NBSIR 79-1936

An Analysis of the Responses from an Associated General Contractors of America (AGC) Survey of Trenching and Shoring Practices

Occupational Safety and Health Administration
Department of Labor
Washington, D.C. 20210

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AN ANALYSIS OF THE RESPONSES FROM AN ASSOCIATED GENERAL CONTRACTORS OF AMERICA (AGC) SURVEY OF TRENCHING AND SHORING PRACTICES

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PREFACE

In June 1976, The Occupational Safety and Health Administration (OSHA) engaged the National Bureau of Standards, (NBS), to a) study the compatibility of the technical provisions in the OSHA regulations for excavation, trenching and shoring with actual construction practice and with the state of knowledge in geotechnical and structural engineering, b) review the experience accumulated since their promulgation and, c) recommend potential modifications that could improve their effectiveness.

As part of this effort, a field study of present practice in excavation, trenching and shoring and of the impact of the OSHA regulations as perceived by contractors was conducted. Some of the information was provided by the Associated General Contractors of America (AGC) who sent a questionnaire to its members. In this report the responses to this questionnaire are summarized and discussed.

Mr. Arthur Schmuhl, Director of Safety and Health Services, and Mr. Joseph P. Ashooh, Director of the Municipal - Utilities Division of AGC, conducted the survey and provided many useful suggestions. The data were reviewed and analyzed by Dr. Richard L. Tucker and Dr. Lymon C. Reese of the University of Texas at Austin and by Dr. Jimmie Hinze of the University of Missouri at Columbia.

ABSTRACT

Results of an Associated General Contractors of America (AGC) survey of present practice in excavation, trenching and shoring and of the impact of the OSHA Regulations for Excavation, Trenching and Shoring as perceived by a selected number of the membership are presented. The survey consisted of forty-seven (47 questions. A response of about fifty percent resulted in twenty-three (23) questionnaires being completed and returned to AGC. Although the twenty-three responses did not merit a rigorous statistical analysis, the data are useful in making some general statements about trenching and excavation operations.

Keywords: Construction practices; Construction Safety; Excavation; Shoring; Trenching.

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1.0 INTRODUCTION

1.1 GENERAL

The OSHA Regulations for Excavation, Trenching and Shoring were promulgated in 1974 [1]*. Experience accumulated since their promulgation indicates that the regulations are difficult to enforce because of technical ambiguities. Consequently in June 1976, OSHA engaged the National Bureau of Standards (NBS) to study construction practices and to recommend potential modifications that could improve the effectiveness of these regulations. The state of knowledge in geotechnical and structural engineering and the experience accumulated since the promulgation of the regulations were to be considered.

The NBS study consisted of: 1) a field survey of present practice in excavation, trenching and shoring and of the impact of the OSHA regulations; 2) a study of the technical provisions in the regulations; 3) a study of the timber presently used for shoring and; 4) a federal workshop on excavation safety held on September 19 and 20, 1978.

As part of the field survey, data were collected from various geographical regions in the United States. NBS studied field conditions in nine metropolitan areas [2]. Essentially all states were represented by more than 300 responses (anonymous) to three letter surveys conducted by the National Utility Contractors Association, the Associated General Contractors of America, (AGC), and the National Association of Plumbing, Heating and Cooling Contractors. This report presents the responses to the questionnaires sent out by the AGC, while the responses from the other letter surveys are presented in Reference 2.

1.2 PURPOSE AND SCOPE

The purpose of the (AGC) survey was: 1) to study field practices in excavation bracing, particularly empirical practices that seem to be adequate and generally accepted in the industry, and 2) to obtain information on the problems and difficulties encountered by contractors with existing OSHA regulations.

The information presented herein was obtained through a 17-page questionnaire sent by AGC to its members in the fall of 1977. Forty-seven questions were included in the questionnaire, which covered such topics as trench bracing systems, soil types encountered, OSHA decision-making processes on field work and field investigations. Respondents were free to elaborate in their answers. A response of about fifty percent resulted in twenty-three (23) questionnaires being completed and returned to AGC. It should be pointed out that due to the amount of time required to complete this 47-question survey only a small number of questionnaires was sent out. When interpreting the responses, how representative they

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* Numbers in brackets indicate reference given on page 5.

are must be considered. This question involves factors that differentiate those that responded from those that did not. For example, the respondents might be those contractors most anxious to comment on the OSHA provisions. This and other possibilities must be considered when interpreting the responses.

With the small sample size obtained, it was determined that the most meaningful analysis of the data could be made by tabulating the results. Although the twenty-three responses did not warrant a rigorous statistical analysis, the data are useful in making some general statements about trenching and excavation operations. A discussion of the responses to questions follows in Section 2.0.

2.0 DISCUSSION OF RESULTS

2.1 INTRODUCTION

A copy of the questionnaire is provided in Appendix A and the results of the survey are presented in tabular form in Appendix B. All but two of the questions have been tabulated. The responses to Question 3 have not been presented. This question concerned the location of the area in which each company did most of its work. It was thought that the identity of some of the firms might be revealed if the responses to this question were presented. Consequently, this information is presented in a generic manner because anonymity of the companies responding to the survey had been agreed to. The data from Question 5 are also omitted. This question involved the number of injuries incurred by the workers in each company during the previous year. This information was not relevant to this report because normalized injury frequencies would not be tabulated as the corresponding manhours of exposure was not obtained. The data which are presented in the next section show similarities between some contractor practices concerning trenching and excavation operations and in some instances the data demonstrate how widely some of the seemingly similar contractors differ in their daily operations. General conclusions will be drawn. However, these conclusions are largely conjecture as no statistical analysis was made. Further study may reveal that other relationships exist.

2.2 FINDINGS

The annual volume of business conducted by each firm was related to the characteristics of the firm's operations. Sixty percent of the firms participating in the survey had an annual volume of business less than or equal to five million dollars. The service area of the larger firms were over a wider geographic area and trenching comprised only a small fraction of their total volume. On the other hand the smaller firms had trenching as a major portion of their annual volume. About 70 percent of the trenching work was reported for sewerage, with another 23 percent for water systems. Fifty percent of their work utilized sloped sides, and bracing systems were used an average of 43 percent of the time.

Soil type had a strong influence on field practices. Typical soil types identified by the respondents were:

Stiff Clay	29%
Medium Clay	18%
Soft Clay	16%
Sand & Gravel	15%
Loose Sand	10%
Muck	6%
Loess	6%

In addition, written responses were given regarding the soil type causing the most concern for safety against collapse. Although they varied somewhat, the most frequent responses were "clay likely to crack" and "loose silt or sand". Bracing systems are used more frequently in soft to medium clays, loose sand, muck and loess. Trench boxes are the most frequently used bracing system for trenches, while hydraulic shores and screw jacks are the second most common form of trench bracing. Sloped trench walls are most often used in stiff clays or in soils comprised of sand and gravel.

Most trenches deeper than 15 feet (4.6m)* are braced. Braced trenches are generally 4 feet (1.2m) to 8 feet (2.4m) wide. The majority of the contractors stated they left their trenches open less than one day. In fact, almost half of the trenches are left open less than 2 hours. The equipment used in opening a trench is usually a backhoe with the typical length of an unbraced trench section averaging 40 feet (12m) and the typical length of a braced section averaging approximately 50 feet (15m). Although the greater percentage of the contractors stated that collapses of trenches more than five feet (1.5m) deep were rare, six contractors indicated that this happened occasionally.

