings throughout the U. S. are going to be held as discussed in the workshop. If we can be of any other assistance, please contact me.

Very truly yours,

James H. Kleinfelder

James H. Kleinfelder, Chairman
ASFE OSHA Committee

JHK:jcb
Enclosure

cc w/Enclosure: Mr. John Bachner
Mr. James Schnabel
Mr. Gardner Reynolds
Mr. John Gnaedinger
Mr. William Zoino

1. General Definition:

Protective measures are deemed acceptable if they meet the minimum requirements stipulated by OSHA. Acceptability does not necessarily insure that the measures are adequate under all circumstances.

2. Sloped Excavations:

Sloped short-term excavations are acceptable if they comply either with Condition 1 or with Condition 2.

Condition 1: The excavation is designed by a licensed engineer in accordance with proposed guidelines (see Appendix).

Condition 2: The slopes are no steeper than the stable slope under the prevailing condition[1] and do not exceed the following allowable maximum slopes:

Option 1:[2] 3/4 horizontal-in-1-vertical (intact rock is exempt from any maximum sloping provision).

---

[1] If there is any indication of general or local instability slopes shall be cut back by at least 1/4 hor: 1 vert.
an additional

[2] Option 1 is predicated on a simple soil classification scheme and on the premise that maximum allowable slopes, like maximum speed limits, are not necessarily safe in all conditions.

Rating for conditions of use shall include designation of maximum allowable depth and maximum w_e value (See 3(b)). Rating for allowable working load shall include the designation of the allowable horizontal load per unit area. Thus a trench box that can be used in a 10 ft deep trench in soft clay may be rated as follows:

H_e = 10 ft (see 3(b) for symbols)
w_e = 80 lb/ft^3

Alternatively this trench box could be rated for an allowable lateral pressure of 960 lb/ft^2.

Rating of trench boxes and other protective devices shall also consider loads other than lateral loads attributable to construction and installation methods.

Trench boxes used at the bottom of sloped excavations shall be rated for the full equivalent height or the depth from the bottom of the excavations to level ground whichever is less, and shall protrude not less than 1 ft above the sideslope of the excavation.

Rating shall be ~~certified~~ based on a professional opinion by a licensed engineer in accordance with proposed Guidelines (see Appendix) and shall be valid for a period not to exceed 1 year. The rating and its effective date shall be permanently marked on the protective device.

*

APPENDIX

ENGINEERING GUIDELINES FOR THE DESIGN OF SHORING

SYSTEMS. AND OTHER MEANS TO ~~PROTECT~~ MINIMIZE MASS SOIL AND ROCK MOVEMENTS ~~WORKERS IN TRENCHES AND EXCAVATION~~

NOT FOR PUBLICATION
OR FOR REFERENCE

1. INTRODUCTION

When workers are required to enter any excavation deeper than 5 feet, protective measures must be taken in compliance with the OSHA Regulations for Excavations, Trenching and Shoring. OSHA recognizes that in the case of shallow trenches, where there is rapid progress of work, it is in many instances unrealistic to require that a licensed engineer be in responsible charge of the design of the shoring for all the portions of the excavation. It is also noted that even if an engineer designs the shoring under these conditions on the basis of soil exploration data, he has no knowledge of the subsurface conditions between borings. OSHA therefore stipulated protective measures which are deemed acceptable. These include the following: a maximum permissible slope in sloped excavations; empirical provisions for timber shoring; shoring systems designed to resist pre-defined lateral pressures which OSHA deems acceptable for a wide range of conditions; pre-fabricated shoring systems and protective devices such as hydraulic shores or trench boxes which are rated for maximum allowable loads they may be used to support or maximum depths to which they can be used under certain pre-determined subsurface conditions.

In the following instances a licensed engineer must be in responsible charge of the design of shoring systems ~~or other protective measures.~~ and/or slopes,

(1) Whenever the depth of the trench or excavation exceeds 20 ft in all soils, or 12 ft in soft clays.

(2) Whenever there is a deviation from the protective measures which are deemed acceptable by OSHA.

~~(3) For all excavations defined herein as long-term excavations.~~

Furthermore, a licensed engineer will have to provide a professional opinion regarding ~~certify~~ the rating of pre-fabricated shoring systems or trench boxes.

In some exceptional cases, it will be possible to modify the OSHA stipulations for acceptability on a regional basis, when a well documented case can be made by a licensed engineer on the basis of readily identifiable regional conditions and substantial past experience.

These guidelines are for professional engineers who design shoring systems or other means to protect workers in excavations. The guidelines are not meant to be a standard from which a professional engineer cannot deviate. Rather, they convey minimum design loads and safety margins (against mass soil and rock movements) which OSHA considers appropriate and design limit states which should be considered. It is recognized that the design of shoring systems, the stability analysis of slopes, and the assessment of soil conditions are not an exact science which can be approached with a set of rigid rules, but rather an art which requires judgment, experience and recognition of unique local conditions. Thus these guidelines can neither be imposed as mandatory rules, nor can a professional engineer forego his responsibility to determine in each instance whether the stated guidelines ~~provide adequate protection~~. are adequate.

2. Scope

The guidelines contain recommended minimum requirements ~~for the protection of workers in excavations against death and injury~~ to control mass soil and rock movements. They do not cover other important parameters which an engineer must consider, such as protection of adjacent structures, utilities and improvements against damaging settlements, or effects of ground water fluctuations on adjacent properties. They also do not cover other aspects of trench safety provided by the contractor, which are covered in other sections of the OSHA regulations.

Three methods of ~~protection~~ minimizing mass soil and rock movements are considered in the guidelines.

Sloping of the banks of excavations;

Shoring;

Shielding of the work space by protective devices.

Other methods could also be used such as soil stabilization by freezing or grouting.

