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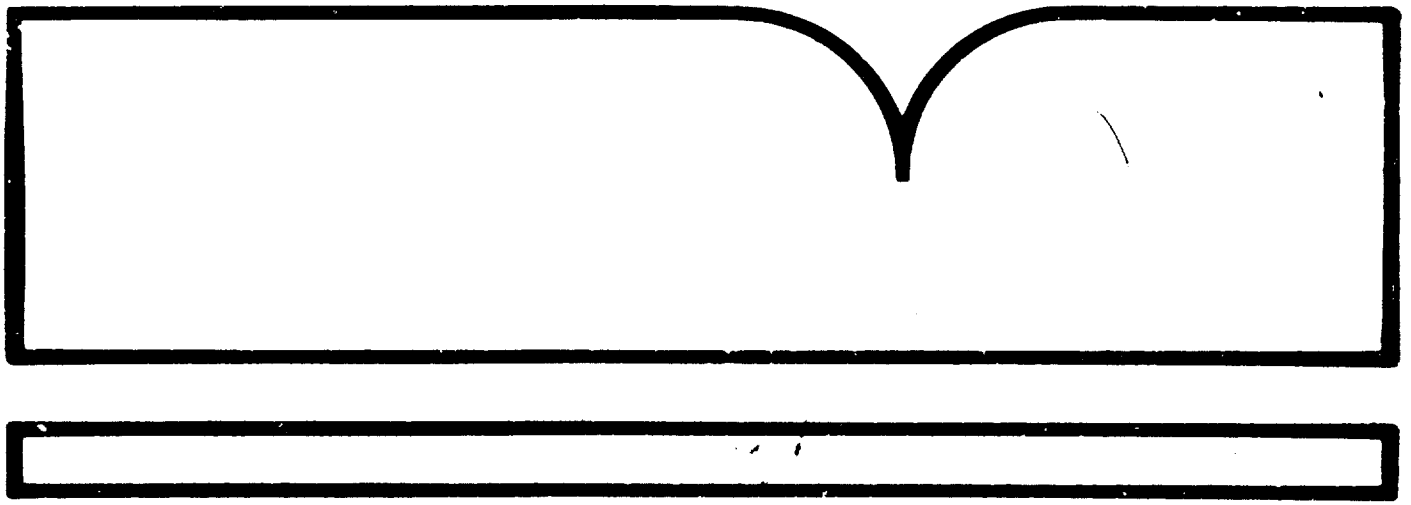
Development of Draft Construction Safety Standards for Excavations. Volume 2

(U.S.) National Bureau of Standards
Washington, DC

Prepared for

National Inst. for Occupational Safety and Health, Morgantown, WV. Div. of Safety Research

Apr 83



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Felix Y. Yokel and Ronald L. Stanevich

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

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National Institute for Occupational Safety and Health
Division of Safety Research, Morgantown, WV 26505

10. SUPPLEMENTARY NOTES

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

11. 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 record of an interim stage in the development of revisions to existing Occupational Safety and Health Administration (OSHA) regulations governing excavations, trenching and shoring practices in the construction industry, Subpart P 29 CFR 1926, is presented. The National Bureau of Standards (NBS) prepared a working draft of recommended changes to the regulations based on previous NBS technical studies.1/ Five regional industry workshops were held to discuss the proposed revisions. Included in the report is a copy of the recommended revisions, which were submitted to the workshops, and a record of industry's response in the form of suggestions, commentary and summaries of workshop activities. The key section of the report presents an analysis of industry response and resulting recommendations. The document is a record intended to aid OSHA during subsequent stages of the rulemaking process.

1/ Yokel, F. Y., "Recommended Technical Provisions for Construction Practice in Shoring and Sloping of Trenches and Excavation," NBS Building Science Series 127, June 1980.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

braced excavations; construction; Federal regulations; retaining structures; safety; shoring; slope stability; soil classification; soil pressures; standards; trenching

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An NBS/NIOSH Publication

Volume II

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
Center for Building Technology
Geotechnical Engineering Group
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April 1983

Prepared under Interagency Agreement No. 82-06-M for:
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DEVELOPMENT OF DRAFT CONSTRUCTION SAFETY STANDARDS FOR EXCAVATIONS

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U.S. DEPARTMENT OF COMMERCE
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and

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

TABLE OF CONTENTS

1. INTRODUCTION

This volume contains background information and supplements Volume I of the report. Section 2 contains workshop summaries prepared by the NBS author and by workshop organizers; Section 3 contains responses by the NBS author to correspondence associated with the industry workshops; Sections 4 through 8 contain depositions made in the five workshops; Section 9 contains source documents for the present version of Subpart P; and Section 10 contains miscellaneous input and information contributed by workshop participants and others.

2. WORKSHOP SUMMARIES AND PROCEEDINGS

The following workshops were held:

Milwaukee, WI	June 9, 1981
Atlanta, GA	June 16, 1981
Dallas, TX	June 30, 1981
San Francisco, CA	July 9, 1981
Boston, MA	July 14, 1981

This section contains a memorandum by the NBS author on each of the workshops which summarizes the comments. Depositions made in the workshops are attached to these memoranda. Additionally, there are reports by the local sponsors on the Milwaukee, WI, and Dallas, TX, workshops.

The workshop reports contain information on the workshops as well as analyses of some of the comments and depositions.

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234
Bldg. 226, Room B162
(301) 921-2648

June 23, 1981

Mr. Edward Hayden
Mr. Arthur Schmuhl
Mr. James Lapping
Mr. John Ramage
Mr. Paul Bouley
Mr. Ronald Stanevich
Prof. Jack Mickle
Mr. John Pannullo

Gentlemen:

Attached is a copy of my draft memorandum on the Milwaukee Workshop. Please send me your comments before July 3. I shall revise the memo after I receive your comments. In particular, I want to make sure that I have no inaccuracies and that I didn't fail to address important issues which were raised.

Sincerely,

Felix

Felix Y. Yokel, Leader
Geotechnical Engineering Group
Structures and Materials Division
Center for Building Technology, NEL

Attachment

cc: Mr. John Chambless
Mr. William Driskill
Mr. Paul Henson
Mr. Clifford Simmons
Mr. Bill Zoino

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234
Bldg. 226, Room B-162
Phone (301) 921-2648

D R A F T

June 23, 1981

MEMORANDUM FOR Records of the NIOSH Excavation Project

From: Felix Y. Yokel

Subject: Workshop in Milwaukee, Wisconsin, June 9, 1981

This memorandum is to record my overall impression and my reaction to important questions that were raised in the Workshop. A Workshop Report, containing recommendations is being prepared by the Organizing Committee, using taped records and written depositions.

(1) General: There were both negative and positive comments. However, it is in the nature of this type of a Workshop that individuals who have negative comments and recommendations for change will go on record, while those who generally agree with the recommendations will see no need to make a statement. There were some statements particularly from contractors from Illinois, that a change in the present standard is not desirable. To the extent that these statements are not accompanied by specifics it is difficult to determine whether the status quo is considered desirable because Subpart P as written is satisfactory or because of the fact that the present version of Subpart P is unenforcable.

(2) Soil Classification: There were substantial comments to the effect that a 1/2 to 1 slope should be permitted in Type A soil In a technical sense I see no problem in changing the allowable slopes for Type A soils to 1/2 to 1 for 12 ft. or less and 3/4 to 1 for 12 to 20 ft. We originally did not recommend 1/2 to 1 slope because there was no substantial evidence that it is being used and there was some concern that it could become a vertical slope when the work is sloppy.

(3) Local Provisions Which Have a Proven Performance Record: In our summary recommendation (BSS 127) the following statements were made in Appendix A: page 59, A.3, 1st paragraph:

> "Traditional timber shoring practice varies widely from location to location and frequently depends on such variables as sizes and characteristics of available timber, soil conditions, and local work practices. In some locations these practices have been used for many years and appear to be satisfactory to all the parties concerned. Three such locations are the State of Wisconsin, New York City, and the State of California (where mainly softwood is used)."

Page 65, 2nd paragraph:

> "Since, in spite of the results of this analysis, NBS could find no evidence that traditional timber practice, if properly executed, is unsafe, consideration could perhaps be given to temporarily exempting conventional timber shoring from the lateral load requirements until lateral load effects can be further studied by actual measurements in the field. If such an approach is adopted, it may be more reasonable to endorse proven local shoring practices on a regional basis, only where such shoring is widely used. It is not recommended to use a single scheme such as Tables A.2, and A.3 nationwide, since local practice evolved on the basis of local workmanship, material supplies and soil conditions."

It can be seen from our summary report that the question which arose in the Milwaukee Workshop was anticipated. It may arise again in the San Francisco and the Boston Workshops. The question is this:

> If we have a local shoring practice which is satisfactory to all the parties concerned, should it be changed to comply with the new provisions?
>
> If it is <u>not</u> changed, by which mechanism can it be approved without jeopardizing the consistency of the new provisions?

This is a question which must be taken up by the Advisory Committee in order to come up with a definite recommendation to OSHA. I would like to state some of my preliminary thoughts:

(a) If we have a traditional practice which has a good track record and we force contractors to change it, we may well cause an increase in the accident risk and thus defeat our overall purpose. On the other hand, one of our goals was to get away from prescriptive provisions and provide more options. Thus it would <u>also</u> be wrong to enforce this traditional approach to the exclusion of other approaches.

(b) The evidence on which we can base the permission to use a traditional practice which does not comply with our recommended provisions is its track record, rather than compliance with engineering principles. Thus, if it is allowed, <u>no changes in it should be permitted</u>. Such changes would include substitution of any of its members by other members of "equivalent" strength.

Thus I think that one way to deal with this problem could be some kind of "grandfather clause," by which <u>widely used</u> traditional practices could be allowed on a regional basis. However, care should be exercised to permit only those parts of these practices which are <u>actually</u> widely used, and discard other parts which do not have a proven track record.

Since we are dealing with a specific case of the Wisconsin Administrative Code, I analyzed their timber tables (see Appendix). My compliance measure is the "Safety Index" S/Sa, where S = calculated stress and Sa = allowable stress. My "Allowable Stress" is the stress for "Mixed Hardwood I", Table 5, page 29, multiplied by 1.33 for short term: fb = 964 psi, fc = 499 psi.

The safety index for struts was calculated for 2 situations: with the 240 lb. gravity load at the center of the strut as required, and without the gravity load to assess general adequacy in resisting lateral loads.

Hereafter is a summary of the assessment:

Table 1: Struts in rows 1-5 are generally adequate to resist the lateral loads, but are overstressed when the 240 lb. gravity load is applied. In row 6 the situation is similar for Type B soil (no water) but very marginal for Type C soil. The wales in row 6 are heavily overstressed.

Table 2: Situation is similar to Table 1 including that in row 5, which corresponds to row 6 in Table 1.

Table 3: The table is more stringent than the proposed spacing provisions.

Table 4: This table is for Type B soils. Struts tend to be overstressed and wales severely overstressed.

Table 5: This table is for wide trenches in Type A soils. It was analyzed for 6 ft. widths and 12 ft. widths. It can be seen that, with the 240 lb. load the struts are adequate to 6 ft. width, but overstressed for the 12 ft. width.

There was some evidence from the answers to my questions in the Workshop that only Table 1, rows 1-5 and Table 3 are widely used. If this is the case, some of the more marginal cases should probably be eliminated, while the rest of the practice could be endorsed on the basis that it is successfully used. It should be noted that the greatest deficiency occurs in wales where the spacing is 11-1/2 ft.

(4) Exposure: Section 1926.650 (a), which was formulated in the Washington AGC Workshop, sets a scope for the provisions. After the Wisconsin Workshop it appears that this section needs to be made more explicit to state that the provisions don't apply where workers are not exposed to the effects of mass movement of soil or rock. This may have to be further amplified to state how far away from an unshored or inadequately shored face workers would have to be when they are not exposed.

Resolution of this question would solve two problems:

(a) In wide excavations the provisions would not necessarily apply. Thus the demand to distinguish between trenches and excavation would be satisfied in this way.

(b) When long pipe sections are laid, cross braces interfere even when they are widely spaced. Thus it is sometimes

(5) Scope of Standard Practice: In the Workshop document it was originally proposed to limit the standard practice to a 20 ft. depth. The AGC Washington Workshop recommends 24 ft., and this seems to be supported by most contractors. AFL-CIO proposed 15 ft. ASFE originally proposed 20 ft. This issue should receive serious discussions in the other Workshops and the parties should attempt to reach a resolution.

(6) Engineer, Qualified Person, Competent Person: Almost all the parties seemed to agree that there must be a competent person on the job site.

There is disagreement whether a "qualified person" must be a licensed engineer. AFL-CIO maintains that this is necessary, while many contractors use a broader definition. There is agreement that the "registered architect" should be dropped from the definition of "Accepted Engineering Requirements."

There was considerable confusion between the terms "competent person" and "qualified person," however, it was probably caused by inadequate study of the Workshop document.

(7) Dust Control: It was noted that Section 1926.651 (i) conflicts with present EPA requirements. The section is also advisory rather than mandatory and may not belong in the regulation (it could be in the guidelines).

(8) Stoplogs: It was noted that the provisions of Section 1926.651 (g) are not practical for excavation work.

(9) General Recommendations: One of the speakers noted that the environment changed, and the contractor is now in a position of responsibility rather than in an adversary position when it comes to work safety. This Workshop convinced me that, while we have a good basic approach, we will need to resolve many issues, some of which result from regional differences. The Workshops will bring these issues to the surface, but there will not be enough time to resolve any of these issues. This will have to be accomplished after the Workshops.

I therefore strongly recommend that the parties participating in the Workshop form a committee which can work with NIOSH-OSHA-NBS when the recommendations are formulated. I also strongly urge OSHA-NIOSH to fund an additional effort in this area, so that a strong justification (technical, statistical and other) can be developed for all the final recommendations.

NOTES ON ANALYSIS OF TABLES

H = depth of excavation
h = horizontal center to center spacing of struts
v = vertical center to center spacing of struts
B = width of trench

Table 1: Row 2 could be A or B soils
Row 6 could be B or C soils

Table 2: Row 2 could be A or B soils
Row 5 could be B or C soils

Table 4: Analysis was carried to 24 ft. depth, for greater depths safety index will decrease.

Table 5: Analysis was made for 6 and 12 ft. widths.

