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TRENCH-RELATED FATALITIES IN CONSTRUCTION: AN ANALYSIS OF FATALITY ASSESSMENT AND CONTROL EVALUATION (FACE) RECORDS

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ABSTRACT
Every year, there are over one hundred estimated fatalities in the U.S. associated with excavations and trenching operations. Causes of fatalities include: cave-ins, contacts with electrical cables, equipment related accidents, and utility damages. To improve the effectiveness of accident prevention programs in trenching operations, the primary causes of trenching accidents and fatalities have to be identified. Developing a database to identify the causes of fatalities in trenching operations is the first step in the development of effective intervention strategies. This paper describes the analysis of trenching-related fatalities based on the National Institutes for Occupational Safety and Health (NIOSH) Fatality Assessment and Control Evaluation (FACE) records.

KEYWORDS
Trenching, Accident Prevention, Fatalities, Injuries

1. INTRODUCTION

Trenching fatalities continue to plague the construction industry. While accurate records of the actual number of fatalities ocurring in trenching incidents are not maintained, the estimate of 100 fatalities per year is perhaps a reasonable approximation of the magnitude of the problem (Hinze and Bren, 1997). According to an analysis performed by NIOSH of workers' compensation claims in the Supplementary Data System of the Bureau of Labor Statistics (BLS), there are approximately 1000 work related injuries each year due to excavation cave-ins. Of these, about 140 result in permanent disability and 75 in death (NIOSH, 1995).

In addition to fatalities, injuries caused by unsafe trenching practices are costly in terms of direct and indirect costs to the construction industry. 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.

To improve the effectiveness of accident prevention programs in trenching operations, the primary causes of trenching accidents and fatalities have to be identified. This paper describes the analysis of trenching-related fatality reports in NIOSH Fatality Assesment and Control Evaluation (FACE) program. Based on this analysis, an overview of the main causes of fatalities in trenching is described.

2. FATALITY ASSESMENT AND CONTROL EVALUATION (FACE) PROGRAM

The FACE program focuses on investigations of fatal occupational injuries. The goal of this program is to prevent occupational fatalities across the U.S by identifying and investigating work situations at high risk for injury, and formulating and disseminating prevention strategies to those who can intervene in the workplace (NIOSH 2000).
The primary activities of FACE program are:

- Conducting surveillance to identify occupational fatalities
- Performing investigations of specific types of events to identify injury risks
- Developing recommendations designed to control or eliminate identified risks
- Making injury prevention information available to workers, employers, and safety and health professionals.

During the on-site investigations, facts and data are collected on factors such as: type of industry involved, number of employees in the company, company safety program, the victim's age, gender, occupation, the working environment, the tasks the victim was performing at the time of the accident, the tools or equipment the victim was using and the role of management in controlling the interaction of these factors. The names of employers, victims, and/or witnesses are not used in written investigative reports nor included in the FACE database.

Surveillance and investigative reports are maintained by NIOSH in a database. NIOSH researchers use this information to identify new hazards. FACE information may suggest the need for new research or prevention efforts or for new or revised regulations to protect workers. NIOSH publications are developed to highlight these high-risk work situations and to provide safety recommendations.

2.1 Data Analysis

Fifty two (52) reports related to trenching fatalities were identified using NIOSH database, available on-line. These reports covered the period from 1985 – 2000. The main information extracted from each report included: date and time of accident, geographical information, age and gender of the victim(s), event exposure as determined by Bureau of Labor Statistics (BLS) category, depth of the trench, type of operation, occupation, presence of competent person on site, official safety program, worksite inspection, training and education, and categorization by Standard Industrial Classification (SIC).

Geographical distribution The geographical distribution of the reports is presented in Table 1.

Table 1: Geographical Distribution

State	Reports	State	Reports	State	Reports
Alaska	2	Maryland	4	Ohio	1
Arizona	2	Massachusetts	4	Pennsylvania	1
California	9	Michigan	1	South Carolina	1
Florida	1	Minnesota	4	Texas	2
Georgia	2	Nebraska	2	Wisconsin	1
Indiana	1	New Jersey	7	Wyoming	5
Iowa	1	North Carolina	1		

Accident occurrence classified by BLS code
The BLS classification system (BLS, 1992) was used to categorize each accident as shown in Table 2. FACE reports include not only excavations or trenching cave-ins, although they are the most frequent cause of fatalities in trenching operations. As shown in Table 2, 68% of the accidents were not caused primarily by cave-ins. The equipment related accidents involved mechanical failures and incorrect maneuvering by operators. Some reports

indicated that the workers were in the vicinty of equipment and they did not adhere to the signals and warnings from the operator. In some cases, accidents occurred when the operator performed complex work tasks without adequate training and experience.

