

**THE  
CENTER  
TO  
PROTECT  
WORKERS'  
RIGHTS**

**CPWR**

# **Strategies to Prevent Trenching-Related Injuries and Deaths**

**Barbara A. Plog, MPH, CIH, CSP**  
University of California at Berkeley

**Barbara Materna, PhD, CIH**  
California Department of Health Services

**Jim Vannoy, MPH**  
Public Health Institute

**Marion Gillen, PhD, MPH, RN**  
University of California at San Francisco

**March 2006**

---

The Center to Protect Workers' Rights  
Suite 1000 • 8484 Georgia Ave. • Silver Spring, MD 20910  
301-578-8500 • Fax: 301-578-8572 • [www.cpwr.com](http://www.cpwr.com) • [www.elcosh.org](http://www.elcosh.org)

© 2006, The Center to Protect Workers' Rights. All rights reserved. This research was made possible by the Center to Protect Workers' Rights (CPWR) as part of a cooperative agreement with the National Institute for Occupational Safety and Health, NIOSH (NIOSH grant CCU317202). The research is solely the responsibility of the authors and does not necessarily represent the official views of NIOSH. CPWR – a research, training, and service arm of the Building and Construction Trades Department, AFL-CIO – is uniquely situated to serve workers, contractors, and the scientific community. A major CPWR activity is to improve safety and health in the U.S. construction industry: CPWR, Suite 1000, 8484 Georgia Ave., Silver Spring, MD 20910, 301-578-8500, [www.cpwr.com](http://www.cpwr.com).

## Acknowledgements

The authors wish to thank all of the people who graciously contributed their time and expertise to assist us in this project, including: the key informants from industry, labor, academia, and government agencies; the safety directors, competent persons, and workers who met with us during jobsite visits; Robert Hayes from Cal/OSHA who provided us with data on trenching-related injury and fatality investigations; and Sue Dong, Data Center Director, CPWR, for providing additional national data. We also thank CPWR for funding this project as a CPWR Small Study; and the National Institute for Occupational Safety and Health for supplemental funding under Cooperative Agreement Award Number 5-U01-OH007307-04.

## Abbreviations

BLS	U.S. Bureau of Labor Statistics
Cal/OSHA	California State OSHA program
CFOI	Census of Fatal Occupational Injuries, BLS
IMIS	Integrated Management Information System, OSHA
NIOSH	National Institute for Occupational Safety and Health
OSHA	U.S. Occupational Safety and Health Administration

## How to Reach the Authors

Barbara A. Plog, MPH, CIH, CSP; Center for Occupational and Environmental Health, University of California at Berkeley School of Public Health, 2223 Fulton Street, 2<sup>nd</sup> floor, Berkeley, CA 94720; [baplog@berkeley.edu](mailto:baplog@berkeley.edu); 510-643-7203

Barbara Materna, PhD, CIH; Occupational Health Branch, California Department of Health Services, 850 Marina Bay Parkway, Building P, Richmond, CA 94804; [bmaterna@dhs.ca.gov](mailto:bmaterna@dhs.ca.gov); 510-620-5730

Jim Vannoy, MPH; formerly with the Public Health Institute/Occupational Health Branch, California Department of Health Services; [javannoy@mindspring.com](mailto:javannoy@mindspring.com)

Marion Gillen, PhD, MPH, RN; Occupational and Environmental Health Nursing Program, University of California at San Francisco, Box 0608, 2 Koret Way, San Francisco, CA 94143-0608; [marion.gillen@nursing.ucsf.edu](mailto:marion.gillen@nursing.ucsf.edu); 415-476-1382

## Contents

Methods, *Page 1*

Literature Review, 2

Review of Data on Trenching-Related Injuries and Deaths in Construction, 3

Trenching-Safety Stakeholders in California, 5

Stakeholder Interviews, 6

    Barriers to safe trench work, 6

    Suggestions for improving trench safety, 9

Jobsite Visits, 10

Review of Media Coverage of Trenching Incidents, 11

Discussion and Conclusions, 11

Recommendations, 12

References, 14

Box: Near-Misses and Cave-Ins Described by Interview Participants, 7

Tables

1. Summary of selected reports on trenching-related safety in construction, 2

2. Trenching-related deaths from injuries in construction, United States, 1992-2002 and 2003, 3

3. Construction industry sectors that include trench work: number of establishments and employees, United States, 2002, 4