TABLE I—TRENCH TIMBERING REQUIREMENTS

For trenches not exceeding 10 feet in depth and width not exceeding 42 inches

	Kind of Soil	Uprights	Cross Braces	Stringers**	H	h	v	B	Soil	SAFETY INDEX: Strut with 240-lb. load	SAFETY INDEX: Strut Without 240-lb. load	SAFETY INDEX: Wale
Where no parallel excavations exist or have existed within 10 ft.	Hard, solid soil	2x6 inch planks spaced 6 ft. c—c	*2—2x6 inch planks or equivalent for depths under 7 ft.; 3 for depths 7 ft. to 10 ft.	None	10'	6'	3.3'	3.5'	A	0.76	1.51	
Previous excavations 5-10 ft. from trench	Hard, solid soil	2x6 inch planks spaced 4 ft. c—c	*2—2x6 inch planks or equivalent for depths under 7ft.; 3 for depths 7 ft. to 10 ft.	None	10'	4'	3.3'	3.5'	A B	0.91 0.65	2.27 1.13	
Previous excavations less than 5 ft. from trench	Hard, solid soil	2x6 inch planks spaced 3 ft. c—c	*2—2x6 inch planks or equivalent for depths under 7 ft.; 3 for depths 7 ft. to 10 ft.	None	10'	3'	3.3'	3.5'	B	0.76	1.51	
Irrespective of any previous excavation	Soil that splits easily	2x6 inch planks spaced 3 ft. c—c	*2—2x6 inch planks or equivalent for depths under 7ft., 3 for depths 7 ft. to 10 ft.	1x6 inch boards placed back of uprights near top of trench	10'	3'	3.3'	3.5'	B	0.91	2.27	
Irrespective of any previous excavation	Gravelly or filled in ground	2x6 inch planks spaced 2 ft. c—c	*2—2x6 inch planks or equivalent for depths under 7 ft.; 3 for depths 7 ft. to 10 ft.	1x6 inch boards placed back of uprights near top of trench	10'	2'	3.3'	3.5'	B	0.91	2.27	
Irrespective of any previous excavation	Sand or very wet soil	2 inch tight sheathing	3x6 inch timbers or equivalent horizontally spaced not exceeding 8 feet	3x6 inch timbers or equivalent—2 for depths 7 ft.; 3 for depths 7 ft. to 10 ft.	10'	6'	3.3'	3.5'	B C	0.85 0.45	1.13 0.57	0.3 0.15

[illegible] inches center to center.

* In lieu of three cross braces for each upright, [illegible] may be used with substantial cross braces spaced horizontally sufficient to give equivalent protection, but in no case exceeding 8 feet.

**Stringers shall be properly supported by posts or cleats.

TABLE 2—TRENCH TIMBERING REQUIREMENTS

For trenches over 10 feet and not exceeding 15 feet in depth and width not exceeding 42 inches

	Kind of Soil	Uprights	Cross Braces	Stringers**	H	h	v	B	Soil	SAFETY INDEX Strut with 250-lb. load	SAFETY INDEX Strut Without 250-lb. load	SAFETY INDEX Wale
Where no parallel excavations exist or have existed within 15 ft.	Hard, solid soil	2x6 inch planks spaced 4 ft. c—c	*3—2x6 inch planks or equivalent for depth under 13 ft.; 4 for depths 13 ft. to 15 ft.	None	15'	4'	3.75'	3.5'	A	0.71	1.33	
Previous excavations 10 to 15 ft. from trench	Hard, solid soil	2x6 inch planks spaced 3 ft. c—c	*3—2x6 inch planks or equivalent for depths under 13 feet, 4 for depths 13 ft. to 15 ft.	None	15'	3'	4'	4'	A B	0.82 0.56	1.77 0.89	
Previous excavations less than 10 ft. from trench	Hard, solid soil	2x6 inch planks spaced 2 ft. c—c	*3—2x6 inch planks or equivalent for depths under 13 ft.; 4 for depths 13 ft. to 15 ft.	None	15'	2'	4'	4'	B	0.71	1.33	
Irrespective of any previous excavations	Soil that splits easily	2x6 inch planks spaced 2 ft. c—c	*3—2x6 inch planks or equivalent for depths under 13 ft.; 4 for depths 13 ft. to 15 ft.	1x6 inch boards placed back of uprights near top of trench	15'	2'	4'	4'	B	0.71	1.33	
Irrespective of any previous excavations	Sand, gravel filled in ground or very wet soil	2 inch tight sheathing	3x6 inch timbers or equivalent, spaced 6 ft. c—c	6x6 inch timbers or equivalent—3 for depths under 13 ft.; 4 for depths 13 ft. to 15 ft.	15'	6'	3.75'	3.5'	B C	0.56 0.30	0.66 0.33	0.36 0.18

Notes: c means center to center

*In lieu of three cross braces for each upright, 8x8 inch stringers may be used with substantial cross braces spaced horizontally sufficient to give equivalent protection, but in no case exceeding 6 feet.

**Stringers shall be properly supported by posts or cleats.

TABLE 3—TRENCH TIMBERING REQUIREMENTS

For trenches over 16 feet in depth and width not exceeding 42 inches

	Kind of Soil	Uprights	Cross Braces	Stringers**	Depth	Wisconsin C-C	Wisconsin CLR	Table 4 (a) C-C	Table 4 (a) CLR
Irrespective of any previous excavations	Hard, solid soil	2"x6" 2' c—c 16'-17' 2"x8" 1' c—c 17'-20' 2"x8" tight over 20'	Use Table No. 4	Use Table No. 4	15'-17'	2'	1.5'	4'	2'
	Soil that splits easily, sand, gravel, filled in ground, or very wet soil	2" tight sheathing			17'-20'	1'	0.5'	4'	2'

Notes c—c means center to center

**Stringers shall be properly supported by posts or cleats.

TABLE 4—TRENCH TIMBERING REQUIREMENTS

For trenches over 42 inches in width up to and including 12 feet in width

Depth of Trench	Uprights	Cross Braces	Stringers	H	h	v	B	Soil	SAFETY INDEX Strut With 2400-lb. load	Strut Without 2400-lb. load	Wale
Over 4½ ft. to 10 ft. inch	(*)	6x6 inch timbers spaced horizontally 7 ft. 6ins to 6ins	6x6 inch timbers spaced 4 ft. c—c	10	7.5	4	12	B	0.64	1.00	0.21
		6x6 inch timbers spaced horizontally 11 ft. 6ins to 6ins	6x6 inch timbers spaced 4 ft. c—c	10	11.5	4	12	B	0.52	0.65	0.09
Over 10 ft. to 20 ft. inch	(*)	6x6 inch timbers spaced horizontally 7 ft. 6ins to 6ins	6x6 inch timbers spaced 4 ft. c—c	20	7.5	4	12	B	0.63	0.75	0.16
		6x6 inch timbers spaced horizontally 11 ft. 6ins to 6ins	6x6 inch timbers spaced 4 ft. c—c	20	11.5	4	12	B	0.79	0.87	0.16
Over 20 ft. to 30 ft. inch	(*)	6x6 inch timbers spaced horizontally 7 ft. 6ins to 6ins	6x6 inch timbers spaced 3 ft. c—c	24	7.5	3	12	B	0.9	1.08	0.30
		6x6 inch timbers spaced horizontally 11 ft. 6ins to 6ins	6x6 inch timbers spaced 3 ft. c—c	24	11.5	3	12	B			
Over 30 ft. to 40 ft. inch	(*)	6x6 inch timbers spaced horizontally 7 ft. 6ins to 6ins	6x6 inch timbers spaced 3 ft. c—c								
		10x10 inch timbers spaced horizontally 11 ft. 6ins to 6ins	10x10 inch timbers spaced 3 ft. c—c								

(*) Uprights shall consist of 2 inch planks and spaced to comply with specifications for trenches less than 42 inches in width.

TABLE 5—TRENCH TIMBERING REQUIREMENTS

For trenches 4½ to 16 feet in depth, 3½ to 12 feet in width, and cut in hard soil*

Depth (ft.)	Width (ft.)	Uprights	Cross Braces	H	h	v	B	Soil	SAFETY INDEX Strut With 2400-lb. load	Strut Without 2400-lb. load	Wale
4½- 8	3½-12	2x6 inch planks spaced 4 ft. c—c	2 - 2x6 inch struts spaced 4 ft. c—c	8'	4'	4'	12'	A	0.78	3.51	
							6'		1.28		
8 -12	3½-12	2x6 inch planks spaced 4 ft. c—c	2 - 6x6 inch struts spaced 4 ft. c—c	12'	4'	4'	12'	A	0.70	2.34	
							6'		1.08		
12 -16	3½-12	2x6 inch planks spaced 4 ft. c—c	4 - 6x6 inch struts spaced 4 ft. c—c	15'	4'	4'	12'	A	0.65	1.87	
							6'		0.97		

*In case unstable soil is encountered, bracing shall immediately revert back to that outlined in Table 4.

Historical Cr. Register, December, 1968, No. 64, eff. 1-1-69, am (1) (intro.), (9) and (10), Register, September, 1970, No. 273, eff. 10-1-70.

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Gentlemen:

Attached is a copy of my draft memorandum on the Atlanta Workshop. Please send me your comments before July 10. I shall revise the memo after I receive your comments. In particular, I want to make sure that I have no inaccuracies and that I didn't fail to address important issues which were raised.

Sincerely,

Felix Y. Yokel, Leader
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D R A F T

June 23, 1981

MEMORANDUM FOR Records of the NIOSH Excavation Project

From: Felix Y. Yokel

Subject: Workshop in Atlanta, Georgia, June 16, 1981

This memorandum is in addition to proceedings which are being prepared by the Construction Trade Department of the AFL-CIO and is intended to cover important issues raised by the Workshop as perceived by me.

(1) General: My general impression from this Workshop was that even though many important points in our input document were disputed and criticized, the document was by and large well received. We did not encounter the problem which exists in Wisconsin, where existing shoring regulations and practices, which are locally considered satisfactory do not meet all the provisions in the proposed standard. We also did not encounter comments such as those voiced by Indiana contractors who question the need for any change in the existing regulations. However, several very important issues were raised and are subsequently discussed.

(2) Soil Classification: The overall approach in Table 1 was well received, but several important issues were raised:

> As in the previous Workshop, the need to permit 1/2 in 1 slope for Type A soil was perceived. Beyond that, the AGC of Kentucky proposed that a 5 ft. cut at the bottom of a 1/2 in 1 slope be permitted for Type A soil and a 3 ft. cut at the bottom of a 3/4 in 1 slope be permitted for Type B soil. The Kentucky AGC, as well as the ASFE representative also raised a question about the lack of specifics in defining "vibrations" in the footnote 1 to Table 1. In addition, it was suggested that instead of changing abruptly from one slope to another at the 12 ft. depth, the slope be gradually decreased as the depth increases from 12 to 20 ft.

I have the following comments on these suggestions:

> I would go along with a 1/2 in 1 slope for Type A soil. I also do not object to a gradual transition in allowable slopes as you go from 12 ft. to 20 ft. depth, though I think it may cause enforcement problems (originally we proposed a gradual transition, but we dropped

it subsequently because we thought it may be too complicated to implement). I consider the 5 ft. cut at the bottom of a 1/2 in 1 slope for Type A soil as too risky. I think that the comment on vibrations is valid, and I think we may have to drop our reference to vibration unless we can come up with specifics (heavy traffic and pile driving within a specific distance). However, such specifics without research data may be difficult to justify.

(3) Need for Simplicity: The need for simplicity and elimination of all duplication was stressed. I believe that there is a need to take a look at the entire write-up of the revised Subpart P, to eliminate all duplication and to use simpler, more precise language wherever possible. This is endorsed by all the parties participating in the Workshop.

(4) Layered Soils: Footnote to Table 1 was strongly endorsed. This is important, since I had some second thoughts about this conservative provision.

(5) Fractured Rock: The definition of fractured rock was criticized as lacking precision, however, we were unable to provide a better definition.

(6) Definition of Short Term Excavations: Different opinions were expressed, however, there seemed to be a consensus that 7 days is too long and considerable sentiment to increase the time to more than 1 day. The ASFE representative warned against extending the time period too much.

(7) Role of Professional Engineer: The troubling observation was made that it may be often impossible to find a consulting engineer who wants to assume responsibility for the safety of trenches even if they are deeper than 20 ft. This may make the requirement for a professional engineer academic.

(8) Bank Next to Work Area: There seemed to be consensus that the bank next to the work area should be increased to 4 ft.

(9) Excavation Below Bottom of Trench: There seems to be consensus that allowable excavation below the bottom of sheeting should be increased to 3 ft.

(10) Competent Person: There seems to be consensus that a competent person should be at the job site.

(11) Section 652(b)(4)(ii): It was suggested to move this Section to the end of Section 652(b) since it does not concern field personnel.

(13) General Comment: Some general comments were made which touch on problems which transcend the scope of Subpart P. There are three reasons which make it difficult for professional engineers to get involved in job site safety problems:

- Inadequate workmen's compensation coverage and resulting third party suits.
- Lawyers which take on cases for a 50% contingency fee, eliminating all financial risks for those who initiate legal actions.
- Adversary relationships between the parties involved in the excavation process.

My suggestion that there should be a consensus industry standard in addition to Government regulation was strongly endorsed.

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234
Bldg. 226, Room B162
(301) 921-2648

July 7, 1981

Mr. William Driskill
Mr. Arthur Schmuhl
Mr. James Lapping
Mr. John Ramage
Mr. Paul Bouley
Mr. Ronald Stanevich
Prof. Jack Mickle
Mr. John Pannullo

Gentlemen:

Attached is a copy of my draft memorandum on the Dallas Workshop. Please send me your comments before August 7. I shall revise the memo after I receive your comments. In particular, I want to make sure there are no inaccuracies and that I didn't fail to address important issues.

Sincerely,

Felix Y. Yokel, Leader
Geotechnical Engineering Group
Structures and Materials Division
Center for Building Technology, NEL

Attachment

cc: Mr. Edward Hayden
Mr. John Chambless
Mr. Paul Henson
Mr. Clifford Simmons
Mr. Bill Zoino
Mr. George Bradberry
Mr. John Cook

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234
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(301) 921-2648

D R A F T

July 7, 1981

MEMORANDUM FOR Records of the NIOSH Excavation Project

From: Felix Y. Yokel

Subject: Workshop in Dallas, Texas, June 31, 1981

This memorandum is in addition to proceedings which are being prepared by the Dallas AGC and is intended to cover important issues raised in the Workshop as perceived by me.