Table 2: Accident occurrence classified by BLS code

BLS Code	Code Description	Reports	Percentage (%)
041	Excavation or trenching cave-in	17	32
039	Caught in or compressed by equipment or objects	12	23
314	Contact with underground, buried power lines	7	14
1124	Fall from ground level to lower level	4	8
049	Caught in or crushed in collapsing material	3	6
021	Struck by falling object	2	4
313	Contact with overhead power lines	2	4
522	Explosion of pressure vessel or piping	1	2
031	Caught in running equipment or machinery	1	2
381	Drowing, submersion	1	2
3411	Inhalation in enclosed, restricted or confined space	1	2
9999	Not classifiable	1	1

In the case of excavation or trenching cave-ins, 9 fatalities (53%) were reported in trenches between 5-10 ft (1.5-3m) deep and 8 fatalities (47%) in trenches deeper than 10 feet (3 m). Only one report indicated that the trench had adequate protection (trench box).

Time of occurrence

The time of occurrence of the fatalities was provided for 30 cases. More fatalities occurred during the afternoon and early evening hours (as shown in Figure 1).

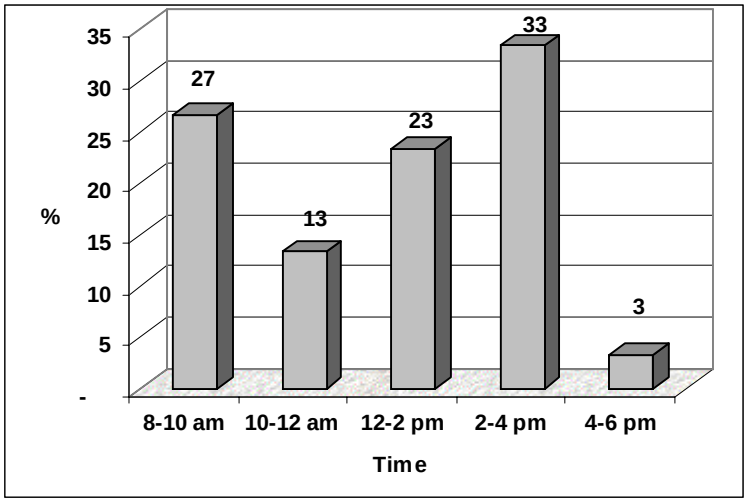

Figure 1. Fatalities according to Hour of Occurrence

Most of the accidents occurred between 12 pm and 4 pm. According to Hinze and Bren (1997), it is possible that during the lunch break, the apparent cohesion of the trench walls has begun to relax. If the trenching work does not commence for another hour, the trench walls would be even more unstable. Also, it is important to consider that after 3:00 pm, the workers are often preparing to leave the site (at the end of the work day) and sometimes the safety procedures are overlooked or not strongly adhered to.

Type of operation

Sewer system installations comprised a large proportion (37%) of cases in which trenching related fatalities occurred. This is followed by construction of water supply lines (17%) and electric installations (15%).

Month of the year

Forty two percent (42%) of the fatalities occurred during the June-August time frame, when trenching operations are underway (as shown in Figure 2). The presence of high water table during the month of October, and the pressure to complete projects before the onset of winter, may explain the high incidence of fatalities during the month of October.

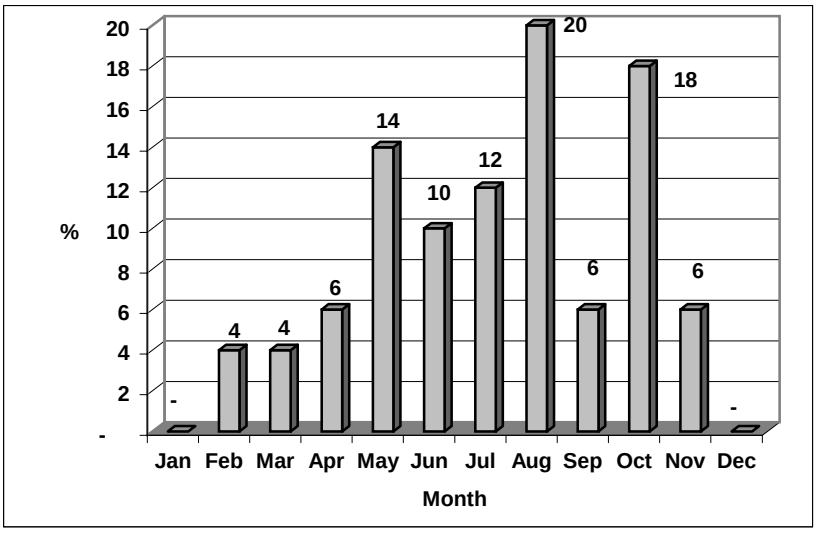

Figure 2. Fatalities according to Month of Occurrence

Age of workers

Data regarding the age of victims involved in trench related fatalities were available for 44 out of 52 reports studied, and in shown in Figure 3. The average age at death was 37.2 years.