*

4.3 Operational Loads

All loads caused by the anticipated excavations work must be considered. These include excavated or construction material supported by portions of the shoring system and workers climbing on the shoring system. The following minimum load should be used for design: A gravity load of 240 lb, distributed over any 1 ft long portion of any strut.

4.4 Dynamic Loads

which can reasonably be anticipated to occur as a result of

Dynamic loads ~~caused by~~ pile driving, blasting, traffic and construction equipment should be considered.

4.5 Restraint loads. Restraint loads caused by temperature, moisture, shrinkage, swelling or other dimensional changes in structural members of the shoring system should be considered when applicable. In general it can be assumed that the empirically-based lateral loads that can be calculated in accordance with these guidelines contain a reasonable allowance for temperature effects on struts.

5. Design Criteria

5.1 Sloped Excavations

5.1.1 Design Limit States:

1. Slope stability failure (part or all of the embankment)
2. Sloughing

5.1.2 Design Criteria

5.1.2.1 Long-term Excavations

Granular soils (no cohesion)
slope angle should not exceed angle of internal friction.

*

Cohesive Soils

The safety margin against stability failure should be greater than 1.5, unless monitered by an engineer by instrumentation or other means. In this once it should not be lower then 1.3.

Suitable surface and subsurface drainage should be provided to prevent stability failures or sloughing induced by seepage or erosion.

For deep excavations

6 ft wide benches should be provided at vertical intervals not exceeding 30 ft.

Maximum unbraced height of vertical bank:

5 ft for all soils or fractured rock. No limitation for sound ~~unfractured~~ rock, as determined by a competent geotechnical engineer or engineering geologist.

5.1.2.2 Short-term Excavations

The safety margin against stability failure should exceed 1.5 except that for dry cohesionless soils a slope angle equal to the angle of repose may be maintained. Short term strength properties could be utilized, provided that there are adequate safeguards against conditions which could cause strength degradation.

Maximum unbraced vertical bank: For intact hard clays the unbraced height could exceed 5 ft provided that there is substantial empirical evidence that the risk is not excessive. For all other soils, including fractured rock, the maximum unbraced height should not exceed 5 ft. There are no limitations for sound rock, as determined by a competent geotechnical engineer or engineering geologist.

5.2 Braced Excavations

5.2.1 Design Limit States

(1) Stability failure of the bank
(2) Base instability
(3) Partial caving or sloughing of the bank between spaced vertical or horizontal supports.

5.2.2.3 Soil Stability Between Spaced Supports

There is no generally accepted theoretical approach by which the ability of a soil to arch between successive supports can be evaluated or correlated with strength properties of the soil. There is empirical evidence that short-term supports can be spaced up to 8 ft on center in hard clay, very stiff sandy clays or glacial tills and 4 to 6 ft on center in slightly fissured stiff clays. Guidance can be derived on a regional basis from empirical evidence.

5.2.2.4 Soil Support for Struts, Anchors or Soldier Piles

A minimum safety margin of ~~3~~ 2 is recommended against bearing failures of members of the shoring systems such as raker braces.

A safety margin of not less than 1.5 against soil failure should be used when passive earth pressure is relied upon to support embedded portions of soldier piles and sheeting or deadmen.

All soil anchors should be proof load tested to 1.33 times their working load. If the load capacity of soil anchors is determined by tests, it should be not less than 1.5 times the working load for anchor inclinations of 1 vertical in 2 horizontals or less, and increase to 2.0 times their working load for inclinations of 1 horizontal in 2 verticals. When anchor capacity is determined by analysis the margin of safety should not be less than 3. Soil anchors subjected to the working load should not show measurable creep when the load is sustained for 15 minutes.

5.2.2.5 Design of Structural Components of the Shoring System

5.2.2.5.1 Applicable Standards

Structural members should be designed in accordance with the following standards:

A.2 References

The following references provide guidance which is considered adequate. Lateral loads calculated in accordance with these references are considered to be working loads.

(1) Peck, R. B., "Deep Excavations and Tunneling in Soft Ground," State-of-the-Art Report, Proceedings 7th International Conference on Soil Mechanic's and Foundation Engineering, State-of-the-Art Volume, pp. 225-250, Mexico, City (1969).

(2) Peck, R. B., Hanson, W. E., Thurnburn, T. H., Foundation Engineering, Chapter 27, John Wiley and Sons, New York, N. Y., Jan. 1974.

(3) Goldberg, D. T., Jaworski, W. E., and Gordon, M. D., Lateral Support Systems and Underpinning, Report No. FHWA-RD-75-129, Vol. II, Federal Highway Administration, Office of Research and Development, Washington, D.C. April, 1976.

(4) Department of the Navy, "Soil Mechanics, Foundations and Earth Structures," NAVFAC-DM-7, Chapter 10, U.S. Naval Publications and Forms Center, Philadelphia, Pa., September 1971.

(5) United States Steel Company, "Steel Sheet Piling Design Manual," U.S. Steel, Pittsburgh, PA., July, 1975.

(6) Joe De Salvo's paper ?

The preceding references contain design approaches which are not necessarily identical. However, all these approaches are widely used and are considered to be adequately conservative.

A.3 Summary of Information

Hereafter is a brief summary of information derived from the references listed in A.2. The suggested pressure envelopes are not intended as an

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THE NEIL HOUSE MOTOR HOTEL
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September 14, 1978

Mr. J.O. Bryson, Chief of
Construction Safety Program
National Bureau of Standards
Washington, D.C. 20234

Dear Mr. Bryson:

Due to conflicting commitments, I will be unable to attend your Trenching and Excavation Workshop on September 19th. However, I would offer some comments addressing your summary of recommended acceptable practice.

1. The main thrust of the recommendations seems to be the use of a licensed engineer to design shoring systems and determine adequate slope angles. In theory, or when confronted with unusual conditions, this approach can be the best course. However, in the everyday wrold of the contractor there are not enough available engineers with the expertise to design such systems for all of the anticipated work nor in the majority of cases is there a need for this approach. As has been recognized in the report, the rapid progress of the work, the known conditions and soil types makes the engineering approach additionally impractical.