Most contractors indicated that disturbed soil was a major contributing factor to trench hazards and that this type of condition was met occasionally. Soils changing radically in character such as granular to cohesive and unanticipated utilities are the most frequently encountered worse conditions. Rainfall, vibration, subsurface water and drying were the most common causes of soil instability.

While most firms have at least one registered engineer on the staff, the majority of the field decisions are not made by engineers but by field personnel. The responses to the questionnaire showed a preponderance of decision-making authority belonging to job site supervisors. General superintendents and foremen are heavily involved with decisions regarding bracing or sloping. The job foreman or superintendent is almost universally considered to be the person most qualified to describe the physical characteristics of a soil.

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* 1 ft = .305 meters

In familiar areas many contractors will use the soil borings provided by the owner. A large number of contractors also will drill additional soil borings and/or dig test holes. When work is to be performed in a new area, the contractors surveyed generally indicated that they explored the subsurface conditions in slightly greater detail.

No further generalization can be made. Many of the remaining questions of the survey drew specific responses. Any attempt to generalize these responses could be misleading. However, the responses to these questions are presented in Appendix B so that they may be studied individually. Specifically, the reader should refer to the responses to Questions 44 and 45 for comments on OSHA standards.

3.0 SUMMARY

The smaller firms participating in the survey had trenching as a major portion of their annual volume. Of the 23 responses the greater percentage of their trenching work was for sewerage. Fifty percent of their work utilize sloped sides with bracing systems used an average of 43 percent of the time.

Contractors encounter a wide variety of soils which have a strong influence on field practice. Soils often vary with depth in a trench. Unexpected conditions frequently occur and soils may lose stability with time due to weather or environmental factors.

Most trenches are opened for less than a day using a backhoe. Trenches deeper than 15 (4.6m) feet are braced. Braced trenches are generally 4 feet (1.2m) to 8 feet (2.4m) wide with a typical length of a braced section averaging approximately 50 feet (15 m). Most decisions regarding bracing or sloping are made by job site supervisors.

In general, the contractors were dissatisfied with the OSHA standards. OSHA Tables P-1 and P-2 were considered inappropriate, impractical and needed revision. The experience of field personnel and the use of trench boxes should be considered and be made a part of the OSHA standards.

4.0 REFERENCES

1. Department of Labor, Occupational Safety and Health Administration, Construction Safety and Health Regulations, Part II, Subpart P, Washington, D.C., June 1974.

2. Hinze, J., "A Study of Work Practices Employed to Protect Workers in Trenches," NBSIR No. 79-1942, National Bureau of Standards, December, 1979.

APPENDIX A

THE ASSOCIATED GENERAL
CONTRACTORS OF AMERICA (AGC)
QUESTIONNAIRE

QUESTIONNAIRE FOR CONTRACTORS

1. Approximate average annual volume of work of your company: $______________________

2. Approximate percentage of this total volume of work in trenching and excavation:

   Trenching ______________% Excavation ______________%

3. In what areas (or states) does your company do most of its work? ______________________

   ____

   ____

4. Type of trenching work your company does (circle appropriate ones):

   storm sewer _________% telephone __________% water _________%

   sanitary sewer ______% electric ___________% gas ___________%

   other: ____

5. How many recordable injuries occurred in the company in 1975? ____________________

   Of these injuries, how many were lost time injuries? _____________________________

6. In terms of linear footage, what percent of your trenches are:

   sloped __________% Braced __________% Unsupported Vertical ____________%

7. What soil types do you typically encounter?

   Hard, solid, stiff clay _________________%

   Likely to crack or crumble,
   medium clay _______________%

   Loose silt, soft clay _______________%

   Sand and gravel _________________%

   Loose sand _______________%

   Muck ___________________%

   Loess __________________%

   Which of these soils causes you the most concern for safety against collapse?

   ____

   ____

8. Bracing systems you use in trenching:

Trench box __________%

Steel sheet piles __________%

Tight timber sheeting with
timber wales and struts __________%

Skeleton (skip) bracing __________%

Hydraulic shores or skrew jacks __________%

Soldier piles and lagging __________%

Other __________% Specify ____________________________________

9. Support systems in excavations:

Backties __________%

Raker braces __________%

Cross lot braces __________%

Sheetpiles (cantilever) __________%

Other __________% Specify ____________________________________

10. Depth of trenching work (give percent in terms of linear footage of trench):

Depth (feet)	Braced Trenches	Sloped Trenches
0 - 5	__________%	__________%
5 - 10	__________%	__________%
10 - 15	__________%	__________%
15 - 20	__________%	__________%
20 - 25	__________%	__________%
over 25	__________%	__________%

11. Width of braced trenches:

less than 4 feet __________%

4 feet to 8 feet __________%

8 feet to 12 feet __________%

12 feet to 15 feet __________%

over 15 feet __________%

12. Length of time braced trenches are left open before backfilling:

less than 1 hour __________%

1 to 2 hours __________%

less than 1 day __________%

1 to 2 days __________%

longer than 2 days __________%

13. Length of braced trench open at one time:

	Unbraced Portion	Braced Portion
typical	________ft.	________ft.
maximum	________ft.	________ft.

14. What horizontal clearance between cross braces in trenches do you need in order to carry out your work? (explain reasons carefully) For excavation: ________

____

____

for insertion of pipe: ________

____

____

for other operations where clearance is important: ________

____

____

____

15. Do you need several choices of horizontal spacings of cross braces to keep member sizes down? (explain carefully) ________

____

____

____

____

16. What vertical clearance between the lowest brace and the bottom of the trench do you need to carry out your work? (explain carefully) ________

____

____

____

17. Do you ever need to do one of the following in a braced trench?

a) Temporarily remove a horizontal cross brace:

length of time ________

reason ________

b) Impose a load on a horizontal cross brace:

load in pounds ________

reason ________

18. Would you consider an allowance for a surcharge of 300 lb/ft^2 (equivalent of 3 ft. of surcharge) to account for storage of excavated material and other construction loads

to be excessive______ reasonable______ inadequate______

Explain:____

____

____

____

19. Percentage of trenches (in terms of linear footage) where a high water table is a problem: ______________%

20. What methods do you normally use in trenches to deal with a high water table?

Explain:____

____

____

____

21. Slopes in temporary sloped excavations:

Soil type

____________	________vertical in	________horizontal
____________	________vertical in	________horizontal
____________	________vertical in	________horizontal
____________	________vertical in	________horizontal
____________	________vertical in	________horizontal
____________	________vertical in	________horizontal

22. Do you ever use compound (composite) slopes? ______YES ______NO

If YES, draw typical cross-section.

23. Timber sizes used by your company (note if you use rough cut or dressed timber, softwood or hardwood, and if cross-brace size is changed for wide trenches). Give sizes you consider best, regardless of OSHA provisions.

(a) Timber shoring (wales and cross braces) -- include large horizontal spacings (16-24 ft.) if used by your company, but do not include skip-bracing.

