

Analysis of Safety Issues in Trenching Operations

Javier Irizarry, George Washington Carver Doctoral Fellow, School of Civil Engineering, Purdue University

Dulcy M. Abraham, Associate Professor, School of Civil Engineering, Purdue University.

Reini D. Wirahadikusumah, Post Doctoral Research Engineer, School of Civil Engineering, Purdue University.

Carlos Arboleda, Graduate Research Assistant. School of Civil Engineering, Purdue University

ABSTRACT

Trenching related accidents account for a large percentage of accidents in the construction industry. These accidents can be caused by failure of the soil in which the trench was excavated, or the lack of protection of the trench walls by means of structures such as trench boxes or contacts with equipment or materials near the trench area among others.

OSHA (Occupational Safety and Health Administration) inspections are limited to establishing the cause of the trenching related accident and verifying if the required measures, according to their standards, were used. If the required measures to ensure safety were not taken, then OSHA can impose fines to the company performing the work. However, these inspections may not indicate the reasons why the OSHA trench safety standards were not used or why they failed to protect the workers.

This paper will describe a comprehensive analysis of the events leading to the accidents in trenching related work. It will examine those aspects of the trenching operation that are not fully addressed in the OSHA inspections. The paper will provide a synopsis of possible modifications to the existing OSHA standards that could provide alternatives to provide a safe working environment when traditional standards are not feasible or practical to apply. The research study underlying this paper, is funded through a grant from the National Institutes of Occupational Safety and Health (NIOSH) to the Construction Safety Alliance (CSA).

INTRODUCTION

Trenching fatalities and injuries continue to plague the construction industry. While complete and accurate records of the actual number of fatalities occurring in trenching incidents are not maintained, “the estimate of 100 fatalities per year due to cave-ins and other excavation accidents (Hinze and Bren 1996),” and 7000 injuries, is perhaps a reasonable approximation of the magnitude of the problem. Many studies have analyzed accident reports of agencies such as the Occupational Safety and Health Administration (OSHA) and the Bureau of Labor Statistics and determined the various reasons for trenching related accidents (Hinze and Bren 1996, Suruda et al. 1988). These accidents can be caused by soil failure, the lack of protection of the trench walls by means of structures such as trench boxes, etc. A study conducted by OSHA in 1990 that analyzed construction fatalities from 1985 to 1989 determined that seventy-nine percent of trenching related fatalities occurred in trenches less than 15 feet (4.6 meters) deep and thirty-eight percent occurred in trenches less than 10 feet (3.0 meters) deep.

OSHA inspections are limited to establishing the cause of the trenching related accident and verifying if the required measures, according to their standards, were used. However, the OSHA inspections may not include the reasons why the OSHA trench safety standards were not used or why they failed to protect the workers.

If the required measures to ensure trench safety were not taken at the scene of the trenching operation, then OSHA can impose fines on the company performing the work. These fines can increase the cost of construction work by increasing the contractor’s insurance costs. Thompson (1982) reported that the cost of excavation failures that result from unsafe excavation procedures add about seven to eight percent to the cost of construction.

In order to determine possible intervention strategies, it is important to learn more about the circumstances under which the accidents occur, and to investigate the relationship between the accidents and the adherence/non-adherence to OSHA Safety Standards. Such an endeavor is pivotal in understanding why applicable standards were not used, or if they were used, why they were unsuccessful in ensuring safety in the trenching operation.

In September 2001, Purdue University, in partnership with the University of Cincinnati, the University of Florida, Gainesville, and the University of Texas, Austin received a grant from the National Institutes of Occupational Safety and Health (NIOSH) to develop, implement and evaluate a national research program in construction safety and health. One of the target areas of study is the Development of Safer Trenching Operations. The general objectives of this study are three-fold:

1. Analyze the causes of accidents in trenching operations.
2. Establish an information database on work risk factors associated with trenching operations.
3. Develop strategies to prevent fatalities and reduce injuries in trenching operations.

This paper presents some initial findings underlying the relationship between the OSHA Safety Standards for Excavation Safety and the causes of trenching related accidents.