(1) General: Art Schmuhl in his introduction raised the issue of development of industry recommendation in a Washington, D.C. Workshop after completion of the Regional Workshops. I am very much in favor of such an effort and I think it needs to be undertaken promptly. However, I think that Art's appraisal that this can be accomplished in one Workshop, which is based on the AGC 2-day Workshop we had, is overly optimistic. This time there will be several groups with different views on some issues, and we will have to deal with many important problems that were raised in the Workshops. I think that perhaps, in preparation for such a Workshop, a very small task committee should prepare a revised draft, revise it once more after corresponding with all the industry committee members, and then have a Workshop on the latest draft. This way you can get all the non-controversial issues out of the way before the Workshop, and in the Workshop concentrate on solving the more controversial issues (depth for standard practice, qualified person, sloping provisions, recognition of regional practices, etc.).

My general impression from the Dallas Workshop was that, overall, the concepts in the draft were well received, but several important issues were raised which will require some substantial revisions in the draft. As in the Wisconsin Workshop, a contractor from Illinois expressed the view that the present OSHA provisions should not be changed. While this view is not shared by the vast majority of contractors who responded to NUCA and AGC questionnaires and who were interviewed in the NBS field study, it is based on several legitimate concerns which in my view will have to be carefully addressed. The trench box manufacturers also submitted a statement and expressed disagreement with some of the recommendations, based on technical considerations. The objections will have to be carefully studied. There was some concern about my statement that the scope of the NBS work was confined to the soil classification and to shoring and sloping provisions.

While this is true, I feel that the participants in these Worshops have the knowledge and experience to address all the issues involved and will do so successfully.

(2) Opposition to Change in Existing Provisions: Opposition to a change in the present version of Subpart P was expressed by an Illinois contractor who works primarily on highway projects. This time I gained some insight into the rationale for this position. I noted in my Wisconsin memo that people who tend to agree with our recommendation are less likely to express their opinion in the Workshop than those who oppose certain recommendations. The same thing happened to some extent when we conducted our field study. Almost all the contractors that responded were dissatisfied with Subpart P. However, the responding contractors who now have concern about changes in the existing regulations are more involved in earthwork, wide excavations, borrow pits, etc., where conflicts with OSHA do not normally arise. They are concerned with two issues.

a. The present provisions have been interpreted in the courts in past litigations. These interpretations by court rulings tell the contractor precisely what he can do. When we now propose to change the wording of many provisions, there will again be uncertainty about their interpretation by the courts, and we will lose the benefit of experience gained in past conflicts.

b. We merged "trenches" and "excavations". There is now concern that as a result new restrictions will be imposed on excavation work. Part of this problem can probably be resolved by a clear definition of "exposure." However we need to carefully review our new recommendations to make sure that they do not inadvertently result in unnecessary restrictions on excavation work. An example of this, which was noted in the Workshop, would be the application of Section 1926.651(d) to borrow pits.

(3) Use of OSHA Regulations on Federal Projects: It was noted that other Federal Agencies are not bound by OSHA regulations and use their own procedures. This situation can lead to specifications which are difficult to implement while using methods which comply with our recommendations. I am not sure what can be done about that, but the situation could be brought to the attention of the Administration at an appropriately high level by the participating organizations of the Workshops.

(4) Trench Boxes: Trench box manufacturers suggested that the lateral-load requirements for trench boxes should be different from those for shoring. This is based on the contention that a trench box can deflect considerably and in general will not restrain lateral soil movement as much as a shoring system, thus causing the pressure distribution to resemble that acting on a retaining wall. This would make the square pressure diagrams associated with the Standard Practice too conservative. At this time I cannot evaluate the technical merits of this claim in detail, but I have several preliminary thoughts:

a. In addition to the allowable stress increase for short-term excavation, we also allow a 20 percent load reduction for wales and a 33 percent reduction for sheeting. These reductions, which account for arching effects would apply to the horizontal framing members and the skin of a trench box. I wonder if the industry considers taking advantage of these reductions in their analysis.

b. The trench boxes I saw had about equal stiffness (in terms of lateral displacement characteristics) near the top and bottom. Thus, I cannot see how a trench box could act like a retaining wall, namely rotate inward while the base is fixed.

c. It is obvious that a trench box permits greater lateral inward displacements of the excavation wall than a shoring system. In granular soils this will result in a reduction in lateral soil pressures. In clays, however, the situation is more complex. Overconsolidated clays such as those is Austin, Texas where we conducted pressure measurements (NBS GCR 80-202) will develop tension cracks upon lateral expansion, resulting in increased lateral soil pressures. It should be noted that Type B soils include clays.

d. The greatest problem that would arise if stiffness characteristics of shoring systems are considered is complexity (which our recommendations are designed to avoid). Each case would have to be considered on its own merit. Considering the inadequacies and complexities of present models for soil/structure systems and our general lack of data on lateral pressures in shallow braced excavations, it may be difficult to make a convincing case, and detailed analysis would not be much better than an educated guess.

e. While the proposed square pressure diagrams may be on the conservative sides, the 40 lb/ft.^{3} equivalent weight effect is <u>not</u> conservative for medium clays which fall under Type B soils and are the most common soil type.

It may be helpful if ASFE could review this problem. I am very much afraid that we may be creating an albatross as soon as we deviate from the principle of simplicity in the standard practice.

(5) <u>Configuration of Excavations with Compound Slope</u>: Two problems were discussed in conjunction with Figure 2, page 12:

a. It was suggested to remove the sharp corners in the drawn cross-sections, since these cannot be dug in the field with ordinary equipment. I suggest that we draw broken lines for the idealized cross-section and back these up with solid lines showing more rounded corners.

b. The bank adjacent to the work area was discussed. In the previous two Workshops there seemed to be a consensus that the height of the bank should be increased to 4 ft. In this Workshop it was suggested to permit a 5 ft. bank for large pipes. In the latter case, worker protection would be derived from the large diameter pipes. I have some problems with the suggestion:

1. If we permit a 5 ft. bank at the bottom of a slope this would be inconsistent with our requirement to limit the height of an unsupported bank in level ground to 5 ft. This inconsistency would inevitably lead to a court challenge of the 5 ft. bank on level ground on the grounds that a higher unsupported bank would provide equivalent stability.

2. I believe that this configuration would be much more hazardous than a 5 ft. bank in level ground, since a much greater quantity of soil would slide into the trench in case of a stability failure.

   It should be noted that Section 1926.652(c) in the present provision states that "... the sides of the trench above the 5 ft. level may be sloped to preclude collapse, but shall not be steeper than 1 ft. rise in 1/2 ft. horizontal." This conflicts with present Figure P-1 and is less conservative than anything we permit in our present proposal. In the Atlanta Workshop, members of the Kentucky AGC suggested that we permit this configuration for Type A soils.

(6) Exit Provisions: It has been suggested that "climbing upon struts" should be recognized as a legitimate means of exit from a trench. My comment on that is that our proposed loading provision for a 240 lb. concentrated load at the center of the strut would provide adequate strength for an emergency exit of a worker whose weight is within the normal range. However, stepping on struts should be prohibited for non-emergency cases, unless a higher design load is used. This exit option should not be permitted for systems, such as the Wisconsin system, if these systems are permitted on the basis of prior use.

(7) Short-Term and Long-Term Excavations: Several participants suggested to drop the distinction between short- and long-term. It was noted that manholes frequently remain open for 2-3 weeks. I have some problems with this suggestion:

a. It may force us to do away with Type A soil, the way California did. This would impose economic penalties on some regions.

b. It may force us to drop the 33 percent overstress. This in turn would cause us to require wooden struts which are heavier than those commonly used (now we come out about right).

c. The proposed compound slopes (Figure 2) are questionable for long-term use.

The problem may be that our definition of short-term, which is independent of site conditions, may be too simplistic. It was for instance pointed out that in New Mexico, Arizona, and some parts of California and Texas, where there is no rain for long periods of time and no other erosive effects there is really no difference between the short-term and long-term condition. I think that this statement is only partially valid. It is for instance not valid for overconsolidated clays which are common in semi-arid regions.

(8) Depth to Which Standard Practice Applies: Opinions were split between AGC (24 ft.) and AFL-CIO (15 ft.) as in the previous Workshops. An additional rationale was advanced for the 24 ft. depth.

24 ft. is a practical limit for the reach of backhoes. Thus work methods for greater depth will be different.

Some sentiments were expressed for a more restrictive limit for Type C soils.

(9) Engineer vs. Qualified Person: It seems that the AGC group in this region are particularly strong supporters of the use of the term "qualified person." This may have something to do with regional work practices. Two pertinent comments were made:

a. It was noted that neither a Federal regulation nor a standard can force people to be ethical. If somebody wants to let an unqualified person design his shoring he may do so regardless of provisions.

b. It was suggested that if we require an engineer in Section 1926.652(a)(2)b, it should also be required that shoring and underpinning be a bid item and thus part of the plans and specifications. I think that, while this is a good idea, OSHA does not have the authority to enforce such a requirement.

I believe that at the core of this controversy is that AFL-CIO would like to have some way by which they can determine if a person is qualified. Perhaps this could be accomplished by a better definition.

(10) Maximum Allowable Slope: It was pointed out that there are gypsum and caliche formations which stand safely at a 1/4 in 1 slope. This raises again two questions: Can our definition of unfractured rock be improved? - It was suggested in this Workshop that perhaps the "competent person" should determine when rock is unfractured. This is probably a good idea as long as there is no dispute. If there is a dispute, we would still have to go back to a precise definition. The other issue is "maximum allowable slope." I do not really believe, that if we go to a quantitative definition (as we have now) it is reasonable to permit slopes steeper than 1/2 in 1. This could conceivably be combined with regional approval of steeper configurations by a "grandfather clause" (see Wisconsin memorandum). The other way would be to allow the "stable slope" concept - this is opposed by the AFL-CIO.

(11) Section 1926.651(e): It was suggested that this section is redundant and should be eliminated.

(12) Section 1926.651(j): The requirements in this section received some discussion:

a. It was pointed out that these are the requirements for confined space and that there perhaps should be referenced.

b. It was noted that there were some meetings with OSHA in which modifications in this section were discussed. These modifications did not make their way into our draft. (I never heard about them.)

(13) Section 1926.651(o): It was suggested that this section not be eliminated from Subpart P. It was further noted that the requirements for a harness is in some instances counterproductive since harnesses do not work very well and other protective measures are frequently used. I hope that specific recommendations for re-wording will be made.

(14) Section 1926.651(s): Trench box manufacturers suggested modifications in this section.

(15) Section 1926.651(t): It was noted that the requirements in this section do not apply to many shoring systems. It was suggested to eliminate this section. I would recommend that we try to rewrite the section to simply require that workers engaged in the removal of shoring be not exposed to mass movement of soil or rock from banks where shoring was removed.

(16) Figure 3: It was suggested to eliminate the projection of the shoring above the top of the bank, as this is not always the method used to protect workers from rolling objects.

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Washington, D.C. 20234
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(301) 921-2648

July 13, 1981

Mr. Paul Henson
Mr. Arthur Schmuhl
Mr. James Lapping
Mr. John Ramage
Mr. Paul Bouley
Mr. Ronald Stanevich
Prof. Jack Mickle
Mr. John Pannullo

Gentlemen:

Attached is a copy of my draft memorandum on the San Francisco, California Workshop. Please send me your comments before August 14. I shall revise the memo after I receive your comments. In particular, I want to make sure there are no inaccuracies and that I didn't fail to address important issues.

Sincerely,

Felix Y. Yokel, Leader
Geotechnical Engineering Group
Structures and Materials Division
Center for Building Technology, NEL

Attachment

cc: Mr. William Driskill
Mr. Bruce Summers
Mr. Edward Hayden
Mr. John Chambless
Mr. Clifford Simmons
Mr. Bill Zcino
Mr. George Bradberry
Mr. John Cook
Mr. James Kleinfelder

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(301) 921-2648

D R A F T

July 13, 1981

MEMORANDUM FOR Records of the NIOSH Excavation Project

From: Felix Y. Yokel F. Yokel

Subject: Workshop in San Francisco, California, July 9, 1981

This memorandum conveys my personal notes and comments relating to the California Workshop. In this instance, it is not clear whether AGC will produce a detailed Workshop report. However, participants have been requested to submit their comments in writing. These comments will be compiled in one document.

(1) General: The California Occupational Safety and Health Standard Board recently prepared a new draft standard for excavation, trenches and earthwork (see Attachment), which seems to be acceptable to the affected parties. It was the understanding of the Workshop participants that the Standards Board delayed adoption of this draft standard until Subpart P is revised. There are similarities between the underlying philosophies of our draft and the proposed California Standard, however there are considerable differences in the substance of these documents. Many of the suggestions made were in the direction of trying to eliminate some of the differences between the proposed California Standard and our proposed standard - generally suggesting that our draft, rather than the California draft, be changed.

In general, California contractors seem to favor a much more conservative practice than contractors in other parts of the country. This trend manifests itself in comments on depth limits for the Standard Practice, allowable slopes and compound slopes, allowable stresses and soil classification (as perceived by the participants). One of the reasons for this approach is the widespread use in California of a contract bid item covering shoring. Such a bid item seems to somewhat reduce the incentive for trying to cut the shoring costs resulting from safety regulations. Most of the participants suggested that OSHA require inclusion of shoring as a bid item in construction contracts. I indicated that I would favor such an approach, but that it is my understanding that OSHA does not have the authority to enforce such a requirement. Before discussing detailed comments, I want to briefly discuss some of the differences between our draft and the proposed California Standard.

A. Excavation and Trenching: In the present version of Subpart P, excavation and trenching are covered in a redundant fashion. In our proposed revision of Subpart P, the distinction between excavations and trenches is eliminated, and instead we distinguish between short- and long-term excavations. The applicability of some of the requirements to excavations can also be further limited by better defining exposure. In the proposed California draft there are

requirements which apply to both excavations and trenches, and then additional requirements for trenches only.

While the California draft eliminates the redundancy resulting from separate requirements for trenches and excavations, it does not fully eliminate the problems associated with the definition of a trench.

B. Soil Classification: We introduced a simple soil classification with three soil types - hard and compact, medium, and saturated soft and submerged. The proposed California Standard has two soil classes: "hard compact" and "running." Running soils are defined as: "Earth material whose angle of repose is approximately zero, as in the case of soil in a nearly liquid state, or dry, unpacked sand which flows freely under slight pressure. Running material also includes loose and disturbed earth that can only be contained with solid sheeting" (the last sentence was added recently).

