Excavation and Trenching Safety: Existing Standards and Challenges

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ABSTRACT

Excavation and trenching related accidents account for a large percentage of accidents in the construction industry. It is estimated that there are more than one hundred fatalities every year associated with excavations and trenching operations, including by cave-ins, lack of protective systems, and improper rescues and utilities damages.

A worker performing excavation and trenching operations is protected by OSHA standards. These standards involve most safety aspects: knowledge, training, and experience of the people responsible under the codes. Unfortunately, the codes are often misunderstood or ignored, for example, the requirements for a "competent person."

This paper discusses the existing OSHA's excavation and trenching standards, specifically describing the requirements and the roles of a competent person, and other issues in OSHA Standard 1926 Subpart P. Recent efforts on investigating the causes of trenching-related accidents are also presented.

1. 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. In addition to the possibility of trench cave-ins, workers in trenches can "be

harmed or killed by engulfment in water or sewage, exposure to hazardous gases or reduced oxygen, falls, falling equipment or materials, contact with severed electrical cables or improper rescue (ELCOSH website)."

Findings of a mail survey conducted by Equipment World (1998) show the following alarming statistics:

- Nearly 41% of all respondents said they experienced a trench collapse on one of their jobs. Out of this group, 29.4% said that someone was injured or killed in the collapse.
- Of the nearly 41% who had experienced a trench collapse on a job, 76.5% said that the trench collapse was due to unstable soil, 29.4% said it was due to human error, and 11.8% said it was due to insufficient shoring/shielding.

In addition to fatalities, injuries caused due to unsafe trenching practices are costly in terms of direct and indirect costs to the construction industry. The direct costs include medical and workers' compensation payouts. In 1995, construction accounts for 15% of all workers' compensation spending while construction workers are only about 6% of the labor force (CPWR 1998). The employers and society also pay large indirect costs. Hinze (1991) estimated that the ratio of indirect to direct costs for injuries resulting in lost work time was 20 to 1. The indirect costs range from lost productivity among co-workers and management, and lawsuits, to reduced worker morale, especially when fatalities occurred.

In September 2001, Purdue University received a grant from the National Institutes of Occupational Safety and Health (NIOSH) to develop strategies for safer trenching operation. This paper discusses the initial findings of this study and focuses on the following issues:

- Role of the competent person in excavation safety
- OSHA regulations related to excavation safety
- Causes of accidents
- Characteristics of accidents

2. ROLE OF THE COMPETENT PERSON IN EXCAVATION SAFETY

To function as a competent person at an excavation site a competent person must be:

- Thoroughly knowledgeable with excavation safety standards including soil classification.
- Capable of identifying existing and predictable and 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 requirement four. Construction management must be aware

of these requirements, and that the responsibility to comply with these requirements rests with the managers or owners of construction companies.

3. OSHA REGULATIONS RELATED TO EXCAVATION SAFETY: OSHA STANDARD 1926 SUBPART P

The OSHA (Occupational Safety and Health Act) standard consists of three main sections with six (6) appendices. The first section contains definitions clearly defining the terms used in the excavation standard. It is important that these definitions be understood before reading the standard and applying the rules of the standard to the worksite.

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 e xcavations over 4 feet in depth to prevent falls when entering or exiting excavations. Employees working in trenches shall be protected from cave-ins, loose rock and soil, from 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 shall 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 or greater in depth be protected from cave-ins. The eight OSHA options are the methods that must be used to protect the employees and must be understood by the competent person. The requirements for protective systems are divided into two categories, *sloping and benching* and *support systems*, each of which contains four options, thus eight OSHA options are available to the competent person. *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. Excavations deeper than 20 feet require the approval of a registered professional engineer

The primary appendices of the standard are: Appendix A, Soil Classification; Appendix B, Sloping and Benching; Appendix C, Timber Shoring; and Appendix D, Aluminum Hydraulic Shoring.

4. CAUSES OF ACCIDENTS

Data on occupational accidents can be obtained from several agencies: the Bureau of Labor and Statistics (BLS), the Occupational Safety and Health Administration (OSHA), and the National Institute for Occupational Safety and Health (NIOSH). Each agency maintains its database for different specific objectives; thus, the types

of information included in the database and the focus of the investigation varies from agency to agency.

The National Safety Council has adopted the BLS figures (beginning with the 1992 data year), as the authoritative count for work related deaths in the United States. However, the categories in the BLS system on fatal injuries do not isolate "trench-related" injuries. While most injuries would be classified as "caught in or crushed in collapsing materials" or "excavation or trenching cave-in," trench-related injuries could also be categorized as "falls," "contact with electric current," etc. Using the BLS data alone, the death or injury counts can be misleading and they are in most cases, understated. Therefore, to measure the trenching hazard and to study the causes of trench-related accidents, the database from all three agencies should be used concurrently.