OSHA STANDARDS AND EXCAVATION SAFETY

The OSHA (Occupational Safety and Health Act) standard related to trenching (OSHA Standard 1926 Subpart P) consists of three main sections with six (6) appendices. The first section contains definitions clearly defining the terms used in the excavation standard. The second section contains the general requirements. All underground and aboveground installations must be located before starting excavation work. Access and egress must be provided for employees in excavations over 4 feet (1.2 meters) in depth to prevent falls when entering or exiting excavations. Employees working in trenches shall be protected from cave-ins, loose rock and soil, falling loads, and hazardous atmospheres. Both surface and subsurface water must be controlled with water removal equipment supervised by a competent person. Adjacent structures must be underpinned before start of excavation work. All required inspections should be conducted by a competent person on a daily or as-needed basis. Fall protection must be provided where appropriate, in excavations and over trenches.

The third section specifies the actual Requirements for Protective Systems that must be provided by the employer to protect workers who enter excavations. The standard requires that employees entering excavations which are five feet (1.5 meters) or greater in depth be protected from cave-ins. The requirements for protective systems are divided into two categories, *sloping and benching* and *support systems*. *Support systems* include *shoring systems* and *shielding systems*. It must be noted that the competent person can use the standard to a maximum depth of 20 feet (6.1 meters). Excavations deeper than 20 feet (6.1 meters) require the approval of a registered professional engineer.

In 1991 OSHA conducted a study on the most cited standards in the construction industry. The purpose of this study was to identify the causes of accidents and provide suggestions on how to eliminate, control or mitigate such hazards. This study showed that 4 of the top 25 standards cited were related to trenching as shown in Table 1

Table 1 Most cited trenching related standards (adapted from OSHA 1991)

Rank	Description of Standard		Standard (1926.____)
5	Trenching/Excavation	Protective Systems for trenching/excavation	652(a)(1)
11	Trenching/Excavation	Daily inspection of physical components of trench and protection systems	651(k)(1)
16	Trenching/Excavation	Spoil pile protection	651(j)(2)
22	Trenching/Excavation	Access/Egress from trench/excavation	651(c)(2)

ROLE OF THE COMPETENT PERSON

In order to ensure the safe execution of the trench excavation activities in the construction site, OSHA requires the presence of a “Competent Person” during the activity. To function as a competent person at an excavation site a competent person must be (Lew 1994):

- Thoroughly knowledgeable with excavation safety standards including soil classification.
- Capable of identifying existing and predictable hazards and unsafe conditions.
- Knowledgeable in the proper use of protective systems and trench safety equipment.
- Designated to have the authority to stop work when unsafe conditions exist.

A person must have documented experience and training in the first three requirements, and be designated as the competent person by the employer with the authority indicated in the fourth requirement.

CHARACTERISTICS OF TRENCHING ACCIDENTS

An important source of information related to trenching related accidents is the OSHA investigation reports, which makes up the largest single source for this type of information. To analyze this information a total of fifty fatal and non-fatal cases were identified from 1996 to 1997. The data was obtained from the OSHA Database System. The following parameters were analyzed, and the observations are discussed in the remainder of this section:

- Month of event
- Accident outcome (injury or fatality)
- Classification of accident by Bureau of Labor Statistics (BLS) code (exposure)
- Gender of workers affected
- Age of workers affected
- Classification by Standard Industrial Classification (SIC) code
- Time of day of accident
- Union status of workers
- Trench characteristics
- Risk factors

Month of Event

In 1996, twenty one percent of the accidents occurred during the month of October. In 1997, eighteen percent of the accidents occurred during the month of December. Overall, the month with the highest incidence of accidents during the period of investigation (1996-1997) was October as shown in Figure 1

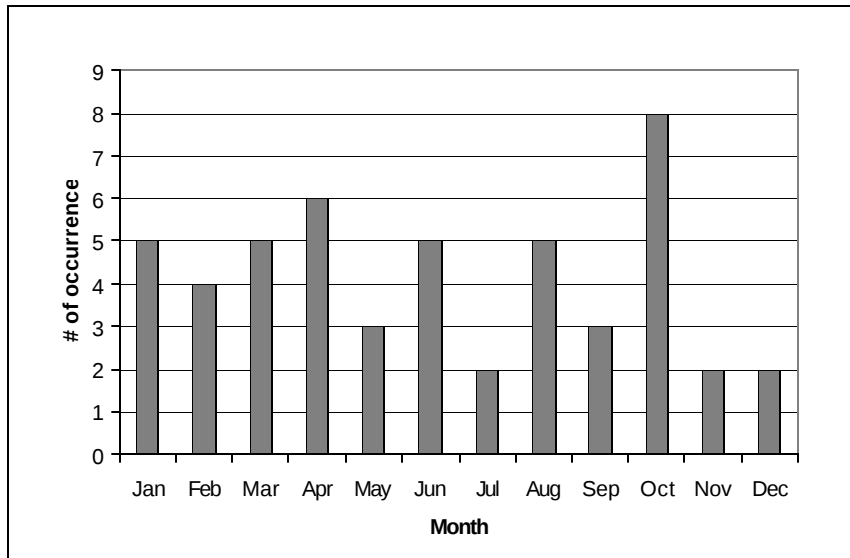


Figure 1 Total occurrences of trenching accidents by month (1996-1997) – From OSHA’s Integrated Management Information System (IMIS)