   If an engineered shoring system were to become a requirement the annual installation of laterals to the nearly two million private dwellings would be economically impractical.

   A major problem confronting the contractor is the lack of recognition of consulting engineering firms for the need of protecting personnel during the installation of underground utilities. This problem is evident in restrictive right-of-way locations and the lack of provisions for payment of the additional materials needed.

2. Soil classifications and various shoring methods are the areas we experience the most problems of interpretation by OSHA inspectors. More technical data is needed on hydraulic shores and their limitations.

3. My investigations of cave-in accidents have revealed the cause of this type of accident was the complete lack of any protective measures, not failure of materials or devices used for protection.

4. Recognizing the many fatalities resulting from trenching operations demand standards of performance to minimize exposure we hope all factors will be considered before finalizing a regulation.

5. I urge that concensus recommendations be developed which will be the minimum allowable performance standards.

Sincerely,

Leonard Freed
Manager of Safety

LF:jj

AMERICAN LUMBER STANDARDS COMMITTEE

J. L. KELLY, Chairman
J. RAJALA, Vice Chairman
G. H. BOWERS, JR., Treasurer
T. D. SEARLES, Secretary-Manager

SUITE 204
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TELEPHONE: 301—972-1700

September 22, 1978

Mr. James O. Bryson, Chief
Construction Safety Program
National Bureau of Standards
Washington, D.C. 20234

Dear Mr. Bryson:

Thank you for the opportunity to comment on the proposed OSHA Regulations for Excavation, Trenching, and Shoring. Our comments will be limited to those proposals concerning lumber.

The American Lumber Standards Committee (ALSC) is appointed by the Secretary of Commerce. It is composed of manufacturing, distribution, and consumer-user representatives. Its purpose is to establish and maintain the lumber standards for the United States. Canada and Japan have adopted our standards. Grading rules conforming to the American Softwood Lumber Standard are used for virtually all softwood lumber produced in the United States and Canada. Those rules contain standard grades that are recognized by manufacturers, distributors, consumers, and purchasers of lumber throughout the United States. This standards effort was started in the early 1920's and is recognized throughout the world as a system that has accomplished a wide degree of lumber standardization. These standards are adopted by reference in purchase specifications and other requirements of FHA, DSA, GSA, and all major building codes.

We are opposed to development of additional standards or grades which are unnecessary and will cause confusion and possible misrepresentation in the market place. The NBS has recommended that allowable stresses be based on No. 2 as a minimum grade. However, the NBS analysis indicates only 80% of the pieces are No. 2 grade or higher and that these percentages do not reflect pieces that have wane and decay. The American Softwood Lumber Standard requires all grades (No. 2 in this case) to be 95% on grade to be in conformance and excludes lumber that has excess wane and decay. For NBS to set such arbitrary quality limits could be construed as permitting only 80% of the pieces to be on grade which could undermine the present standard and lead to competition to see who could furnish the lowest quality. Further comment on the NBS reports indicates quality control is necessary and can be implemented in two steps: (1) A specification; and (2) A grading system. It is our recommendation that the standard grading rules in existence be used by reference. If this is done, the quality control becomes a part of the system in that any purchaser has reasonable assurance that pieces containing an ALS-approved stamp are within the specification.

When standards are written, differences will occur in the interpretation and application. Therefore, a system is needed to assure that the standard is interpreted and applied uniformly. A major strength of the ALS system is that it provides this assurance thru a program of actual field inspections to see that the specifications are being applied uniformly.

The importance of having equal specifications in the market is illustrated in Paragraph 3.2.(c) Wane. . .where it is noted that 42% of the hardwood wales were reduced an average of two grades and 8% of the softwood wales were reduced an average of one grade. Wane did not appear to be a problem for softwood values. Whatever specification is finally adopted, if indeed such a specification is necessary, must require equal quality levels. Under the American Lumber Standard system, stress levels are assigned to all grades including No. 3 in softwood dimension lumber. Stress levels are also assigned to Post & Timbers and Beams & Stringer sizes. Use of the present system would be a simplification of the proposal and would do away with the necessity of having another method of assigning and applying both grades and stress levels.

The slope of grain under Paragraph 3.2.(g) indicates 95% of the hardwood values had a slope of grain of 1:20 or less. Since slope of grain is an important indicator of strength and the steeper the slope the weaker the piece, it would be imperative to know the slope of grain in individual pieces; i.e., 1 in 6, 1 in 8, or 1 in 10, before any conclusion could be made regarding assignment of values. This is an example of how interpretations are needed and play an important part in a standard. Slope of grain of 1:20 or less means that 95% of the piece had a slope of grain of less than 1:20 and thus would not be intitled to the values for straight grained lumber. It appears a different meaning was intended.

In summary, we recommend that any system devised incorporate by reference the national standards, grades, and quality control now in existence and that no additional standards, grades, or quality control programs for softwood be included in the NBS recommendation to be forwarded to OSHA.

Hardwood could be graded to existing specification; i.e., No. 2 grade, and strength properties could be assigned based on the same methodology already approved by NBS and the Forest Products Laboratory. The National Hardwood Association, 332 S. Michigan Avenue, Chicago, Ill. 60604 should be requested to furnish the necessary information.

Thank you for permitting us to comment on the NBS proposal. If we can furnish you with any additional information, please advise. We will appreciate your keeping us informed of further developments.

Sincerely,

Thomas D. Searles

Thomas D. Searles
Secretary-Manager

TDS/SKW

cc: R. Hewitt, NFPA
Administrative & Finance Subcommittee

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Forest Products Laboratory, P.O. Box 5130
Madison, Wisconsin 53705

4040 (NBS)
October 11, 1978

Dr. Felix Yokel, Chief
Geotechnical Engineering Program
National Bureau of Standards
U.S. Department of Commerce
Washington, DC 20234

Dear Dr. Yokel:

I would like to pass on to you both reflections on the workshop and further specific comments on the text as prepared for the workshop.

