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Causal Analysis of Fatal Trenching Accidents

John Patrick Wagner
University of Tennessee, Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by John Patrick Wagner entitled "Causal Analysis of Fatal Trenching Accidents." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Industrial Engineering.

Denise Jackson, Major Professor

We have read this thesis and recommend its acceptance:

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Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Vice Chancellor and Dean of Graduate Studies

Causal Analysis of Fatal Trenching Accidents

A Thesis
Presented for the
Master's of Science
Degree
The University of Tennessee, Knoxville

John Patrick Wagner
December 2004

Dedication

This thesis is dedicated to my family. Thank you for your support.

Acknowledgments

Occupational Safety and Health Administration (OSHA) provided the data, upon which this paper was based, under contract with The University of Tennessee Construction Industry Research and Policy Center. The author expresses his gratitude to Joseph J. Dubois, Director, Office of Statistics and Analysis, Directorate of Evaluation and Analysis, OSHA; Berrien Zettler, Deputy Director, Directorate of Construction, OSHA; and Dr. William Schriver, Director, Construction Industry Research and Policy Center for generously providing helpful comments and suggestions.

Abstract

A study was performed by the Construction Industry Research and Policy Center at The University of Tennessee, Knoxville, to identify causation for U.S. trench collapse fatalities in the construction industry that occurred during the years 1997-1999. Of the 1217 fatality case files analyzed, 44 were categorized as trench collapse fatalities. The 44 trench collapse case files were analyzed and the contributed factors of the fatalities were identified in an effort to determine the causation of collapses. The results of the study showed a large number of trenches without any type of protective devices being used. The findings of the fatal trench collapse investigation events suggest the fatal events might have been prevented if there was compliance with OSHA regulations for protective devices in the trenches, training of employees, and having an OSHA trained competent person on site.

Preface

This thesis is an expanded and revised version of a paper published in the journal *American Journal of Industrial Medicine* by J. Harold Deatherage, Lisa K. Furches, Mike Radcliffe, William R. Schriver, and John P. Wagner.

Deatherage, J. Harold et al. (2004). "Neglecting Safety Precautions May Lead to Trenching Fatalities." *American Journal of Industrial Medicine*, June 2004. 45:522-527.

My primary contributions to this paper included (1) aiding in the selection of the topic for research, (2) review of the fatality case files for the collection of the data, (3) most of the gathering and interpretation of the literature, (4) co-wrote the paper, (5) developed all tables and figures, and (6) co-analyzed the statistical data for conclusions.

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I. Introduction

OSHA conducts investigations of fatalities for two main purposes. The first is to support the issuance of citations on a case-by-case basis. The second reason is to collect data for a national fatality database, which is used to track trends and guide the intervention process.

By tracking trends it was discovered that trench collapses rank, on average, as the fifth most frequent category of construction fatalities investigated by the Occupational Safety and Health Administration during the 1991-2001 period (Schriver, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002).

While falls from elevations, run-overs by construction equipment and electrocutions were found to rank higher than trench collapses as categories of construction fatalities, there are two reasons why the understanding of trench fatalities may lead to cost-efficient intervention strategies. (1) Only workers in trenches (a very small percent of on-site work) were exposed to injury from trench collapse while many more construction workers were exposed to falls, electrocutions and run-overs by construction equipment; therefore, the number of workers requiring safety training would be quite small. (2) There were numerous causes of falls and electrocutions, while there were fewer and certainly more controllable causes of fatal trench collapses.

History

One of the few documented construction trades as well as one of the oldest in history was the trench digger. Prior to the 1950's all trenches were dug by hand and shovel. Trenches could be found in construction work as well as warfare. Trenches were used in both World Wars to protect the soldiers that were on the front lines. These trenches were dug by hand and as they dug down deeper in the earth the workers/soldiers would use pieces of timber to shore or support the walls of the trench.

Following World War II, the trench digger trade was quickly disappearing as an established profession with the new “cabled” backhoes, and later the hydraulically actuated backhoes. With the new high-powered backhoes, trenches could be dug quickly and efficiently. Since workers were not inside digging and shoring as they go, trench walls dug by the new backhoe were not shored or supported as often.

Trenching also shows up in other professions and other points in history as well. Trenches are used in archeological digs to help determine where to dig, but the trenches are small and shallow and are rarely deep. The Romans also used trenches for the transport of water and were typically used along the sides of their roads to keep water from collecting. Thus, trenching is a well-established activity in the construction industry.

Purpose

The goal of this study is the analysis of the fatal trenching accidents, in United States during 1997-1999, to determine why fatalities are occurring. The direct cause of the fatality and the contributing physical and organizational factors are examined to determine the effect on the accident. While examining the accidents, the usefulness of the Integrated Management Information System (IMIS) database is assessed. The case files and IMIS are both used to compare the result and gather additional information.

II. Background of Trenches

There is a balance of the forces acting within the earth's soil, by the pressure of the soil's weight acting downward and the horizontal confinement support from the surrounding soil. Trenching removes some of the horizontal confinement and disturbs the balance, resulting in a net increase in horizontal force toward and into the trench opening. The internal soil strength, tries to resist this pressure (Matheson and Naylor, 1997). The balance of forces can be greatly affected and disturbed by simple vibrations, large weight on the edge of the trench, cracks in the soil, and moisture content. The soil strength, or stability, is classified using a soil classification system based on an analysis of the soil's properties and performance characteristics. One important property is the soil's cohesiveness, or the ability of the soil sticking together.

OSHA classifies soils into four categories in a decreasing order of stability: Stable Rock, Type A, Type B, and Type C. A solid/stable rock trench is typically not found because to trench into rock takes drilling or blasting. When the drilling or blasting is done it normally causes cracks in the rock and can make it less stable.

Type A soil is the one step down from stable rock and can be composed of silt clay or sandy clay. Soil cannot be classified as A if it has cracks, is subject to vibrations (from cars, pile drivers, etc.), has been previously excavated, is layered soil (which is less stable at the bottom), or there is water, and freezing or thawing conditions.

The soil categorized as Type B can include both cohesive and non-cohesive soil. Typically if a soil is typed B, it's a Type A soil but has either cracks or is subjected to vibrations. The soil can consist of silts, sandy loams, medium clays, and unstable rock.

Type C is the least stable and can be easily typed, because of the soil sloughing or rolling into the trench. It can consist of any type of soil mix and often has standing water or very high moisture content. It also can be overly dry and crumbly. It is critical for a competent person onsite to classify soil type correctly because soil type is a determining factor in specifying a protective system for trench work. For soil to be typed correctly a competent person trained by OSHA needs to examine it and continue examining it throughout the duration of the project. A trained person uses two types of tests to judge the soil, a visual test and a manual test. A visual test can include inspecting the soil as it is being removed and examining the spoil pile, the soil removed from the dig, and the color and make-up of the excavation walls. A manual test means working with the soil with either your hands or with an instrument designed to measure soil strength. For example, if you can roll the soil in your hand into a long worm or ribbon, the soil is cohesive and many be classified as A or B, depending on the conditions. (www.afscme.org) But the prudent practice for trenching soil types, if a person is uncertain of the type, then always assume Type C and plan for the best protection available.

Trenches between five feet and twenty feet require acceptable protective measures to protect the workers in the trench. Acceptable protective measures can consist of shoring and sheeting, shielding, sloping, and/or benching. The layout, project, soil, and characteristics of the trench are used to determine the correct level of protection. If the depth of the trench is greater then twenty feet a registered professional engineer is required to design the protective system in the trench. Shoring involves installing a structure, such as a metal hydraulic or timber system that presses tightly against the trench wall to prevent cave-in while shielding provides a sheltered space for the employees to work. Sheeting is another shoring method that keeps the earth in place. The sheeting can be driven into the ground for added support for the trench sides. Driven sheeting is typically used when a trench is left open over a long period of time. Trench boxes, or sometimes called shielding, are another common protective system used in trenching (Figure 1 and 2). Trench boxes are typically used when a long trench is needed (an example would be installing sewer/water lines). Trench boxes can be dragged along the trench as the work is completed while continuing to protect the workers. Below are some commonly accepted practices that need to be followed but are typically overlooked:

- All personnel should be out of the trench box and out of the excavation when the shield is being moved. If not, a person could be caught between the moving box and a fixed object, like a pipe.
- The top of the shield (or trench box) should extend at least eighteen inches above the level of the trench. If it doesn't, material that was excavated could cave or roll into the trench.
- Some trench boxes are designed to be stacked on top of one another. Never stack boxes that are not designed for that purpose, and do not stack them from different manufacturers, as they may not be compatible and could fail if a collapse occurs.
- The forces of a cave-in can push a trench box sideways, causing a hazard to the workers in the trench. After a box is positioned, the voids between the box and the trench wall should be filled with excavated material to prevent movement of the box during a cave-in.

Figure 1 – 10 X 16 Single Wall Steel Trench Box

Figure 2 - Example of a Trench Box in Use

- Shielding, trench boxes, sheeting, and shoring equipment should always be used according to manufacturers tabulated data.
- Workers should never leave the confines of the sheeting, shielding, or trench box. Collapses can happen very quickly and without any warning.

(www.afscme.org)

Sloping is a technique used to cut the walls at angles; this reduces the forces placed on the soil, which can cause collapses. The cut of the angle or "angle of repose," as it is typically called, differs depending on the type of soil. For Type A soil each foot in depth, the trench needs to be sloped back at least half a foot (Figure 3). Type B soil needs to sloped back at least ¾ of a foot for each foot in depth (Figure 4), and Type C at least a full foot and a half sloped is required (Figure 5). If the sloping meets all the correct dimensions then the trench meets the standards set by OSHA.

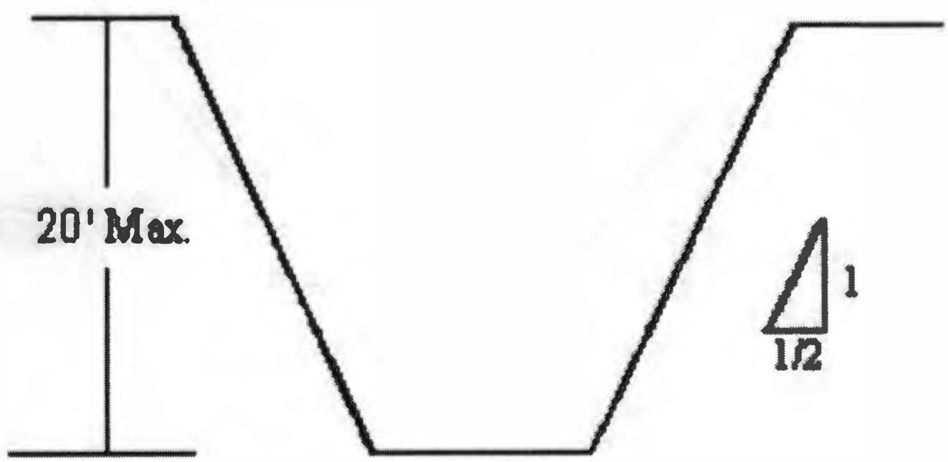

Figure 3 - An Example of a Sloped Trench for Type A Soil

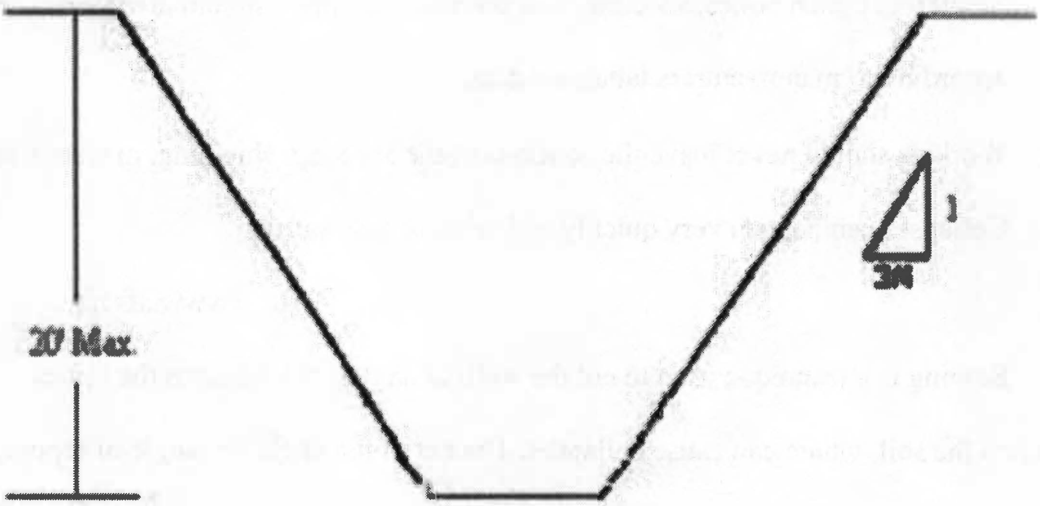

Figure 4 - An Example of a Sloped Trench for Type B Soil

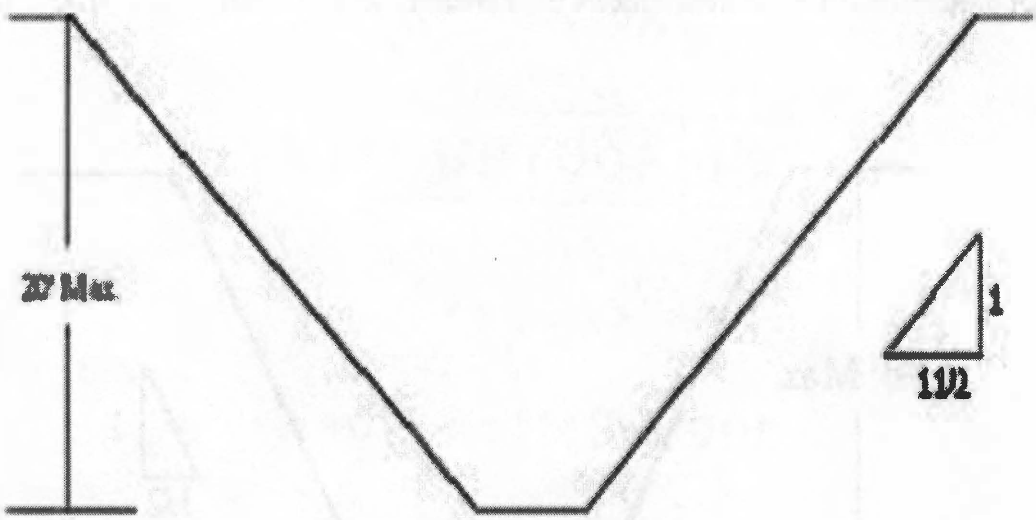

Figure 5 - An Example of a Sloped Trench for Type C Soil

Benching (Figure 6) is a similar technique to sloping, in that the walls of the trench are cut back. But instead of cutting the walls at angles, benching cuts the walls into 90-degree angles or steps. It uses the same slope requirements needed in sloping with maximum step height of 5 feet and width at 4 feet.

Stable excavating occurs when soil movement is limited by methods to reduce the lateral stress at the excavation opening such as shoring, sloping, or shielding. The stability of the trench is affected by many factors including: an increase in depth of cut, change in soil water content, unstable or previously disturbed soil, surface cracks near the excavation face, shock or vibration, changes in weather, and the weight and proximity of excavated soil (Matheson and Naylor, 1997).