Accident Outcome

Of all the cases studied, more than half (65%) resulted in fatalities and only 35% resulted in injuries. The most cited reason for the accidents resulting in fatalities was excavation or trenching cave-ins. The degree of the injuries varied from sprained muscles to fractures. In most cases, injured workers were treated and released the same day from the hospital because their injuries were not severe. In such cases, the nature of the injury was not reported.

Classification of Accident by BLS Code

Based on the Bureau of Labor Statistics (BLS) Classification System, it was observed that 19 of the 50 cases studied (38%) of the accidents fell under the BLS Code 041 (Excavation or Trenching Cave-in) and that the remaining 62% fell under other BLS Codes (Table 2).

The number of accidents that were categorized under other codes varied from 2% to 8% per code. This shows that there are many dangers related to trenching work and that the majority of the accidents are caused by reasons other than trench cave-in. The following table shows the occurrences of each type of exposure by BLS code.

Table 2 Accident occurrences by BLS Code - From OSHA's Integrated Management Information System (IMIS)

Exposure Code	Description	Occurrences	%
012	Struck against stationary object	2	4%
013	Struck against moving object	1	2%
0220	Struck by flung object, unspecified	1	2%
021	Struck by falling object	4	8%
030	Caught in or compressed by equipment or objects, unspecified	2	4%
039	Caught in or compressed by equipment or objects, n.e.c.	1	2%
0040	Caught in or crushed in collapsing materials, unspecified	1	2%
041	Excavation or trenching cave-in	19	38%
042	Other cave-in	1	2%
0049	Caught in or crushed by collapsing materials, n.e.c.	4	8%
113	Fall from ladder	2	4%
0239	Struck by swinging or slipping object, n.e.c.	1	2%
313	Contact with overhead power lines	3	6%
319	Contact with electric current	3	6%
1120	Fall from floor, dock, or ground level, unspecified	1	2%
1124	Fall from ground level to lower level	3	6%
384	Depletion of oxygen in other enclosed, restricted, or confined space	1	2%

Gender of Workers

From the data obtained from the OSHA reports, it was observed that all of the workers involved in trenching accidents were male. Due to the dangerous and physically demanding nature of trench related work it is expected that the majority of the workers will be male.

Age of Workers

The mean age of workers involved in the fifty reported trenching accidents during the 1996-1997 time frame was 34 years. The distribution of ages was skewed toward younger ages, the largest group (20) being in the range of 20 to 30 years as shown in Figure 2.

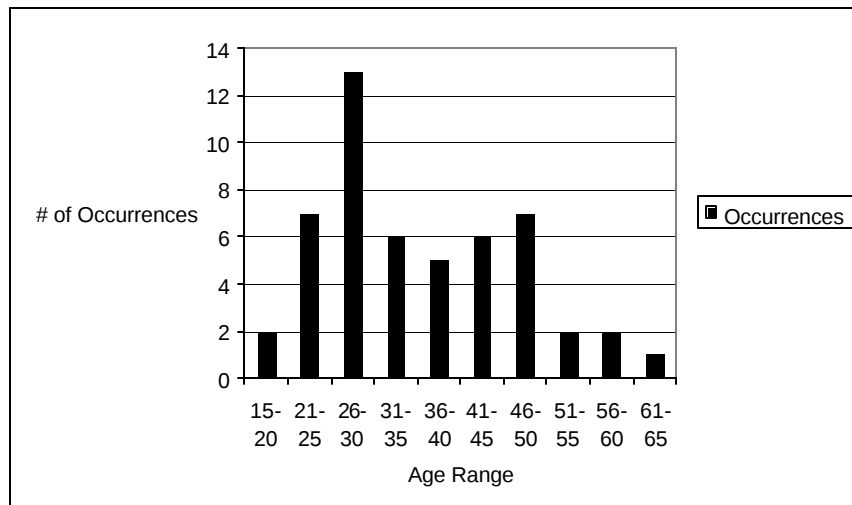


Figure 2 Age Distribution of Workers Involved in Trenching Accidents - From OSHA's Integrated Management Information System (IMIS)

Classification by SIC Code

According to the data from the OSHA reports forty percent of the accidents reported involved workers for water, sewer, and pipeline contractors, i.e., SIC (Standard Industrial Classification) Code – 1623.