You are to be commended on the workshop. It was well formulated and carried out in a professional way. I was pleased to be able to participate and felt that I learned a great deal as a participant.

I tend to agree with the comments of the AGC and others--that regional reviews are desirable. And I disagree with Mr. Tom Seymour on timing. Of course, I appreciate there are monetary concerns. Nevertheless, if there is justification for <u>any</u> workshop before completion of the technical documents, there is justification for more balance than was present in D.C. We may have met our mutual administrative need as specified in our contract relationships, but I feel that if NBS needed this feedback we have to recognize it has a heavy geographic bias. We (the technical input) will have to be extremely careful in our response to this workshop in recognition of these limitations.

I would also like to address, for the record, our notion of certification. I'm not sure professional engineering requirements are as untenable as some proposed. For example, no code people were present to represent views which can be expected to go beyond worker safety, of course, but also may have to be anticipated as a potential jurisdictional conflict. However, if a PE cannot be required and if no contract or licensing procedures are available, the alternative we discussed is to conduct certification workshops in each State using the facilities of land grant engineering extension and the cooperation of AGC, etc.

6200-11 (1/69)

I do have one constructively critical comment concerning the presentations on soil and timber made by you and Dr. Tucker. Basically, as engineers we can be firstly positive in our observations on successful traditional practice and secondarily correctly negative about our inability to put the analytical tools together to explain present practice. Note I did not say to justify present practice.

In particular we need to be careful about statements that imply soil or wood (both natural materials) do "not check out." The materials don't "not check out." Our engineering data and capabilites don't measure up to the task. This is a decidedly different statement. For example, I am absolutely convinced that if we had the correct soil data, more wood variability information, and the correct analytical models for composite structural performance, we could explain the past performance of soil and timber in trenches. As you and I discussed in 1973 or 1974, as a matter of fact, deterministic design methods are almost totally incapable of addressing this problem.

All the above was in your messages and those of Dr. Tucker, but the emphasis appeared to be reverse in some cases. I'm convinced that many in the audience didn't fully understand the serious nuances of the comments that you made. I don't like to see too much emphasis on ignorance to the wrong audience; your engineering guidelines are perhaps the correct place to be explicit on these matters.

Another matter that came up, but which was foggy because of the somewhat adversary positions taken, was the need for alternative routes for product acceptance. I believe this is essential, particularly when proprietary products would be involved. These products also may "not check out" because of inadequate data. A very difficult subject is whether empirical methods of acceptance can be used, perhaps based on tradition and on comparison with other traditional systems. I have no good suggestions to make in this regard except to echo the comment made at the workshop--that perhaps provision needs to be made for something like the research card approvals of ICBO.

I have a few specific comments on the text handed out, in addition to those in my letter of September 14:

1. In section 1, 3(a), rating, the 3rd paragraph states that the "rating shall be valid for the period of time stipulated by the licensed engineer of for 1 year, whichever is less ..." (underline is mine). This statement will be at variance with our use recommendations of a maximum of 9 months of effective use for a site

index greater than 65. This is because of the intense decay hazard in these areas. The easiest way to side step this dilemma would be to change 1 year to 9 months. Maybe there are other ways.

2. There seem to be discrepancies between tables la and 1 because la includes 4 by 4's, while the smallest size in table 1 is 4 by 6. Is there a column missing in table 1?

3. I suggest the Use Recommendations for Timber be made a specific part of the engineering guidelines (perhaps a section 5.2.2.5.3) by reference at least, so that the attention of the engineer is drawn to the recommendations. Nowhere in the documents as presented is there any recognition of the specific concerns for storage, useful life, etc.

4. The wane limitations in section 3 are based on performance criteria far more severe than those placed on strength ratios. There are two concerns here: (a) Liberalization would more correctly represent what the survey identified as current successful practice. (b) At a minimum, we suggested adopting the SPIB wane for No. 2 SR--but it should be recognized that these limitations are not based on structural assessment of a cross section loss. The question boils down to the fact that it would be easier to accept the southern pine wane limitations for all of the grades and sizes (i.e., No. 2 for dimension sizes and No. 2 SR for the larger sizes), but this still might be restrictive on hardwoods. Is there any point in trying to liberalize for hardwoods?

5. In the engineering guidelines for <u>load capacity</u>, there is a potentially serious, hazardous definition. The factor 1.65 applies only to very large sample sizes, implying the samples are a very accurate representation of the true population. Since no minimum sample size is specified, we court disaster if an engineer decides to test only a few specimens, assumes normality, and uses 1.65. As noted in my earlier correspondence, the NBS monograph by Natrella offers a better alternative of a factor that is sample size dependent, and it also requires the engineer to face the issue of the confidence he must have in the result. Many engineers are not acquainted with this issue. This is the place to draw the line and give the engineer the Natrella reference, instead of 1.65. The basic definition remains the same, but the factor is defensible.

Secondly, some materials will be found to have definitely skewed distributions rather than normal. This can result in either highly conservative or highly liberal results. I suggest that this section have a sentence warning that the engineer be alert to high degrees of skewness and to seek help in analysis if such is found.

6. I addressed the strength ratio problem very briefly in my letter of September 14. I believe that Dr. Knab and I should work out the appropriate ways of handling strength ratio in subsequent versions of the document as well as in his analyses. We have had some tentative discussions already. The issue here merely is that the commercial grade that we used as a reference point actually contains a range of effective strength ratios because of the need to permit a variety of member sizes in the same category. I believe these are technical concerns that Dr. Knab and I can resolve.

Again, let me congratulate you on the way in which the workshop was handled, and I hope something can be resolved for additional input from other geographic sectors of the United States.