In order to understand the fatalities causes associated with trenching operations, and to develop the intervention strategies, it is necessary to access the National Institutes for Occupational Safety and Health (NIOSH), specifically, the Fatality Assessment and Control Evaluation (FACE) program. This is a research program designed to identify and study fatal occupational injuries. The goal of the FACE program is to prevent occupational fatalities across U.S by identifying and investigating work situations at high risk for injury and then formulating and disseminating prevention strategies to those who can intervene in the workplace.
As a bibliographic reference, the research project funded by NIOSH has considered and studied 52 (48 out 52 construction operations) reports associated with Trenching and Excavation Operations. All reports were extracted from NIOSH web site. The reports covered the period from 1985-2000.

The preliminary **r**esults show a similarity with previous research studies (Hinze 1998). Again, sewer systems (35%) and water supply systems (15%) are areas with the highest trenching related fatalities. It was revealed that electrocutions in trenching accidents are increasing.

An analysis of the ***type of accidents***, cave-in was cited as the main cause in seventeen cases. In sixteen+ cave-in cases (94%), the walls were not protected by shoring, shielding or sloping. Eighteen equipment related accidents were included in the FACE reports. These accidents were due to improper equipment operations, equipment working near trenching areas, lack of signals, inexperienced operators and mechanical deficiencies.

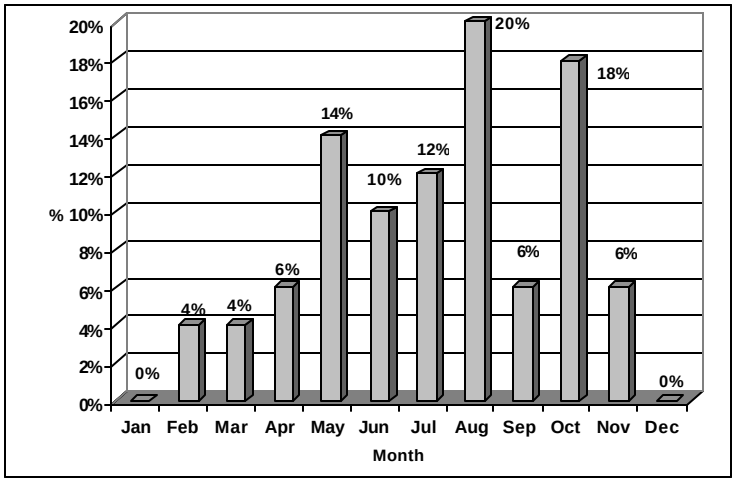

Figure 1. Month of occurrence vs. fatalities

The ***month of occurrence*** of the accident was examined. Figure 1 identifies August and October as the months with the highest percentages of fatalities.

Next, ***Company Safety Programs*** were analyzed. In fifty percent of the cases, the company had an Official Safety Program, but in sixty of the cases, a competent person did not conduct a safety site evaluation prior to the accident.

Another characteristic that was analyzed was the worker's age. In seven percent of the cases, the workers were younger than eighteen. Figure 2 shows the age range for all cases in the FACE reports. It is noted that fifty one percent of the workers were younger than thirty-five.

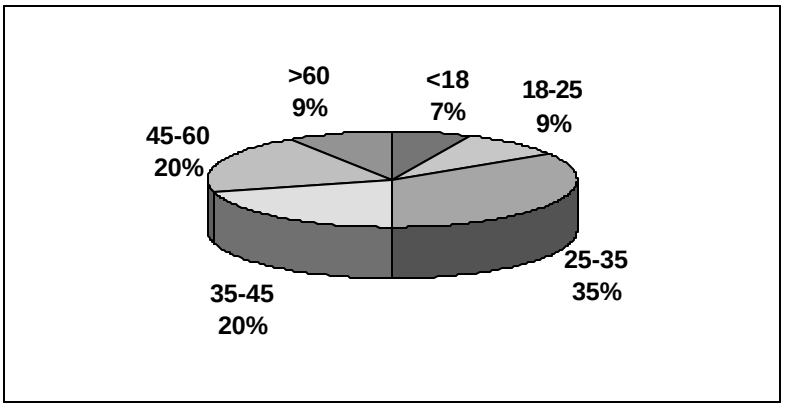

Figure 2. Age vs. percentage of trenching accidents

5. CHARACTERISTICS OF ACCIDENTS

Another source of important information related to trenching related accidents are the OSHA investigation reports, which make 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 studied, and the observations of this study are discussed in this section:

- Month of event
- Accident outcome (injury or fatality)
- Gender of workers affected
- Classification by SIC code
- Time of day of accident
- Union status of workers
- Trench characteristics.