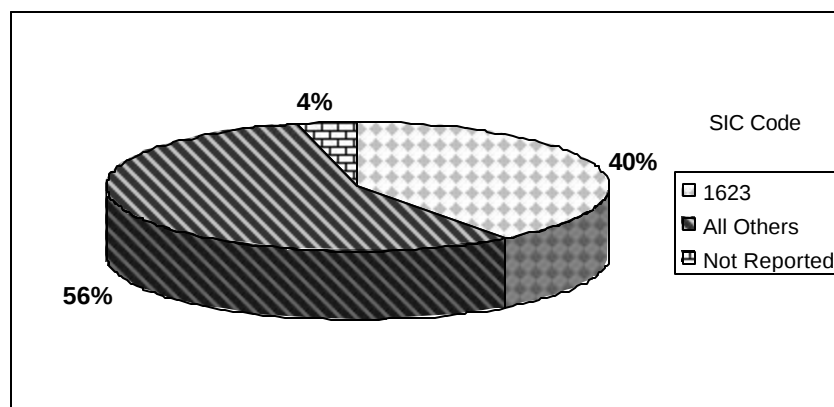


Figure 3 Total accident occurrence by SIC code - From OSHA's Integrated Management Information System (IMIS)

Time of Day

From the data available a comprehensive analysis of the time of day of occurrence of the accidents was not possible. The time of day of the accidents was reported on only seven (14%) of the 50 cases analyzed.

Union Status

The majority of the workers involved in trenching related accidents were non-union workers (98%). The low rate of trenching accidents among union workers could be attributed to the extensive training they receive prior to arriving at the jobsite. .

Trench Characteristics

Of the fifty cases studied, twenty-seven reported information related to the depth of the trenches in which the accidents took place. The depth of the trenches varied from 0 to 20 ft (0 to 6.1 meters) with ten instances (37%) in the range from 0 to 5 ft (0 to 1.5 meters) (Figure 4). This gives us an indication that even in shallow trenches the possibility of accidents still exists.

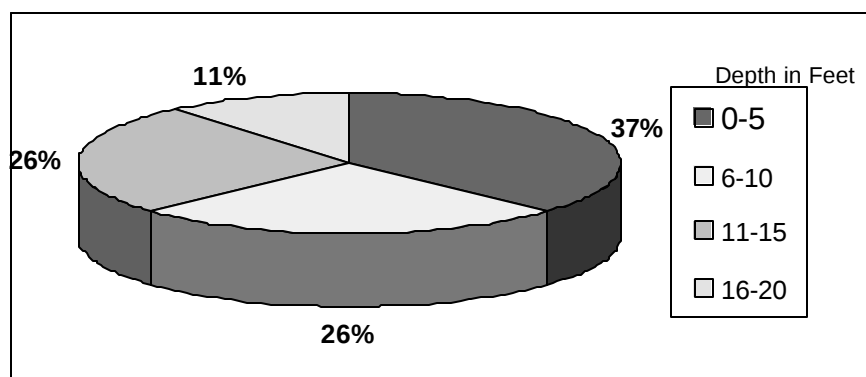


Figure 4 Total accident occurrence by trench depth - From OSHA's Integrated Management Information System (IMIS)

In five cases studied (10% of total number of cases analyzed) the presence of excavation support structures was reported. In eight cases there was no trench support structure present and in thirty-seven of the 50 cases (74% of the cases analyzed) the presence of excavation support structures could not be determined from the OSHA accident reports (as shown in Figure 5). The reporting format used by OSHA can be enhanced to seek such information for determining the causes of trenching related accidents.