Sincerely,

WILLIAM L. GALLIGAN, Project Leader
Engineering Properties of Wood

cc: J. Bryson
L. Knab
A. Bendtsen

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October 12, 1978

Dr. Felix Yokel
National Bureau of Standards
Room B 168, Building 226
Washington, D.C. 20234

Dear Felix:

The seminar on shoring method and that cross section of persons was very interesting.

In your closing statements you requested that each of us address a letter to you outlining any ideas, suggestions or otherwise that we may have.

My general comments are as follows:

1. I felt that the final recommendations on timber shoring were unsatisfactory. Admittedly, the structural strength of these pieces can vary with the individual unit and cannot be depended upon consistently. As consistency and safety go hand in hand, then timber specifications can clearly not be used in a safety standard unless a design overkill sufficient to eliminate chance, be instituted. Undoubtedly, this would change the specifications as now published to a significant degree.

2. I was frankly amazed that no discussion or study was made as to the effect of preloading the trench wall. While I heard some mild discussion in general assembly, (I was not in the specific method workshop) the whole subject seemed generally ignored. I would like to see a recognized study made of preloading effect, with the results published for the general industry.

All in all I thought it an excellent meeting and most effective in every way. If I can ever be of assistance in this or any other such work please do not hesitate to let me know. As former operations manager of Equipment Guidebook Company, a firm that publishes several explanatory manuals on OSHA regulations, etc., I have had considerable experience along this line.

Very best regards,

Robert O. Middleton

NATIONAL UTILITY CONTRACTORS ASSOCIATION

815 Fifteenth Street, N.W. • Washington, D.C. 20005 • Phone/Area Code 202 737-0037

October 16, 1978

Dr. Felix Yokel
National Bureau of Standards
Bldg. 226, Room B-168
Washington, D. C. 20034

Dear Dr. Yokel:

Following the NBS workshops, we summarized several of the topics discussed and solicited comments from our membership.

On that basis, the National Utility Contractors Association would like to endorse the following changes in the OSHA standards:

1) The standards should not require that the services of a registered professional engineer be obtained on trenches conforming to certain physical criteria. The standards should stipulate that specific standards be met but also permit the option of obtaining engineering services if the contractor so desires regardless of the configuration.

2) Compound trenching should be permitted by the standards. The primary trench (that portion with vertical walls) can be no deeper than three feet before trench shoring must begin. Case II as proposed should be considered adequate.

3) The standards for trenching and excavating should be kept entirely separate.

4) A simple soil classification system which would distinguish AT LEAST four different soil categories would be an asset to a trenching contractor.

5) Trench boxes should not be required to ride on the bottom of the trench. Ease of laying pipe is increased with adequate safety provided if the trench box rides about two feet up from the bottom of the trench.

6) If a trench has compound sloping with shoring being provided in the primary trench, the shoring members are to extend a reasonable height above the vertical walls such that soil material cannot roll or slide back into the trench.

7) Shoring in a shored trench should not be required to extend to the bottom of the trench. The shoring should be kept within two feet of the trench bottom.

8) Shoring should be encouraged to be included in contract

We dig America

documents as a bid item.

9) A means of exit should be provided in all trenches. This should not necessarily be required to be a ladder. A sloped bank is often quite adequate as a means of entrance and exit in a trench.

We do not agree than an engineering analysis should be required for trench boxes. We feel that this requirement would impose undue hardship on our members since many contractors build their own boxes. We feel that there is no evidence that suggests that trenchboxes are not sound.

We would like to thank you for allowing us to participate in this process and hope our input will be of some value.

Sincerely,

Robert G. Griffith

Robert G. Griffith
Chairman,NUCA Safety Committee

cc: Goodwin, Shevock

ASSOCIATED CONTRACTORS
OF NEW MEXICO
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SANTA FE, NEW MEXICO 87501
JAMES E. HOLLIS, Manager

October 18, 1978

National Bureau of Standards
Room B 168, Building 226
Washington, D.C. 20234

Attention: Felix Y. Yokel

Dear Mr. Yokel:

Regarding the revision of Subpart P, of the 1926 Construction Standards, the Associated Contractors of New Mexico wish to make the following comments:

1. The requirement of a designing engineer as proposed is unfair and impractical.

    a. It does not provide the option of recommended slopes based on soil classification deeper than 20 feet or left open for more than 48 hours.

    b. It neglects consideration of the small contractor who may not intend to leave a trench open for 48 hours, but due to circumstances beyond his control may have to.

    c. It does not consider such items as subdivisions where a 5 foot manhole is allowed to remain open. Surely NBS and OSHA would not intend to have an engineer design 20 cuts for manholes in a 5,000 foot sewer system.

2. It does not define sound unfractured bedrock. As stated, all trenches in rock would require shoring or be slopped to be in compliance.

3. The language is not clear in reference to trench boxes used at the bottom of slopped excavations.

We believe that one meeting in Washington is not adequate to get public response to revisions of a very major item in the standards. More meetings in other areas of the country would seem mandatory to get the maximum input to the final decisions. We urge you to consider these requests.

Very truly yours,

James E. Hollis
Manager

cc: A. L. Schmuhl, Director
Safety and Health Division
The Associated General Contractors of America

APWA-Utility Committee

Safety Committee

Joe Kinnikin
Director of Safety, ACNM

BIG RED SAFETY & PRODUCTION, INC.

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December 1, 1978

Felix Y. Yokel
Chief, Geotechnical Engineering Program
National Bureau of Standards
Washington, D. C. 20234

Dear Felix:

Thank you very much for taking the time from your busy Holiday schedule to meet with us last Wednesday, the 22nd. Hope your Thanksgiving Day was as enjoyable as ours. Jean and I are looking forward to your visit out here. We will send you full information on the Cal-Poly seminar as soon as it is set.

To make good suggestions on your summary, I sent the comments and recommendations that NUCA people sent to me, to the Underground Contractors Association members here in Northern California, with comments of mine for consideration. Since I have returned, I have a few that have been sent back to me. In general, they all OK what NUCA presented.