Soil Type	Depth (ft)	Wales		Cross Braces		Max. Vertical Spacing (ft)	Sheeting Thickness (in)
		Horizontal Span (ft) (Unsupported)	Size	Horizontal Spacing (ft)	Size		
(1) Hard, Compact, Solid	5-10						
	10-15						
	15-20						
	20-25						

(continued)

23. (a) Continued

Soil Type	Depth (ft)	Wales		Cross Braces		Max. Vertical Spacing (ft)	Sheeting Thickness (in)
		Horizontal Span (ft) (Unsupported)	Size	Horizontal Spacing (ft)	Size		
(2) Likely to crack	5-10						
	10-15						
	15-20						
	20-25						

(continued)

23. (a) Continued

Soil Type	Depth (ft)	Wales		Cross Braces		Max. Vertical Spacing (ft)	Sheeting Thickness (in)
		Horizontal Span (ft) (Unsupported)	Size	Horizontal Spacing (ft)	Size		
(3) Sand	5-10						
	10-15						
	15-20						
	20-25						

(continued)

23. (a) Continued

Soil Type	Depth (ft)	Wales		Cross Braces		Max. Vertical Spacing (ft)	Sheeting Thickness (in)
		Horizontal Span (ft) (Unsupported)	Size	Horizontal Spacing (ft)	Size		
(4) Soft Clay	5-10						
	10-15						
	15-20						
	20-25						

(continued)

23. (a) Continued

Soil Type	Depth (ft)	Wales		Cross Braces		Max. Vertical Spacing (ft)	Sheeting Thickness (in)
		Horizontal Span (ft) (Unsupported)	Size	Horizontal Spacing (ft)	Size		
(5) Hydro-Muck	5-10						
	10-15						
	15-20						
	20-25						

23. (b) Skeleton (skip or spot) bracing.

Soil Type	Depth (ft)	Timber Uprights		Cross Braces	
		Size	Spacings (c to c)	Size or Type	Number
	5-10				
	10-15				
	15-20				
	5-10				
	10-15				
	15-20				

(continued)

23. (b) Continued

Soil Type	Depth (ft)	Timber Uprights		Cross Braces	
		Size	Spacings (c to c)	Size or Type	Number
	5-10				
	10-15				
	15-20				

(c) Hydraulic Shores (such as speedshores)

Soil Type	Depth (ft)	Horizontal Center-to-Center Spacing Between Uprights (ft)
	5-10	
	10-15	
	15-20	
	20-25	

(continued)

23. (c) Continued

Soil Type	Depth (ft)	Horizontal Center-to-Center Spacing Between Uprights (ft)
	5-10	
	10-15	
	15-20	
	20-25	
	5-10	
	10-15	
	15-20	
	20-25	

24. Under what conditions do you use skeleton bracings and how do you decide on horizontal spacing of uprights? ______________________________

____

____

____

____

25. On a normal project, who in your firm will be most familiar and qualified to describe the physical characteristics of the soil?

Owner/Management   General Superintendent   Job Foreman

Backhoe Operator   Other______________

26. If you have previously done trenching work in the vicinity of a project, what type of soil investigation do you accomplish prior to beginning work?

_____Make and evaluate soil borings
_____Utilize information from available soil borings and other related information
_____Dig test holes
_____Other (please explain)______________________________
____
_____None

27. If you have not previously done trenching work in the vicinity of the project, what type of soil investigation do you accomplish prior to beginning work?

_____Make and evaluate soil borings
_____Utilize information from available soil borings and other related information
_____Dig test holes
_____Other (please explain)______________________________
____
_____None

28. On most jobs, who decides that sloping or bracing of a given segment of a trench will be required?

_____Management
_____Contractor's design engineer, or consultant
_____General superintendent
_____Job foreman
_____Based on local codes or design by owner

29. On trenches where sloping is employed, who determines the angle of the slope?

_____Owner/management, based on ______________________________

_____General superintendent, based on ______________________________

_____Foreman, based on ______________________________

_____Other (please explain) ______________________________

30. What percentage of the time do you use the following items of equipment in trenching operations?

Backhoe_______%

Trenching machine_______%

Power shovel_______%

Drag line_______%

Clam shell_______%

Other (please specify) ______________________________

Do not do trenching_______

31. Are the soils in which you normally work generally the same from the ground surface to the bottom of the trenches?

YES_______
NO _______
If NO, please give typical characteristics ______________________________

____

____

32. Do you ever add moisture to a dry, sandy soil to increase its stability long enough for your trenching operation?

YES_______
NO _______

33. Which of the following site conditions do you consider the most hazardous from the standpoint of safety?

_____Straight trench

_____Manhole

_____Intersections of trenches

_____Vibrating areas

_____Disturbed soils

_____Narrow right of way

_____Other (please specify) ______________________________

34. Listed below are some factors which might be difficult to anticipate throughout a trenching project. Please identify, with a symbol, the frequency with which these or other surprises occur on your projects.
Symbols: r = rarely; o = occasionally; f = frequently.

_____Unexpected ground water
_____Radical change in soil type
_____Tree roots
_____Utility lines not anticipated
_____Previous excavations or disturbed soil
_____Unusually heavy surcharge
_____Other (please specify)____

35. Do you frequently encounter soils which lose stability as a result of:

_____Rainfall
_____Vibration
_____Increased subsurface water
_____Drying
_____Temperature changes
_____Inclinded bedding
_____Other

If any of the above secondary factors cause significant concern, please explain further:____

____

____

____

36. If there is an environmental change such as a heavy rainfull, or unanticipated subsurface conditions which require a change in bracing, who makes the decision on the required changes?____

____

37. How often has your firm experienced unexpected collapse of sides of trenchings more than 5 feet deep (with or without persons in the trench)?

_____More than once per month
_____Several times per year
_____Occasionally
_____Very rarely

38. In what types of soils and circumstances do these collapses most often occur?

____

____

____

39. Did a braced excavation ever collapse on any of your projects? ____YES ____NO
If not, are you aware of any cases where a braced excavation did collapse?
____YES ____NO Please explain reasons if known: ______________________________

____

____

____

40. What, in your experience, are identifyable signs of imminent distress in trenches and excavations? ____

____

____

____

____

____

41. What are the most likely causes of collapse of bracing systems (other than carelessness) in trenches? ______________________________________

____

____

____

In excavations? ____

____

____

____

42. On what occasion would the company consult the following: (state if never)

A. A soils engineer to explore subsurface conditions? ____________________

____

B. A professional engineer to design bracing systems? ____________________

____

43. Do you have a registered professional engineer on your staff? ____YES ____NO
Do you have a trained engineer who designs bracings? ____YES ____NO

44. In the OSHA standards, contractors are provided with guidelines as set forth in OSHA Tables P-1 and P-2. Please comment on how these could be improved:

45. What specific other changes would you recommend to be made in the OSHA standards regarding "Excavation, Trenching, and Shoring"?

46. From your experience with trenching, can you suggest simple field tests which will indicate the stability of the trench (for both braced and sloped excavations)? If so, please explain.

47. From your experience, please suggest any practices of <u>any</u> type which might be commonly adopted and would improve trenching safety.