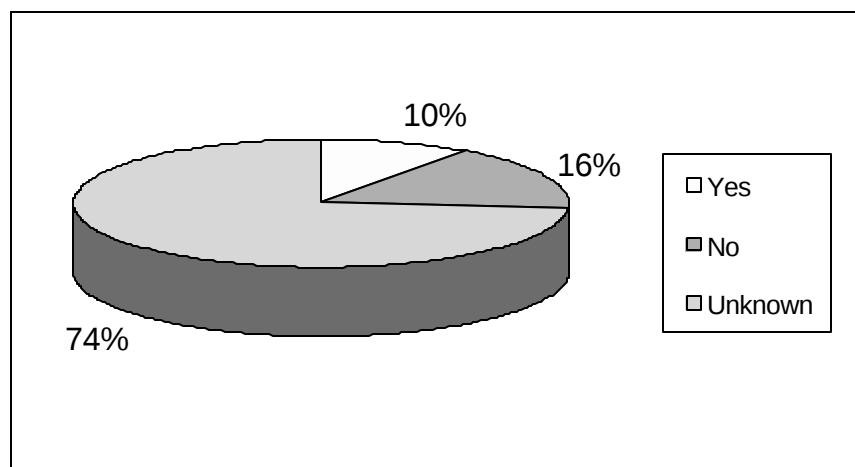


Figure 5 Presence of excavation support - From OSHA's Integrated Management Information System (IMIS)

The type of excavation protection structures or methods depends on the characteristics of the trench. Depth and soil condition are the predominant factor when deciding if and what type of protection will be used. Of the five cases where excavation support structures were present, shoring was used to protect two of the trenches, trench boxes were used in two cases and sloping was used in one case.

Risk Factors

Various risk factors that contribute to trenching accidents (as shown in Table 3) were identified from the OSHA accident reports. Misjudgment of hazardous situations was identified in 39% of the instances, making it the most common risk factor. This reinforces the need to have a "Competent Person" capable of correctly identifying risks so that actions can be taken to reduce the probability as well as severity of accidents.

Table 3 Identified risk factors associated with trenching accidents - From OSHA's Integrated Management Information System (IMIS)

Risk Factor	# of Occurrences	% of total
Unstable soil condition	7	15%
Misjudgment of hazardous situation	18	39%
Inappropriate handling of materials or equipment	8	17%
Overhead load hazard	7	15%
Failure to secure trench walls/ or protection not present	6	13%
	46	100%

SUMMARY

This paper discussed the characteristics of trenching related accidents based on an analysis of OSHA accident reports for trenching accidents that were reported in 1996-1997. The paper also reviewed the actual OSHA standards related to trench safety and the role of the "Competent Person" in trenching related work. Failure of trench walls continues to be the main cause of trenching related accidents in the construction industry particularly when protection systems are not employed. In many cases, the failure to employ such protective systems may be the result of misjudgment of the hazardous situation present at the work site or the lack of a "Competent Person" to make such evaluations. Additional data collection will be necessary to better assess the causes of trench related accidents. Site visits and interviews with craftspeople, and front-line supervisors will be conducted during Spring and Summer 2002 to identify potential intervention strategies.

REFERENCES

- Boom, J. (1999) Trenching is a Dangerous and Dirty Business, *OSHA's Job Safety and Health Quarterly Magazine*, 11(1) Fall 1999
- Hinze, J., and Bern, K. (1997). The Causes of Trenching Related Fatalities and Injuries, Proceedings of Construction Congress V: Managing Engineered Construction in Expanding Global Markets, Stuart D. Anderson ASCE pp 389-398
- Lew, J.J., Trenching and Excavation Safety. Proceedings of the Fifth Annual Rinker International Conference Focusing on Construction Safety and Loss Control. October 1994. pp. 43-52
- OSHA Standard 1926 Subpart P, *U.S. Department of Labor, Occupational Safety and Health Administration*, July 1992.
- Stanevich, R. L., and Middleton, D. C. (1988). An Exploratory Analysis of Excavation Cave-In Fatalities. *Professional Safety* (Vol. 33) 1988: 24-28.
- Suruda A., Smith G. and Baker S. (1988) Deaths from Trench Cave-in in the Construction Industry *Journal of Occupational Medicine* 30(7) July 1988: 552-555
- Thompson, L.J. Trenching and Excavation Safety. ASCE Specialty Conference on Construction Equipment and Techniques for the Eighties. Purdue University, West Lafayette, Indiana, March 28-31, 1982. pp. 302-307
- U. S. Department of Labor: Occupational Safety and Health Administration (1995). *29 CFR 1926/1910; Construction Industry-OSHA Safety and Health Standards*. Revised July 1, 1995. Washington, D.C.
- U. S. Department of Labor: Occupational Safety and Health Administration (1990) Analysis of Construction Fatalities – The OSHA Data Base 1985-1989. November 1990. Washington, D.C.
- U. S. Department of Labor: Occupational Safety and Health Administration (1995) The Most Frequently Cited OSHA Construction Standards in 1991: A Guide for Abatement of the Top 25 Associated Physical Hazards. March 1995. Washington, D.C.