Enclosed are these 11 points and my comments, along with 6 points of my own.

I will be getting into your summary deeper for additional comments and will send them to you as I do.

I can see now that it is going to be most important that we hold a meeting on this here on the West Coast. Perhaps this can be done in April when NUCA is having its West Coast Conference in San Francisco. The dates are April 25 through 29, 1979. I am trying to set the seminar at Cal-Poly for April 19 and 20, 1979. This would be a good time for another summary meeting here in the Bay Area,--say April 23-24 . I can pull AGC and others involved into it.

I will be in touch with Dr. Wall at Cal-Poly this week and get more information tied down.

Thanks again.

Very truly yours,

W.M. "Red" Cass PE

WMC/nlb

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COMMENTS & RECOMMENDATIONS

1. [NUCA] OSHA standards should require that trench boxes have an engineering analysis to show that adequate protection is provided for workers in the trench. Each box should be permanently marked as to the lateral earth pressures which can be supported. The marking should indicate the source certifying the trench box strength. The fabricator should be responsible for the certification.

   OK ☐ [Red's Comments] Certification by a Registered Engineer.

2. [NUCA] Contractors should be required to document their safety training efforts such as safety meetings, first-aid courses and emergency drills.

3. [NUCA] The standards should not require that the services of a registered professional engineer be obtained on trenches conforming to certain physical criteria. The standards should stipulate that specific standards be met but also permit the option of obtaining engineering services if the contractor so desires regardless of the configuration.

4. Compound trenching should be permitted by the standards. The primary trench (that portion with vertical walls) can be no deeper than three feet before trench shoring must begin. Case II as proposed should be considered adequate.

   OK ☐ [Red's Comments] We are, at present, working with three and one-half feet vertical then sloping. This has been well engineered for AGC contractors here in the state.

5. The standards for trenching and excavation should be kept entirely separate.

6. A simple soil classification system which would distinguish four different soil categories would be an asset to a trenching contractor.

   OK ☐ [Red's Comments] For the past 10 years, we have been having field training personnel here in Northern California use a Trench Wall Standing Time, rather than using highly qualified soil categories. This has worked very well and has begun to get the attention of Civil Engineers, both in the field and in universities.

7. Trench boxes should not be required to ride on the bottom of the trench. Ease of laying pipe is increased with adequate safety provided if the trench box rides about two feet up from the bottom of the trench.

8. If a trench has compound sloping with shoring being provided in the primary trench, the shoring members are to extend above the vertical walls such that soil material cannot roll or slide back into the trench. This extension should be about 18 inches.

9. Shoring in a shored trench should not be required to extend to the bottom of the trench. The shoring should be kept within two feet of the trench bottom.

   OK ☐ [Red's Comments] Two feet from the bottom of the trench has been in our code for several years.

10. Shoring should be encouraged to be included in contract documents as a bid item.

    OK ☐ [Red's Comments] This has een law here in California since 1973 (AB150 Paragraph 6707). It has become over 90% effective. However, we do believe that all bids, where trenches are five feet or more in depth, have the bid item for shoring. Not just government agencies.

11. A means of exit should be provided in all trenches. This should not necessarily be required to be a ladder. A sioped bank is often quite adequate as a means of entrance and exit in a trench.

OK ☐ [Red's Comments in addition to the above] OSHA, on a national level, should set up Basic Shoring Safety Training Schools, such as those I have developed for the American Society of Safety Engineers of Sacramento, California. The school and bid item are a must for this modern age.

OK ☐ The service of a registered Civil Engineer should only be required when shoring system is other than shown on the codes.

OK ☐ We would like to see that there be no open trench overnight, weekends or holidays. In those areas where it is necessary to leave the trench or excavation open, the area should be fenced eight feet or secured by other means.

OK ☐ We would like to see, when trench is being dug on existing streets, that at least one block be completely closed to traffic except emergency & mail. Our survey shows this would allow completion of projects 25% quicker.

OK ☐ We feel that all OSHA personnel should be better trained for observing trench operations. The untrained person has caused problems and hardships for the contractor in the past.

OK ☐ We should have a Safety Committee of not more than 10 people from across the U. S. to carefully go over all considerations.

YOUR COMMENTS:

1. ....

2. ....

3. ....

4. ....

5. ....

6. ....

7. ....

8. ....

9. ....

10. ....

11. ....

SOIL TESTING SERVICES
111 PFINGSTEN ROAD NORTHBROOK, ILLINOIS 60062
PHONE Chicago 312-273-5440 Northbrook 312-272-6520

January 2, 1979

Mr. Felix Yokel
National Bureau of Standards
Center for Building Technology
Structures Section
Building 226, Room B-168
Washington, D. C. 20234

Dear Felix:

Several months ago, I received a copy of the "Summary of Findings and Recommendations to be discussed at the Federal Workshop on Excavation and Safety" document, prepared by the National Bureau of Standards. Unfortunately, I was unable to attend the September 19 workshop and apologize.

At the level at which these findings and recommendations are presented, I have a number of comments that I will make subsequently in this letter. These comments will deal with the Section 1 on Technical Provisions, Section 2 on the Soil Classification System, Section 3 on Allowable Stresses in Timber Shoring, and Section 4 on the Summary of the Field Survey.

However, I would like to comment first on the entire question of job safety and methods of improving job safety.

LEVELS OF RISK ACCEPTABLE TO SOCIETY IN U.S.A.

On the broadest possible level concerned with worker safety in the construction industry, construction is a risky business and all risks cannot be eliminated. In this regard, I might point out that in 31 years of professional practice, we have had no deaths due to our field operations involving soil exploration, or caisson inspection, or any other job related activities. However, we have had approximately a dozen employees die in 31 years, all due to automobile accidents in personal vehicles not on company time.