The proposed California classification is based on a recent Stanford University study which I did not see. All earth that is not "running" is "hard compact." The lateral pressures associated with these soil classes are not explicitly defined. Rather, there are prescriptive tables for wood, aluminum pipe and hydraulic systems, and steel pipe and hydraulic systems. However, on Page 26, Plate C-22, which is addressed to engineers, it is stated that "A minimum coefficient of active earth pressure of 35 pcf (KW=35) shall be used in all calculations unless a soil evaluation indicates otherwise."

Normally the "coefficient of active earth pressure" is dimensionless, so I assume that 35 pcf represents the product of the coefficient and the unit weight of the soil. Whether it is suggested to also use a square pressure diagram of 0.8KW as stipulated in the present California Standard is not clear. There is no specific guidance for "running" soils.

I did some back calculating from the proposed table, using the allowable timber stress of 1300 psi - 20 /d which is stipulated on Page 14, and got minimum distributed pressures of about 40 pcf for the compact soil, and about 68 pcf for the running soil, with most member sizes much more conservatively designed. (The equation proposed for allowable timber stresses is no longer used in timber engineering practice. Allowable stresses come out much higher than those we propose for hardwood, though they may be O.K. for stress graded softwood.)

I have some problems with the proposed California classification: as far as I can see, "running" soil would include muck, dry and submerged sands and probably other dry and submerged cohesionless soils including fill, and possibly some very fissured and very soft clays. "Hard compact" soils would include all but the very soft intact clays and a great many fissured clays which can be contained by spaced sheeting, and probably many moist cohesionless materials. Hydrostatic conditions are not mentioned.

This leaves me confused. You could have a soft clay under "hard and compact" (as long as it has enough cohesion to stand up temporarily to the bottom of the excavation) and a dry sand under "running." Yet the clay will develop high lateral pressures while the sand would develop very low pressures. Thus, while it is probably true that a man in the field could relatively easily identify "running" soils, the soils do not seem to be sorted out with respect to anticipated lateral pressures and stable slopes.

There is no one-to-one correspondence between our "hard and compact" soils and the "hard compact" soils proposed for the California classification, even though I sense that some of the Workshop participants may have had that perception. Considering the wide range of soils that could fall within this category, the 40 pcf I calculated for the table may be on the low side (California "hard compact" soils could include soft clays). Our "Type A" soils are not broken out in this classification, but some of our Type B soils are thrown into "running" (the dry cohesionless soils) and some of our Type C soils are thrown into "hard compact" (the soft clays). I believe that if we do insist having only two soil classes, a more logical split would be obtained by putting Type A and B together and leaving Type C soils as we now define them.

Another significant feature of the proposed California system is that our Type A soils are not broken out as a category. Their 35 pcf minimum "KW" is an indication of that. I was aware that the lateral pressure presently stipulated in the California Standard for "hard compact" soils were deemed inadequate in the "California Trenching and Shoring Manual" (Caltrans). If we were to likewise eliminate Type A soils on a nationwide basis, many shoring systems presently successfully used would be deemed inadequate.

Somehow the proposed California classification conveys the impression that soils which will stand vertically when you dig require less shoring. If we take for instance a clay that would stand up in a 12 ft. cut, its cohesion would be about 300 lb/ft.^{2}. This is a soft clay, which according to what we know could develop a very high lateral pressure, certainly much higher than that of a dry sand. Yet the clay would be classified as "hard compact" in the California scheme if the trench dug is less than 12 ft. deep. In our classification it would be Type C.

In closing, I would like to note that the present California Standard contains a soil classification which is very compatible with the one we are proposing and which to my knowledge has a successful 20 year track record.

C. Shoring System Selection: As I already noted, the proposed California Standard stipulates specific shoring systems. Such an approach may be attractive for our standard practice, and could be accomplished in an Appendix. However, it would be probably impossible to do this for timber shoring on a nationwide basis. We also would have to make sure that all existing and potential future systems get equal consideration.

(2) Qualified and Competent Person: Several contributions were made to this controversy: ASFE suggested that it be required that the qualified person, when designing shoring, should submit calculations. This would put him on the spot when something happens. But it would only reveal deficiencies before an accident if some kind of peer review is used. Peer review is now successfully used with ASFE. California AGC proposed to require that the qualified person be "designated by the contractor." This would make the contractor responsible for the competence of the person. California AGC also proposed to eliminate the competent person and use only qualified persons for everything. It seems that both the ASFE and the AGC suggestions contain concepts which would improve our definition. Another interesting and important point was made by the Oregon AFL-CIO: a "qualified person" from Montana was in charge of an excavation in Oregon. The excavation in Oregon collapsed, because the man was not familiar with local conditions. This perhaps underscores the importance of assigning responsibilities to the contractor which was stressed by the California AGC.

(3) Depth Limitation of Standard Practice: California AGC supports 20 ft. - as in the California Standard. A representative of the American Gas Association (AGA) noted that backhoes in his area have a depth reach of about 20 ft. and not 24 ft. as was noted in Texas.

(4) Accidents: A representative from Liberty Mutual noted that he has no record whatsoever of fatalities in shored excavations. Some of the participants noted that they are aware of such cases. I pointed out, that even though our evidence tends to indicate that many of the collapsed trenches were not shored, we looked at two cases of fatalities in improperly shored excavations during our study.

(5) Allowable Slopes: California AGC suggested that the compound slope case shown in Figure 2, Case IV should be limited to 12 ft. depth in hard compact soils (California definition) and shown as in the California Standard. It was also noted that a California study shows that the bank next to the work area in Case III would be safe at 4 ft. depth. I have no problems with these suggestions (except that we do not have the California "hard compact" category), except perhaps that they may be too restrictive. They are based on a study by R. T. Frankian and Assoc. (see Attachment). The concept used in this study was that of equivalency to an unsupported 5 ft. deep vertical bank. Such a bank would "just stand up" in a very soft clay with cohesive strength of only 150 pcf - a very soft soil indeed, which is only rarely encountered. For such a soil, if it can be sloped at all, our allowable slope would be only 1-1/2 to 1, a very flat slope. Our proposed compound slopes in Figure 2 are based on a somewhat different set of assumptions: equivalent stability to a sloped trench for whatever the depth of the trench happens to be. Of course many of our Type B soils will not stand with an unsupported bank of any depth, since they would be "running" by the California Standard.

Another point that was made was that our steepest allowable slopes in Table 1 are not necessarily stable for the soil type in all cases. This is correct, and that is the reason why I have trouble with dropping the "stable slope" concept. It is not practical to come up with slopes which would be stable for all cases. What we have now is maximum allowable slopes which should not be exceeded without an engineering study.

(6) Short-Term and Long-Term Excavations: California AGC suggested to drop the distinction. Similar suggestions were made in other Workshops. The problem I have with those suggestions is that they would force us to increase the safety margins. But if we increase those by much we will end up with a scheme which is much more conservative than what we now consider good practice. One interesting suggestion that was made is that a reassessment of shoring in a long-term situation could be made whenever people are exposed.

(7) Local Options: It was stressed that any National Standard should be flexible enough to accomodate local options. As I stated in my previous memoranda, I strongly recommend that we have a mechanism by which we can permit local options with proven track records which deviate from the "Standard Practice."

(8) Excavation Below Bottom of Shoring or Trench Box: The California groups tend to support the 2 ft. limit we have, which is also in the California Standard. This again is an indication of the conservatism of the California AGC. It also may be related to work methods.

(9) Section 1926.651(d): Add "... water shall not be allowed to accumulate in an excavation while work is in progress ..."

(10) Section 1926.651(e): "... the side of the excavation shall be shored ..." is too restrictive. Other methods may be used. Also Section is considered redundant altogether.

(11) Section 1926.651(g): Should be eliminated, or perhaps changed to proposed California provision.

(12) Section 1926.651(h): "remotely located" should be eliminated.

(13) Section 1926.651(k): There should be a height limitation. In the proposed California Standard it is 7-1/2 ft. (no reason for height was suggested).

(14) Section 1926.651(k): There should be a general requirement for good access like in the California Standard.

(15) Section 1926.651(i): Should perhaps be eliminated.

(16) Section 1926.651(e): It is suggested that the California Standard has a better formulation. However the problem of defining "vibration" which was noted in Texas is not solved in the proposed California Standard either.

(17) Section 1926.651(h): There should be rather a performance requirement for protecting workers against falling into a trench.

(18) Section 1926.651(g): It was strongly suggested to eliminate this statement.

(19) Section 1926.652(b)(4)(ii): Should be in an appendix or in the definitions.

(20) Section 1926.652(b)(4)(i): Was considered perhaps too complicated

(21) Section 1926.652(b)(5)(i): Option should be provided to "block off" the intercepting trench with shoring.

(22) Section 1926.653(g): Authorized by whom?

(23) Section 1926.653(h): Engineer should be "Civil."

Attachments

R. T. FRANKIAN & ASSOCIATES
Theoretical and Applied Earth Mechanics
224 SOUTH BUENA VISTA STREET
BURBANK, CALIFORNIA 91505
(213) 849-6878

January 10, 1977

Associated General Contractors
of California
Safety Committee
c/o Granite Construction Company
P.O. Box 900
Watsonville, California 95076

Attention: Mr. Bruce G. Summers, Chairman

Gentlemen:

Transmitted herewith are ten copies of our "Study to Determine Compound Slopes Equivalent to CAL-OSHA Allowable Unshored Slope," dated January 10, 1977.

This study was planned in consultation with Mr. Summers and Mr. J. M. Lyles.

It is the conclusion of this study that when the total depth of the excavation does not exceed 8 feet, a 3/4 horizontal to 1 vertical slope with a 3½-foot vertical cut at the toe, is equal and equivalent in stability to a 5-foot high vertical slope. The same condition exists for cuts up to 12 feet in total height when the gradient of the slope above a 3½-foot vertical cut is 1 to 1.

Should you wish to discuss the study further or have any questions, please do not hesitate to call.

Yours very truly,

R. T. FRANKIAN & ASSOCIATES

Kenneth S. Pitcher
Civil Engineer 24232

R. T. Frankian
Civil Engineer

KSP/RTF/rk (10)

STUDY TO DETERMINE COMPOUND SLOPES THAT ARE EQUIVALENT TO CAL-OSHA ALLOWABLE UNSHORED SLOPES

INTRODUCTION

The purpose of this study is to determine which unshored configurations of compound slopes would possess stabilities equal and equivalent to the stability of either a 5 foot high vertical or a 12 foot high 3/4 to 1 unshored slope, as allowed in the CAL-OSHA Construction Safety Orders. The 5 foot vertical and the 3/4 to 1 slopes are plain, that is, consist of a single, unbroken slope face. The compound slopes reported in this study consist of a vertical cut at the toe of an inclined plane.

This study is limited to soils which possess strengths sufficient to stand at those configurations permitted by the CAL-OSHA standards. Consideration of clean, running sands, saturated sands, and other soils which would not be stable on a 5 foot high vertical slope have been eliminated from this study.

BASIS OF ANALYSIS

The analysis began with the determination of those strengths which are required for the stability of the plain 5 foot vertical slope and the 12 foot high 3/4 to 1 plain slope. The method of analysis was that commonly used and referred to as the slip circle method. The analysis included consideration of a variety of tension crack locations and calculations were extended until the most critical combination of slip circle and tension crack was obtained.

It was found that the 5 foot high vertical slope was more critical than the 12 foot high 3/4 to 1 slope, that is, the 5 foot high slope would require soil strengths [illegible] than the strengths required to maintain the same degree of stability for the 3/4 to 1 slope. For purposes of this report we will refer to the 5 foot vertical slope as the standard slope, since it is that slope which will set the standard for stability of the compound slopes.

Starting with the strengths which were required for stability of the standard slope a variety of compound slopes were analyzed, each with an entire new series of trial slip circles for each configuration. Each of the calculations included consideration of the most critical location for a tension crack. Thus for each total slope height (depth of trench) one specific configuration was obtained which would possess a stability equal and equivalent to the stability of the standard slope.

Equivalent stability is defined by means of the ratio of the soil resistance available (Sa) as determined from the standard slope, to the soil resistance required (Sr) to provide stability for the compound slope. When Sr is equal to Sa, that is, when the resistance required is equal to the resistance available, the compound slope would have a stability equal and equivalent to the standard slope.

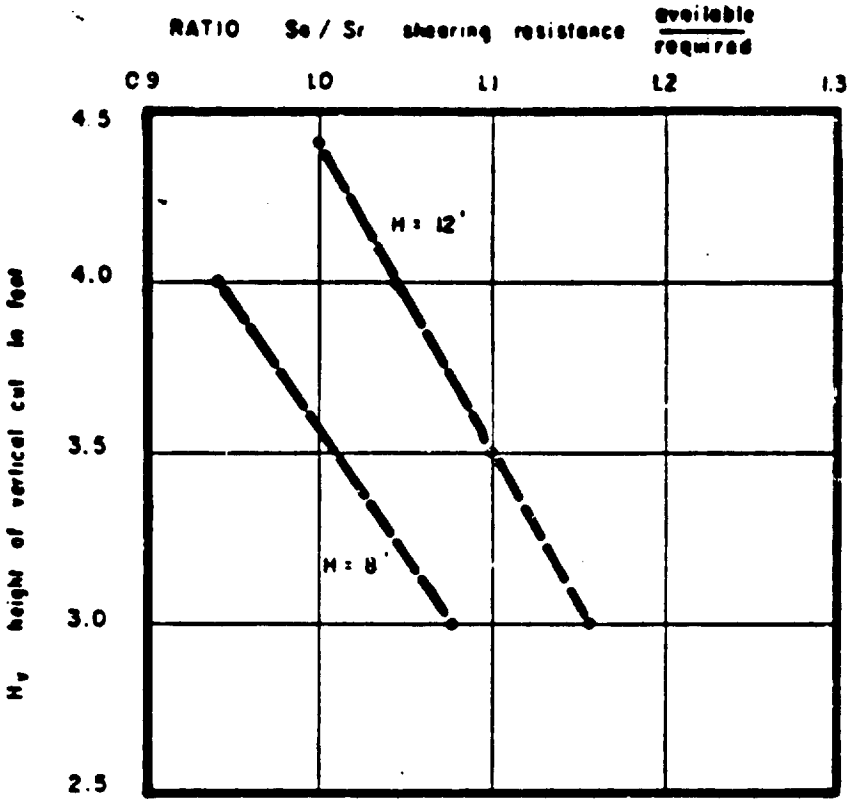
Other ratios of Sa/Sr may be considered, and where the same ratio occurs between a compound slope and the standard slope, it can be stated that the stabilities of these two slopes are equal and equivalent.