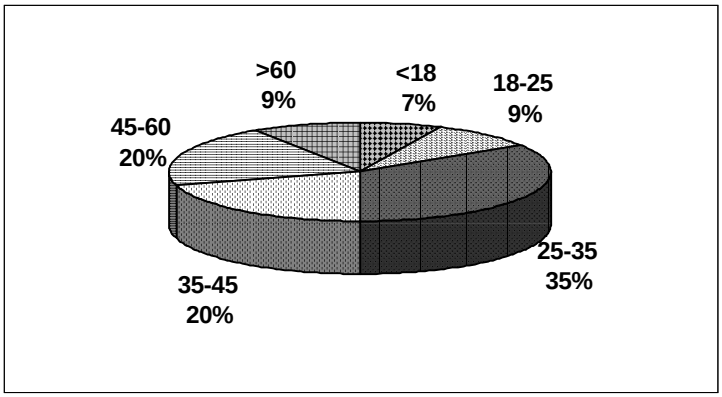

Figure 3: Age Distribution of Victims of Trenching Fatalities

Occupation of workers

The occupation of workers described in the reports is shown in Table 3. Sixty one percent (61%) of the fatalities involved laborers and construction workers. Only one fatality (out of 52 cases) involved a female worker.

Table 3: Occupation of Victims of Trenching Fatalities

Occupation	Percentage (%)	Occupation	Percentage (%)
Laborer	44	Pipe Layer	4
Construction worker	17	Line Man	4
Foreman	12	Subcontractor	2
Equipment operator	6	Other	11

Classification of companies involved in the operation Table 4 shows the distribution of companies based on the Standard Industrial Classification-SIC.

Table 4: SIC Classification (OSHA, 2001) of companies involved in trenching related fatalities

SIC Code	Code Description	Percentage (%)
1623	Heavy construction (Water, sewer, pipeline, communications and power line)	40
1794	Excavation work	13
1611	Highway and street construction	6
4911	Electric services	6
4923	Natural gas transmission and distribution	4
Others	Additional categories with one report	21
N.A	Not available data	10

Safety program
Fifty percent (50%) of the cases reported that official safety program was in place at the time of the accident. Thirty eight percent (38%) of the cases reported that a site inspection was performed on the job. However, the reports did not indicate if the site inspections were performed prior to the commencement of the trenching operation, or if they were performed at the beginning of the work day. This is an important feature to consider because, the site conditions can change during the day, and these changes can impact the nature of the trenching operation. Fifty percent (50%) of the cases reported that training in construction work was provided to the workers. Thirty three percent of the cases reported no specific training was provided by the company other than generic weekly safety meetings, and in 17% of the cases, no information was available regarding training.

2.2 OSHA Recommendations

Each FACE report concludes with the recommendations to prevent future occurrences. Table 5 shows the most frequently cited recommendations, and a brief description of the top five recommendations follows.

Table 5: OSHA Recommendations

#	Description	Percentage (%)
1	Shoring – Shielding – Sloping	16
2	Competent person	13
3	Equipment improvement	13
4	Safety program	13
5	Job safety analysis	13
6	Equipment location	8
7	Worker age	3
8	Safety training	3
9	Safety meeting	2
10	Miscellaneous	16

The first recommendation is based on OSHA standard 29 CFR (Code of Federal Regulations) 1926.652-a (OSHA 2002). The recommendation says that employers should ensure that employees working in trenches are protected from cave-ins by an adequate protection system. These systems may include either sloping techniques or support systems such as shoring or trench boxes. Sloping involves positioning the soil away from an excavation trench at an angle that would prevent the soil from caving into the trench.

The second recommendation is based on 29 CFR 1926.651-k. This recommendation says that employers should ensure that excavations are inspected by a competent person prior to start of work and as needed throughout a shift to look for evidence of any situation that could result in possible cave-in. The OSHA stantards requires that the daily inspections of excavations, the adjacent areas, and protective systems be conducted by a competent person for evidence of a situation that could result in cave-ins, failure of protective systems, hazardous atmospheres, or other hazardous conditions. A competent person is one who is capable of identifying existing and predictable hazards in

the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has the authorization to take prompt corrective measures to eliminate them.

The third recommendation is related to equipment. In general, the recommendations are related to new signals and devices to improve the performance of the equipment and the safety during operation.

The fourth recommendation is based on 29 CFR 1926.21-b. This recommendations says that the employers should design, develop and implement a comprenhensive safety program. A comprehensive safety program should address all aspects of safety related to specific tasks that employees are required to perform. Employers should ensure that all employees are trained to recognize and avoid hazardous work conditions.

Finally, the fifth recommendation is based on 29 CFR 1926.21-b. This recommendation instruct employees on how to recognize and avoid hazardous conditions on the construction site. This recommendation is related to the availability and use of an official safety program and the presence of a competent person on the construction site.

3. SUMMARY

This paper discussed the characteristics of trenching related accidents based on an analysis of NIOSH FACE reports during the period 1985-2000. 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. Preplanning plays a pivotal role in reducing and preventing trenching accidents. Preplanning should involve thorough investigation of the soil condition to enable the selection of appropriate protective systems, and the identification of existing utility lines. Operation-specific training should be provided to workers before the commencement of trenching operations. OSHA requires the presence of a competent person to evaluate the nature of the trenching operation and to ensure that all aspects of the operation (including equipment, protective devices, and personnel protection and procedures) are in compliance with OSHA safety standards.

4. ACKNOWLEDGEMENTS

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