4. Worker occupation, trenching- and excavation-related injuries, fatal and nonfatal, inspected by Cal/OSHA, January 1993 - June 2004, 4

5. Nature of trenching- and excavation-related injuries, fatal and nonfatal, inspected by Cal/OSHA, January 1993 - June 2004, 5

6. Leading events causing trenching- and excavation-related injuries, fatal and nonfatal, inspected by Cal/OSHA, January 1993 - June 2004, 5

Annex

A. Review of Training Programs and Materials, 16



Trenching-related injuries continue to plague the construction industry, despite the availability of well-known and effective control methods, such as sloping and benching, shoring, and trench boxes and shields. Although trench collapses are not the most common cause of construction deaths, collapses are likely to result in death or serious injury within minutes. Other workers are often at risk trying to conduct rescues.

U.S. Bureau of Labor Statistics (BLS) data show that, in 2003, construction workers were 7% of the U.S. workforce, but suffered 21% of the nation's 5,575 reported work-related deaths. That same year, nonfatal rates of injury and illness involving days away from construction work were 259.4 per 10,000 full-time equivalents (FTEs),<sup>1</sup> higher than for agriculture, mining, and manufacturing. More than 30 construction workers are killed each year nationwide in trenching- or excavation-related incidents, and many more suffer injuries and near-misses (BLS data). There is clearly a need to better understand why these injuries continue to occur and to take further action to prevent them.

The goal of this project was to use data, interviews, site visits, and observation to develop strategies to prevent trenching-related injuries and deaths. The project focused on safety interventions for trenching workers in California, where the authors are based, but the strategies should be applicable throughout the United States construction industry.

## Methods

The authors conducted the following activities:

- Reviewed the scientific literature (mainly from 1997-2004) on trenching and excavation hazards in construction, the causes of trenching-related injuries, and recommendations for interventions.
- Reviewed available data on trenching-related injuries and investigations of injury incidents nationwide and in California.
- Analyzed detailed data from 162 investigations of serious or fatal trenching-related injuries, conducted by California's Division of Occupational Safety and Health (Cal/OSHA) from January 1993 through June 2004.
- Identified stakeholders in the California trenching/excavation industry who could play a key role in future injury prevention efforts.
- Interviewed 34 people associated with excavation work and trenching safety, including training providers; experts in universities, industry, and government; representatives from trade associations, employers, and unions; and Cal/OSHA enforcement staff.
- Visited four jobsites to observe trenching practices and to interview the designated "competent person" and excavation workers (9 interviews total). (OSHA defines "competent person" as 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 authorization to take prompt corrective measures to eliminate them.)

---

<sup>1</sup> Because many construction workers work part time at construction, safety and health statistics are defined in terms of full-time equivalents to allow comparisons with other industries. Full-time work is defined as 2,000 hours worked per year.

- Observed two competent-person training programs and reviewed course manuals.
- Reviewed trench safety educational materials, including videos and computer-based training materials.
- Reviewed media coverage of trenching/excavation-related deaths throughout the United States during the approximately one-year project period.

## Literature Review

Recent published research most often uses data from the Census of Fatal Occupational Injuries (CFOI) or OSHA’s Integrated Management Information System (IMIS), which reports incidents investigated by OSHA, to provide insights into the most common causes of deaths and serious injuries to construction workers (*see* table 1). One report used a survey of utility contractors to identify factors that might prevent injuries. Another study tried to apply a predictive tool for risk to utility trenching. Most trenching deaths are due to cave-ins; however, other serious hazards exist, such as working at heights, exposure to heavy machinery, overhead power lines and other electrical hazards, and working near gas lines and other utilities.

### 1. Summary of selected reports on trenching-related safety in construction

<i>Authors</i>	<i>Approach or data source</i>	<i>Findings/insights</i>
Hinze and Bren 1997	765 fatal and nonfatal cases, 1984-95, review of abstracts from OSHA investigation reports	Risk of collapse increases the longer a trench is open. Most incidents would have been prevented by following OSHA requirements for sloping or shoring.
Hinze and Walsh 1997	Various state construction contracts and fatal injury reports in OSHA IMIS	Mandating shoring as a separate bid item was shown to reduce trenching deaths; Texas was the first state to do so in 1987, followed by Washington state in 1988 and Illinois, Michigan, New Mexico, North Dakota, Oklahoma, Oregon, South Carolina, and Utah.
Irizarry and others 2002	50 fatal and nonfatal cases, 1996-97, IMIS	Cave-ins caused most deaths; other hazards included moving machinery/equipment, contact with electric current, falls, oxygen depletion; 19 incidents (37%) were in trenches zero to 5 feet; 98% of injuries were among non-union workers.
Lew and others 2002	Studied 52 deaths from NIOSH Fatality Assessment and Control Evaluation (FACE) investigations, 1985-2000	Half of deaths occurred during work on sewer or water systems. 98% of workers involved in these incidents were non-union. Identified need for a competent person onsite and effective worker training before work starts.
Lee and Halpin 2003	Developed predictive tool for injury risk and applied it to utility trenching	Preplanning, supervision, and worker training are critical factors.