RESULTS OF ANALYSIS

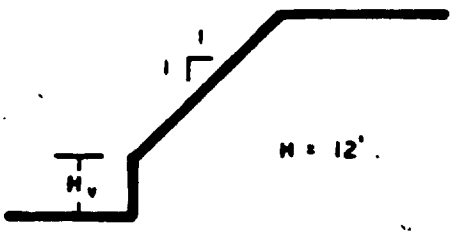
Calculations were made for compound slopes with overall heights (depth of trench) of 8 feet and 12 feet. For both 8 and 12 foot slopes the gradient of the upper portion of the slope was varied and the height of vertical toe was varied. The results of the calculations for the final configurations are presented on the following pages.

Where the height of the vertical portion of the slope at the toe is 3½ feet, the stability of the 8 feet high slope is equal and equivalent to the standard slope when the upper portion of the slope is inclined at 3/4 to 1.

Where the height of the vertical cut is again 3½ feet and the overall height is 12 feet the stability of this configuration is at least equal and equivalent to the standard slope when the upper portion of the slope is inclined at 1 to 1.


RATIO Se / Sr shearing resistance available / required
0.9
1.0
1.1
1.2
1.3
4.5
4.0
3.5
3.0
2.5
H_v height of vertical cut in feet
H = 12'
H = 8'


3
4
H_v
H = 8'


1
1
H_v
H = 12'

The effect of water collected in the most critical tension crack has also been investigated. If it is assumed that the critical tension crack for the standard slope is filled by water and calculations are made on the effect of water filling the most critical tension crack of any of the compound slopes, the ratio of Sa to Sr for the compound slope is greater than unity, that is, the compound slope possesses a stability at least equal to that of the standard slope.

CONCLUSIONS

If the total depth of the cut does not exceed 8 feet, the stability of a 3/4 to 1 slope with the lower 3½ feet cut vertically is equal and equivalent to the stability of a 5 foot high vertical cut excavated in the same soil.

If the total depth of the cut does not exceed 12 feet, the stability of a 1 to 1 slope with the lower 3½ feet cut vertically is at least equal and equivalent to the stability of a 5 foot high vertical cut excavated in the same soil.

-oOo-

The following Plates are attached and complete this report:

Sample Calculations

Respectfully Submitted,

R. T. FRANKIAN & ASSOCIATES

Kenneth S. Fitcher
Civil Engineer

R. T. Frankian
Civil Engineer

KSP/RTF/rk

SAMPLE CALCULATION -

DETERMINE SHEARING RESISTANCE REQUIRED TO PROVIDE STABILITY FOR A 5 FOOT HIGH SLOPE WHICH IS VERTICAL. USE UNIT SOIL WEIGHT, γ, OF 120 POUNDS / FOOT^3.

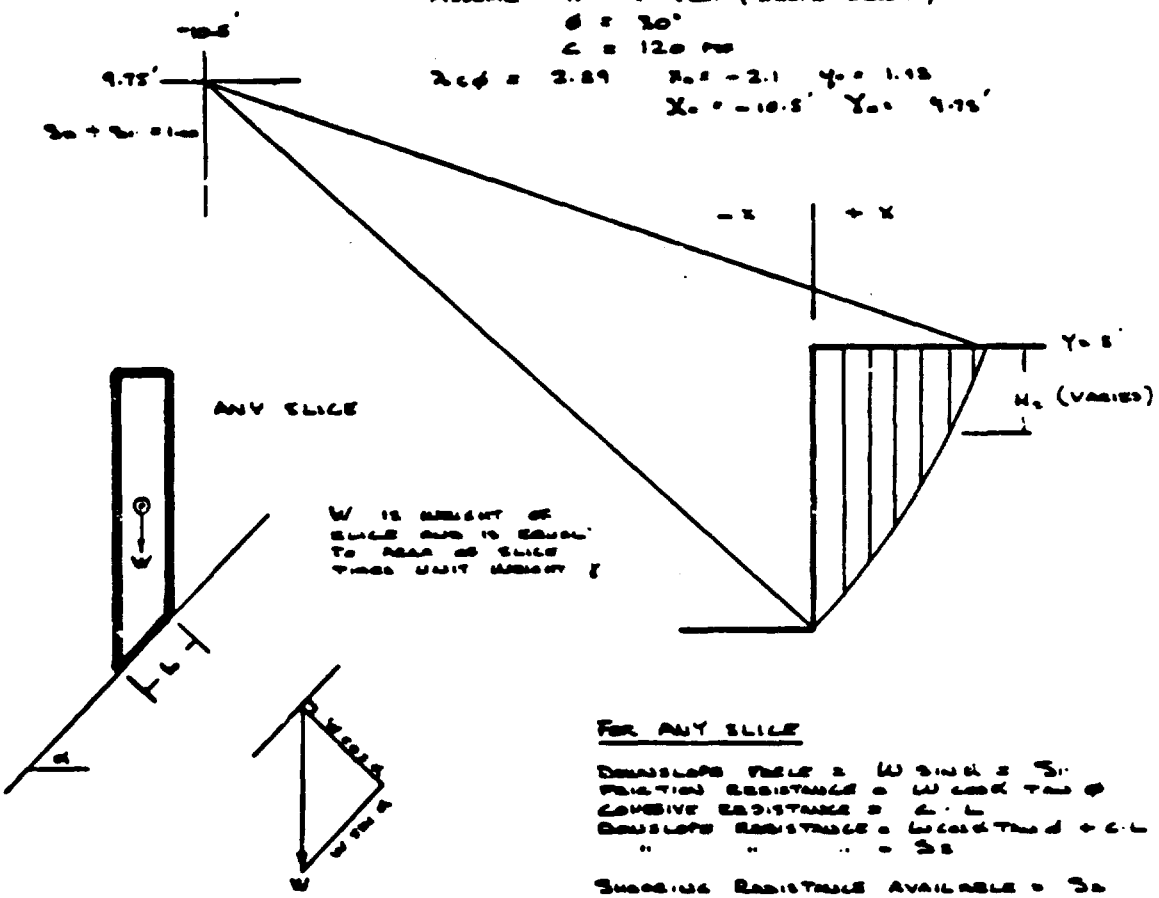
USE SWEDISH METHOD OF ANALYSIS. ORIGIN OF CENTER OF MOST CRITICAL CIRCLE IS A FUNCTION OF SLOPE GEOMETRY AND SOIL CONSTANTS γ, ϕ AND C. ϕ IS THE ANGLE OF SHEARING RESISTANCE IN DEGREES AND C IS THE UNIT COHESION IN POUNDS / FOOT^2.

FOR PLANE OR SIMPLE SLOPES THE LOCATION OF THE ORIGIN OF THE MOST CRITICAL SLIP CIRCLE MAY BE OBTAINED FROM DIMENSIONLESS PARAMETERS EVALUATED BY TAMBU (SEE NAV-DOCKS DM-7).

$\lambda_{c\phi} = \gamma \cdot H \cdot \tan\phi / c$

ASSUME $H = 5$ FEET (SLOPE HEIGHT)
$\phi = 30°$
$C = 120$ PSF

$\lambda_{c\phi} = 3.89$ $\quad X_o = -2.1$ $\quad Y_o = 1.15$
$X_o = -10.5'$ $\quad Y_o = 9.75'$



FOR ANY SLICE

DRIVING FORCE = $W \sin\alpha = S_r$
FRICTION RESISTANCE = $W \cos\alpha \tan\phi$
COHESIVE RESISTANCE = $C \cdot L$
RESISTANCE AVAILABLE = $W\cos\alpha\tan\phi + C \cdot L$
" " REQUIRED = S_r

SHEARING RESISTANCE AVAILABLE = S_a
SHEARING RESISTANCE REQUIRED = S_r

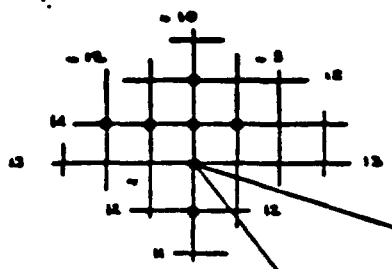
FOR EACH SLICE CALCULATE S_r AND S_a. COLLECT SUM OF THESE VALUES FOR ALL CASES OF VARIABLE TENSION CRACK LOCATIONS. FOR EACH CALCULATION EXCLUDE THOSE SLICES TO RIGHT OF THE TENSION CRACK SELECTED. OBTAIN CONFIGURATION WHICH WILL PRODUCE LOWEST VALUE OF THE RATIO OF $S_a \div S_r$.

SOIL STRENGTHS WHICH PRODUCE MINIMUM $S_a \div S_r$ OF UNITY ARE THE STRENGTHS WHICH REPRESENT STABLE STANDARD SLOPE.

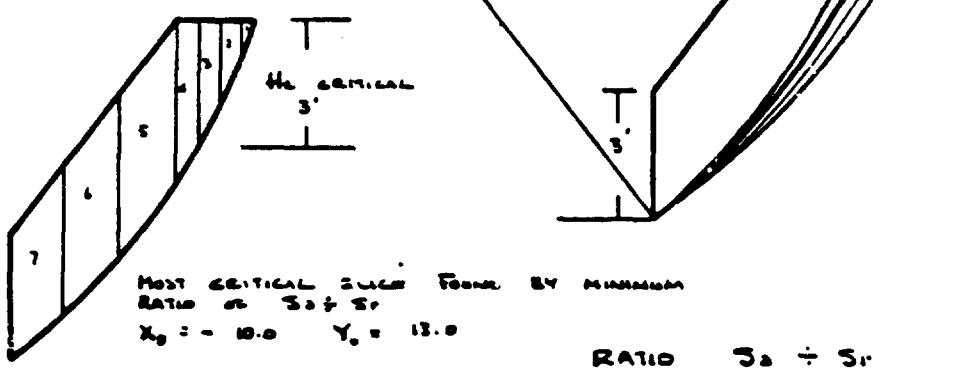
SAMPLE CALCULATION

DETERMINE MINIMUM VALUE OF THE RATIO OF AVAILABLE SHEARING RESISTANCE S_a TO ALONG THE SHEARING RESISTANCE REQUIRED S_r FOR ANY ARBITRARY COMPOUND SLOPE

CONSTRUCT COMPOUND SLOPE WITH OVERALL HEIGHT OF 8 FEET AND VERTICAL CUT H_v OF 3 FEET. SLOPE ANGLE β = 53° (3/4:1)



CONSTRUCT SERIES OF SLIP CIRCLES — VARY DEPTH OF TENSION CRACK FOR EACH TRIAL SURFACE.



MOST CRITICAL SLICE FOUND BY MINIMUM RATIO OF $S_a \div S_r$

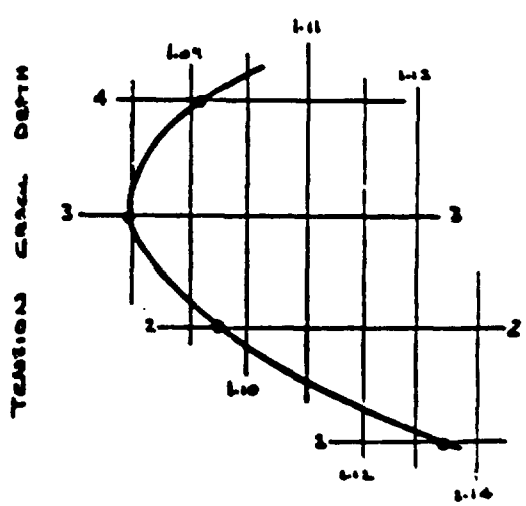
X_o = - 10.0 Y_o = 13.0

RATIO $S_a \div S_r$

CALCULATE STABILITY IN TERMS OF RATIO OF $S_a \div S_r$ (SEE PREVIOUS PAGE)

EFFECT OF TENSION CRACK IS TO ELIMINATE THOSE SLICES TO THE RIGHT OF CRACK LOCATION, E.G. FOR TENSION CRACK 3' DEEP... CALCULATE $S_a \div S_r$ FOR SLICES 4 THRU 7

MINIMUM $S_a \div S_r$ OCCURS AT CONFIGURATIONS X_o = - 10 Y_o = 13 AND H_c = 3 FEET. RATIO IS 1.073 THIS REPRESENTS ONE POINT ON GRAPH PRESENTED IN TEXT.



CALIFORNIA OCCUPATIONAL SAFETY AND HEALTH STANDARDS BOARD

Amend the definition of Excavation, Trenches, Earthwork in Sectio 1504 to read:

Excavation, Trenches, Earthwork.

(A) Bell Hole. An additional excavation made into the sides or bottom of a trench to provide additional work space.

(B) Belled Excavation. A part of a shaft or footing excavation, usually near the bottom and bell-shaped, that makes the cross-sectional area at that point larger than that above.

(C) Braces for Excavations. The horizontal members of the shoring system whose ends bear against the uprights or stringers.

(D) Earthwork. The process of excavating, moving, storing, placing, and working any type of earth materials.

(E) Excavation. A man-made cavity or depression in the earth's surface, including its sides, walls, or faces formed by earth removal and producing unsupported earth conditions by reason of the excavation. If installed forms or similar structures reduce the depth to width relationship, an excavation may become a trench.

(F) Hard Compact. All earth material not classified as running. ~~or unstable.~~

(G) Qualified Person. A person designated by the employer who by reason of experience or instruction is familiar with the operation to be performed and the hazards involved.

(H) Running. Earth material whose angle of repose is approximately zero, as in the case of soil in a nearly liquid state, or dry, unpacked sand which flows freely under slight pressure. Running material also includes loose or disturbed earth that can only be contained with solid sheeting.

(I) Shaft. An excavation under earth's surface whose depth, either horizontal or vertical, is much greater than its cross-sectional dimensions such as those formed to serve as wells, cesspools, certain foundation footings, and under streets, railroads, buildings, etc.

(J) Sheet Pile. A pile, or sheeting, that may form one of a continuous interlocking line, or a row of timber, concrete, or steel piles, driven in close contact to provide a tight wall to resist the lateral pressure of water, adjacent earth, or other materials.