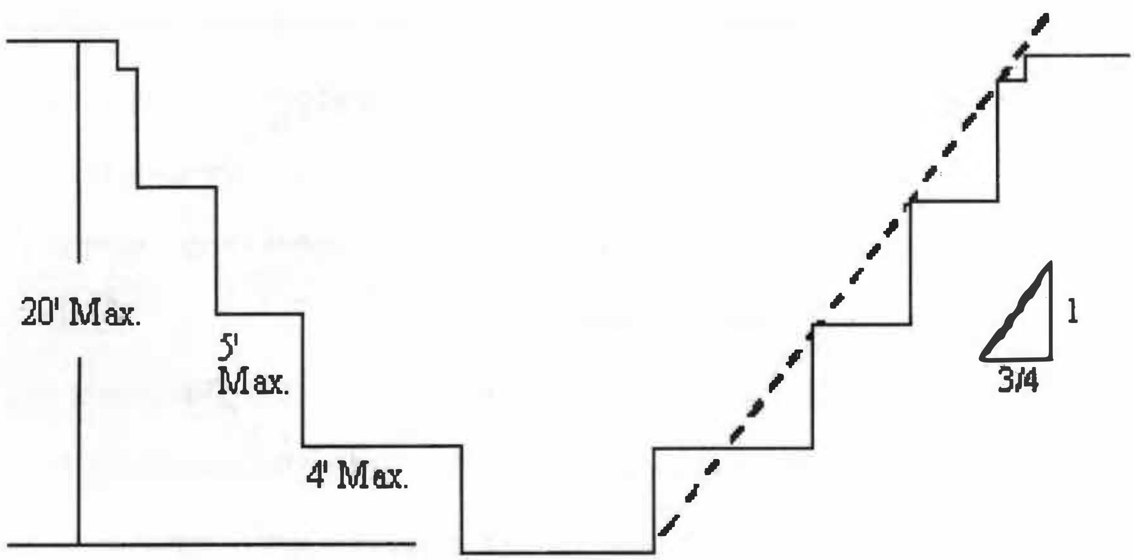

Figure 6 - An Example of a Benched Trench for Type B Soil

(Other soil types are constructed similarly)

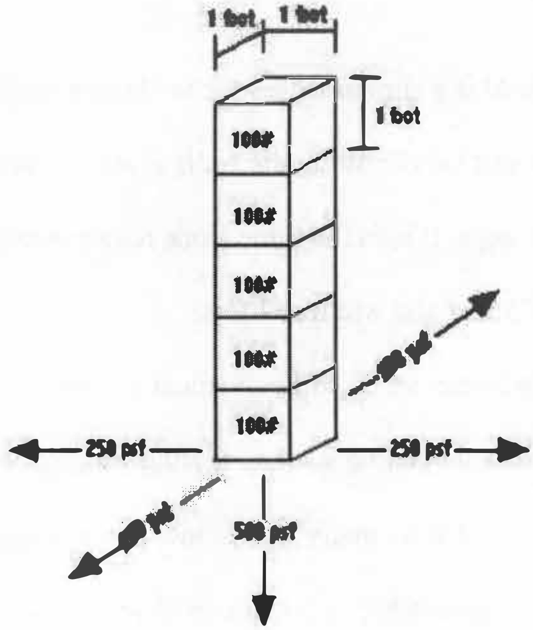

Figure 7 – Example of Soil Weight (Mickle, 1991)

During a trench failure, the walls collapse suddenly with little or no time for the worker to react. A small amount of dirt falling on a worker does not seem so treacherous, but a single cubic yard of dirt can weigh over 2,700 pounds and could reach up to 4,000 pounds for some types of soil and moisture content (Figure 7). This is equivalent to the weight of a small pick-up truck. The weight of this soil can crush the body, which can cause death in a matter of minutes (Hayslip, 2002).

Because of the dangers involved, OSHA requires a competent person onsite on a daily basis that has a thorough knowledge of the Code of Federal Regulations (CFR 1926.650-652/ Subpart P). See Figures 8 and 9 for examples of unsafe trenching conditions. This competent person should understand how to classify soil types, know the

Figure 8 – Example of a Trench without Protection

Figure 9 – An Example of Trench without any Protection and Numerous Other Hazards

different types and proper use of safety equipment, and have the ability to recognize, prohibit, and correct unsafe conditions (www.afscme.org).

Common Myths of Trenching

In trench collapses there are always "tall tales" or myths. These myths are often believed because people can be afraid of the real truth. One such "tale" is the belief that if the trench starts to collapse I can out run the soil before it gets me. If dirt is falling only a distance of 10 feet, it can be moving 25 feet per second, or a little over 17.5 mph. Another myth is the belief that I can tie a rope around my waist and if the trench collapses the rescuers can find me. This is somewhat true; the rescuers could find you, but not in time. A person can suffocate in only 4 to 6 minutes when buried in a trench, and under the best rescue conditions, e.g. removing 2 cubic feet of dirt every minute, it could typically take 15 minutes to rescue a victim. An additional myth is that a backhoe can easily save somebody in a few seconds if the trench collapses. Possibly true, but one miscalculation and the backhoe could really cause some serious injuries to the victim. Lastly, is the belief that a trench can smell "funny" or the dirt can smell peculiar just before a cave-in. Unfortunately, there is not an olfactory indication before a trench collapses (Rekus, 1992).

OSHA and Trenches

In September 1985 OSHA announced a special emphasis program for enforcement of the existing trench and excavation standard, and in April 1987 issued a

Notice of Proposed Rulemaking announcing that OSHA intended to revise the standard (OSHA, 1987). This update was recognized as being needed because of the hazardous conditions in trenches as well as the numerous injuries and fatalities. OSHA believed an update of the standard would bring awareness and attention to safety and would decrease injuries and fatalities. Viscusi reported that during the 1970's OSHA enforcement had no effect on injury rates (Viscusi, 1979). A later analysis for 1973 to 1983 found that OSHA inspections resulted in a 2 to 3% decline in injury rates (Viscusi, 1986). It has long been thought if the guidelines, e.g. if trench boxes (or sloping) are used, then the fatally level would be greatly decreased. The majority of the deaths in trenches were where protective measures, such as sloping or shoring, were not properly implemented. After a new standard was adopted at the beginning of 1990, Dr. Anthony Suruda conducted a study to determine the effect that the new standard had on the construction industry. Suruda examined the five years before the new standard and five years after the adoption. There was a 2-fold decline in the rate of fatal injury after the revision of the standard, which substantially exceeded the decline in other causes of fatal injury in the construction industry during the same period (Suruda, 2002). Unlike in the past, OSHA's new standard did aid in the decrease of fatalities. However, the question still exists as to why were trenching fatalities are still occurring? Over the next five years after Suruda's study, the trenching fatality rate compared to the total construction fatalities was fairly consistent (Table 1). Suruda's study proved that OSHA's new guidelines decreased the fatalities, yet fatalities over the next five years (after his study) have not decreased.

**Table 1:
Trenching Fatality Rate vs. Total
Construction Fatality Rates
(Schriver, 1996-01)**

Year	Percent	Rank
1995	3.70%	11
1996	5.40%	7
1997	4.10%	8
1998	3.80%	10
1999	4.10%	12

The intent of this work is to take the next step and try to determine if the trenching fatalities have any pattern, or if there were violations that may have led to the events. So the main question is asked, what is causing the fatalities in trenches?

OSHA issues citations during surprise inspections, and also as a result of fatality investigations. OSHA uses these citations as a way to penalize the employers for not following the safety guidelines. Normally the financial penalty is commensurate with the seriousness of the violations. OSHA classifies four levels of violations, Willful, Repeat, Serious, and Other. A Willful violation is only assigned when it is clear that the employer has complete knowledge of the safety standards he was breaking, but performed the construction work anyway. A Repeat violation is where an employer has been previous cited for the same safety standard violation. A Serious violation, which are the most common issued, are assigned anytime a safety standard is broken. This level can be issued when the employer is unfamiliar with the standard or did not know they were breaking a standard. The "Other" level of violation is a less serious violation. These are "lesser safety standards" and are typically reporting or paperwork violations.

The financial penalties associated with the violations can depend on many factors, including the size of the company (number of employees), the history of the company's violations, and the good faith of the company. A good faith reduction can be assigned depending on "how willing" the employer is to change for future safety. The size reductions typically range from 10 to 75% depending on the company, where history is a 10% drop if the company has not had a violation in the past 3 years and typically good faith is a 15% reduction.

Violations are one of the techniques OSHA uses to convince or help force companies into compliance. Despite the increased OSHA emphasis on safety standards enforcement in the mid-80's, open trenching contractors continued to dominate the construction industry in OSHA standards violations. In a 1995 OSHA report listing the 100 most frequently cited OSHA construction safety violations, open trenching rated in the top five (Anonymous, 2001). The situation has not changed and the violations for trenching still rank very high. According to the 2001 OSHA Industry Report: Open-trenching has the highest number of OSHA safety violations of all heavy construction industries...Further, open trenching leads all of the above (all US occupations) in dollar volume of assessed penalties by OSHA (Anonymous, 2001). So they are high in dollar as well as having a large number of violations.

The National Database

The Integrated Management Information System (IMIS) database is a collection of fatality investigations that OSHA has maintained on each fatal event. This national database consists of data from OSHA Forms (Appendix D), completed by inspectors during investigations. The information in the database contains information on the employer, the victim, accident, and the construction project.

The employer data contains the company name, location of the company, violations associated with the accident, number of employees, and the Standard Identification Code (SIC) number. The SIC number is used to identify the normal work a company does. For example, a painting contractor (1720) would have a different SIC number then an excavation contractor (1794).

The victim data will contain the sex, age, occupation, and task of the victim. The occupation and task differ in that occupation is what a person normally does, where the task asks if, when the victim died, was this their normal task or was this a new job for them.

The accident data will have the operation the victim was performing, contributing operation, the fatality cause, and a brief narrative (description of the event). The difference between the operation the victim was performing and contributing operation is that the contributing could have nothing to do with the victim's operation. An example would be a carpenter is cutting a piece of wood for framework on a new residential house, when the roofers on the roof drop some shingles on his head. The operation would be carpentry with a contributing operation of roofing.

The last collection of data in IMIS is the project data. The project data will include the end use of the project, the project type, and cost of the project. The end use is a code given to the project by its definition of what the finished construction will be. Hotels, residential houses, waterlines, and excavations are all examples of different end use codes. The project type is different from the end use in that it asks if the project is new construction, an addition, an alteration, or demolition work. The project type can normally be easily identified.

With all this data in one central location, it can be used to identify trends and track fatalities in various construction projects and the different construction operations.

III. Methods

Since 1991, the Construction Industry Research and Policy Center (CIRPC) at The University of Tennessee, Knoxville, has analyzed the causes of fatal incidents in the construction industry for the Occupational Safety & Health Administration (OSHA) using "investigation-collected data" (Schriver, 1993-2001). CIRPC has analyzed this data in an effort to identify and rank the leading fatal operations in construction, assist OSHA in identifying factors that contribute to fatal incidents, and suggest intervention strategies aimed at preventing similar types of incidents. The CIRPC recently completed a review of 1997-1999 fatality cases files provided by OSHA area offices. The review centered on the information in the cases, the correctness of the national database, and to discover any trends of the fatalities in the construction industry. Two principal sources of "investigation-collected data" were used in this study: the IMIS database data entered from the OSHA Form 170 (Investigation Summary), and the case files (Case files exact content is varied but typically includes: OSHA forms 1 (Inspection Report), 1A (Inspection Narrative), 1B (Worksheet), 2 (Citation & Notification of Penalty), and 36 (Fatality/Catastrophe Report), along with field notes, photographs, police reports, interviews, newspaper clippings, autopsies, and sketches) that document OSHA's investigations of the fatal incidents. OSHA's Office of Statistics maintains the IMIS database.

To assist in the review and coding of the cases, a checklist (Figure 10) was created. CIRPC only reviewed the fatal incidents in Federal Planned States (See Table 2).

Table 2:
Federal and State Planned States

Federal Planned States		State Planned States	
AL	MS	AK	NM
AR	MT	AZ	NC
CO	ND	CA	OK
CT	NE	HI	OR
D.C.	NH	IN	SC
DE	NJ	IA	TN
FL	NY	KY	UT
GA	OH	MD	VT
ID	PA	MI	VA
IL	RI	MN	WA
KS	SD	NV	WY
LA	TX		
ME	WI		
MA	WV		
MO			

1. Check Activity Number (Make sure it matches file)
2. Check Event Date (Make sure it's the right year)
3. Check Company Name
4. Check the Degree, only accept a Degree of 1
5. Check State (Do not accept states Alaska, Arizona, California, Hawaii,
6. Indiana, Iowa, Kentucky, Maryland, Michigan, Minnesota, Nevada, New
7. Mexico, North Carolina, Oregon, Puerto Rico, South Carolina, Tennessee,
8. Utah, Vermont, Virgin Islands, Virginia, Washington, and Wyoming)
9. Check the SIC Number, accept only construction
10. Check Occupation
11. Check or Re-code End Use Code
12. Check or Re-code Project Type Code
13. Check or Re-code Construction Operation Codes
14. Check or Re-code Fatality Cause (Direct Cause) Codes
15. Do not accept any natural cause deaths (i.e. Heart Attacks)
16. Do not accept any drug related deaths
17. Remove any Duplicate Files
18. Check Day of the Week and Time of Day
19. Check Contributing Causes
20. Check Soil Type and Depth of Trench
21. Check Age of Victim

Figure 10:
Check list for Federal Data File Review

Fatal incidents in State Plan States, Puerto Rico, Guam, and the Virgin Islands were not included in the analysis. The degree of injury was checked and only degrees coded "1" (fatality) were accepted. If the injury code was labeled either "0" (no injury) or "2" (injury) the case was removed from the study. Non-accidental fatalities (natural deaths or drug-related deaths) on construction sites/contractor yards and fatalities of construction workers killed in off-site traffic accidents were also excluded from the analysis. The files then were separated by the different fatalities cause codes and checked for accuracy. All the fatality causes coded as trench collapses were then pulled and the other files were boxed up for later studies. Forty-four files remained, and these files were read, reviewed, and compared. After reviewing the cases in depth, looking at all pictures, and all of the material in the files (OSHA forms, police reports, violation data, coroners reports, etc.) a data collection form (Appendix B) was created and used to review each file. Several data categories were documented describing each individual event. Information consisted of, but were not limited to, the following categories: project type, final structure end use, victim's occupation, construction operation in which the victim was engaged, common factors (that may have contributed to the fatalities), date, time of day, trench dimensions, types of protective devices used, soil conditions, weather conditions, citations, violations, existence of training programs, presence of competent person on-site, and means of access/egress from the trench. The data collection form was filled out and the above categories were recorded for each case. The information was then collected and transferred into an excel spreadsheet (Appendix C). Using the spreadsheet, the data was compared and contrasted to determine which factors were important and aided to the fatality. The contributing factors were then graphed and charted to determine the leading causes and discover any trends in the data.

IV. Data and Results

After reviewing all the case files, the results of: victim's occupation, age, contributing physical and organizational factors (the little factors that may have aided in the accident), day of the week, time of day, trench dimensions, types of protective devices used, soil conditions, and citations were analyzed. The direct cause of each of the 44 fatal events was by definition, crushing or suffocation, due to the physical collapse of trenches in which the victims were working.

The occupations of the majority of the victims were laborers (See Appendix A, Figure. A-1) and their ages ranged from 25 to 34 (Figure. A-10). Figure A-10 shows the comparison of the Annual Age Average in the Construction Industry for 2001 reported by Current Population Survey (CPS) with the age breakdowns of all construction fatalities and trenching fatalities. When comparing this age data with the Current Population Survey's (CPS) Annual Age Average (Figure A-9) for the Construction Industry, there was a similarity between the total ages for each category (www.bls.census.gov/cps).