APPENDIX B

RESPONSES TO THE ASSOCIATED
GENERAL CONTRACTORS OF AMERICA (AGC)
QUESTIONNAIRE

RESPONSES SUMMARIZED IN TABULAR FORM

	RESPONSE NUMBER																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Q. 1 Dollar Volume/Year (in millions)	1	5	-	1	4.5	50	6	2	20	95	.6	1.5	7	6	2	25	14	1.8	.5	3.5	3	.3	.6
Q. 2 Volume of Work (% Trenching)	25	70	25	0	92	-	2	70	10	12	85	90	75	70	100	1	90	75	90	98	100	50	100
Q. 2 Volume of Work (% Excavation)	25	0	25	100	8	-	3	15	20	25	15	10	25	10	0	3	2	5	10	2	0	50	0
Q. 4 Type Trenching																							
(% Storm Sewer)	50	10	50	20	10	-	0	15	50	-	10	30	20	-	-	60	10	15	30	30	30	10	50
(% Sanitary Sewer)	40	70	50	60	50	-	30	30	50	-	60	50	40	-	-	20	30	30	30	70	40	20	50
(% Telephone)	0	0	0	0	0	0	0	15	0	-	0	0	0	0	0	0	10	0	0	0	0	20	0
(% Electric)	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	5	0	0	0	0	10	0
(% Water)	0	20	0	20	40	-	70	30	0	-	30	20	40	-	-	0	40	35	40	0	30	20	0
(% Gas)	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	20	5	0	0	0	0	20	0
Q. 6 Trench Support (%)																							
Sloped	50	40	50	70	5	50	90	80	0	90	95	50	20	30	60	75	20	70	80	40	25	50	10
Braced	50	40	50	30	70	50	10	20	90	5	0	50	60	70	40	25	40	20	20	60	75	10	90
Unsupported Walls	0	20	0	0	25	0	0	0	10	5	5	0	20	0	1	0	40	10	0	0	0	40	0
Q. 7 Typical Soils																							
Stiff Clay (%)	10	25	10	30	0	-	80	40	30	25	0	10	40	20	60	45	20	30	80	20	30	30	10
Medium Clay (%)	0	50	40	20	10	-	15	20	20	10	0	5	0	25	10	30	40	10	10	20	30	10	10
Soft Clay (%)	60	10	40	10	30	-	3	15	20	15	5	35	0	20	10	5	20	0	0	20	10	10	10
Sand & Gravel (%)	20	10	0	10	10	-	2	0	5	10	95	35	20	10	5	5	10	0	10	10	20	40	10
Loose Sand (%)	10	0	10	20	40	-	0	10	20	5	0	10	20	22	5	5	10	0	0	0	5	10	10
Muck (%)	0	2	0	10	10	-	0	10	5	10	0	5	0	3	5	10	0	0	0	10	5	0	50
Loess (%)	0	5	0	0	0	-	0	0	0	25	0	0	20	0	5	0	0	60	0	20	0	0	0

		RESPONSE NUMBER																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Q. 8 Type of Bracing in Trenches																							
Trench Box	(%)	70	80	50	95	95	-	0	60	95	50	95	90	50	95	15	10	10	25	80	80	50	90	30
Steel Sheet Piles	(%)	0	5	25	5	5	-	0	20	0	25	0	0	20	5	3	15	0	0	0	0	0	10	0
Timber Sheeting	(%)	0	5	25	0	0	-	0	0	3	0	0	0	0	0	2	5	0	0	0	10	10	0	30
Skip Bracing	(%)	0	0	13	0	0	-	0	20	0	15	0	0	0	0	0	30	0	0	0	0	0	0	0
Hydraulic Shores, Screw Jacks	(%)	30	10	12	0	0	-	100	0	2	10	5	0	30	0	75	10	90	75	20	10	40	0	40
Soldier Piles/ Lagging		0	0	0	0	0	-	0	0	0	0	0	0	0	0	5	30	0	0	0	0	0	0	0
Q. 9 Type of Support in Excavations																							
Backties	(%)	0	-	25	-	0	-	0	75	40	0	-	0	0	-	-	60	-	-	-	0	-	0	-
Raker Braces	(%)	0	-	25	-	0	-	0	0	0	25	-	0	0	-	-	20	-	-	-	0	-	0	-
Cross Lot Braces	(%)	0	-	25	-	100	-	0	0	50	25	-	0	0	-	-	20	-	-	-	0	-	90	-
Sheet Piles	(%)	0	-	25	-	0	-	60	25	10	50	-	0	100	-	-	0	-	-	-	100	-	10	-
Other	(%)	100	-	0	-	0	-	40	0	0	0	-	0	0	-	-	0	-	-	-	0	-	0	-

	RESPONSE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Q. 10 Trench Depth (%)																							
Braced																							
0 FT.-5 FT.	0	5	0	0	0	-	0	10	100	0	-	0	0	0	0	0	0	0	0	0	0	0	0
5 FT.-10 FT.	0	5	50	12	100	-	0	15	100	0	-	20	100	70	25	50	62	25	10	50	50	0	0
10 FT.-15 FT.	40	5	50	25	100	-	0	25	100	0	-	80	0	80	50	20	50	25	50	75	50	10	100
15 FT.-20 FT.	5	10	75	50	100	-	38	20	100	100	-	80	25	90	50	100	-	25	90	90	36	10	94
20 FT.-25 FT.	0	60	100	100	100	-	100	0	100	100	-	80	-	100	75	100	-	25	100	100	100	20	100
25 FT. +	0	60	100	100	100	-	100	0	-	100	-	100	-	-	100	100	-	0	-	100	100	-	100
Sloped																							
0 FT.-5 FT.	0	95	100	100	100	-	100	90	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100
5 FT.-10 FT.	0	95	50	88	0	-	100	85	0	100	100	80	0	30	75	50	38	75	90	50	50	100	100
10 FT.-15 FT.	60	95	50	25	0	-	100	75	0	100	100	20	-	20	50	80	50	75	50	25	50	90	0
15 FT.-20 FT.	95	90	25	50	0	-	62	50	0	0	100	20	75	10	50	0	-	75	10	10	64	90	6
20 FT.-25 FT.	0	40	0	0	0	-	0	0	0	0	100	20	-	0	25	0	-	75	0	0	0	80	0
25 FT. +	0	40	0	0	0	-	0	0	-	0	-	0	-	-	0	0	-	100	-	0	0	-	0
Q. 11 Width of Braced Trench																							
Less than 4 Ft.	90	10	50	0	50	-	90	20	0	100	-	10	0	5	90	0	75	0	20	0	80	0	50
4 Ft.-8 Ft.	10	90	50	95	50	-	10	80	100	0	-	80	90	85	4	30	25	30	75	90	15	0	25
8 Ft.-12 Ft.	0	0	0	0	0	-	0	0	0	0	-	5	0	10	3	50	0	50	5	10	5	100	25
12 Ft.-15 Ft.	0	0	0	5	0	-	0	0	0	0	-	5	10	0	3	20	0	20	0	0	0	0	0

		RESPONSE NUMBER																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Q. 12 Time of Open Exc. (%)																							
Less than 1 Hr.	80	98	0	90	100	-	-	10	0	1	-	50	0	85	0	0	30	0	80	50	30	0	0
1 Hr.-2 Hr.	20	0	50	4	0	-	-	20	30	19	-	40	0	10	0	0	30	20	20	30	30	0	0
Less than 1 Day	0	0	50	2	0	-	-	35	50	80	-	4	100	5	100	0	40	80	0	20	25	0	50
1 Day - 2 Days	0	2	0	2	0	-	-	10	10	0	-	4	0	0	0	10	0	0	0	0	15	0	25
Over 2 Days	0	0	0	2	0	-	90	25	10	0	-	2	0	0	0	90	0	0	0	0	0	100	25
Q. 13 Length of Open Trench																							
Unbraced																							
Typical (Ft.)	100	10	50	-	25	-	-	-	35	-	-	20	10	10	-	15	200	15	30	20	20	50	8
Maximum (Ft.)	-	20	100	10	60	-	-	-	40	-	-	40	20	10	-	3-	200	25	50	100	30	50	10
Braced																							
Typical (Ft.)	100	20	100	20	20	-	-	-	15	50	-	20	10	20	75	30	200	100	20	20	65	50	50
Maximum (Ft.)	-	50	200	20	20	-	-	-	20	100	-	20	20	26	-	30	200	200	40	40	100	50	150
Q. 25 Who Describes Soil																							
Job Foreman			✓	✓	✓						✓	✓											✓
Gen. Supt.	✓	✓	✓		✓	✓		✓	✓	✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	
Engineer								✓								✓							
Owner			✓		✓		✓			✓					✓			✓	✓				