John P. Gnaedinger, P.E.
Clyde N. Baker, Jr., P.E.
Robert G. Lukas, P.E.
Safdar A. Gill, Ph.D., P.E.
Douglas E. Keats
Kenneth H. Kastman, P.E.

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- Foundation Borings and Testing
- Environmental Testing and Evaluation

I realize that the much greater risks involving automobile travel should not in a sense have any influence on deliberations of job safety, particularly job safety involving trench excavations, but this is mentioned only because society does accept a certain level of risk involving travel and there must be a comparable attitude toward excavation safety, particularly since EPA requires every community to have a safe water supply and sewage treatment systems, installation of which requires trenching.

THIRD PARTY INVOLVEMENT

If the risks involving excavations were to uninvolved third parties, such as is the case with many automobile accidents, then perhaps society should have a greater concern. However, the risks are in fact almost always to the persons involved in the construction itself. In a majority of the cases that I have been aware of, the injured workman was himself at least partially and frequently solely responsible for his injury or death.

In spite of the negligence of the workers who are injured, the system is so designed that it is the employers who in fact are held responsible, whether they should have been or not, and are held financially accountable, funded through insurance premiums. Designers, owners and other contractors frequently are the victims of contingency fee lawyers' lawsuits that are filed on a shot gun basis, and therefore include many firms involved with a project which had nothing to do with the accident.

To try to improve job safety involving excavations without dealing with the need to enforce the laws of barratry and maintenance against contingency fee lawyers and shot gun suits, is not likely to be productive.

NO FAULT WORKMEN'S COMPENSATION

Workmen's compensation insurance was created more than 40 years ago, I believe, as a no fault concept to reimburse workers for the medical care, lost income, and other costs involved with job injuries and death. Certainly some states have miniscule compensation rates that need revision, but it seems to me that on the establishment of adequate compensation rates for injuries, that legislation should be passed in each state that will in fact make workmen's compensation the sole remedy for job injury.

Since it has been estimated that as much as 83% of the cost of workmen's compensation insurance goes to legal fees for the plaintiffs and the multitude of defendants, and insurance administration, a no-fault concept would substantially reduce workmen's compensation insurance rates, at the same time permitting a greater portion of the present insurance premiums to be used to increase compensation to the injured workman.

CONSTRAINTS AGAINST SAFETY

However, on a broader level, because every participant to the construction process considers himself a sitting duck waiting for some contingency fee lawyer to sue him for something that was not his responsibility, all of the participants to the construction process are gun shy and are warned to stay away from matters involving job safety because that is the responsibility of the general contractor on a project. It would be highly desirable that all participants to a project, including the geotechnical engineers, could in fact discuss matters of job safety openly, without fear that the mere mention of job safety in a report would give the contingency fee lawyer all he needed to win a decision against the concerned party.

It is therefore my firm opinion that great improvements in job safety could be accomplished through tort reform, workmen's compensation reform, and cooperative job safety attitudes and procedures, to replace the present adversarial system where most of the money goes to lawyers who have no qualms whatsoever about citing a geotechnical engineer's comments on job safety as evidence to bypass workmen's compensation remedies for an accident.

For those states where workmen's compensation rates are inadequate, supplemental accident insurance can be purchased, I understand from knowledgeable people in the insurance industry. That would then permit, on a project basis, raising the level of compensation to any injured workman to a national standard. The standard should however vary from place to place in the country because of differences in medical and other costs.

IS GOVERNMENT REGULATION EFFECTIVE?

The entire concept of OSHA should be subjected to scrutiny, as well as its attitudes and procedures.

I'm sure that you, I and the formulators of OSHA, all agree that job safety is a very worthwhile goal, and that every effort should be made to provide adequate compensation to injured workers. However, it is not axiomatic that a government program is the best way to achieve job safety. It is unquestionable that OSHA costs the taxpayers a lot of money directly, and costs the consumers a lot of money through increased cost of construction in order to comply with OSHA regulations. Nothing is free and both the taxpayers and the consumers should be aware of the cost increases resulting from OSHA regulations.

However, even worse, in spite of OSHA regulations being in effect for eight years, it is my understanding that there have been just as many construction job accidents with the regulations as there ever were without the regulations. I am sure you have better information than I do, but at least we know that there have not been substantial reductions in accidents, judging by the continuous increase in workmen's compensation rates, inflation notwithstanding.

On an attitudinal level, it seems to me that the basic premise of applying negative sanctions to firms not complying with OSHA regulations is a win-lose attitude. What we need is a win-win attitude, showing everyone that an improvement in job safety will also, besides being humanitarian in its goals and results, results in lower costs and fewer delays.

To simply create safety regulations, and then fine contractors who ignore the regulations, does not really bring any injured workman back to his original condition, certainly not one killed in a construction accident. It has long been known that punishment of any type, including the death penalty, does not serve as an effective deterrent to crime. By the same token, the threat of punishment to an employer does not necessarily serve as an effective deterrent to accidents, largely because the attitude among workers toward job safety is wrong.

The Department of Labor several years ago sponsored through the Laborers' International Union, a job safety training program, support for which was later dropped. This program was open to workers and contractors as well. However the number of people attending was a drop in the bucket. Furthermore, the support for the program was dropped.

It is my opinion that a win-win approach to the problem would be to create a required course in job safety, for all design and construction engineers and architects as a part of their curriculum, all contractors and subs, and for all workers as a condition of employment. I don't think that millions of dollars necessarily has to be funded through the unions to do this, but existing institutions dealing with civil engineering and construction should offer the courses to undergraduates, to graduate students and on a continuing education basis to workers, contractors and subs.

Extension services of the schools should provide local training programs on job safety as a condition prerequisite to working on a construction project. Wallet cards showing completion of such courses should be on the person of every person working on a construction project.