Figure A-2 shows the frequency of the presence of contributing physical and organizational factors that may have contributed to either the collapse itself or the collapse resulting in a fatality. In 52 percent (23) of the fatal cases there was no training provided on safety procedures for trenching, and in 48 percent (21) of the cases no competent person was present at the work sites. There were eight other contributing physical and organizational factors which contributed to the trenching fatalities: 41 percent (18) of the cases had spoil piles within two feet of the trench edge; in 30 percent (13) of the cases known procedures/training/warnings were disregarded; in 30 percent

(13) of the cases there was a failure to conduct safety walks (or daily inspection); in 25 percent (11) of the cases there was no written procedures for trenching/excavation; in 21 percent (9) of the cases safety rules were not likely to have been known; in 21 percent (9) of the cases there was an improper classification of soil types or required sloping specifications.

Table 3 indicates the most frequently cited violations of OSHA's trenching regulations. The top citied OSHA violation was the lack of protection (benching, sloping, shoring, trench box, etc.) of employees in excavations (1926.652(a)(1)). The second highest was the lack of daily inspections of excavations by a competent person (1926.651(k)(1)). OSHA requires a competent person to inspect the trench site often to check for possible dangers. Instructing employees in recognition and avoidance of unsafe conditions (1926.21(b)(2)) was the next highest. This requirement was violated when employees have not been trained in the recognition of a dangerous situation. The fourth highest was the violation of materials and equipment that are within two feet from edge of the trench (1926.651(j)(2)). Lastly, the lack of means of egress from a trench (1926.651(c)(2)) ranked the fifth highest. OSHA requires a ladder for the safe entrance and exit out of a trench.

Figure A-3 shows the trenching fatalities broken down by the day of the week. Each day showed a similar total, except for a drop on the weekends. OSHA found that fatalities were spread proportionately among: 1) the days of the week, 2) union and nonunion sites, 3) age groups, 4) various size companies, and 5) federal plan and state plan sites (OSHA, 1991).

TABLE 3:
Leading Citations for Trench Fatalities Inspected by OSHA, 1997–1999

Citation	Frequency	Percent Cited
29 CFR **1926.652(a)(1)**: failure to provide adequate protection (benching, sloping, shoring, trench box, etc.)	29	65.9%
29 CFR **1926.651(k)(1)**: failure to conduct daily inspections of excavations by a competent person	23	52.3%
29 CFR **1926.21(b)(2)**: failure to instruct employees with respect to recognition and avoidance of unsafe	17	38.6%
29 CFR **1926.651(j)(2)**: materials and equipment were placed within two feet from edge of the trench	16	36.4%
29 CFR **1926.651(c)(2)**: failure to provide adequate means of egress from trench	12	27.3%
29 CFR **1926.100(a)**: failure to require/enforce the use of head protection by employees in trench	6	13.6%
29 CFR **1926.651(h)(1)**: failure to provide sufficient water drainage from trench	3	6.8%
29 CFR **1926.651(j)(1)**: failure to protect employees from loose soil or rock in excavations	3	6.8%
29 CFR **1926.20(b)(2)**: failure to establish and maintain a safety program requiring frequent inspections of job sites, material and equipment by a competent person	3	6.8%
29 CFR **1926.651(k)(2)**: failure to remove employees from unsafe excavation when hazard condition was recognized by competent person	3	6.8%

The depth of the trench data showed a large number of fatalities in the 5 to 9 foot range with fewer fatalities, as the depths got deeper. Two other notable details observed were a large number of the trench collapses occurred during the 11:00 am to 1:59 pm time period (Figure A-4), and the soil type was typically tested as Type C (Figure A-6).

Figure A-5 shows that 66 percent (29) of fatal events might have been avoided if, proper shoring, sloping or benching, had protected the excavation. Figure A-5 also shows that 20 percent (9) of the fatal events were due to inadequately designed or selected protections. In 11 percent (5) of the cases the victim left the protected area and in 2 percent (1) of the cases the victims were in a trench box but crushed by a pipe (displaced by the collapse) and the inner trench box wall.

The trenching fatalities OSHA violation levels were also broken down for each case file. The largest group was the Serious level with 143 citations followed by Willful with 16 citations (Table 4).

Table 4:
Trenching Violation Data

Level	Number of Citations
Serious	143
Willful	16
Repeat	2
Other	2

The trenching fatalities sorted with respect to the companies total employment (Figure A-11) showed a large number of fatalities occurring in companies with 1 to 25 employees (31 fatalities) and companies with 26 to 100 employees (11).

The total dollar amount for all the trenching citations associated with the violations was over $930,000 with a range of $3,000 to $153,450, and an average of $21,000 per fatality. The OSHA violation history (Figure A-13) showed 12 (of 44) cases of the company having a previous history of violations with OSHA, where 26 (of 44) cases did not.

Only 3 victims (7%) were union members where 41 (93%) were not members of a collective bargaining agreement (Table 5).

Table 5:
Trenching Fatalities by Union Member

Classification	Percent
Not a Union Member	93.2%
Union Member	6.8%

V. Analysis and Discussion

The top three categories of occupations of the victims of trench collapses were laborers (32), plumbers (6), and pipe layers (4). The laborers typically could be described as the least skilled (or the "new guy"). Many of them might feel that the conditions are not safe, but might not have been properly trained to recognize the hazards. It also isn't a surprise that plumbers and pipe layers were the next two highest occupations. These two occupations typically work in trenches more often then others. Thus, if these occupations were commonly found in trenches, then it would be common for them to be involved in more fatalities. Perhaps this number is lower than laborers because plumbers and pipe layers typically have more training and maybe more familiar with the dangers of a trench.

Figure A-9 shows the comparison of the age averages of all construction fatalities, trenching fatalities, and the total of all employees in the construction industry in 2001 (it is assumed the total would not greatly change from 1997-99 to 2001). The construction fatalities age and the annual age average for 2001, showed a very consistent comparison that was very close to equal in percentage. The trenching fatalities for the age group 16-19 showed twice as many fatalities and may be caused by the inexperience of their age and construction work experience. They were fairly new to construction work and may not be aware of the dangers of a trench collapse. The 25-34 age category was higher because a large number of the construction work force is in this age range.

The contributing physical and organizational factors of a trench collapse were typically indirect causes that would not directly cause the accident, but may have aided it in occurring. The number one factor was the lack of training provided for trenching. It is important to point out that ten of the fourteen different factors are violations of an OSHA regulation. If OSHA regulations and training of the employees had occurred, then many of the contributing physical and organizational causes would not be factors and may have prevented the fatality from occurring.

The leading citation for trenching fatalities was the lack of trench boxes, benching, sloping (29). Performing trench excavation without a diligent, trained, “competent person” (the second highest with 23 cases) exposes employees to risk of injury or death. If the employer had trained the employees (the third highest citations with 17 cases) many of the accidents may have been prevented. Trained employees may recognize the hazards and dangers of the worksite and many accidents may be prevented.

The article from Concrete Products, “OSHA Conducts Study of Construction Fatalities,” (Hayslip, 2002) showed that fatalities were spread proportionally through the days of the week. This was found to be true for this study for the regular work week (Monday thru Friday), but it did show a large decrease during Saturdays and Sundays. This would be expected because there is less construction work occurring during the weekends.

The trenching fatalities, by the time of the day, showed a very large number of accidents during the 11:00 am to 1:59 pm time period, where the rest of the times were fairly consistent. It is typically believed that the longer a trench stays open the greater the likelihood of it collapsing. It is also believed the mid-day sun (if the day is sunny) can heat up/bake/dry out the trench to the point where it becomes crumbly and less cohesive. While it is not known if these factors can explain the reason for the increase during this time periods, it is known that each factor can definitely affect the stability of a trench and may be the explanation. Anytime the soil type changes moisture content, the odds of a collapse are greatly increased.

The depth of the trench involved in fatality showed a large number of collapses (20) in the 5 to 9 feet depth. The most likely reason for so many deaths in the 5 to 9 feet range was because there are more trenches dug at this depth than other depths. It could be assumed the total number of fatalities in each category may be proportional to the total number of trenches dug (in each category) for all construction over a certain time period.

The direct causes of trench collapses can be defined as the leading factor that caused the fatality. There only needs to be one of these factors and it can lead to an employee's death, where the contributing physical and organizational factors only aided (and many of them could occur simultaneously) and the trench would not necessarily collapse. The leader, by far, of the direct causes was the lack of a trench box, shoring, or sloping (29 cases). Again 39 of the fatalities cases (no sloping/benching/shoring and inadequately design/selected protection) could have been prevented, if the contractor had followed OSHA regulations. The last direct cause (workers left the protected area) was postulated to be related to the lack of employee training. It is noteworthy that all of the top factors indicated a failure to comply with OSHA regulations for trenching.

If the soil type is unknown, then the best management practices would be to assume the worst case or the Type C soil type level of protection. The trenching fatalities by soil type showed a combined 39 soil types of Type C (assuming unknown is C). Type B was only typed in 5 fatality cases, even though it's a slightly more cohesive soil, it still needs a certain level of benching/shoring. There were no cases of Type A soil or Stable Rock.

The number of employed workers by the company showed that 75% percent of all the trenching fatalities occurred in companies with 1 to 25 employees. The larger companies did not have as many fatalities. There were only two fatalities with companies with over 100 employees. The larger companies were more likely to have a safety program as well as a safety department with a director. The smaller companies could be the "ma and pa" type businesses and may not have a safety director or department because of the added expense.

OSHA violation history showed 26 cases that did not have a history of violations (three years without a citation) with OSHA. While 12 fatality cases had been cited for a violation in the past three years

The trenching fatalities indicated that over 93% of the cases (41) were not union members and only 7% of the cases (3) were union members. Some unions have training programs available for their members, which may have influenced this total. Union members also have union stewards, which can stop all construction work if they deem the worksite as dangerous.

VI. Conclusions

Unlike all previous studies, the OSHA inspector's case file report was available for review and data collecting. Using these files was significant in aiding in identifying the causative factors. The original purpose of the review of the IMIS records and case files was to improve the quality and causal specificity of data obtained from OSHA's investigations of fatal construction events. Data improvements are necessary for OSHA to develop and implement strategies to improve workplace safety on construction sites (Shriver 2002). The IMIS database is not sufficient to analyze the fatal accident's causal factors by it self. The case file is needed to determine all the factors, direct and indirect, of the accident.

As an obvious first step in preventing such fatalities in the future, we conclude that all such operations should be done only in full compliance with existing OSHA standards (NIOSH, 1995). The findings of this investigation of fatal construction events suggest that fatal events, which occurred during the study period due to trench collapse, could have easily been prevented if a competent person onsite had followed OSHA regulations. In almost all trench cave-in cases, the workers in trenches were not protected properly by either sloped sides, trench boxes, or shoring. In some fatality cases, trench boxes were being used but workers would step out of the area protected by the trench box and would be caught by a cave-in (Hinze, 1998). When there was not a diligent competent person on-site, it reflects a lack of training in the proper trenching requirements. For trenching operations, employees need to be trained in safety of trenches, their hazards, and all the regulations required by OSHA. It could be that many construction companies were aware of the excavation regulations, but working safely was often sacrificed from ignorance of the situation, acceptance of employee risk, or schedule demands. The long-term financial impact of potential penalties, lawsuits, and bad publicity can, and in many cases should, put a contractor out of business (Johnson 1996). Abiding by OSHA's regulations is the key to decreasing fatalities in trenching operations.

VII. Comments and Recommendations

Even with all the known dangers of trenching and the numerous violations cited by OSHA, it appears that employers were still taking substantial risks in trenching. So the question of "why" needs to be asked and addressed. Many cases reviewed show evidence that if the regulations had been followed there may not have been a death. Contractors need to be made aware of the human and monetary costs involved when they do not take the proper safety precautions. Additionally, they lose money due to the time lost for the rescue attempt, time and labor to re-excavate the trench, hefty violation fines, increased insurance premiums, and additional paperwork. In many cases, employers just didn't think it could happen to them (www.ohioline.ag.ohio-state.edu 2001). Fatal accidents also cost the employer money. Costs can stem from utility line damage when excavations fail, increased construction and insurance costs, and increased liability costs (Stidger, 2001). If the employer loses money then why ignore the safety standards? A construction company may have the added incentive to finish construction work early. Some companies receive large bonuses if the work was finished on schedule or before time. If a company received a million dollar bonus for finishing early, a $20,000 dollar penalty by OSHA may not be a concern.

OSHA needs to take a stronger stance. The violation penalties do not appear to be high enough to force the companies into compliance. Willful and repeat violations should be penalized harshly. And in many criminal charges should be made on companies that knowingly neglect the safety regulations and especially companies that have repeated willful violations.

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Appendices

Appendix A

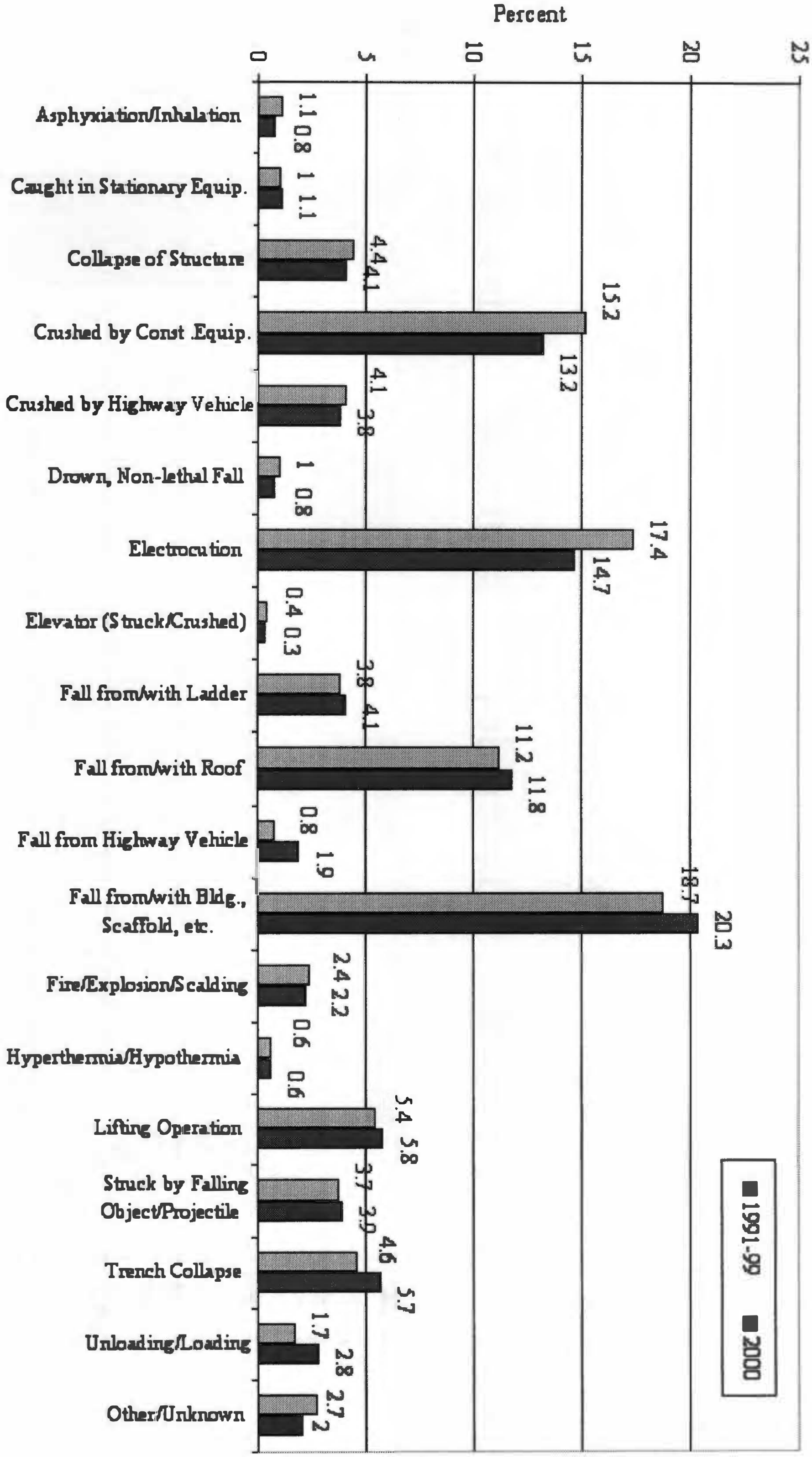

Figure A-1:
Comparison of Construction Fatality Events (1991-99 and 2000)