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
									RESPONSE NUMBER														
Q. 26 Soil Study - Familiar Area																							
Make Borings		✓	✓		✓	✓			✓				✓	✓		✓	✓		✓	✓	✓		
Use Avail. Borings		✓	✓			✓	✓	✓	✓	✓		✓			✓	✓		✓	✓		✓	✓	✓
Dig Test Holes	✓	✓	✓		✓	✓		✓		✓			✓		✓	✓	✓			✓	✓		✓
Other		✓		✓							✓		✓					✓					
Q. 27 Soil Study - New Area																							
Make Borings		✓	✓	✓	✓	✓			✓			✓		✓	✓	✓	✓				✓		✓
Use Avail. Borings		✓	✓	✓		✓	✓	✓	✓		✓	✓	✓		✓	✓		✓			✓		✓
Dig Test Holes	✓	✓	✓	✓	✓	✓		✓				✓			✓	✓	✓	✓	✓		✓	✓	✓
Other		✓						✓			✓												
Q. 28 Who Decides: Brace or Slope?																							
Manager		✓	✓		✓	✓				✓					✓			✓	✓	✓			✓
Engineer			✓			✓		✓	✓							✓					✓		✓
General Supt.	✓	✓	✓			✓	✓	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓
Job Foreman		✓	✓	✓		✓					✓	✓			✓					✓			✓
Q. 29 Who Decides Angle of Slope?																							
Manager		✓	✓		✓			✓		✓					✓			✓		✓			
Engineer		✓	✓		✓							✓					✓			✓			
Gen. Supt.	✓	✓	✓		✓		✓	✓		✓		✓		✓		✓	✓	✓	✓	✓	✓	✓	
Job Foreman		✓	✓	✓	✓						✓	✓	✓		✓					✓			

		RESPONSE NUMBER																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Q. 30 Equipment Used in Trenching (%)																							
Backhoe	100	80	70	100	100	-	99	90	100	90	100	95	95	90	100	75	35	85	95	100	90	95	60
Trenching Machine	0	10	10	0	0	-	0	5	0	0	0	0	0	1	0	0	65	15	5	0	0	5	0
Drag Line	0	5	10	0	0	-	1	5	0	7	0	3	0	7	0	15	0	0	0	0	0	0	20
Clamshell	0	5	10	0	0	-	0	0	0	3	0	2	5	2	0	10	0	0	0	0	10	0	20
Q. 31 Same Soil from Top to Bottom of Trench	✓									✓							✓	✓	✓				
Q. 32 Water is Added to the Soil										✓		✓											
Q. 33 Major Trench Hazards																							
Vertical Banks			✓			✓				✓													
Manholes	✓																						✓
Intersections	✓		✓	✓				✓	✓			✓		✓					✓		✓		✓
Vibrating Areas			✓							✓	✓							✓			✓		✓
Disturbed Soil			✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓		✓
Narrow Right of Way	✓	✓		✓											✓					✓		✓	

	RESPONSE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Q. 34 Frequency of Occurrence																							
Unexpected Ground Water	F*	R**	F	R	R	-	R	0***	0	R	0	0	R	0	F	0	R	R	0	0	0	0	R
Radial Soil Change	R	0	F	R	0	-	R	F	F	R	0	0	F	F	F	F	0	R	0	F	0	F	0
Tree Roots	R	0	F	R	R	-	0	R	R	0	0	0	0	0	0	R	0	F	0	F	R	R	0
Unanticipated Utilities	F	F	0	0	F	-	F	0	0	0	F	F	0	0	R	R	F	0	F	0	R	0	0
Disturbed Soil	R	0	0	R	0	-	0	0	R	0	F	0	0	0	R	F	0	0	0	F	0	0	0
Heavy Surcharge	R	R	0	-	0	-	R	0	R	-	-	R	0	0	R	-	-	R	R	0	R	R	0
Q. 35 Cause of Soil Instability																							
Rainfall	-	-	✓	-		✓			✓	✓		✓		✓		✓		✓	✓	-	✓	✓	✓
Vibration	-	-	✓	-		✓			✓	✓	✓	✓				✓	✓	✓	✓	-	✓	✓	✓
Subsurface Water	-	-		-	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓					-	✓	✓	✓
Drying	-	-	✓	-	✓	✓	✓	✓		✓	✓	✓	✓			✓				-			✓
Temperature Changes	-	-		-		✓				✓										-			
Inclined Bedding	-	-		-		✓							✓						✓	-			
Q. 36 Who Decides on Bracing Changes																							
Manager	-				✓	✓				✓				-	-								
General Supt.	-		✓	✓	✓		✓	✓	✓	✓			✓	-	-	✓		✓	✓	✓	✓	✓	
Job Foreman	-	✓		✓	✓				✓		✓	✓		-	-		✓	✓		✓			✓

*F = Frequently
**R = Rarely
***0 = Occasionally

	RESPONSE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Q. 37 Unexpected Collapse in Trenches																							
Several per year															-		✓		-		✓		
Occasionally						✓			✓			✓			-	✓		✓	-		✓		
Rarely	✓	✓	✓	✓	✓		✓	✓		✓	✓		✓	✓	-				-	✓		✓	✓
Q. 39 Braced Excavations Have Collapsed			✓			-	✓	✓							✓			✓		✓	✓		
Q. 43A A P.E. is on the Staff		✓	✓			✓	✓	✓	✓	-		✓		✓	✓	✓		✓	✓	✓	✓		✓
Q. 43B A P.E. Designs the Bracing Systems			✓			✓	✓	✓		-		✓			✓	✓		✓	✓	✓	✓		✓

SPECIFIC REPONSES TO THE AGC QUESTIONNAIRE

Question 14: What horizontal clearance between cross braces in trenches do you need in order to carry out your work?

Response Number	For Excavation	For Insertion of Pipe
2	10 feet (minimum)	Pipe length plus 2 feet
3	---	Pipe length plus 2 feet
5	---	20 feet
8	12 feet (minimum)	Depends on pipe length
9	---	3-5 feet
12	---	3-20 feet
13	8 feet (minimum)	8 feet
14	10-24 feet	Depends on pipe length
15	4 feet	4 feet
16	25 feet (2 or 3 yd backhoe)	25 feet (large pipe)
17	12 feet	8-40 feet
18	---	6-10 feet
19	6 feet	6 feet (use box or jacks)
20	---	Pipe length plus 2 feet
21	---	Depends on pipe length
23	6-8 feet (backhoe)	4-8 feet

Question 15: Do you need several choices of horizontal spacings of cross braces to keep member sizes down?

Response Number	Yes or No	Explanation
2	Yes	Size of the cross brace is dependent upon horizontal and vertical spacing and size of waler.
3	Yes	Use different sizes of work braces and even steel braces.
5	No	---
12	Yes	Needs to fluctuate with the length of pipe
13	Yes	Spacing is dictated by size of items installed.
9,14	N.A.	Use trench box almost exclusively.
15	Yes	---
16	Yes	Largely dependent on size of pipe
18	Yes	Rarely
19	Yes	Different pipe lengths
21	---	Not necessarily -- see tables in the Wisconsin Admin. Code
22	No	---
23	No	One size used regardless. Probably too big for some close spacing

Question 16: What vertical clearance between the lowest brace and the bottom of the trench do you need to carry out your work?