(K) Shore (Strut). A supporting member that resists a compressive force imposed by a load.

( ) Shoring System. A temporary structure for the support of earth surfaces formed as a result of excavation work.

(M) Sides, Walls, and Faces. The vertical or inclined earth surfaces formed as a result of excavation work.

(N) Sloping of Earth. ~~The angle with the horizontal which a particular earth material will stand indefinitely without movement.~~ A method of excavation whereby the faces of an excavation or trench are laid back to provide protection from moving ground.

(O) Spoil. The earth material that is removed in the formation of an excavation.

(P) Stringers. The horizontal members of the shoring system whose sides bear against the uprights or earth.

(Q) Trench. ~~Shall mean an excavation in which the depth exceeds the average width of its cross section. Excavations that are more than 15 feet wide at the bottom, shafts, tunnels, and mine excavations are not trenches.~~ A narrow excavation made below the surface of the ground. In general, the depth is greater than the width at the bottom, but the width of a trench at the bottom is not greater than 15 feet.

(R) Trench Jack. Screw or hydraulic type jacks used as cross bracing in a trench shoring system.

(S) Trench Shield. A shoring system generally composed of steel plates and bracing, welded or bolted together, which support the walls of a trench from the ground level to the trench bottom of which can be moved along as work progresses.

~~(P) Unstable, as used in Article 6, Earth material other than running that, because of its nature or the influence of related conditions, cannot be depended upon to remain in place without extra support, such as would be furnished by a system of shoring.~~

(T) Uprights. The vertical members of the shoring system.

(U) Waler. A structural member in a horizontal or nearly horizontal position used for stiffening or securing other components of concrete forms, excavation sheeting, or similar temporary structures.

Adopt new Section 1540 to read:

1540. Excavations.

(a) Scope. Sections 1540(b) through (n) and 1541 apply to all excavations, trenches, shafts or earthwork and establish essential requirements and minimum standards of safety in earth excavation work.

NOTE: (1) Whenever the term "excavation(s)" is used it also applies to trenches, shafts and other earthwork.
(2) For additional shaft and incline excavation details, see Sections 1542 and 1543.
(3) For additional earthwork excavation details, see Sections 1544 through 1547 which apply to such work locations as borrow pits, road or dam construction sites and similar work areas.
(4) The Orders in this Article do not apply to work covered by the Mine Safety Orders or the Tunnel Safety Orders.

(b) Preparations.

(1) Prior to opening an excavation, the employer shall determine whether underground installations such as, sewer, water, fuel, electric lines, telecommunication lines, etc., will be encountered, and if so, where such underground installations are located.
(2) When the excavation work approaches the approximate crossing or parallel location of such an underground installation and danger of accidental contact or disturbance is possible, the exact location shall be determined by appropriate means before proceeding. When it is uncovered, adequate protection shall be provided for the existing installation.
(3) All known owners of underground facilities in the area involved shall be advised of proposed work at least 48 working hours prior to the start of excavation work.

Exception: Emergency repair work to underground facilities.

(4) Trees, boulders, poles and other surface encumbrances located so as to create a hazard to employees involved in excavation work, or in the vicinity thereof at any time during operations, shall be removed or made safe before excavating is begun.

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(c) Exposure.

(1) No employer shall cause or permit his employees to work in or adjacent to any excavation until a reasonable examination of same has been made by a qualified person to determine that no recognizable conditions exist exposing them to injury from possible moving ground.

(2) Excavations shall be inspected by a qualified person after every rainstorm or other hazard-increasing occurrence and the protection against slides and cave-ins shall be increased, if necessary, before employees are permitted to enter the excavation.

(d) Protection. Employees who must enter excavations 5 feet or more in depth shall be protected by a system of shoring, sloping of the ground, benching, or other effective means as provided by these Orders. Protection for employees who must work in excavations less than 5 feet in depth shall also be provided when examination by a qualified person indicates that hazardous ground movement may be expected.

(e) Spoil.

(1) Excavated material shall be prevented from falling back into the area where employees are working. This shall be done by locating the spoil at a distance from the edge of the excavation consistent with the character of the material and the nature of the operations, but unless otherwise contained, in no case shall be excavated material be placed closer than 2 feet from the edge of excavations.

(2) No method that disturbs the soil that is in place (such as driving stakes) shall be used to contain the spoil material.

(f) Supervision. Excavation work and work in an excavation shall at all times be under the immediate supervision of someone with authority and qualifications to modify the shoring, sloping or other system or work methods as necessary to provide greater safety. Such modification shall not permit the specific dimension requirements of other Orders to be less restrictive than shown except as permitted by Section 1541(a)(6). This person shall examine the material under excavation and improve the shoring or other methods beyond the minimum requirements, as necessary, to insure protection of workers from moving ground.

(g) Access.

(1) A convenient and safe means of access shall be provided for employees to enter and leave an excavated area. This shall consist of a stairway, ladder or ramp securely fastened in place at suitably guarded or protected locations where employees are working.

(2) When employees are required to be in trenches 4 feet or more in depth, a safe means of access shall be provided and located so as to require no more than 25 feet of lateral travel.

Exception: In utility trenches less than 5 feet in depth, earth ramps or steps are acceptable provided that they are not more than 75 feet on centers.

(h) Crossings.

(1) Trenches shall be crossed only where safe crossings have been provided.

(2) When walkways or bridges are provided across excavated areas, they shall be provided with standard guardrails and toeboards when the depth of excavation exceeds 7-1/2 feet.

(i) Excavators. An employee working in the vicinity of operating excavating equipment shall be required to work in a safe position such that the employee is not in danger of falling into or otherwise contacting the machine's moving parts.

(j) Undermining.

(1) No excavation work shall take place below the level of the base of an adjacent foundation, retaining wall or other structure until it has been determined by a qualified person that such excavation will in no way create a hazard to workers or until adequate safety measures have been taken for the protection of workers.

(2) Undermined sidewalks and/or pavements shall be supported to safely carry all anticipated loads.

(3) If the stability of adjoining buildings or walls is endangered by excavations, either shoring, bracing, underpinning, or other method affording equivalent protection for workers shall be provided as necessary to ensure their safety. All such systems shall be inspected daily or more often, as conditions warrant, by a qualified person and the protection effectively maintained.

(k) Retaining Walls.

(1) No existing wall or other structure shall be made by reason of an excavation or backfill, to function as a retaining wall until it has been determined that such wall will safely withstand all expected loads that otherwise might be a source of hazard to workers.

(2) Wherever a permanent retaining wall, in lieu of the temporary shoring system of this Article, is constructed to hold any part of an excavation that might endanger workers, such wall shall be designed and constructed to effectively resist all existing and expected loads. Standards of design shall be comparable to those of the California Administrative Code, Title 24, Building Standards, or any comparable local building code of equal or greater restrictiveness.

(l) Barriers at Unattended Work Locations.

(1) Means shall be provided to prevent mobile equipment from inadvertently entering excavations.

(2) Adequate physical barrier protection shall be provided to prevent employees from falling into excavations.

(A) All wells, pits, shafts, caissons, etc., shall be barricaded or securely covered.

(B) Upon completion of exploration and similar operations, temporary wells, pits, shafts, etc., shall be backfilled.

(m) Water Accumulation.

(1) Diversion ditches, dikes, or other effective means shall be used to prevent surface water from entering an excavation and to provide adequate drainage of the area adjacent to the excavation.

(2) Accumulations of water in excavations which endanger the stability of those excavations or pose a hazard to employees shall be controlled before further work progresses.

(n) Vibrations or Superimposed Loads. Special safety provisions consisting of additional bracing or other effective means shall be taken at excavations adjacent to streets, railroads, or sources of external vibrations or superimposed loads. Similar provisions shall be taken in excavations made in areas that have been previously filled.

CALIFORNIA OCCUPATIONAL SAFETY AND HEALTH STANDARDS BOARD

Adopt new Section 1541 to read:

1541. Shoring, Sloping and Benching Systems.

(a) General.

(1) All materials of the shoring system used in complying with the provisions of this Article shall be free from defects and amage that might in any way impair their protection function.

(2) Where a shoring system is used it shall be designed and installed to sustain all existing and expected loads.

(3) Provisions shall be made by the employer to prevent injury to employees engaged in the installation of shoring for trenches and other excavations. In trench work this may be done by providing and requiring the use of devices that will allow upper cross braces to be placed from the ground surface before employees work in the trench at those points. In deep trenches requiring additional braces, workers shall then progress downward, protected by cross braces that have already been set firmly in place. The reverse procedure shall be followed when removing shoring.

(4) No part of the shoring system of any excavation shall be removed until effective means have been taken to avoid hazards to employees from moving ground.

(5) If a newly installed masonary or concrete wall is to be depended upon for protection against moving ground, it shall have attained adequate strength to sustain resulting pressures before employees are permitted to enter.

(6) If the excavation is deeper than 20 feet or an alternate shoring, sloping or benching system or combination thereof is to be used, a civil engineer, currently registered in California, shall prepare detailed plans showing the materials and methods to be used. See Appendix Plate C-22.

Exception: Sloping or benching as permitted by this Article.

(A) Where alternate shoring, sloping, or benching systems are used, the engineer's detailed plans shall be available for inspection by the Division at the work site.

(B) Employees must be adequately trained in the safety precautions and hazards associated with the alternate shoring, sloping, or benching systems used.

(C) The written Code of Safe Practices required by Section 1509 shall be revised as appropriate to incorporate the engineer's recommendations.

(b) Standard Shoring System - General.

(1) Shoring shall be installed in accordance with Tables 1 or 2 of these Orders or as detailed in plans and specifications prepared by a civil engineer currently registered in California. See Apprendix Plate C-22 for engineering criteria.

(2) Solid wood sheeting or wood sheet-piling shall be not less than 2-inches in thickness. However, plywood 1 1/8-inch in thickness may be substituted.

(3) Wood uprights shall be not less than 2 inches by 8 inches.

(4) Wood braces and diagonal shores (struts) shall not be less than 4-inch by 4-inch material and not subjected to compressive stress in excess of values given by the following formula:

$$S = 1300 - (20L/D)$$

Maximum Ratio (L/D = 50

Where L = length, unsupported, in inches
and D = least side of the timber in inches
S = allowable stress in pounds per square inch of cross section.

(5) Diagonal shores (struts) shall be wedged or cleated at the bulkhead end, and, if bearing on the ground, shall not impose loads in excess of test-determined soil-bearing values, or in the absence of test data, those given in Plate C-22 of the Appendix.

NOTE: Allowance should be made for the horizontal component of force.

(6) Diagonal shores (struts) shall not be placed at an angle greater than 45 degrees with the horizontal.

(7) When tie rods are used to restrain the top of sheeting or other retaining systems, the rods shall be securely anchored.

(8) When tight sheeting or sheet-piling is used, full loading due to ground water table shall be assumed, unless prevented by weep holes, drains or other means.

(9) Additional stringers, ties, and bracing shall be provided to allow for any necessary temporary removal of individual supports.

(10) If nonstress grade lumber is used for sheeting and lagging, the following thickness and spacing requirements shall be observed:

Minimum rough thickness of sheeting or lagging	Maximum spacing of shoring
2 inches	4 feet
3 inches	7 feet

(11) All hydraulic shoring systems shall be installed, tested and maintained in accordance with the manufacturers' recommendations or in accordance with good engineering practice.

(c) Trench Shoring Systems.

(1) Trench shoring systems shall be installed in compliance with Section 1541(b) and Tables 1 and 2 of this section.

(2) Shoring systems in trenches shall consist of uprights held rigidly opposite each other against the trench walls by jacks or horizontal cross members (braces) and, if required, longitudinal members (stringers/walers) as required in Tables 1 and 2.

(3) Uprights shall be installed parallel with each other.

(4) A shored trench shall not be sloped in excess of 15 degrees from vertical.

(5) Uprights shall not be less than 2 inches in nominal thickness.

Exception: Plywood panels at least 3/4-inch thick may be used behind the uprights in order to hold loose material not likely to impose heavy loads.

(6) Uprights shall extend to at least the top of the trench and to as near the bottom as permitted by the material being installed, but not more than 2 feet from the bottom.

Exception: When running soil is encountered, shoring shall extend to the bottom.

(7) Cross braces shall consist of metal screw-type trench jacks with a foot or base on each end of pipe, or timbers placed horizontally and bearing firmly against uprights or stringers. Hydraulic metal braces may also be used. See Tables 1 and 2.

(8) The minimum number of horizontal braces, either jacks or timbers, required for each pair of uprights shall be determined by the number of 4-foot zones into which the depth of the trench may be divided. One horizontal brace shall be required for each of these zones, but in no case shall there be less than 2 braces. Trenches, the depths of which cannot be divided equally into these standard zones, shall have an extra horizontal brace supplied for the short remaining zone, if such zone is greater than 1/2 the 4-foot unit. In no case, however, shall the vertical spacing of horizontal braces be spaced greater than 4 feet center to center. Minor temporary shifting of horizontal bracing will be permitted when necessary for the lowering of materials into place.

(9) The dimensions and spacing of the elements of the shoring system shall be governed by the depth of the trench, type of soil encountered, and other special conditions of the site, but in no case shall they provide less strength than the members listed in the following tables which are to be considered as a minimum requirement.