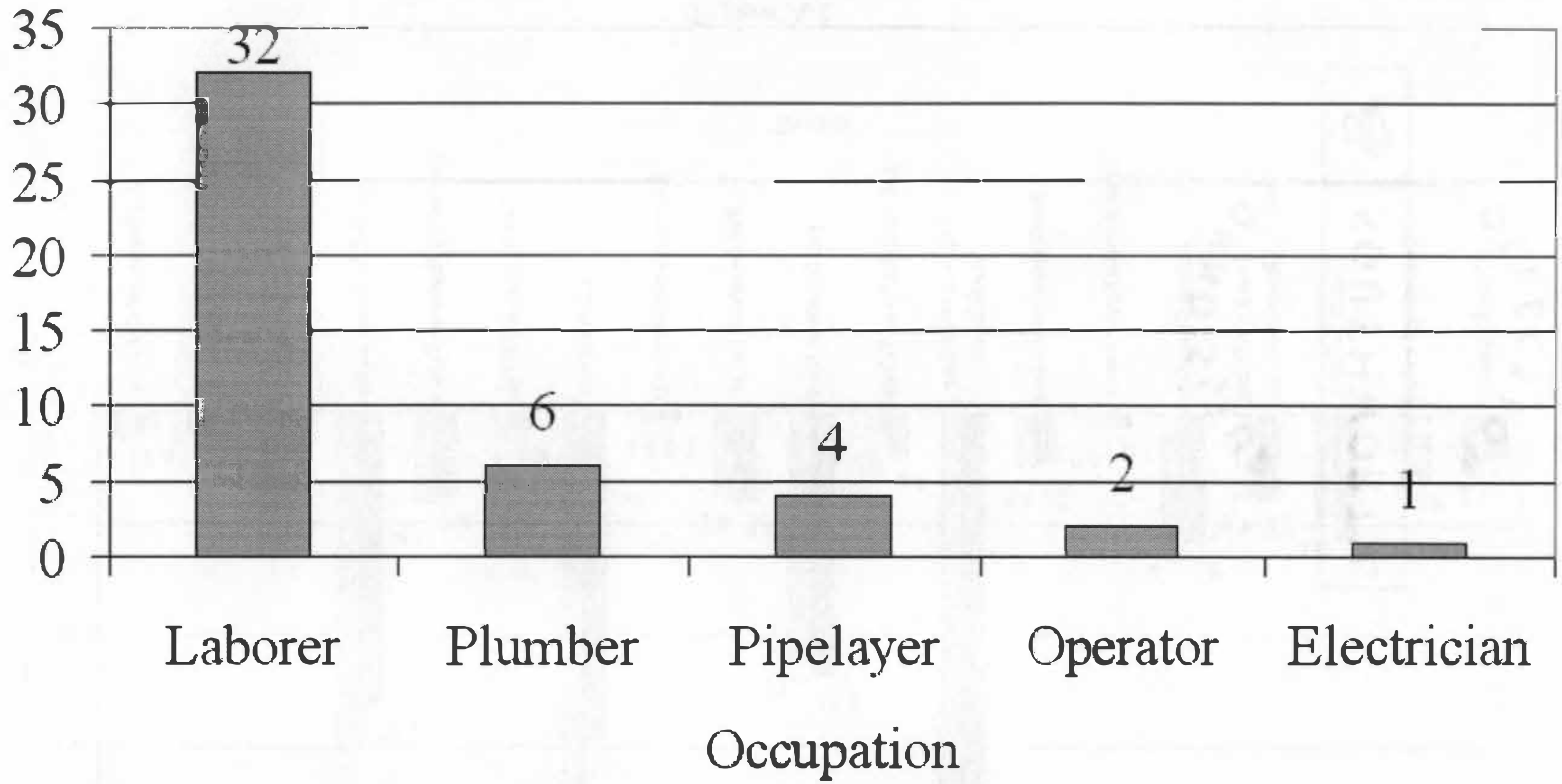

Figure A-2:
Trenching Fatalities by Occupation

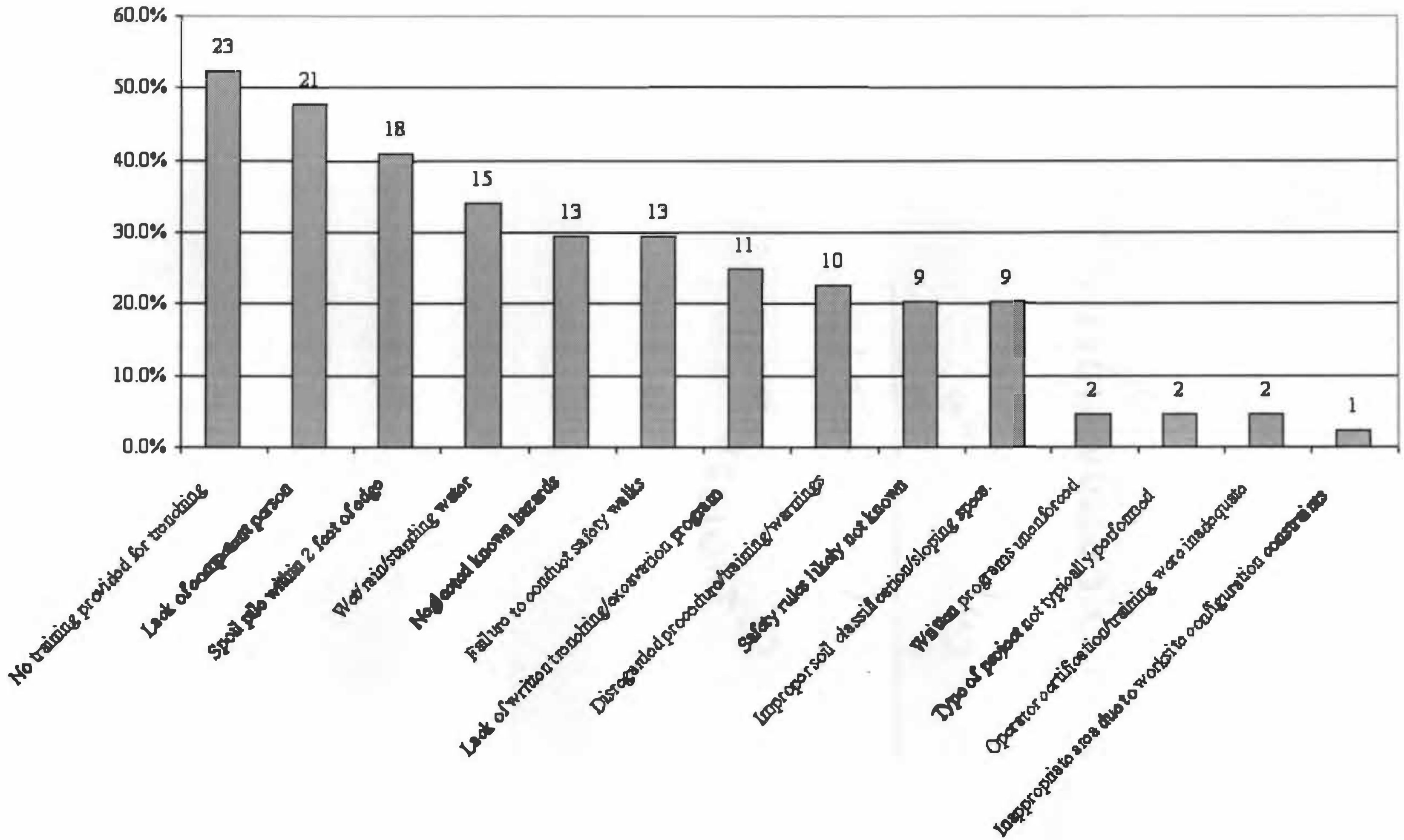

Figure A-3:
Contributing Physical and Organizational Causes of Trench Collapses

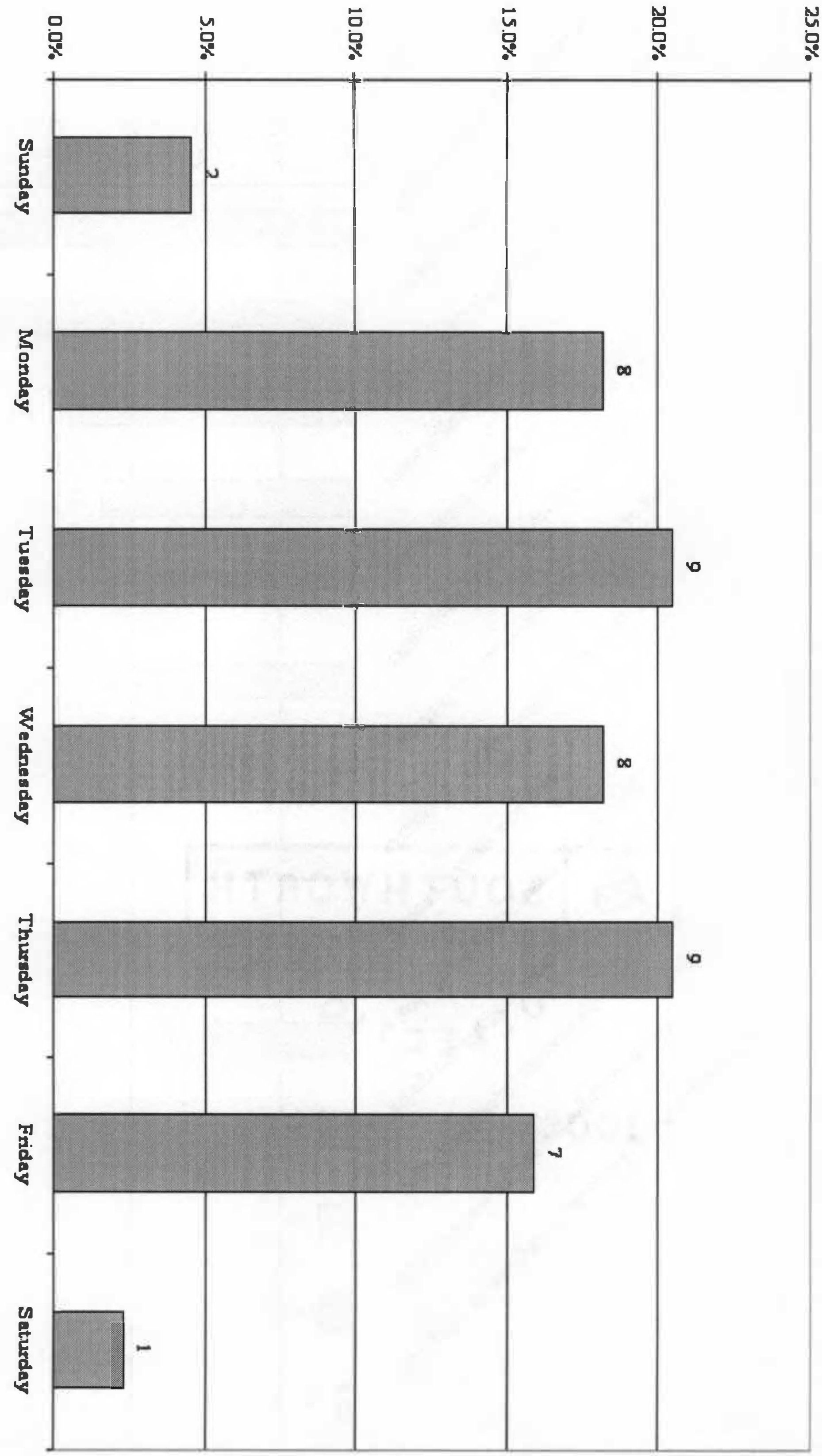

Figure A-4:
Trench Fatalities by Day of the Week

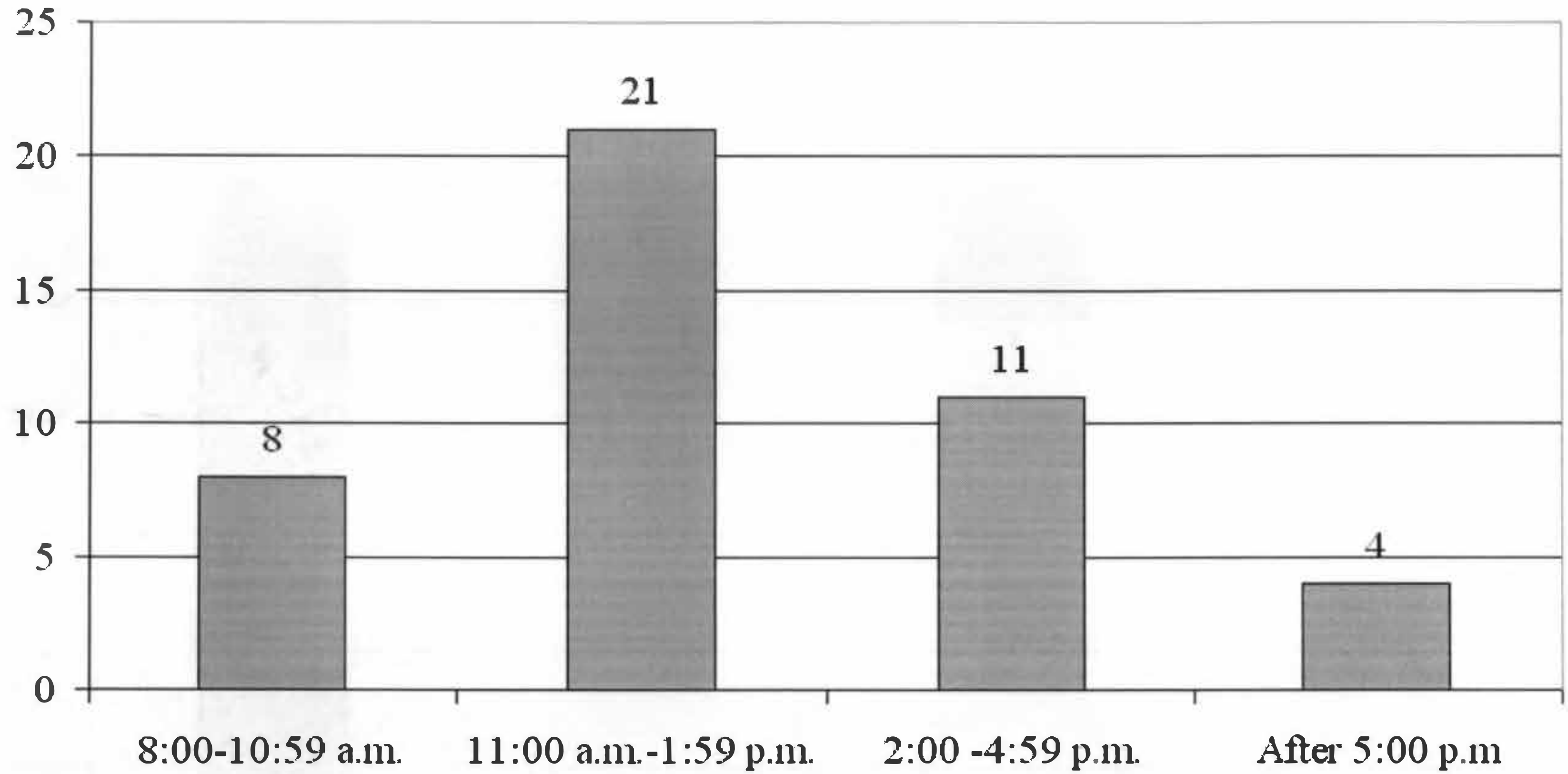

Figure A-5:
Trenching Fatalities by Time of Day

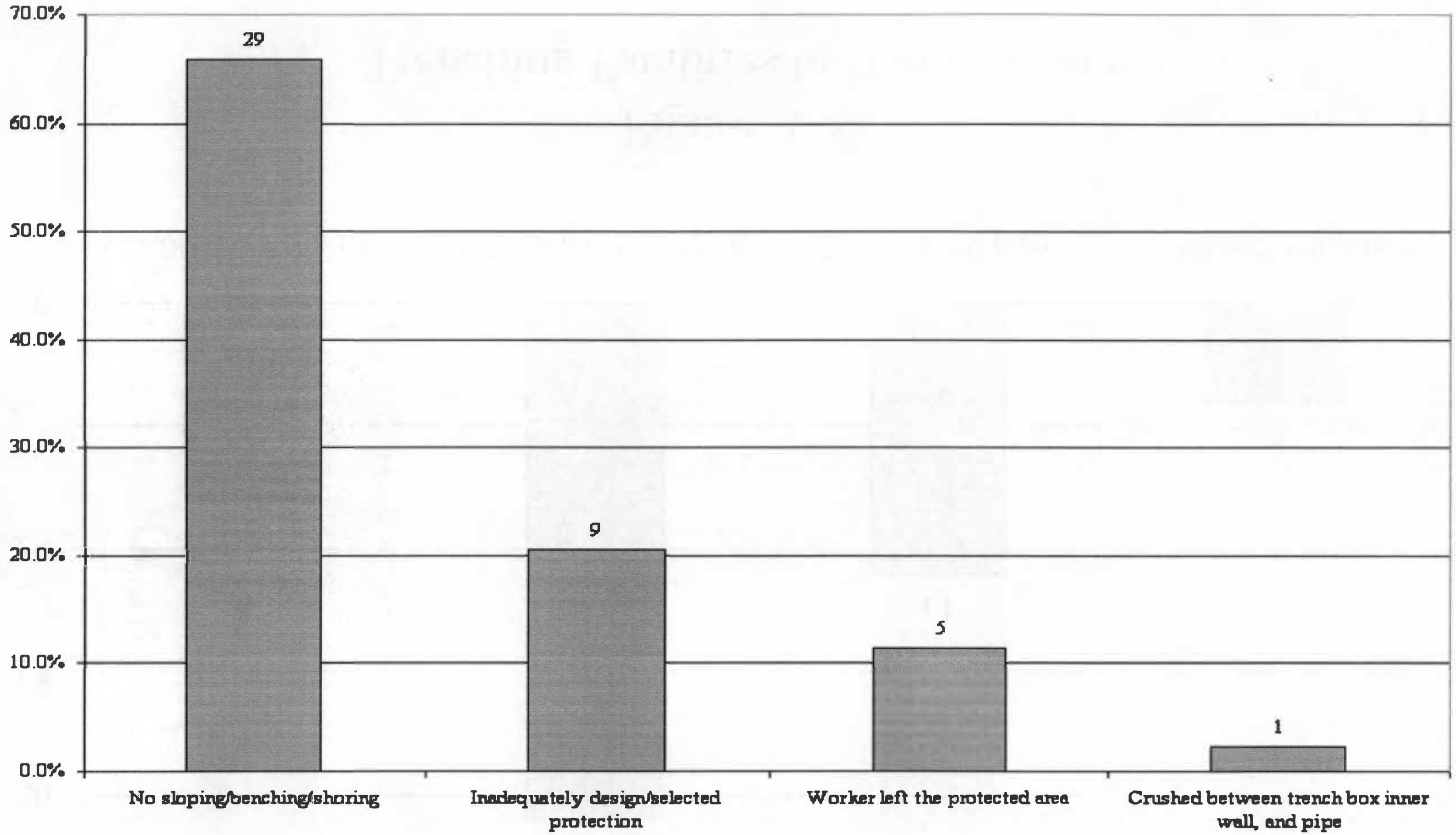

Figure A-6:
Direct Causes of Trench Collapses

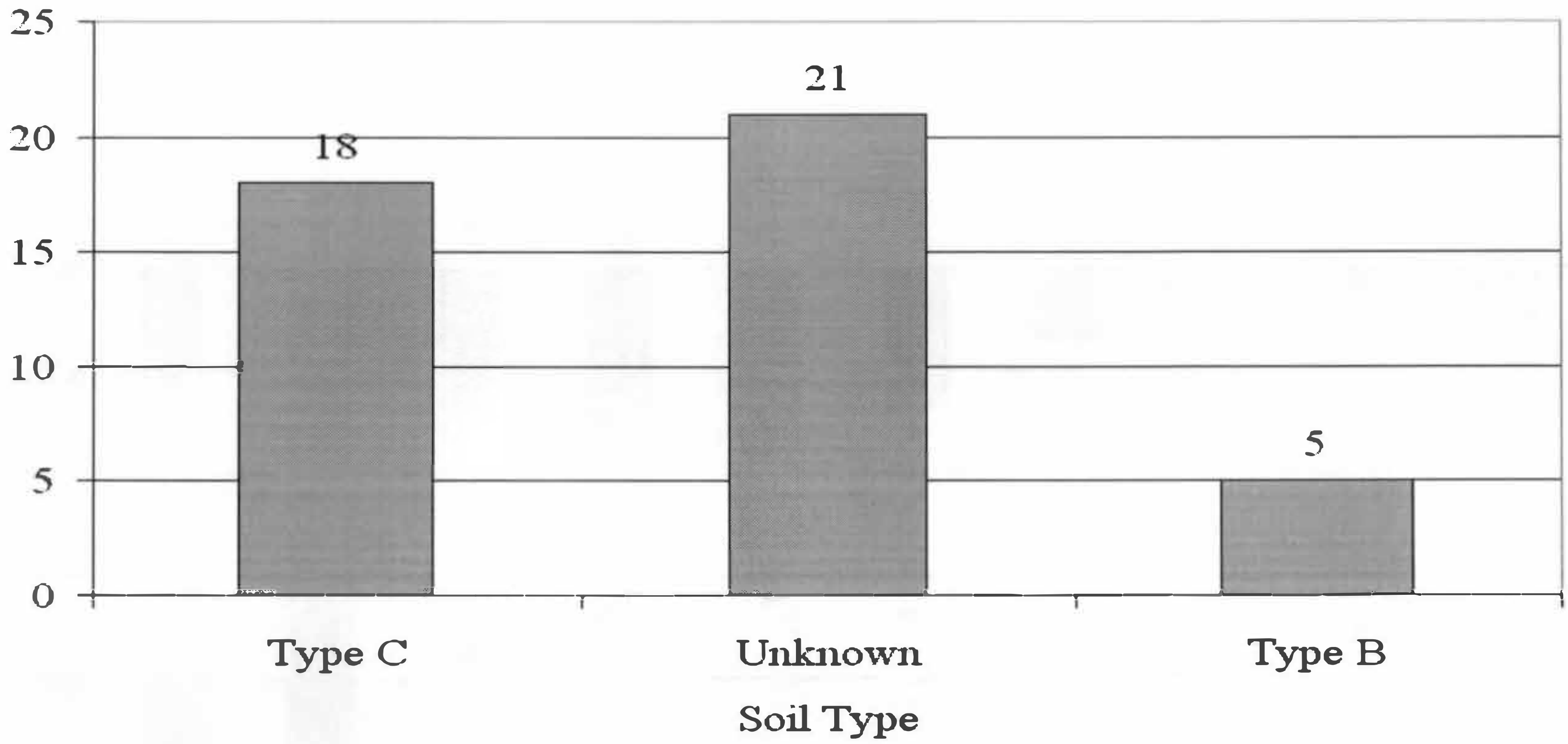

Figure A-7:
Trenching Fatalities by Soil Type