Response Number	Clearance	Explanation
1	N.A.	Use trench box.
2	O.D. of pipe plus 1 foot	---
3	Clearance above the pipe	---
5,12,21	---	Varies with the pipe
8	---	Depends on pipe diameter or special foundation requirement or dewatering equipment
9	2 feet (minimum)	To insert pipe and bedding
13	6 inches above top of pipe	Varies with pipe size
14	12 inch (minimum)	Depends on size of pipe Clearance needed for trench box in order to keep pipe joints intact when moving the box
16	6-10 feet	---
17	---	Depends on pipe diameter
18	3-4 feet (typical)	Depends on size of pipe
19	2-3 feet	Depends on type and size of pipe
20	O.D. of pipe plus 2 feet	---
22	7 feet	For moving boring machine in pit
23	2-8 feet	Depends on pipe size

Question 17A: Do you ever need to do one of the following in a braced trench: Temporarily remove a horizontal cross brace?

Response Number	Yes/No	Length of Time	Reason (or Comment)
2	Yes	---	Would make other provisions to carry load
3	Yes	Under one hour	---
5,9,19,20	No	---	---
8	Yes	Varies	Need for working room
12	Yes	5-15 minutes	To install pipe or structure
13	No	---	Should never have to
15	Yes	---	To insert pipe
16	Yes	4-8 hours	To allow access
17	Yes	10 minutes	To lower long lengths of pipe
18,21	Yes	10-15 minutes	To place a length of pipe
22	Yes	30 minutes	To install longer casing
23	Yes	10-15 minutes	Clearance for pipe or working space

Question 17B: Do you ever need to do one of the following in a braced trench: Impose a load on a horizontal cross brace?

Response Number	Yes/No	Load (lbs)	Reason (or Comment)
3	---	---	Try to avoid it
5,8,13,16,19, 20,22,23	No	---	---
9	Yes (Occasionally)	---	Only minor loads
15	Yes	---	Platform
18	Yes (Rarely)	---	No working room

Question 18: Would you consider an allowance for a surcharge of 300 lbs/ft^2 (14.4 kPa) (equivalent of 3 feet of surcharge) to account for storage of excavated material and other loads to be excessive, reasonable or inadequate?

Response Number	Inadequate Answer	Explanation
2	Inadequate	Force lines in the piles or the banks are rarely if ever vertical. Loads imposed on the ground usually have an inverted conical sphere of influence.
3	Reasonable	Must assume some sort of surcharge
7	Inadequate	---
8	Inadequate	Construction materials, equipment and methods routinely account for surcharges of many times 300 psf without becoming unsafe practices.
9	Reasonable	Usually there is no more room for excavated material. Backfilling loads would depend on equipment being used.
12	---	Each case must be designed on its own conditions.
13,16,18, 19,20,21	Reasonable	---
21	Reasonable	Loads greater than this should be kept from open trench.

Question 19: Percentage of trenches (in terms of linear footage) where a high water table is a problem.

Response Number	Reply
17,18	2%
4,15	5%
7,11,12,22	10%
16	15%
1,2,8,13,19	20%
20	25%
14,21	35%
9	40%
5	70%
23	75%
3	100%

Question 20: What methods do you normally use in trenches to deal with a high water table?

Response Number	Response
1	Pumps
2	Well points
3	Well points, drain water from pipes in stone bedding
4	Pumps, central wells, sand points (use trench box)
5	Well points or stone and pump depending on the volume of water
7	Sump pumps in trenches, drain tile and gravel under line in excavations
8	Dewatering, sheet piling, trench shield
9	Sump pumps
11	Slope the overburden for vertical-walled rock trenches
12	Pumps, well points, deep well
13	Sump pumps, well point (depends on amount of water)
14	Deep wells in clean sand in trenches over 12 feet deep, well points if material is real fine. In trenches under 12 feet deep we use well points because it is faster and less expensive.
15	Pumps and shores
16	Sheet pile - H pile and lagging (trenches open for long periods)
17	Gravel bedding with pumps and in extreme cases - well points
18	Sand casing well point and pumps
19	Pumping from sand pits
20	Sand box and pumping, well points, wells
21	Caissons with submergible pumps
22	Sump and pumps
23	Well points, wells, open sump and submergible pumps (depend on level of water, permeability of soil, drawdown area, depth of invert, money available)

Question 21: Slopes in temporary sloped excavations?

Response Number	Soil Type: Vertical to Horizontal	Soil Type: Vertical to Horizontal
2	Sandy silty clay: 2 to 1	
3	Good clay: 2 to 1 Soft, plastic: 1 to 1 1/2	Loam: 1 to 1 Running: 1 to 2
8	Hard, solid, stiff clay: 1 to 1 1/2 Loose silt, soft clay: 1 to 1	Likely to crack clay: 1 to 1
11	Loose sand and gravel: 1 to 1 Hard solid stiff clay: 1/2 to 1	Compact sand and gravel: 3/4 to 1
13	Sand: 1 1/2 to 1	
14	Hard clay: 1 to 1 Loose silt: 1 to 1	Medium: 1 to 1 Sand and gravel: 1 to 1
16	Firm clay: 1 to 1 Silt: 1 to 3 Muck: 1 to 4	Medium clay: 1 to 2 Sand: 1 to 3
19	Solid clay: 4 to 1 Sand: 1 to 1	Normal clay: 2 to 1
20	Sand: 1 to 1 Firm clay: 1 1/2 to 1	Medium clay: 1 to 1 Loess: 1 to 1
21	Hard clay: 2 to 1	Gravel and sand: 1 to 1 (see Wisconsin code)
23	Sand: 1/2 to 1 Water and Sand: 1 to 1	Silt and loam: 1/4 to 1

Question 22: Do you ever use <u>compound</u> (composite) <u>slopes</u>?

Response Number	Response	Response Number	Response
2	Yes	13	No
3	Yes	16	Yes
5	Yes	17	Yes
7	Yes	18	Yes
8	Yes	19	Yes (benching)
9	No	20	Yes
11	Yes	21	No
12	Yes	22	Yes

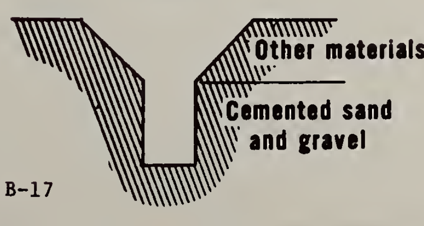
Typical trench cross-sections using composite slopes

No. 3

No. 5, 20

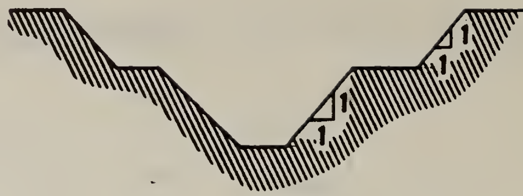
No. 11

No. 12

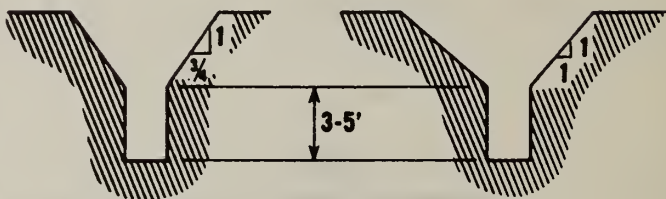


Question 22 (continued)

No. 16



No. 17



No. 18

Question 23: Timber sizes used by your company. Give sizes you consider best, regardless of OSHA provision.