TABLE 1
SHORING FOR HARD COMPACT SOIL

Depth (ft)	Uprights		Braces							Stringers (Walers)	
				Wood		Aluminum Pipe and Hydraulic Systems		Steel Pipe and Hydraulic Systems			
	Horizontal Spacing (ft)	Size (in)	Horizontal Spacing (ft)	Size (in)	Max. Trench Width (ft)	Min. Dia. (in)	Max. Trench Width (ft)	Min. Dia. (in)	Max. Trench Width (ft)	Vertical Spacing (ft)	Wood Size (in)
to 7	8	3X8	8	4X4	8	2½	8	1½	3	None	--
	4	2X10	4	4X4	8	2½	8	1½	3	4	4X4
	2	2X8	2	4X4	8	2½	8	1½	3	4	4X4
over 7 to 10	8	4X10	8	4X4	8	2½	6	2	6	None	--
	4	3X10	4	4X4	11	3	10	2½	12	4	6X8
	2	3X10	2	4X4	11	3	10	3	15	4	6X8
over 10 to 12	8	4X12	8	4X4	6	2½	6	2	8	None	--
				6X6	15	3	8	2½	12		
	4	3X12	4	4X4	8	2½	9	2	10	4	8X8
				6X6	15	3	10	2½	11		
	2	3X8	2	4X4	10	2½	10	2½	13	4	8X8
				6X6	15	3	10	3	15		
over 12 to 15	8	6X8	8	4X4	2	2½	5	2	6	None	--
				6X6	15	3	8	2½	10		
	4	4X10	4	4X4	4	2½	6	2	8	4	8X8
				6X6	15	3	10	2½	12		
	2	3X10	2	4X4	4	2½	10	2½	13	4	8X8
				6X6	15	3	10	3	15		
over 15 to 20	8	6X10	8	6X6	8	2½	3	2½	8	None	--
				8X8	15	3	6	3	12		
	4	6X8	4	6X6	10	2½	6	2½	10	4	8X10
				8X8	15	3	9	3	15		
	2	4X10	2	6X6	12	2½	8	2½	12	4	8X10
				8X8	15	3½	10	3	15		

TABLE 2
SHORING FOR RUNNING SOIL

	Uprights		Braces						Stringers (Walers)	
				Wood		Aluminum Pipe and Hydraulic Systems		Steel Pipe and Hydraulic Systems		
	Horizontal Spacing (ft)	Thickness (in)	Horizontal Spacing (ft)	Size (in)	Max. Trench Width (ft)	Min. Dia. (in)	Max. Trench Width (ft)	Min. Dia. (in)	Max. Trench Width (ft)	Vertical Spacing (ft)	Wood Size (in)
4 to 8	Solid	2	6	4X4	8	2½	8	1½	3	4	8X8
				6X6	10	3	10	2	6		
over 8 to 10	Solid	3	6	6X6	9	2½	6	2	6	4	8X10
				8X8	15	3	8	2½	12		
over 10 to 12	Solid	3	4	6X6	8	2½	4	2	6	4	10X10
				8X8	15	3	6	2½	10		
over 12 to 15	Solid	3	4	6X6	6	2½	3	2½	8	4	10X12
				8X8	15	3	6	3	15		
over 15 to 20	Solid	4	4	8X8	10	3	6	2½	6	4	12X12
				8X10	15	3½	8	3	12		
				10X10	20	4	10	3½	15		

GENERAL NOTES

1. Metal pipe braces permitted by these Orders shall be Schedule 40, or equivalent, and installation shall be as required by these Orders.

2. Timber to be "Selected Lumber" quality. (See Definitions - Section 1504).

3. The braces specified in Tables 1 and 2 apply only to trenches as defined in these Orders.

4. Timber members of equivalent "Section Modulus" (required) may be substituted for uprights and stringers.

5. In lieu of the above metal shoring systems, the use of properly maintained hydraulic metal shoring units with equivalent strength is acceptable.

(d) Protective Shields and Welding Huts.

(1) If protective shields or welding huts are used to protect workers, they shall be constructed of steel or other material that will provide protection at least equivalent to that afforded by the materials specified in Tables 1 and 2.

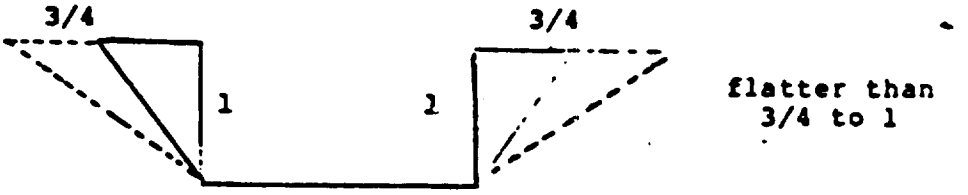
(2) Plans and calculations prepared by a civil engineer currently registered in California shall be made available for field inspection at the site where the shield or welding hut is used.

(e) Bell or Pot Holes.

(1) Bell (or pot) holes shall provide adequate clearance for the work to be done, and shall be supported by shoring and bracing as required by these Orders for trenches unless protective shields or welding huts are used.

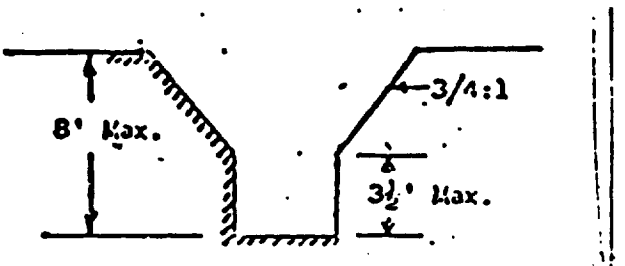
(2) If the operation performed in the bell (or pot) hole requires that an employee use welding equipment from a reclined position on the bottom, the bell (or pot) hole excavation shall be of such shape that the employee will have adequate space for the performance of this operation without removing any of the required shoring system.

(f) Sloping or Benching Systems. In lieu of a shoring system, the sides or walls of an excavation or trench may be sloped or benched, provided equivalent protection is thus afforded. Where sloping is a substitute for shoring that would otherwise be needed, it shall be 3/4 horizontal to 1 vertical except where the instability of material requires a slope greater than 3/4 to 1.

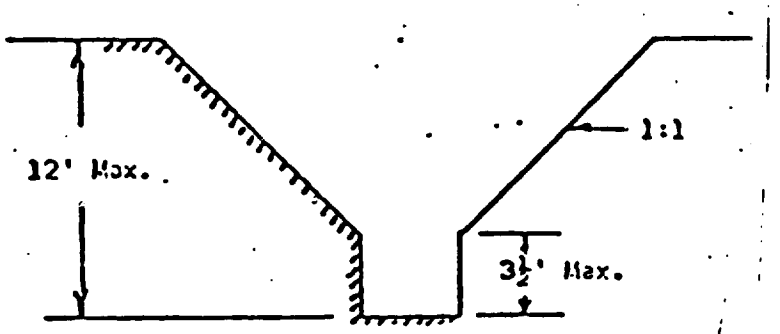


Exceptions:

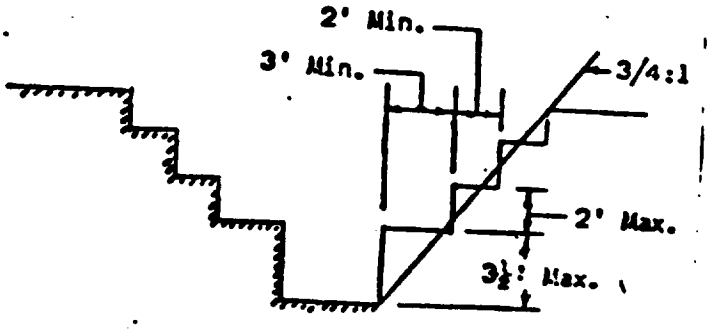
(1) In hard, compact soil where the depth of the excavation or trench is 8 feet or less, a vertical cut of 3 1/2 feet with sloping of 3/4 horizontal to 1 vertical is permitted.



(2) In hard, compact soil where the depth the excavation or trench is 12 feet of less, a vertical cut of 3 1/2 feet with sloping of 1 horizontal to 1 vertical is permitted.



(3) In hard, compact soil, benching is permitted provided that a slope ratio of 3/4 horizontal to 1 vertical, or flatter, is used.



CALIFORNIA OCCUPATIONAL SAFETY AND HEALTH STANDARDS BOARD

Amend Section 1542 to read:

1542. Shafts.

(a) General.

(1) All ~~wells~~ or shafts over 5 feet in depth into which employees are permitted to enter shall be retained with lagging, ~~spiling~~ spiling, or casing.

(2) The lagging, spiling or casing shall extend at least one foot above ground level and shall be provided the full depth of the shaft or at least five feet into solid rock if possible.

NOTE: See pertinent portions of Section 1540 for additional requirements relating to wells and shafts.

(b) Small Shafts ~~Dry, Cemented~~ Hard, Compact Ground. Two-inch (nominal) cribbing may be used in square shafts not over 4 feet square in ~~dry, cemented~~ hard compact ground. Each member shall be cut 1/2 way through the width of the member and dovetailed into position so each member will act as a shore as well as lagging. Strips shall be nailed in each corner to prevent the boards from dropping down.

(c) Shafts in Other Than ~~Dry, Cemented~~ Hard, Compact Ground.

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

(2) Round shafts shall be completely lagged with 2-inch material which is supported at intervals not greater than 4 feet by means of adjustable rings of metal or timber that are designed to resist the collapsing force, or cased in a manner that provides equivalent protection. ~~Means shall be provided to hold rings and lagging in place.~~

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~~(d)--Shafts-over-150-feet-in-depth-shall-have-a-manway partitioned-off-with-1-inch-material-or-equivalent-and-shall-have-a ladderway-with-railed-platforms-every-30-feet.~~

~~(e) Belled Excavation. No workman shall be required or permitted to enter any well or shaft, particularly those drilled for foundation footings, for the purpose of enlarging the bottom by hand, or similar work, unless the walls of the shaft are supported as described in these Orders, or unless a casing affording equivalent protection is in service. The belled section or any additional shaft excavation in which men work shall also have equivalent bracing if the shaft casing does not provide protection. The shaft casing or shoring is not acceptable for belled excavation protection where the height of the bell exceeds 4 feet or its horizontal dimension extends 3 feet or more beyond the shaft wall line. Additionally, men entering such shafts shall wear a body harness securely fastened to a line individually manned and separated from any line used to remove materials from the excavation.~~

~~Note: Refer to Section 1532 for requirements prior to entering confined spaces.~~

~~History: 1. Amendment of subsection (e) filed 5-21-75, effective thirtieth day thereafter (Register 75, No. 21).~~

(d) Bell Excavations. Provisions for the protection of workers that are engaged in belling or enlarging the bottoms of shafts by hand shall include at least the following elements:

(1) Sufficient physical protection from potential ground movement or collapse.

(2) Adequate mechanical ventilation.

(3) A line, suitable for instant rescue, securely fastened to a shoulder harness and worn by each employee entering the shaft(s).

(4) A properly equipped hoist and platform for hoisting or lowering workers in shafts over 50 feet in depth.

(5) Barriers that prevent materials from falling into the shaft(s).

Amend Subsections (a), (d) and (e) of Section 1544 to read:

1544. Earthwork and Excavating.

NOTE: See pertinent portions of Section 1548 for additional requirements relating to earthwork and excavating.

(a) Whenever ~~the Division considers that~~ the height and condition of the face constitutes a serious hazard to employees, ~~it shall require~~ the installation of a bench or other suitable method of working shall be required.

(b) When a bench or multiple-bench method of operation is required, a setback of at least ½ the height of the single face or bank for each section of the face or bank shall be required.

(c) When determining the maximum permitted slope of the face, consideration shall be given to:

(1) Nature of the material being excavated.

(2) Extent to which the material is cemented or consolidated.

(3) Height of the face.

(4) Type and size of equipment used at the face and amount of protection this equipment affords the operator.

(5) Safety of employees who are not protected by such equipment.

(d) Where the face is composed of loose or unstable materials, the slope of the face shall not exceed 3/4 horizontal to 1 vertical where the height is greater than that which can be reached by the ~~dipper or~~ bucket of the excavator or loader being used.

(e) Where the face is composed of moderately compacted materials that are not firmly cemented or consolidated but which experience indicates will stand well in place, the slope shall not exceed 1/2 horizontal to 1 vertical where the height is greater than can be reached by the ~~dipper or~~ bucket of the excavator or loader being used.

Amend Subsection (a) of Section 1545 to read:

1545. Overburden.

(a) No person shall be permitted under a face or bank where stripping or other similar operations constitute a hazard.

Amend Subsections (a), (d) and (e) of Section 1546 to read:

1546. Face Inspection and Control.

(a) A daily physical inspection shall be made of faces and banks, including the tops, where men employees are exposed to falling or rolling materials. The inspection shall be made by a competent-man qualified person who shall dislodge or make safe any material dangerous to employees, or shall cause such material to be dislodged or made safe.

(b) No person shall be permitted to work near a face made unsafe by primary blasting, rains, freezing or thawing weather, or earthquakes until the face has been inspected and made safe.

(c) Overhanging banks are forbidden, except:

(1) Where material is moved away from the face by mechanical equipment having controls located at a safe distance so that no employee is required to approach the face in the course of normal operation.

(2) Where the bank is undercut with a stream of water and the monitor is located at a safe distance from the bank.

(d) Where necessary, a-competent-trained an employee shall be employed at the face, and instructed to give warning when loose rock or other materials are about to fall.

(1) The employee shall be provided with a whistle, siren, or other devices that will give adequate warning to employees.

(2) The employee shall have no other work to distract his attention from his duties as defined above.

(e) When working at night, sufficient illumination shall be provided throughout the working area so that movement of men employees and equipment can be readily observed.

Amend Section 1547 to read:

1547. Protection of Workers at the Face.

(a) No work shall be permitted above or below men employees at the face if such work endangers their safety.

(b) Workers at the face shall be protected as follows:

(1) On top of the bank, by fencing with guardrails or ropes; by using railed platforms or by using safety belts and life lines. This does not apply where the bank is less than 20 feet high or the slope below is less than 3/4 horizontal to 1 vertical or where no work is performed within 10 feet of the edge.

(2) On the face, by removing loose rock from over the working place and by the use of safety belts and life lines, portable staging, boatswain's chair or skips especially designed for use at faces. If a boatswain's chair is used, the employee shall be attached thereto with a safety belt and life line equipped with an approved effective descent control device.

~~When necessary for safety,~~ Two or more persons shall be employed in cooperation with each other in drilling, blasting, or removing loose rock.

Life lines used for scaling or inspection shall be protected from excessive fraying or damage or and shall have a wire center rope.

(3) At the foot of the bank by removing loose rock from above the working place, and maintaining a ready way of exit to a place of safety.