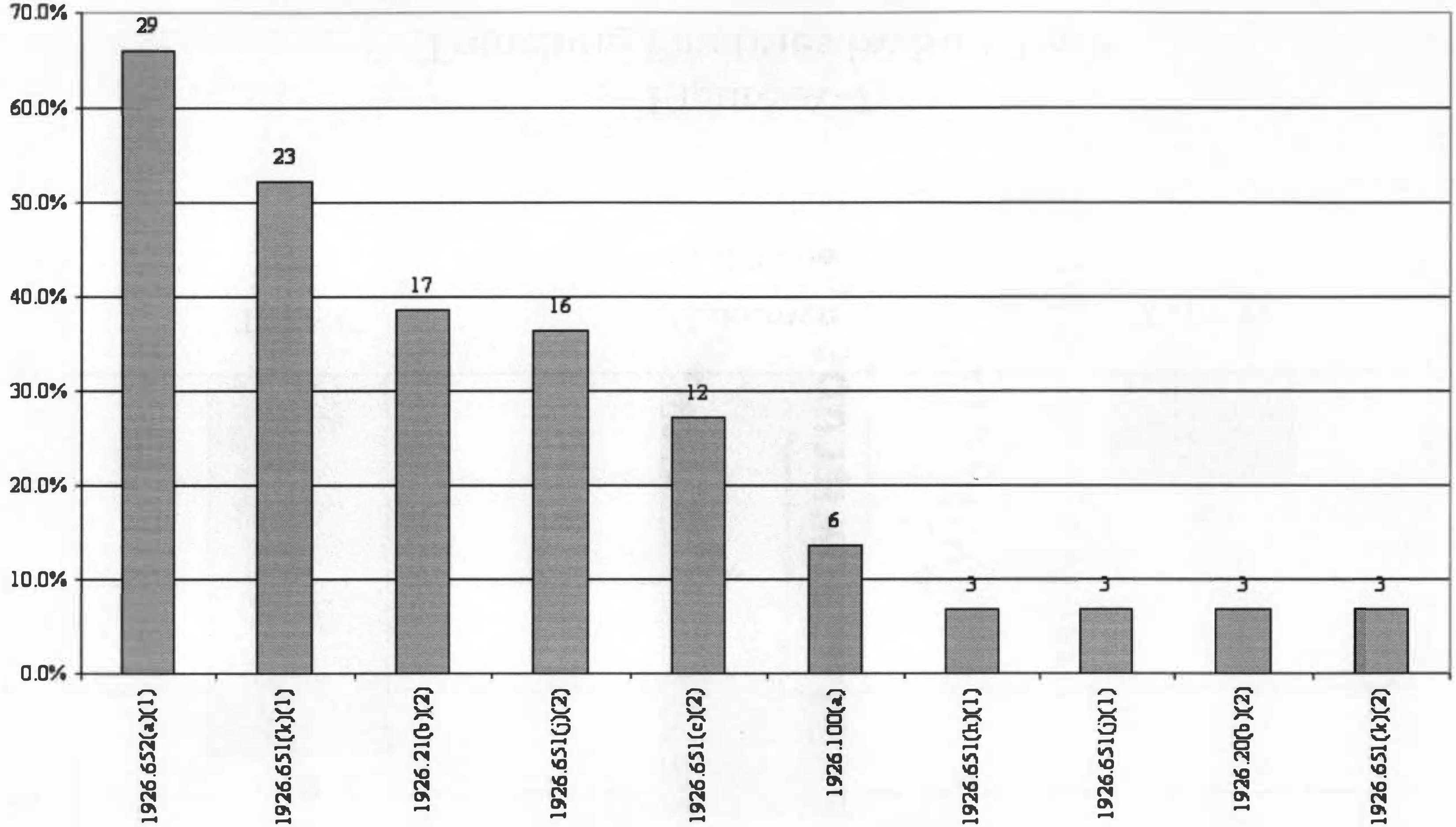

Figure A-8:
Leading Citations for Trenching Fatalities

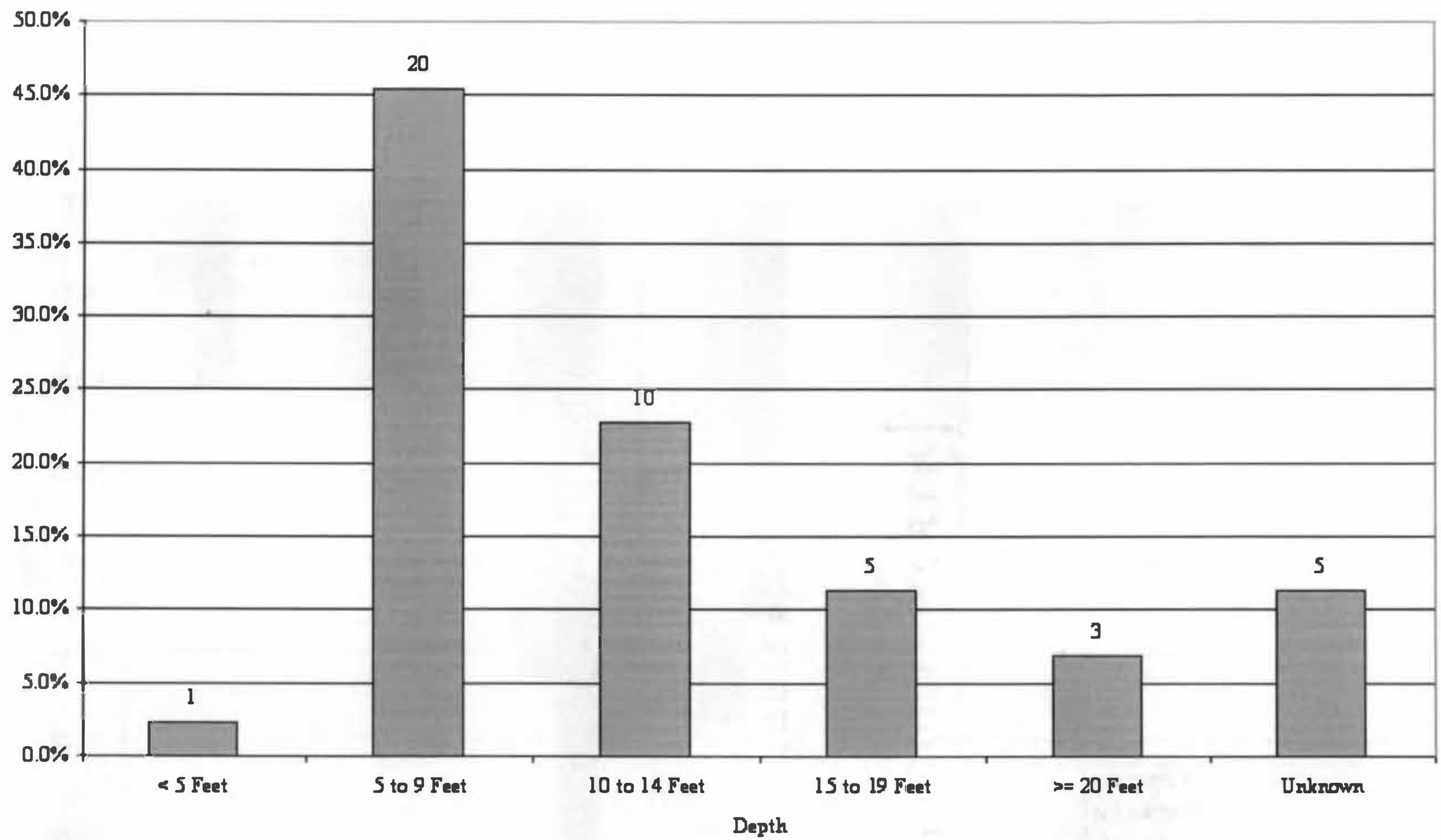

Figure A-9:
Trenching Fatalities by Depth of Trench

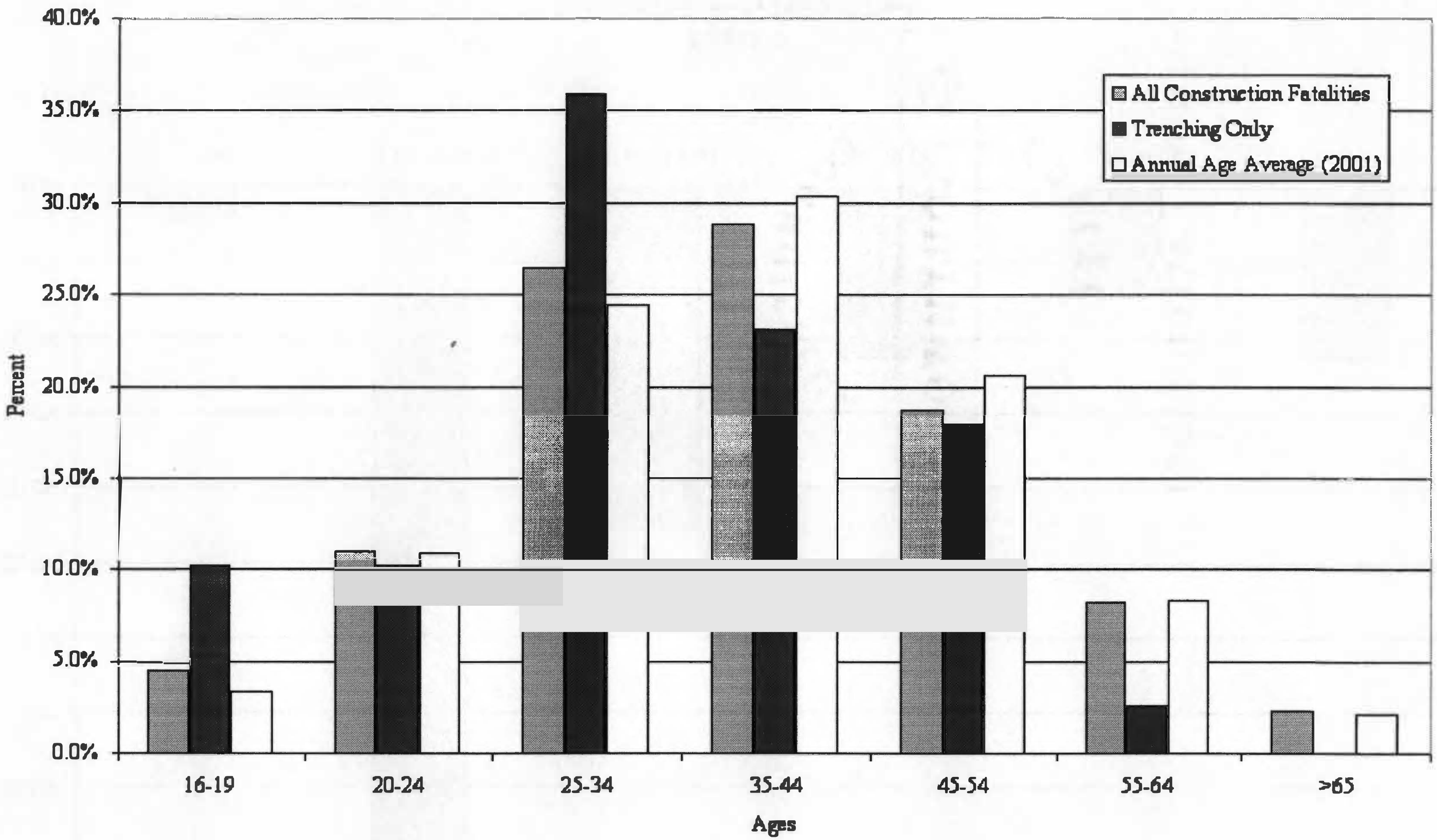

Figure A-10:
Breakdown of Age by Total Construction, Trenching Fatalities, and Age Average
(based by CPS)

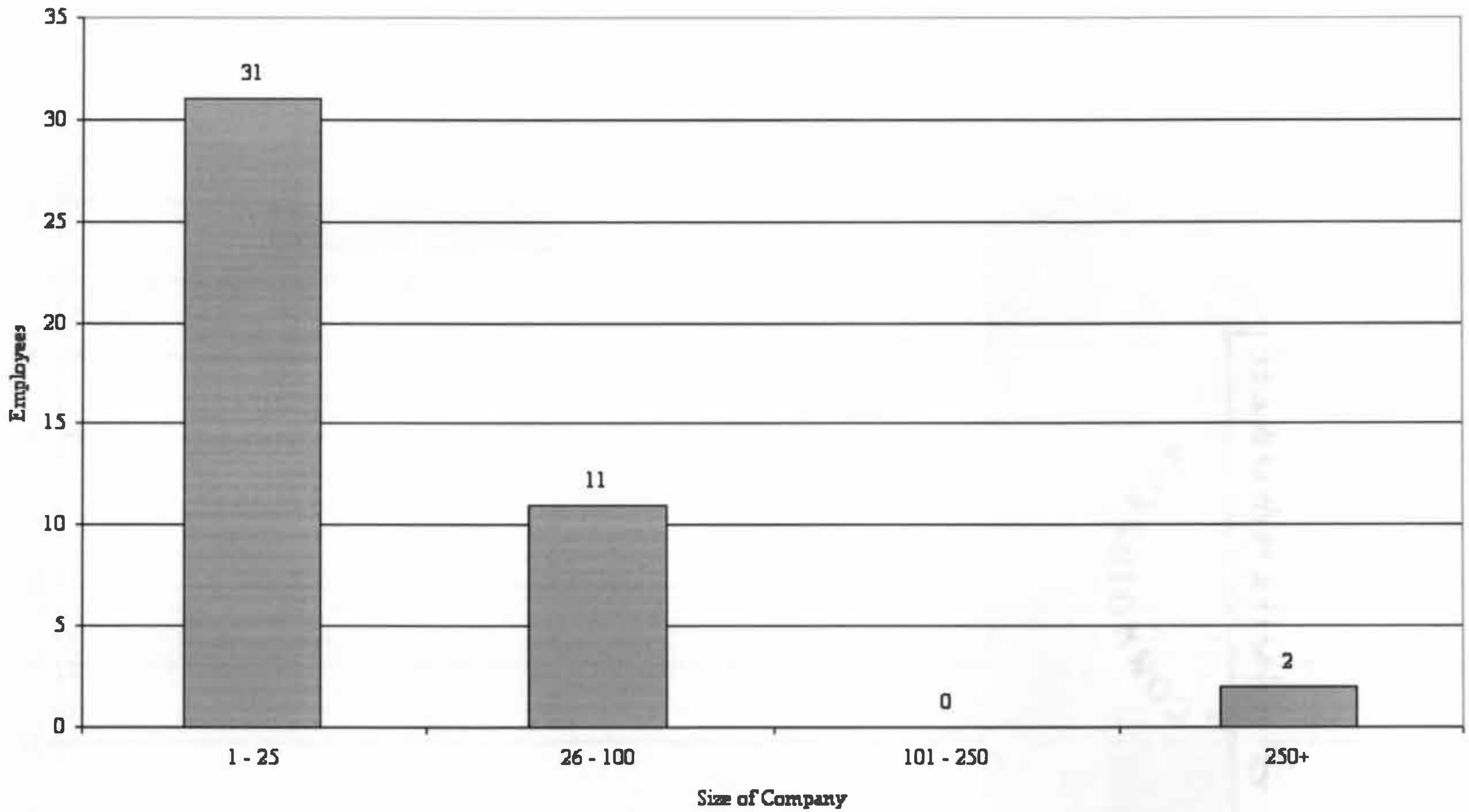

Figure A-11:
Trenching Fatalities by Number of Employees

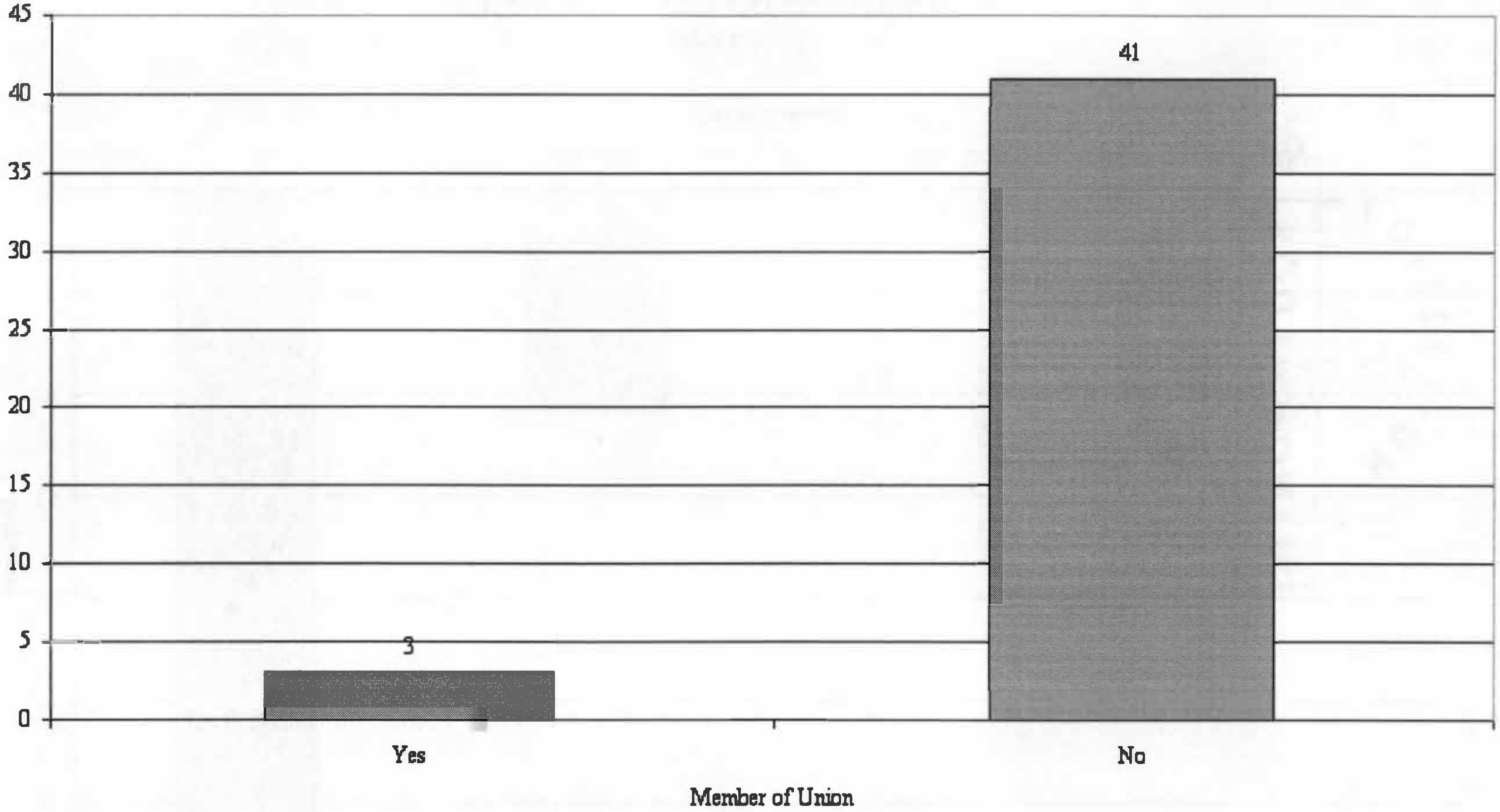

Figure A-12:
Trenching Fatalities by Union Member