Response No. 2	"We almost never use an all timber system for trenching anymore. We do use 2" rough green hardwood for sheeting with prepared steel wales and bracing or with aluminum shoring systems." Work is primarily in soil which is hard, compact, and solid.
Response No. 3	The OSHA tables are used in all soil types. In depths exceeding 20 feet, steel sheeting would be employed which is designed by a professional engineer.
Response No. 5	Where solid sheeting is required, steel sheeting with wide flange beams is used. In situations where skeleton or skip shoring is appropriate, a steel trench box would be used.
Response No. 9	Trench boxes are used.
Response No. 13	Use interlocking steel sheets in all given soil types whether hard, compact, solid, likely to crack, sand, soft clay or hydro-muck. The same applied where skip shoring might be used.
Response No. 15	Do not use hydraulic shores, but use wood for skeleton shoring. Generally 2 x 10 oak members are used for the timber uprights. Trench jacks (screw jacks) are used for cross braces. Spacing depends strictly on site conditions.
Response No. 16	Hard, compact, solid material was encountered in which timber shoring was used. Regardless of trench depth, 14" H steel members were used as wales. The wales were unsupported for 20 feet. The cross braces were also 14" H Steel members with a 10 foot horizontal spacing. Sheeting was generally 3" rough hardwood at 10 foot maximum vertical spacing.
Response No. 17	Use primarily hydraulic shores. In hard soil material the spacing of the shores is 8 feet in depths of 5 to 10 feet and the spacing is reduced to 6 feet in depths of 10 to 15 feet. In medium clay the spacing of these shores is 6 feet in depths of 5 to 10 feet and 4 feet in depths of 10 to 15 feet.
Response No. 18	The following spacing is used for hydraulic shores. These spacings apply to loess and hard clay

Question 23 (continued)

Depth (ft.)	Spacing (ft.)
5-10	6-8
10-15	5-7
15-20	4-6
20-25	4-6

Response No. 19 In hard clay hydraulic shores are used at a 4 foot spacing up to 15 foot depths. At greater depths, two rows of shores are installed with a 4 foot spacing.

Response No. 20 Work is done in hard, compact, solid soil, likely to crack soil, sand, soft clay, and hydro-muck. Regardless of trench depth 6 x 8 wales and cross braces are used. The wales have a 20 ft. unsupported span in depths up to 10 feet but this spacing is reduced to 10 feet in depths beyond 10 feet. Cross braces are spaced in the same manner. Sheeting thickness is increased from 1" to 3" at depths beyond 10 feet. The vertical spacing of wales is 5 feet in depths up to 10 ft and 8 ft. at greater depths. In hydro-muck, however, a 5 foot spacing is always maintained.

In skeleton shoring 2 x 10 uprights are used at an 8 ft spacing. At depths beyond 10 feet, the spacing is reduced to 5 feet. Screw jacks are used for cross braces. Generally 2 screw jacks are used per upright with 3 being employed at depths over 15 feet.

Response No. 23 No skip or skeleton shoring is used. Solid timber shoring is used in hard, compact, solid soil, likely to crack soil, sand and hydro-muck. In soil which is likely to crack, this contractor would use multiple hydraulic shores mounted on 3 x 12's and backed with 3/4" or 1" plywood. In the remaining soils 6 x 8's would be used for wales and cross braces. The wales would be unsupported for 11 feet with wales stacked 4 foot apart in the trench. The skirting used would be 2" rough cut, Douglas fir.

Question 24: Under what conditions do you use skeleton bracings and how do you decide on horizontal spacing of uprights?

Response Number	Reply
2	We only use trench boxes.
3	Used in 8-12 ft cuts with 2 braces minimum, sometimes 3
5,9,19	We don't use skeleton bracing.
8	Soils engineering determines choice of bracing.
13	When existing utilities are in conflict, we use hydraulic shores as needed, determined by the foreman.
16	As per OSHA requirements
20	Used in hard clay. Spacing is based on past successful experience and on the recommendation of the shore manufacturer.
21	See Wisconsin code.
23	Generally don't exceed 4 or 5 feet. It is not that difficult to add an extra hydraulic jack or two.

Question 38: In what types of soils and circumstances do these (trench wall) collapses most often occur?

2 sand

2 clay

2 soft clay

2 joint clay

1 highly expansive clays (exposed to the air)

1 sand (with water)

1 sandy clay

1 disturbed soil

1 ground water

1 silty sand and wet clay

1 medium clay

2 all types of soil

Question 40: What, in your experience, are identifiable signs of imminent distress in trenches and excavations?

Response Number	Signs of Distress
1,7,20,21,22	Tension cracks in the soil
3,16,23	Cracking of timber, bowing or bending of braces or sheeting, cracks behind sheeting and "boils" in bottom of excavation
4	Crack in dirt with a lot of pressure on trench box
5	After heavy rains in sandy clay soils
6	Bottom sloughing away, embankment undercut, cracks in embankment
8	Methods are the most identifiable warnings of distress. There will never be a substitute for a qualified soils engineer and a knowledgeable, experienced general superintendent.
9	Excess groundwater in fine silty sands carrying away trench walls
10	Surface tension cracks, soil movement, moisture content, vibration of equipment, and a bulge in the trench or excavation walls
11	Cracking in soil at edge of trench
12	Cracking soils or lateral movement
13	Water at flow line
15	Ground cracking, bending of cross braces or vertical members
17	Undercutting of vertical wall by sloughing, parallel cracks back from trench edge
18	A crumbling of small pieces of soil like the soil was working
19	Changes in soil conditions (moisture appearing) (cracking) (movements) (changes in soil color)
21	Loose particles dropping from trench walls

Question 41A: What are the most likely causes of collapse of bracing systems (other than carelessness) in trenches?

Response Number	Cause of Collapse
2,14	Inadequate support members
3	Not "squarely" placed braces, excavating operators knocking out braces
4,13	Inexperienced personnel
5	Heavy rains
6	Bracing improperly or inadequately engineered use of poor quality materials.
7	Underdesign, careless installation
8,19	Improper assessment of the loads the bracing was to support
9	Excessive loads from surcharge, trucks too close to trench, excessive rain
10	Improper position, wrong bracing system, improper size and/or grade lumber used
15	Overload, material deficiency
16	Inadequate shoring -- excessive surcharge -- virbrations
18	Water, loading, vibration
20	Not getting bracing installed quick enough
21	Underdesign and poor installation
22	Improper bracing
23	Underdesigned

Question 41B: What are the most likely causes of collapse of bracing systems (other than carelessness) in excavations?

Response Number	Cause of Collapse
3	Superimposed loads, change in water table, operator problem
5	Bottom blowout, sheeting too short, not enough toe or failure of dewatering system
8	Improper assessment of the loads the bracing was to support
9	Excessive rain or ground water
10	Inadequate means of secondary bracing if applicable, lumber used rather than steel piles, wrong type bracing system
12,23	Underdesigned
13	Lack of experience
14	Too light material
20	Failure to do a first class job of waling

Question 42: On what occasion would the company consult the following:
A. A soils engineer to explore subsurface conditions?