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 (16%). Figure 3 shows this information in a graphical format.

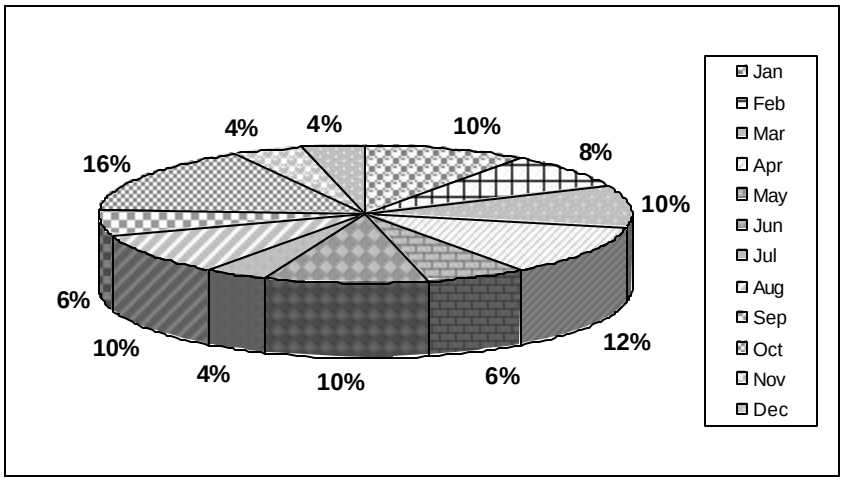

Figure 3. Total accident occurrence by month

Accident Outcome: Of all the cases studied more than half (65%) resulted in fatalities and only 35% resulted in injuries.

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.

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.

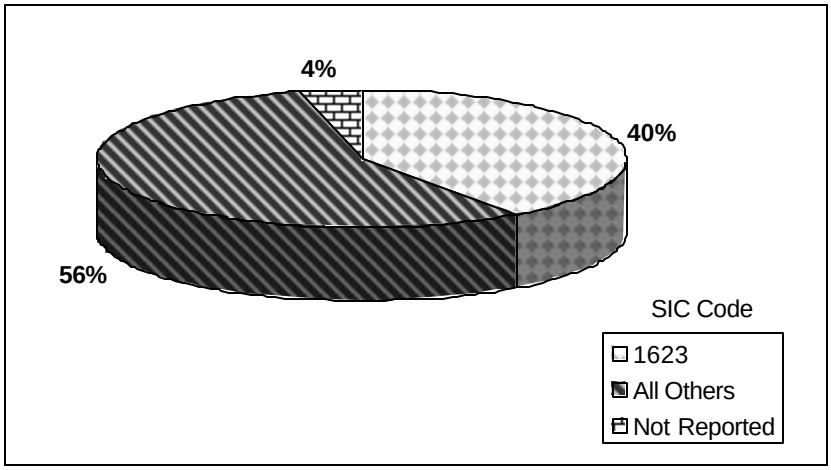

Figure 4. Total accident occurrence by SIC code

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%). This gives us an indication that workers who are not union members are more likely to have accidents due to lack of training.

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 with ten instances (37%) in the range from 0 to 5 ft. This gives us an indication that even in shallow trenches the possibility of accidents still exists.

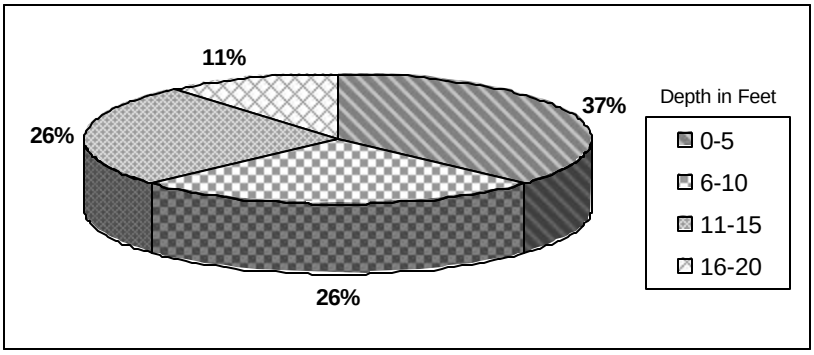

Figure 5. Total accident occurrence by trench depth

7. CONCLUSIONS

This paper discussed the role of the competent person in excavation safety and analyzed characteristics of accidents based on FACE and BLS records. Based on these initial findings, continued site visits and interviews with craftspeople, and front-line supervisors, potential intervention strategies can be identified. These may include recommendations to OSHA regarding the existing standards for trench safety, engineering controls, and safety management issues in construction. Two key observations from the initial review of records point to the need for a competent person at the work site and effective worker training prior to the commencement of construction operations.

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