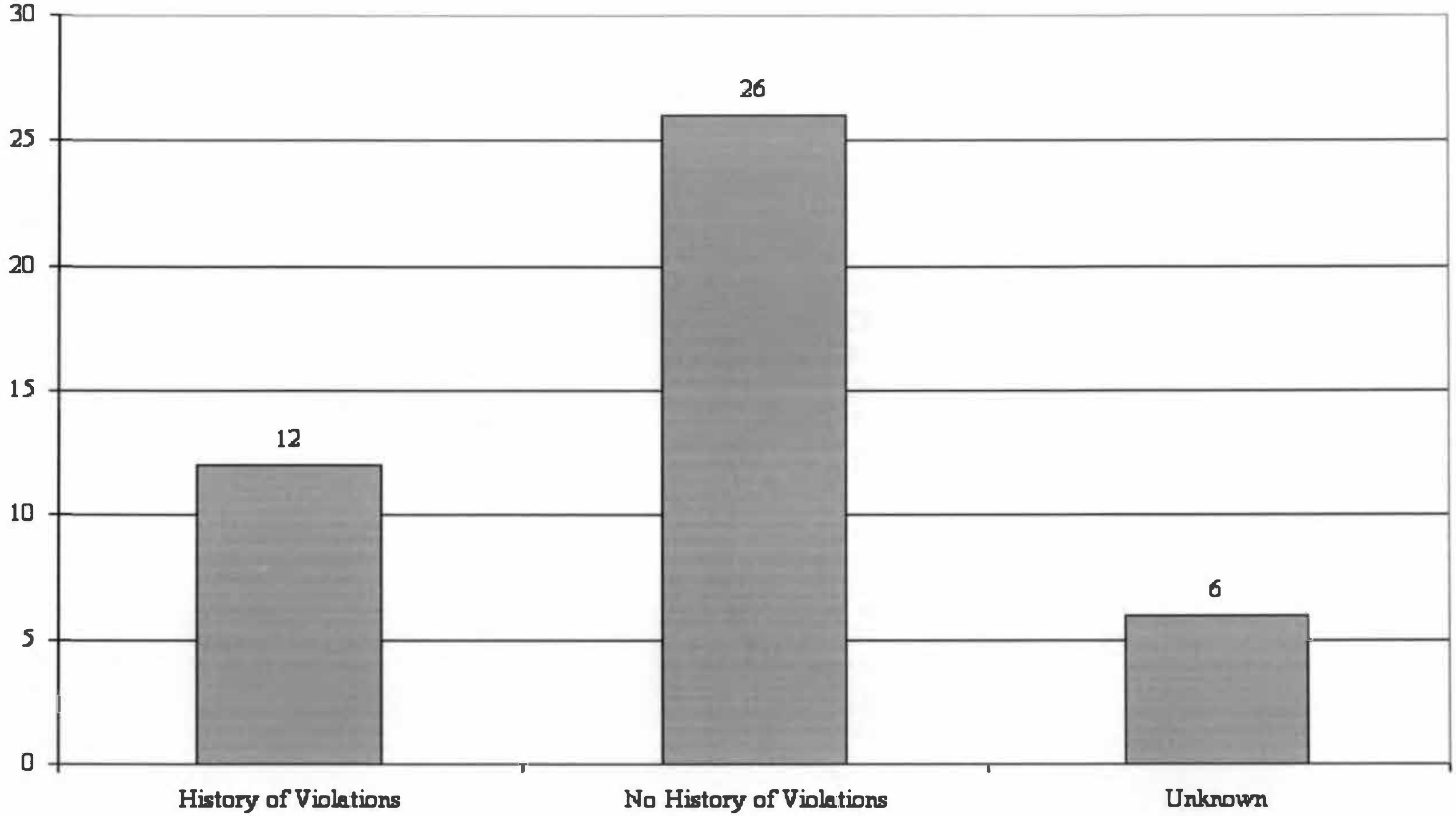

Figure A-13:
Trenching Fatalities by OSHA Violation History

Appendix B

DATA COLLECTION FORM FOR TRENCH COLLAPSES

CIRPC # ___________

1. Deceased's work task prior to the fatal event-- Describe:
   - ❑ What the person was doing when the event occurred--What was the person trying to do?
   - ❑ What was the outcome? (Describe what happened)
   - ❑ What tools or equipment was he/she using? Provide nomenclature if tools/equipment were a direct cause. (See item 5 below.)
   - ❑ What materials (if any) were being handled by the employee?