Response Number	Reply
1	Never
2	Unusual or known treacherous soils
3	If found to be different than bid borings
4	Never
5	Never
7	Documentation
8	In the event of any doubt whatsoever
9	We have in-house engineers
10	Depends on job specifications
11	Never
12	Seldom
13	Excessive leaks. When dispute arises over shoring methods
14	We do our own
16	All projects of any size or concern
17	When doubt exists and economics justify
19	Under bad conditions
20	Never
21	Extremely bad soil conditions
22	Never
23	Never

Question 42: (continued)
B. A Professional engineer to design bracing systems?

Response Number	Reply
1	Never
2	Where soils engineer's analysis indicated unusual loadings
3	Over 20 ft. cuts
4	Never
5	Only if required by the consultant engineer
7	Never (use in-house engineers)
8	All bracing systems
9	We have in-house engineers
10	Confining areas, i.e. between two or more existing structures
11	Never
12	Seldom
13	As required by Cal/OSHA
14	Whenever we have a job where no one in the company had past experience
15	When design data is required
16	All projects of any size or concern
17	When doubt exists and economics justify
19	Never
20	When excavation is to be open for extended periods
21	Extremely deep and wide trench
22	Never
23	Never

Question 44: In the OSHA standards, contractors are provided with guidelines as set forth in OSHA Tables P-1 and P-2. Please comment on how these could be improved.

Response Number	Improvement Suggestion
2	These tables are worth next to nothing -- no consideration is given to types of timber used.
3	Generally, they fit our area pretty well.
8	They are totally inappropriate and in fact conflict with the text of the regulation, i.e., slopes from bottom of trench.
10	Table P-1 is good -- keep it simple. Table P-2 is also a good guideline to follow provided lumber is used. However, hydraulic shores are less costly and more efficient. Hence Table P-2 merely takes up space.
12	Each trench must be designed on its own merits.
15	Instruct inspectors that alternate systems are suitable and equal.
17	There should be a provision for compound sloping with a safety factor equivalent to that permitted 5' vertical unshored. The safety factor of 5'-1" sloped 1/2 to 1 is far beyond 5' unshored vertical that is safe and the additional trenching and backfilling is not justified by increased safety.
19	Adjustment to soil conditions or a closer basis, not a blanket design for entire areas.
20	More leeway should be given for experience of field personnel.
21	These need complete revision. They are impractical for use of today's equipment and are even unsafe in a number of areas.
23	They try to use a blanket design to fit all situations. This is not really practical and it is very expensive for the owner in many cases. In many situations the compliance officer is not knowledgeable in the excavation field and it is one continuous hassle to show him (if possible) that you are working safely even though you have deviated from the book directions slightly.

Question 45: What specific other changes would you recommend to be made in the OSHA standards regarding "Excavation, Trenching and Shoring"?

Response Number	Other Changes
2	Excavation and trenching need to be more completely separated. They are different operations. A continuous trench, regardless of width, is different from an excavation.
5	A more realistic interpretation of the OSHA standards
8	We emphasize that a soils engineer must determine the suitability of the methods, as surely as a structural engineer must design a building skeleton.
11	More realistic sloping of trenches
13	The inclusion of a specification on trench shields, particularly concerning the danger of exposure to the trench walls above the shield
17	Definite provisions for professional engineer-designed bracing based on soils analysis as an alternate only. Obviously many jobs are too small to justify this, consequently sloping or shoring beyond the minimum requirement would have to be done as it is now.
19	More liberal rules on fining contractors for first offenses
21	Refer to the Wisconsin Code for practical standards
23	If some of us have to live by these poorly thought out standards, make sure that there are enough enforcers so that we all are in the same situation. Don't let the cheaters get away with anything.

Questions 46: From your experience with trenching, can you suggest simple field tests which will indicate the stability of the trench (for both braced and sloped excavations)?

Response Number	Field Test
2	Experience itself is the only proven field test. There is simply no way any fool can determine this.
3	Be sure of the water table -- quite often work is done at different conditions than are shown by the borings as the water table changes
5	Common sense
8	Consult: Soil Mechanics in Engineering Practice by Terzaghi and Peck and "Fundamentals of Soil Mechanics" by Taylor
13	Any person experienced in excavation can make a decision about the nature of the soil. Soil is very unpredictable. Most times a test is no indication because soil can change each foot.
15	If it doesn't fail, it is good.
16	Braced trench: pressure gage to indicate loads on bracing. Sloped bank: Soil test performed
19	Experience by qualified sewer foreman and superintendent. Experience from years of working ditches is your most valuable tool for analyzing the existing conditions.
21	There are no simple tests.
23	No simple test! Too many variables

Question 47: From your experience, please suggest any practices of <u>any</u> type which might be commonly adopted and would improve trenching safety.

Response Number	Practices Suggested
1	Use trench boxes
2	The use of trench boxes is the best advance in trench safety in 20 years. Lab tests to determine the coefficient of elasticity and cohesion if coupled with the time element are helpful in determining slope stability.
3	In all excavations over 5 feet deep, always use some protection for <u>your</u> personnel.
4	Stronger and lighter trench boxes
5	The use of trench boxes with a greater allowable trench width
7	Since 80% of accidents are caused by unsafe acts and only 20% by unsafe conditions, scrap OSHA and start a safety education program.
8	The Engineers who prepare the Plans and Specifications, from which contractors build, must engineer virtually every phase and certify thereto by the fact of their seal. Yet soils engineering is not addressed or liability expressly denied which should be a violation of their responsibility. Legislate the review and approval by soils engineers of soils engineering projects, particularly trenching and excavation.
10	Open cut all trenches provided there is enough room to do so. However, this method is also the most costly.
11	Realistic pay items by the contract-letting body (city, state, etc). The contractors is forced to bid work not using shoring in order to be competitive. Shoring like solid rock should be paid for if required. Engineers in their own job estimates rarely provide enough allowance for shoring. If the cost is included in the bid, the job is thrown out for being over the estimate.
12	Experience

Question 47: (continued)

Response Number	Practices Suggested
13	I feel the presence of a trench shield, trench jack and steel sheets are the most up to date, economical method to use.
15	Always have shoring supplies available.
16	Trenching contractors to be licensed by State and required to maintain a qualified Engineer for design of shoring
17	Expenditure of more time and effort on those contractors who do not shore their trenches, either through ignorance or economy. Most accidents occur in unshored trenches of depths exceeding 5 feet.
19	Work with designing engineers on location and depth of work-many times the designers will place the lines in areas of high risk when some common sense would save problems by relocation, etc. Prior location of utilities in relation to your work. Pre-planning by all utilities would be an aid.
21	Bracings systems such as shields (trench boxes) and hydraulic braces installed from trench top are the only sure way to prevent accidents. Any bracing systems which require men to enter an unbraced area to install pipe are dangerous and will result in accidents and deaths!
23	Shore trenches and keep the men behind the shoring as much as possible.

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15. SUPPLEMENTARY NOTES

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

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

Results of an Associated General Contractors of America (AGC) survey of present practice in excavation, trenching and shoring and of the impact of the OSHA Regulations for Excavation, Trenching and Shoring as perceived by a selected number of the membership are presented. The survey consisted of forty-seven (47) questions. A response of about fifty percent resulted in twenty-three (23) questionnaires being completed and returned to AGC. Although the twenty-three responses did not merit a rigorous statistical analysis, the data are useful in making some general statements about trenching and excavation operations.

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

Construction practices; Construction safety; Excavation; Shoring; Trenching.

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