## 1. Summary of selected reports on trenching-related safety in construction (continued)

Authors	Approach or data source	Findings/insights
Arboleda and Abraham 2004	Studied 296 summaries of OSHA fatality investigations, 1997-2001	In 94% of cave-ins, no protective systems in place. 84% of companies (248) had received at least one prior OSHA citation. Smaller contractors (less than 50 employees) and small projects (costs below \$250,000) tended to have higher death rates. Identified need for trench protective systems, proper job planning, and compliance with the OSHA standard to help prevent deaths.
Deatherage and others 2004	44 case files from OSHA inspections of fatal trench collapses, 1997-99	Failure to provide trench protection was cited by OSHA in 29 cases (66%); lack of daily inspections by competent person cited in 23 cases (52%); no training provided in 23 cases (52%); other contributing conditions were spoil pile within 2 feet of edge, 18 cases (41%), and rain/standing water, 15 cases (34%).
MMWR 2004	542 deaths from CFOI, 1992-2001 (includes construction and non-construction industry sectors); 31 deaths investigated by FACE, 1990-2000	Most deaths (76%) caused by cave-ins; most involve excavation contractors (141, 26%) or water/sewer/pipeline construction (131, 32%); most deaths occurred in small businesses (48% in companies with 10 or fewer employees, 70% with 50 or fewer employees).
Hinze 2005	2002 survey of contractor members of National Utility Contractors Association on use of trench boxes and safety practices; 151 respondents	Identified problems with trench boxes, including not using them when they are onsite, and taking other shortcuts that violate the OSHA standard and put workers at risk; a higher number of worker training sessions per year was tied to lower reported injury rates.

## Review of Data on Trenching-Related Injuries and Deaths in Construction

A summary of the U.S. Bureau of Labor Statistics data and of IMIS data for California expands on the above findings. In 1992-2002, 384 construction workers were killed by trenching-related injuries in the United States, an average of 35 per year, according to BLS (CFOI) (*see* table 2). Fifty-seven trenching-related deaths were reported in 2003 (CFOI), an increase from previous years. The numbers of reported deaths from 1999 through 2002, in succession, were 43, 42, 41, and 39.

### 2. Trenching-related deaths from injuries in construction, United States, 1992-2002 and 2003

Year(s)	Number of deaths	Event leading to injury: number, %	Main occupations affected: number, % of deaths
1992-2002	384 (35/yr.)	Cave-in, 274 (71%) Struck by falling object, 18 (5%)	Constr. laborers, 201 (52%) Plumbers/pipefitters, 33 (9%)
2003	57	Cave-in, 38 (67%)	Constr. laborers, 33 (58%) Supervisors/mgrs, 9 (16%)

Source: BLS Census of Fatal Occupational Injuries microdata provided to the Center to Protect Workers' Rights.

In most cases, a cave-in was the main event leading to the death. As might be expected, dirt, earth, channels, ditches, and trenches inflicted the injury more than half the time. A single cubic yard of dirt can weigh between 3,000 and 4,000 pounds, depending on soil type and moisture content, highlighting the importance of protecting workers from cave-ins (Deatherage and others 2004). The next-most-common source of injury was backhoes, which caused 25 (7%) and 6 (11%) deaths in 1992-2002 and 2003, respectively. More than half of the victims were construction laborers. Other occupations affected included supervisors/managers, plumbers/pipefitters/steamfitters, and operating engineers. Of the 57 deaths in 2003, 19 (33%) were Hispanic workers (CFOI).

The BLS annual Survey of Occupational Injuries and Illnesses does not provide a breakdown of information about trenching, but construction sectors that may include trench work encompass more than 27,000 establishments and 323,000 employees (*see* table 3).