2. Describe physical location:

   A) Where was the deceased located within the trench?

   B) Located where relative to protective devices (was the person within a protected area)?

3. Describe trench engineering controls in place (trench boxes, shoring):

4. Describe soil/trench variables:
   - ❑ Soil type:
   - ❑ Trench configuration: dimensions, data on benching/sloping :
   - ❑ Other soil variables, such as excessive moisture:

5. Factors contributing to the incident: The following contributing factor categories are provided as examples of the type of information that CIRPC may look for, and are based upon findings from prior data reviews. Since CSHO's do not conduct investigations or document findings in a standardized manner across the country, the selection of any particular code(s) will not indicate that other factors were not present. Note that multiple categorizations typically WILL apply

- ❑ Atmosphere
  - ❑ Inadequate lighting
- ❑ Body position
  - ❑ Near open/active face of excavation without protection
  - ❑ Between trench box inner wall and installed pipe
- ❑ Employee misconduct/attitudes
  - ❑ Bravado
  - ❑ Disregarded prior warnings (except regarding procedures-see below)
  - ❑ Disregarded prior training
  - ❑ Jumped into trench
- ❑ Engineering/planning via process hazard analysis
  - ❑ Improperly selected trench box
  - ❑ Inadequately designed shoring
  - ❑ Material placed at edge of excavation, contributing to cave-in
- ❑ Environment and worksite configuration
  - ❑ Deceased had to work in inappropriate area due to worksite configuration/area constraints
- ❑ Ethnicity/culture/language (non-native speaker)
- ❑ Foreman/superintendent
  - ❑ Failure to conduct job site safety walks
  - ❑ Knowledge of hazards but failure to take action
  - ❑ Lack of designated trenching "competent person"
- ❑ Human Error
  - ❑ Failed to follow procedure
- ❑ Maintenance related
  - ❑ Trench box or shoring design adequate; failure due to inadequate inspection/maintenance
- ❑ New tasks/non-typical work
  - ❑ Employee(s) responded to unplanned event

- Type of project not typically performed by company
- Task seldom performed; management did not give thought to controls or did not think controls were necessary for this infrequent task

- Operator certifications/training inadequate (may not pertain to deceased, but to contributing operation)

- Safety programs
  - Safety program verbal-only
  - Lack of written trenching/excavation program
  - Written programs unenforced

- Site communication
  - Relied on other contractors/specialists to provide "safety"

- Site management
  - Claims it intended protection but failed to provide—supplies not delivered etc.
  - Claims ignorance of applicable regulations
  - Felt client would not pay for proper sloping, shoring or trench box
  - Knew of requirements but did not intend to comply

- Site scheduling
  - Pressured to move quickly

- Training
  - No training provided regarding trenching/excavation hazards/precautions
  - Safety rules likely not known, based on co-worker interviews etc.

- Trenching related:
  - Contractor failed to follow sloping specifications in work plan
  - Improper soil classification by competent person
  - No sloping/benching/shoring/trench box
  - Spoil pile within 2 feet of edge, on side of trench that collapsed
  - Trench box available but not used
  - Trench box needed greater depth (portions of trench wall fell in from top of box)
  - Trench box defective (equipment failure of trench box in place)
  - Trench box in use but worker left the protected area
  - Trench box did not fit into available workspace (e.g. needed shorter or narrower box); utilities crossed trench and were in the way
  - Trench box did not have bulkheads, material entered box from ends
  - Operator failed to check trench before digging (disturbing materials that subsequently caved in onto employee(s))

6. Whether the work activity was a direct cause, vs. adjacent activities. For example, did the trench collapse because the employee did something to disturb the trench wall, or did the operator undercut the excavation near the deceased's location, or was there no distinct event?
    - ❑ Direct
    - ❑ Indirect
    - ❑ Collapse caused neither directly by deceased's actions, nor by surrounding operations. Rather, by collapses/sloughing "waiting to happen."
    - ❑ Insufficient detail to ascertain

7. Whether or not the fatality was the result of an engineering design/equipment failure. (Yes/No)

8. If the result of an engineering design/equipment failure:

    a. Describe the failure:

    b. Answer the following:

    - ❑ Did the controls appear to have met OSHA design requirements under the conditions of use? Yes/No/unsure
    - ❑ Was proper maintenance conducted? Yes/No/unsure
    - ❑ Was the engineered control used in accordance with manufacturer's designer's recommendations? Yes/No/unsure
    - ❑ Describe variances, if any:

9. Was the particular phase of work on-schedule?
Yes/No/unsure

10. Tenure of employment on this job:

11. Time of day of event:

12. Employment size of parent company (enterprise) for which the deceased worked. (CIRPC plans to use Dunn & Bradstreet data to confirm the figures reported within IMIS; we presume funding for this activity.)=____________

13. Was the deceased working for a construction contractor, or another type of employer engaged in force account work? Contractor/force account

14. Was the deceased covered under a collective bargaining agreement, at the project on which he/she was killed?

Yes/No/Unsure

15. Had the employer been subject to an OSHA compliance inspection within one year prior to the fatal event? (CIRPC plans to obtain this data from IMIS inspection records.) Yes/No

16. Describe additional information needs, for this fatality case.

17. Describe what could have been feasibly done that may have prevented the incident. (Compare this project to a compliant "safer" job, with emphasis in this question on engineering controls, project tools/equipment and personal protective equipment.)

18. Describe conditions that made employer perceive compliance would be difficult or impossible, where provided.

19. Other information worth noting and not captured elsewhere:

Appendix C

Table C-1:

Contributing Factors in Trench Collapses, 1997

	Case Files									
Contributing Factors	97-0022	97-0065	97-0078	97-0178	97-0193	97-0201	97-0203	97-0240	97-0341	97-0402
Atmosphere										
Inadequate lighting										
Body Position										
Between trench box inner wall, and pipe										
Near open/active face of excavation with protection								X		
Employee Misconduct										
Bravado										
Disregarded prior warnings (except procedures - see below)										
Disregarded prior training										
Jumped into trench	X									
Engineering Planning										
Improperly selected trench box										
Inadequately designed shoring										
Material placed at edge of excavation, contributing to cave-in		X	X			X			X	
Environment and Worksite										
Deceased had to work in an inappropriate area due to worksite configuration/area constraints										
Ethnicity/Culture/Language										
Non-native speaker										X
Foreman										
Failure to conduct job site safety walks	X	X	X	X	X	X				X
Knowledge of hazards but failure to take action	X							X		X
Lack of designated trenching "competent person"		X		X		X	X	X	X	X
Human Error										
Failed to follow procedure										
Maintenance Related										
Trench box or shoring design adequate										
Failure due to inadequate inspection/maintenance										
New Tasks/Non-Typical Work										
Employee(s) responded to unplanned event										
Type of project not typically performed by company	X									
Task seldom performed										
Management did not give thought to controls or did not think were necessary										
Operator Certification										
Operator certification/training were inadequate for job										
Safety Programs										
Safety program verbal-only	X									
Lack of written trenching/excavation program	X	X					X			
Written programs unenforced										X
Site Communications										
Relied on other contractors/specialists to provide "safety"										
Site Management										
Claims it intended protection but failed to provide										
Claims ignorance of applicable regulations										
Felt client would not pay for proper sloping, shoring or trench box										
Knew of requirements but did not intend to comply								X		X
Site Scheduling										
Pressured to move quickly										
Training										
No training provided for trenching	X				X	X	X		X	
Safety rules likely not known						X	X		X	
Trench Related										
Contractor failed to follow sloping specifications in work plan										X
Improper soil classification by competent person										
No sloping/benching/shoring	X	X	X	X		X	X	X	X	X
Spoil pile within 2 feet of edge, on side of trench	X	X	X	X		X			X	X
Trench box available but not used										X
Trench box needed greater depth					X					
Trench box defective										
Trench box in use but worker left the protected area					X					
Trench box did not fit into available workspace (shorter or narrower)										
Trench box did not have bulkheads, material enter box from ends										
Operator failed to check trench before digging										
Willful violations										
Soil type	C	U	U	U	U	C	U	C	C	C
Time of day	4PM	11:30A	11:13A	4:30P	4:53A	1:45P	11:45 A	1:45P	1P	1:50P
Wet/rain/standing water		X		X		X			X	
Hot/sunny										X
Age	35	39	31	31	30	63	53	18	18	19
Occupation	Laborer	Laborer	Plumber	Laborer	Laborer	Laborer	Laborer	Laborer	Laborer	Pipelayer
State	PA	CO	AL	TX	OH	NJ	NJ	NE	TX	TX

Table C-2:

Contributing Factors in Trench Collapses, 1998

	Case Files																			
Contributing Factors	98-0012	98-0018	98-0060	98-0077	98-0089	98-0150	98-0151	98-0168	98-0184	98-0186	98-0189	98-0205	98-0261	98-0324	98-0359	98-0366	98-0385	98-0391	98-0412	98-0434
Atmosphere																				
Inadequately lighting																				
Body Position																				
Between trench box inner wall, and pipe														X						
Near open/active face of excavation without protection																	X	X		
Employee Misconduct																				
Bravado																				
Disregarded prior warnings (except procedures - see below)														X					X	
Disregarded prior training									X			X								
Jumped into trench																				
Engineering Planning																				
Improperly selected trench box										X						X			X	
Inadequately designed shoring																	X			
Material placed at edge of excavation, contributing to cave-in	X			X		X			X											
Environment and Worksite																				
Deceased had to work in an inappropriate area due to worksite configuration/area constraints																				
Ethnicity/Culture/Language																				
Non-native speaker																				
Foreman																				
Failure to conduct job site safety walks	X								X		X							X	X	X
Knowledge of hazards but failure to take action	X	X	X			X			X						X		X	X		
Lack of designated trenching "competent person"	X		X				X	X		X	X		X			X		X		
Human Error																				
Failed to follow procedure														X					X	
Maintenance Related																				
Trench box or shoring design adequate																				
Failure due to inadequate inspection/maintenance																				
New Tasks/Non-Typical Work																				
Employee(s) responded to unplanned event																				
Type of project not typically performed by company						X														
Task seldom performed						X														
Management did not give thought to controls or did not think were necessary																				
Operator Certification																				
Operator certification/training were inadequate for job																		X	X	
Safety Programs																				
Safety program verbal-only		X				X	X	X			X									
Lack of written trenching/excavation program		X				X		X	X		X							X		
Written programs unenforced																				X
Site Communications																				
Relied on other contractors/specialists to provide "safety"																				
Site Management																				
Claims it intended protection but failed to provide		X																		
Claims ignorance of applicable regulations			X										X							
Felt client would not pay for proper sloping, shoring or trench box																				
Knew of requirements but did not intend to comply	X	X							X								X	X		
Site Scheduling																				
Pressured to move quickly																				
Training																				
No training provided for trenching		X	X			X	X	X	X	X			X			X		X		
Safety rules likely not known						X				X			X			X		X		
Trench Related																				
Contractor failed to follow sloping specifications in work plan																		X		
Improper soil classification by competent person			X	X					X									X		
No sloping/benching/shoring	X	X	X	X	X	X	X	X	X			X	X		X			X		X
Spoil pile within 2 feet of edge, on side of trench				X		X	X		X						X			X		
Trench box available but not used		X	X	X	X		X													
Trench box needed greater depth										X	X								X	
Trench box defective																				
Trench box in use but worker left the protected area														X			X		X	
Trench box did not fit into available workspace (shorter or narrower)																X	X			
Trench box did not have bulkheads, material enter box from ends																				
Operator failed to check trench before digging																				
Willful violations		X	X								X				X					
Soil type	U	U	C	C	C	C	C	U	C	C	C	B	B	U	U	U	C	B	U	B
Time of day	2:00	11:45	12:00	5:40	11:00	11:30	1:45	8:30 A	1:35	3:00	1:30	9:45	11:30	2:30	3:00P	3:00	1:32	11:00	4:20	5:00
Wet/rain/standing water		X		X	X	X			X		X		X							
Hot/sunny																		X		
Age	28	48	33	39	24	27	38	49	27	29	19	30	37	50	42	32	22	28	45	49
Occupation	Laborer	Laborer	Pipelayer	Plumber	Laborer	Laborer	Operator	Laborer	Laborer23	Plumber	Laborer	Laborer	Laborer	Laborer	Pipelayer	Laborer	Laborer	Plumber	Laborer	Laborer
State	PA	KS	PA	AR	WI	GA	MA	NY	NE	NJ	OH	MO	SD	TX	TX	NY	AL	AL	TX	TX

Table C-3:

Contributing Factors in Trench Collapses, 1999

Contributing Factors	99-0058	99-0108	99-0248	99-0255	99-0259	99-0308	99-0314	99-0401	99-0416
Atmosphere									
Inadequate lighting									
Body Position									
Between trench box inner wall, and pipe									
Near open/active face of excavation with protection					X	X			
Employee Misconduct									
Bravado	X								
Disregarded prior warnings (except procedures - see below)									
Disregarded prior training									
Jumped into trench	X							X	
Engineering Planning									
Improperly selected trench box						X	X		
Inadequately designed shoring									
Material placed at edge of excavation, contributing to cave-in		X				X			X
Environment and Worksite									
Deceased had to work in an inappropriate area due to worksite configuration/area constraints							X		
Ethnicity/Culture/Language									
Non-native speaker			X		X				
Foreman									
Failure to conduct job site safety walks									
Knowledge of hazards but failure to take action	X				X				
Lack of designated trenching "competent person"	X			X		X	X	X	
Human Error									
Failed to follow procedure									
Maintenance Related									
Trench box or shoring design adequate									
Failure due to inadequate inspection/maintenance									
New Tasks/Non-Typical Work									
Employee(s) responded to unplanned event									
Type of project not typically performed by company									
Task seldom performed									
Management did not give thought to controls or did not think were necessary									
Operator Certification									
Operator certification/training were inadequate for job									
Safety Programs									
Safety program verbal-only					X				
Lack of written trenching/excavation program	X							X	
Written programs unenforced									
Site Communications									
Relied on other contractors/specialists to provide "safety"									
Site Management									
Claims it intended protection but failed to provide	X								
Claims ignorance of applicable regulations				X					
Felt client would not pay for proper sloping, shoring or trench box									
Knew of requirements but did not intend to comply									
Site Scheduling									
Pressured to move quickly									
Training									
No training provided for trenching	X	X	X	X	X	X		X	X
Safety rules likely not known			X						
Trench Related									
Contractor failed to follow sloping specifications in work plan			X				X		
Improper soil classification by competent person			X						
No sloping/benching/shoring	X	X		X		X		X	X
Spoil pile within 2 feet of edge, on side of trench		X			X	X		X	X
Trench box available but not used									
Trench box needed greater depth					X				
Trench box defective									
Trench box in use but worker left the protected area					X				
Trench box did not fit into available workspace (shorter or narrower)						X			X
Trench box did not have bulkheads, material enter box from ends									
Operator failed to check trench before digging									
Willful violations	X		X						
Soil type	C	U	C	U	U	B	U	C	C
Time of day	3:00	1:30	8:15	2:00	6:16	10:30	9:30	10:00	1:40
Wet/rain/standing water	X						X	X	X
Hot/sunny									
Age	28	46	24	44	29	21	37	29	40
Occupation	Plumber	Operator	Laborer	Pipelayer	Laborer	Laborer	Laborer	Laborer	Laborer
State	CO	NJ	TX	SD	GA	TX	TX	MO	TX

Appendix D

U. S. Department of Labor
Occupational Safety and Health Administration

Investigation Summary

Reporting ID	Investigation Summary Number	OSHA-36 Number	OSHA-36 Establishment Name
Event Date		Event Time	
Type of Event			

Inspection Number/ Establishment Name	
Injured/Deceased Name	
Sex:	
Age:	
Injury:	
Nature:	
Part of Body:	
Source of Injury:	
Event Type:	
Environmental Factor:	
Human Factor:	
Task:	
Substance Code:	
Occupational Code:	

Abstract:

OSHA-170print(Rev. 11/93)

Investigation Nr.