Amend Appendix Plate C-22 to read:

PLATE C-22
BEARING VALUE OF SOIL

Shores and similar members that depend upon earth for support will probably require foot blocks or sills to distribute the load. In the absence of test data that establish the sustaining power of the soils in question, the following information should be helpful in determining the size of ~~fill~~ sill needed to assure adequate support from the soil

Soil type	Tons allowable per square foot
Soft clay	1
Wet clay	2
Sand and clay, mixed in layers	2
Fine dry sand	3
Hard dry clay	4
Coarse compact dry sand	4

DESIGN CONSIDERATIONS
EXCAVATIONS, SLOPES AND BENCHES

The determination of the slope or bench configuration or design of the shoring system shall be based upon careful evaluation of such pertinent factors as the following:

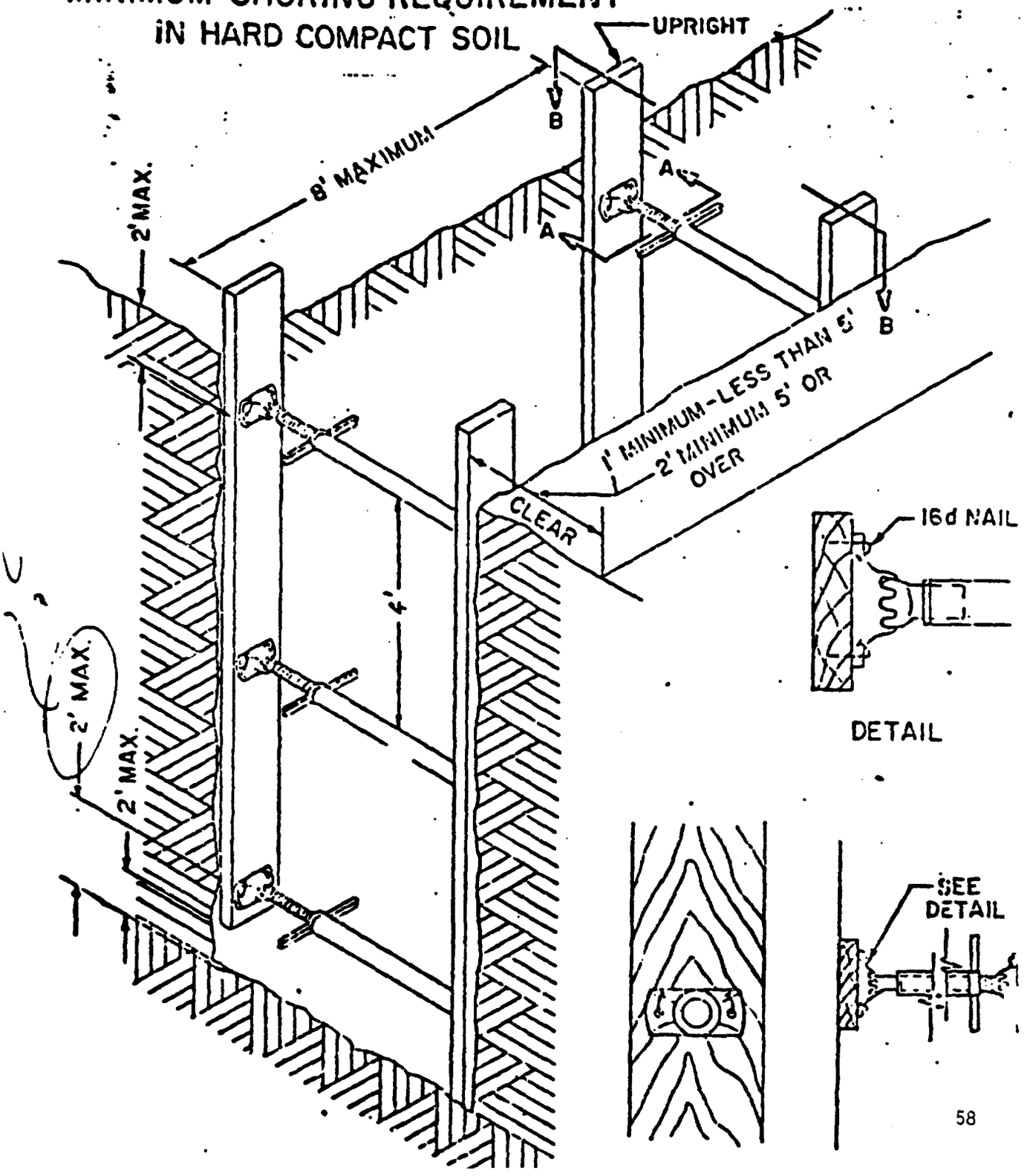
(1) Depth and width of cut.
(2) Possible variation in water content of the material while the excavation is open.
(3) Anticipated changes in materials from exposure to air, sun, water or freezing temperatures.
(4) Loading imposed by structures, equipment, overlaying material or stored material.
(5) Vibration from equipment, blasting, traffic, trains or other sources.
(6) Existing underground facilities.
(7) New or old adjacent excavations.
(8) A minimum coefficient of active earth pressure of 35 pcf (Kw=35) shall be used in all calculations unless a soils evaluation indicates otherwise.

CALIFORNIA OCCUPATIONAL SAFETY AND HEALTH STANDARDS BOARD

Adopt new Appendix Plate C-24-a to read:

Plate C-24-a

MINIMUM SHORING REQUIREMENT IN HARD COMPACT SOIL

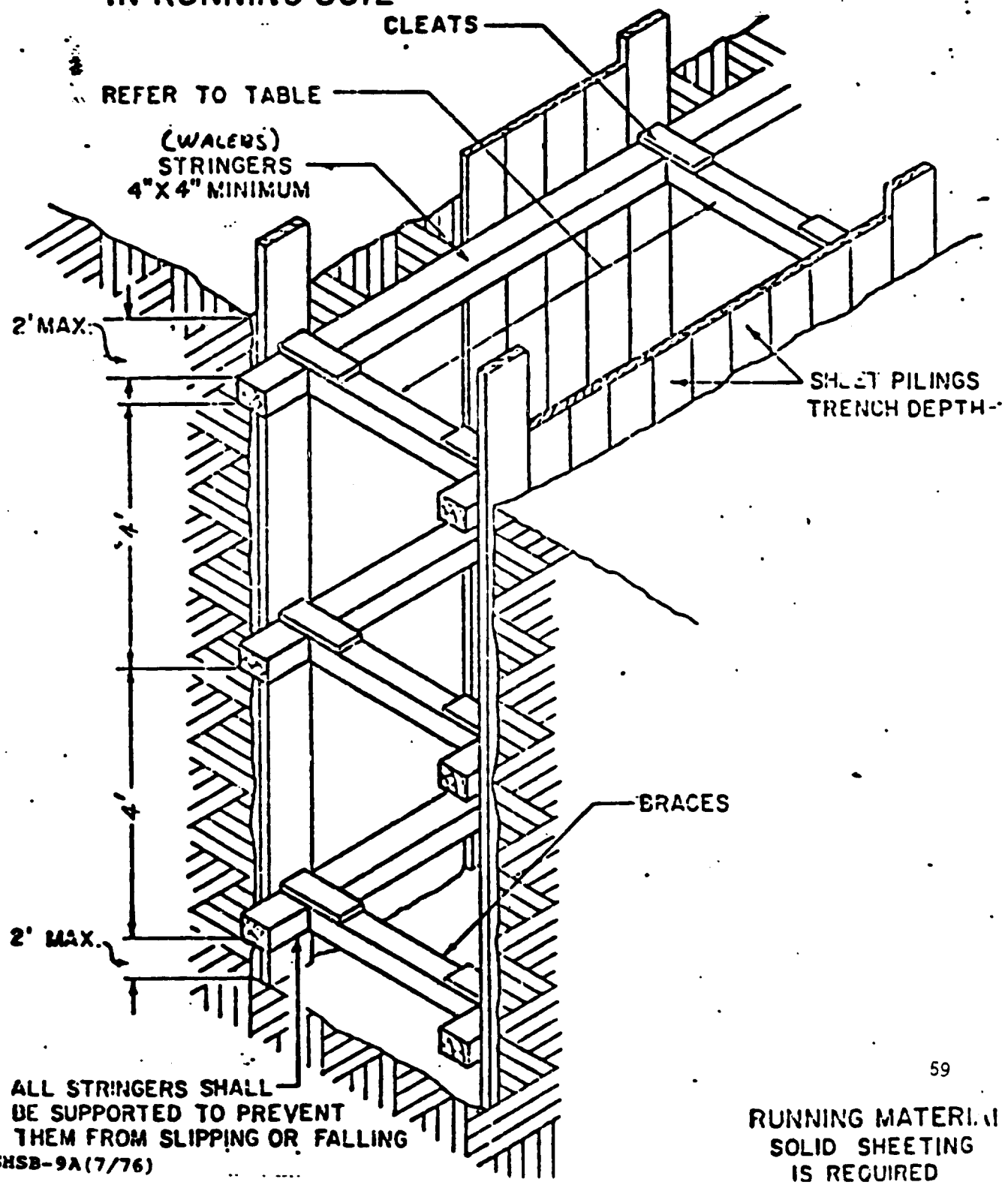


CALIFORNIA OCCUPATIONAL SAFETY AND HEALTH STANDARDS BOARD

Adopt new Appendix Plate C-24-b to read:

Plate C-24-b

CLOSE SHEETING METHOD IN RUNNING SOIL



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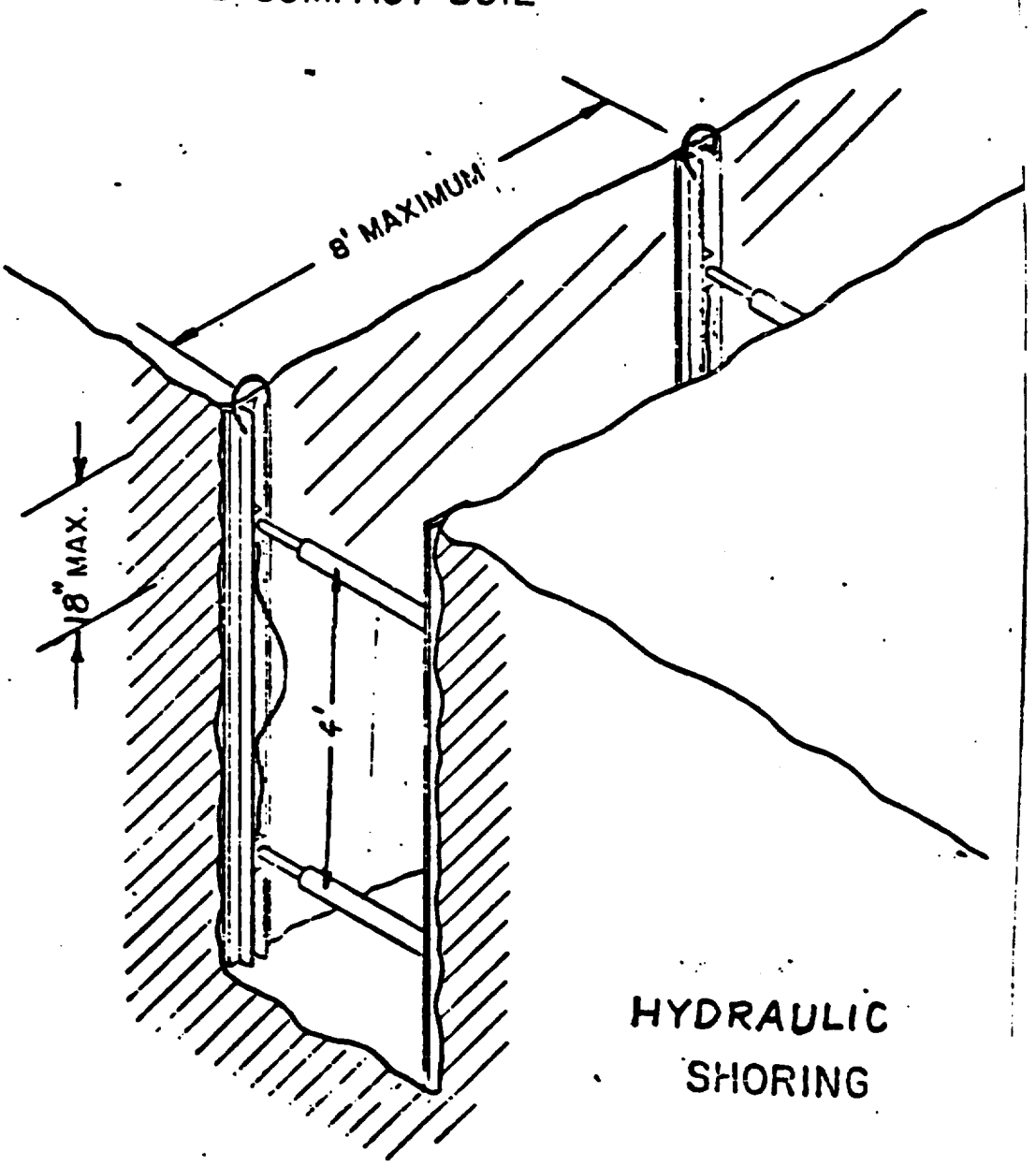
RUNNING MATERIAL SOLID SHEETING IS REQUIRED

Adopt new Appendix Plate C-24-c to read:

Plate C-24-c

MINIMUM SHORING REQUIREMENT IN HARD COMPACT SOIL

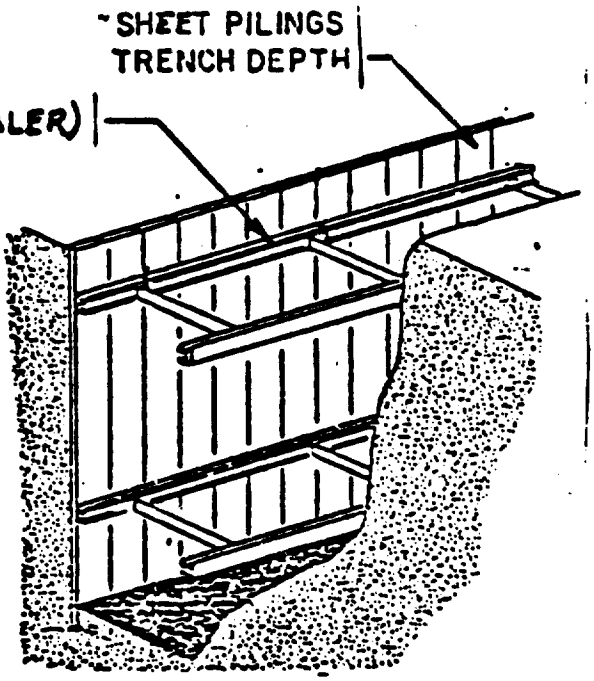


Adopt new Appendix Plate C-24-d to read:

Plate C-24-d

CLOSE SHEETING METHOD

IN RUNNING SOIL



HYDRAULIC SHORING

RUNNING MATERIAL
SOLID SHEETING
IS REQUIRED