It is not sufficient to require that apprenticeship programs incorporate such safety training elements, because only 11% of the journeymen in the construction industry actually went through apprenticeship. However, the lessons learned in the safety training programs organized by Laborers' International Union could well serve as a model for creating additional programs.

WORKER SELF-INTEREST

It is the worker in a trench or excavation who has the greatest opportunity to protect his own health and life. Where a worker does not wear his hard hat or does not wear steel-toed shoes, or smokes in a tunnel or excavation where gas is always a risk, this should not result in negative sanctions against his employer. Furthermore, other firms on the job who are not his employers should never be involved, whatever the demands of the American Trial Lawyers Association. Is there no justice??

WIN-WIN JOB SAFETY COOPERATION

Providing that the tort reform and workmen's compensation reform previously mentioned are implemented, it is my personal feeling that geotechnical engineers, architects, structural engineers, and others involved with the construction process should also have training in job safety. The individual engineers should acquire certificates in job safety, as should the workers.

Assuming again that the above changes in tort procedures have been implemented, then I think a new approach to job safety should be created by requiring, at least on federal projects, that there be a safety team in which every participant to the project must participate, though to appropriate degrees. In other words, if a geotechnical engineer makes soil borings and writes a report long before the construction starts, and has no one on the job during construction, his involvement would be minimal, while the general contractor would have a continuing involvement and should in fact have one person designated as the job safety director. For small jobs it would probably be the superintendent but on large jobs it may be someone's special responsibility. However, instead of everyone being fearful of reporting on unsafe conditions for fear of assuming liability that is not his, this would result in a situation where everyone would feel a concern for job safety and would not feel constrained to suggest to the individual whose life was at risk, or to the safety director, that certain things should be changed. However, to require this responsibility of all parties to the process, without tort reform, training processes, and workmen's compensation reform would compound the problem.

CONCERN FOR SAFETY

With regard to the excavation standards, there is no question but that a geotechnical engineer can greatly improve job safety to the extent that he is involved in the project, not only before construction, but during construction. I am not at all comfortable with the efforts of design professionals to limit their responsibility to permanent construction, leaving temporary construction and bracing entirely up to the contractor.

However, I attribute this problem solely to the contingency fee lawyers with their shot gun suits, not to the indifference of geotechnical engineers or architects or structural engineers to the safety of the workman.

LEARNING FROM EXPERIENCE

There would be a further benefit if workmen's compensation reform and common employer concepts were adopted, in the way of permitting free and open discussions of previous accidents and failures. Fear of litigation prevents knowledgeable parties about construction accidents from permitting others to learn and benefit from knowledge of the causes of the accident. Case histories and failures should be a common element, perhaps even forming the structure of an information document that could be circulated throughout the industry by OSHA or by an industry group. The virtue of this system is that the information would be factual and timely and everyone would recognize his own vested interests in avoiding the problems that created the accident or injured the workman. Such information cannot however be submitted now to the public eye because of the fear of incrimination of the party or parties involved with the accident.

OSHA EXCAVATION STANDARDS

With regard to the summary of findings and recommendations that you have prepared, beyond the comments submitted to you by Jim Kleinfelder, I do not have any additional serious criticisms.

I do know from direct knowledge involving three or four construction accidents in recent months that the present standards are ambiguous. Particularly with regard to the Soil Classification System, the new document is obviously a great improvement, though I do favor the matrix classification system, rather than the simplified system.

RESEARCH

With regard to other techniques for improving construction safety, it is my personal opinion that slurry methods could be used for installing sewer, water, and other piping, to minimize the need for workers to actually be in trenches. Such techniques need subsidy in terms of developing them. To my knowledge, other then dozens of slurry walls and slurry trenches constructed in this country in the past ten years, I am not aware of a pipeline or sewer being installed by a slurry method. This I think bears research effort subsidized perhaps by OSHA.

In the discussions of job safety, little is said about the tremendous pressures on contractors to cut every corner because of the fact that they were selected for the work because they had the cheapest price, not because they had the safest jobs. On a long-term basis, perhaps it could be shown that only a safe job can be profitable, but on a short-term basis, most contractors cut the corners and incur risks that are in fact a state-of-the-art in the construction industry.

Furthermore the state-of-the-art in the construction industry is different than the state-of-the-art in the geotechnical engineering profession. As long as the general accounting office and other government agencies insist on picking contractors for the cheapest price, and ignore whatever extra cost the contractor might incur in order to improve job safety, one might almost blame the owners and government agencies who demand competitive bidding for some of the cost cutting that results in less than a reasonable amount of job safety. Furthermore, this problem is compounded by the fact that even if a soil study is made for a pipeline job, and frequently they are not made, the chances of variations in soil conditions between boring locations are substantial. Yet it is very infrequently that a soil engineer is present on the site.

I think it is therefore crucial that the backhoe operators and the plumbers and laborers all be able to function as paraprofessionals in their own self-interest, certainly sufficiently to be able to differentiate sand from clay, to recognize seepage, to look for shrinkage cracks and evidence of impending slides, and generally to be familiar with the primary sources of risk in excavation and trench work.

I hope these ideas are useful to you. I'm sorry they didn't get to you before your October 20 deadline, but at least now you have them.

Sincerely,

SOIL TESTING SERVICES, INC.

John P. Gnaedinger

/bh

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☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

A two-day workshop was held at the Department of Labor in Washington, D.C. on September 19-20, 1978 to obtain opinions from knowledgeable people on tentative conclusions and recommendations of a NBS Study on excavation safety. The workshop agenda included a series of presentations on Tuesday, September 19, 1978 and a series of group discussions on Wednesday, September 20, 1978. The topic areas covered in the group discussions were:

1) Soil Classification;
2) Acceptable Measures to Protect Workers Against Death by Caving of Banks in Trenches and Excavations; and,
3) Role of the Professional Engineer and Engineering Guidelines.

This report summarizes and synthesizes opinions expressed in these group discussions and presents comments provided by correspondence after the two-day workshop.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

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