CONSTRUCTION ACCIDENT INFORMATION

Project Level Information

Type of Construction	
End-use Type of Construction Site	
If a building site, number of stories (in feet):	
If a non-building structure, height (in feet) :	
Project Cost	

Victim Level Information

Victim's Name	
Cause of Fatality / Accident	
Distance of the Fall (in feet)	
Height above ground (or floor) of the worker when the fall occurred (ft)	
Operation being performed by the victim	
Contributing Operation (if different from the operation above)	

OSHA-170print(Rev. 11/93)

U.S. Department of Labor
Occupational Safety and Healt' nistration

Inspection Report

Rpt ID	Assignment Nr.	CSHO ID	Supervisor ID	Inspection Nr.	Opt. Insp. Nr.

Establishment Name					
Site Address		Site Phone		Site FAX	
Mailing Address		Mail Phone		Mail FAX	
Controlling Corp		Employer ID			
Ownership		City		County	
Legal Entity		Previous Activity (State Only)			

Related Activity					
Type	Number	Satisfied	Type	Number	Satisfied

Employed in Establishment		Advance Notice?		Category	
Covered By Inspection		Union?		Primary SIC	
Controlled By Employer		Walkaround?		Secondary SIC	
		Interviewed?		Inspected	

Inspection Type		Reason No Inspection	
Scope of Inspection			
Classification			
Strategic Initiatives			
National Emphasis			
Local Emphasis			

		Denial Date	Date ReEntered	Date ReDenied	ReEntered
Anticipatory Warrant Served?					
Anticipatory Subpoena Served?					

Entry			First Closing Conference		
Opening Conference			Second Closing Conference		
Walkaround			Exit		
Days On Site			Case Closed		
			No Citations Issued		

Type	ID	Optional Information

CSHO Signature		Date	

OSHA-1(Rev. 6/93)

U. S. Department of Labor
Occupational Safety and Health .inistration

Fatality/Catastrophe Report

Reporting ID		Previous Activity (Type & Number)		Event Number			
Establishment Information	Establishment Name			Employer ID			
	Site Address			City Code		County Code	
		Site Phone	Site FAX				
	Mailing Address						
	Event Address (if different)						
Industry & Ownership	Type of Business			Primary SIC		No. of Employees	
	Ownership						
Receipt Information	Reported By		Date		Time		
	Job Title		Telephone				
Employee Representation	Group Name(s):						
Classification							
Event Description	Event Date	Event Time	Number of Fatalities	Number of Hospitalized Injuries	Number of NonHospitalized Injuries	Number Unaccounted for	
	Type of Event	electrocution					
Preliminary Description							
Action	Inspection Planned?	Supervisor(s) Assigned		CSHO(s) Assigned			
Strategic Initiatives							
National Emphasis							
Local Emphasis							
Optional Information	Type	ID	Optional Information Value				
Comments							

OSHA-36 (Rev. 2/96)

U.S. Department of Labor
Occupational Safety and Health nistration

Inspection Narrative

Inspection Nr.	
Opt. Case Number	

Establishment Name			
Legal Entity		Type of Business	

Additional Citation Mailing Addresses

Organized Employee Groups

Authorized Employee Representatives

Employer Representatives Contacted			
Name	Title	Function	Walk Around?

Other Persons Contacted

Entry			First Closing Conference		
Opening Conference			Second Closing Conference		
Walkaround			Exit		
			Case Closed		

Penalty Reduction Factors					
Size		Good Faith		History	

Followup Inspection?		Reason	

OSHA-1A(Rev. 6/93)

U. S. Department of Labor
Occupational Safety and He Administration

Worksheet

Inspection Number	
Opt. Insp. Number	

Establishment Name					
Type of Violation		Citation Number		Item/Group	
Number Exposed		No. Instances		REC	
Std. Alleged Vio.					

Abatement Period	MultiStep Abatements			Final Abatement	Action Type/Dates
	PPE Period	Plan	Report		

Abatement Documentation Required		Date Verified		

Substance Codes	

AVD/Variable Information:

Penalty Calculations				Adjustment Factors			Proposed Adjusted Penalty
Severity	Probability	Gravity	GBP	Size	Good Faith	History	
Repeat Factor							

Employee Exposure:

Occupation		Employer			
Nr of Employees		Duration		Frequency	
Employee Name					
Address		Phone			

Instance Description: A. Hazard B. Equipment C. Location D. Injury/Illness E. Measurements

4. Date/Time

20. Instance Description - Describe the following
    a) Hazards-Operation/Condition

    b) Equipment
    c) Location
    d) Injury/Illness
    e) Measurements

21. Photo Number	Location on Video

OSHA-1B/1BIHprint(Rev. 9/93)

23. Employer Knowledge :

24. Comments (Employer, Employee, Closing Conference) :

25. Other Employer Information :

26. Classification:				
Serious	Knowledge	S or O	Repeat?	Willful?

First Repeat	Second Repeat	Repeat Penalty

Event Date	Event Code	Action Code	Citation Type	Penalty	Abate Date	Final Order

OSHA-1B/1BIHprint(Rev, 9/93)

U.S. Department of Labor
Occupational Safety and Health Administration

Citation and Notification of Penalty

To:

Inspection Number:
Inspection Date(s):
Issuance Date:

Inspection Site:

The violation(s) described in this Citation and Notification of Penalty is (are) alleged to have occurred on or about the day(s) the inspection was made unless otherwise indicated within the description given below.

This Citation and Notification of Penalty (this Citation) describes violations of the Occupational Safety and Health Act of 1970. The penalty(ies) listed herein is (are) based on these violations. You must abate the violations referred to in this Citation by the dates listed and pay the penalties proposed, unless within 15 working days (excluding weekends and Federal holidays) from your receipt of this Citation and Notification of Penalty you mail a notice of contest to the U.S. Department of Labor Area Office at the address shown above. Please refer to the enclosed booklet (OSHA 3000) which outlines your rights and responsibilities and which should be read in conjunction with this form. Issuance of this Citation does not constitute a finding that a violation of the Act has occurred unless there is a failure to contest as provided for in the Act or, if contested, unless this Citation is affirmed by the Review Commission or a court.

Posting - The law requires that a copy of this Citation and Notification of Penalty be posted immediately in a prominent place at or near the location of the violation(s) cited herein, or , if it is not practicable because of the nature of the employer's operations, where it will be readily observable by all affected employees. This Citation must remain posted until the violation(s) cited herein has (have) been abated, or for 3 working days (excluding weekends and Federal holidays), whichever is longer. **The penalty dollar amounts need not be posted and may be marked out or covered up prior to posting.**

Informal Conference - An informal conference is not required. However, if you wish to have such a conference you may request one with the Area Director during the 15 working day contest period. During such an informal conference you may present any evidence or views which you believe would support an adjustment to the citation(s) and/or penalty(ies).

If you are considering a request for an informal conference to discuss any issues related to this Citation and Notification of Penalty, you must take care to schedule it early enough to allow time to contest after the informal conference, should you decide to do so. Please keep in mind that a written letter of intent to contest must be submitted to the Area Director within 15 working days of your receipt of this Citation. The running of this contest period is not interrupted by an informal conference.

If you decide to request an informal conference, call this office between 7:30 a.m. and 4:00 p.m. for an appointment, then complete, remove and post the page 4 Notice to Employees next to this Citation and Notification of Penalty as soon as the time, date, and place of the informal conference have been determined. Be sure to bring to the conference any and all supporting documentation of existing conditions as well as any abatement steps taken thus far. If conditions warrant, we can enter into an informal settlement agreement which amicably resolves this matter without litigation or contest.

Right to Contest - You have the right to contest this Citation and Notification of Penalty. You may contest all citation items or only individual items. You may also contest proposed penalties and/or abatement dates without contesting the underlying violations. Unless you inform the Area Director in writing that you intend to contest the citation(s) and/or proposed penalty(ies) within 15 working days after receipt, the citation(s) and the proposed penalty(ies) will become a final order of the Occupational Safety and Health Review Commission and may not be reviewed by any court or agency.

Penalty Payment - Penalties are due within 15 working days of receipt of this notification unless contested. (See the enclosed booklet and the additional information provided related to the Debt Collection Act of 1982.) Make your check or money order payable to "DOL-OSHA". Please indicate the Inspection Number on the remittance.

OSHA does not agree to any restrictions or conditions or endorsements put on any check or money order for less than the full amount due, and will cash the check or money order as if these restrictions, conditions, or endorsements do not exist.

Notification of Corrective Action - For violations which you do not contest, you should notify the U.S. Department of Labor Area Office promptly by letter that you have taken appropriate corrective action within the time frame set forth on this Citation. Please inform the Area Office in writing of the abatement steps you have taken and of their dates, together with adequate supporting documentation, e.g., drawings or photographs of corrected conditions, purchase/work orders related to abatement actions, air sampling results, etc. Attached is a fill-in-the-blank form letter for your use to assist you in meeting this requirement.

Employer Discrimination Unlawful - The law prohibits discrimination by an employer against an employee for filing a complaint or for exercising any rights under this Act. An employee who believes that he/she has been discriminated against may file a complaint no later than 30 days after the discrimination occurred with the U.S. Department of Labor Area Office at the address shown above.

Employer Rights and Responsibilities - The enclosed booklet (OSHA 3000) outlines additional employer rights and responsibilities and should be read in conjunction with this notification.

Notice to Employees - The law gives an employee or his/her representative the opportunity to object to any abatement date set for a violation if he/she believes the date to be unreasonable. The contest must be mailed to the U.S. Department of Labor Area Office at the address shown above and postmarked within 15 working days (excluding weekends and Federal holidays) of the receipt by the employer of this Citation and Notification of Penalty.

Abatement Methods - The employer is not limited to abatement methods suggested by OSHA; i.e. methods explained are general and may not be effective in all cases. Other methods of abatement may be equally or more appropriate. Ultimate responsibility for determining the most appropriate abatement method rests with the employer, given its superior knowledge of the specific conditions at its worksite.

Inspection Activity Data - You should be aware that OSHA publishes information on its inspection and citation activity on the Internet under the provisions of the Electronic Freedom of Information Act. The information related to your inspection will be available 30 calendar days after the Citation Issuance Date. You are encouraged to review the information concerning your establishment at WWW.OSHA.GOV. If you have any dispute with the accuracy of the information displayed, please contact this office.

U.S. Department of Labor
Occupational Safety and Health Administration

NOTICE TO EMPLOYEES OF INFORMAL CONFERENCE

An informal conference has been scheduled with OSHA to discuss the citation(s) issued on

The conference will be held at the OSHA office located at

on ____________ at ____________.

Employees and/or representatives of employees have a right to attend an informal conference.

Citation and Notification of Penalty

Company Name:
Inspection Site:

The alleged violations below have been grouped because they involve similar or related hazards that may increase the potential for illness.

U.S. Department of Labor
Occupational Safety and Health Administration

Inspection Number:
InspectionDates:
Issuance Date:

Citation and Notification of Penalty

Company Name:
Inspection Site:

Area Director

See pages 1 through 4 of this Citation and Notification of Penalty for information on employer and employee rights and responsibilities.

U.S. Department of Labor
Occupational Safety and Health Administration

INVOICE/ DEBT COLLECTION NOTICE

Company Name:
Inspection Site:
Issuance Date:

Summary of Penalties for Inspection Number

Citation 1, Serious = $
[redacted]

To avoid additional charges, please remit payment promptly to this Area Office for the total amount of the uncontested penalties summarized above. Make your check or money order payable to: "DOL-OSHA". Please indicate OSHA's Inspection Number (indicated above) on the remittance.

OSHA does not agree to any restrictions or conditions or endorsements put on any check or money order for less than full amount due, and will cash the check or money order as if these restrictions, conditions, or endorsements do not exist.

Pursuant to the Debt Collection Act of 1982 (Public Law 97-365) and regulations of the U.S. Department of Labor (29 CFR Part 20), the Occupational Safety and Health Administration is required to assess interest, delinquent charges, and administrative costs for the collection of delinquent penalty debts for violations of the Occupational Safety and Health Act.

Interest. Interest charges will be assessed at an annual rate determined by the Secretary of the Treasury on all penalty debt amounts not paid within one month (30 calendar days) of the date on which the debt amount becomes due and payable (penalty due date). The current interest rate is 5%. Interest will accrue from the date on which the penalty amounts (as proposed or adjusted) become a final order of the Occupational Safety and Health Review Commission (that is, 15 working days from your receipt of the Citation and Notification of Penalty), unless you file a notice of contest. Interest charges will be waived if the full amount owed is paid within 30 calendar days of the final order.

Delinquent Charges. A debt is considered delinquent if it has not been paid within one month (30 calendar days) of the penalty due date or if a satisfactory payment arrangement has not been made. If the debt remains delinquent for more than 90 calendar days, a delinquent charge of six percent (6%) per annum will be assessed accruing from the date that the debt became delinquent.

Administrative Costs. Agencies of the Department of Labor are required to assess additional charges for the recovery of delinquent debts. These additional charges are administrative costs incurred by the Agency in its attempt to collect an unpaid debt. Administrative costs will be assessed for demand letters sent in an attempt to collect the unpaid debt.

____

Area Director

Vita

John Patrick Wagner was born in Chicago, Illinois on March 28, 1975. He was raised in Oak Ridge, Tennessee and went to St. Mary's Catholic School and then Oak Ridge High School. He graduated with Honors in 1993. From there, he went to Roane State Community College where he received an Associates of Science in 1996. He then attended University of Tennessee and received his Bachelors of Science in Industrial Engineering in 1998 and Masters of Science in Industry Engineering in 2004.

John is currently working for Construction Industry Research and Policy Center as an Engineering Research Associate and enjoys bowling and playing softball.