**3. Construction industry sectors that include trench work: number of establishments and employees, United States, 2002**

<i>Construction industry category</i>	<i>Number of establishments</i>	<i>Number of employees</i>
Water, sewer, pipeline construction	7,708	156,061
Excavation contractors	19,666	166,969
Total	27,374	323,030

*Note:* 1997 NAICS-based industries (in 2002 Economic Census), both of which conduct work besides trenching; employees are all full- and part-time on payrolls, and not subcontractors.

*Source:* U.S. Census 2004a, 2004b, at [www.census.gov/prod/ec02](http://www.census.gov/prod/ec02)

In California, which totals 12% of the U.S. population, 162 cases in OSHA’s IMIS database for which detailed information was available showed that laborers were the most affected and the leading type of injury was fractures. (IMIS includes deaths and multiple injuries but not necessarily all cases.) Asphyxiation accounted for 10% of the injuries. The events causing the injuries most often were listed as “struck by” (39%) or “caught in or between” (34%). (*See* tables 4, 5, and 6.)

**4. Worker occupation, trenching- and excavation-related injuries, fatal and nonfatal, inspected by Cal/OSHA, January 1993 - June 2004**

<i>Occupation of injured workers</i>	<i>Number (% of total)</i>
Construction laborers	63 (39%)
Construction trades, not elsewhere classified	21 (13%)
Carpenters	10 (6%)
Supervisors, not elsewhere classified	9 (6%)
Plumbers, pipefitters, steamfitters	9 (6%)
Helpers	5 (3%)
Unknown/unreported occupation and other	45 (28%)
Total	162 (101%*)

\*Percentages do not add up to 100 because of rounding.

*Source:* IMIS reports of inspections by Cal/OSHA



**5. Nature of trenching- and excavation-related injuries, fatal and nonfatal, inspected by Cal/OSHA, January 1993 - June 2004**

<i>Nature of injury</i>	<i>Number (% of total)</i>
Fractures	59 (36%)
Bruises, contusions, and abrasions	24 (15%)
Asphyxia	16 (10%)
Electrical shock	5 (3%)
Cuts and lacerations	4 (3%)
Concussion	4 (3%)
Amputation, strains and sprains, burns, and other	50 (31%)
Total	162 (101%*)

\*Percentages do not add up to 100 because of rounding.

Source: IMIS reports of inspections by Cal/OSHA

**6. Leading events causing trenching- and excavation-related injuries, fatal and nonfatal, inspected by Cal/OSHA, January 1993 - June 2004**

<i>Type of event</i>	<i>Number (% of total)</i>
Struck by	63 (39%)
Caught in or between	55 (34%)
Fall from elevation	13 (8%)
Electrical shock	5 (3%)
Struck against	5 (3%)
Unknown, not reported, and other	21 (12%)
Total	162 (99%*)

\*Percentages do not add up to 100 because of rounding.

Source: IMIS reports of inspections by Cal/OSHA

## **Trenching-Safety Stakeholders in California**

The authors identified key stakeholders for future injury prevention activities in the California trenching/excavation industry, as follows:

- **Trade associations:** At the national level is the National Utility Contractors Association (NUCA), with three chapters in California: the Engineering and Utility Contractors Association (EUCA) in San Ramon, the Engineering Contractors Association in Downey, and the Engineering and General Contractors Association in San Diego. The Associated General Contractors (AGC) of California (which has a statewide organization and some local affiliates) is a key player, in that many general contractors either do their own trenching work or subcontract it.
- **Labor unions:** The unions involved in trenching/excavation work include the Laborers' International Union of North America, the International Union of Operating Engineers, and the American Federation of State, County, and Municipal Employees (AFSCME). The Laborers and Operating Engineers have training centers in the state and are part of the State Building and Construction Trades Council of California. The council currently has two staff members focused on safety and health issues.
- **Cal/OSHA:** Cal/OSHA's current Construction Safety and Health Inspection Program – for targeted inspection activity – focuses on excavation and trenching. Cal/OSHA requires excavation companies to obtain permits and submit notifications of jobs where

workers will enter trenches five feet or deeper; this program could help identify trenching companies for outreach activities.

- **Worksafe!:** This advocacy organization has statewide membership that includes union workers, safety and health professionals, and people with legal training.
- **Other stakeholders** include vendors of trench protection equipment, training providers and safety consultants, workers' compensation carriers, and the Contractors State License Board.

## Stakeholder Interviews

The authors interviewed 34 people from groups affiliated with the excavation industry and trenching safety, as follows:

- *Trench safety training providers* from unions, excavation companies, trench protection equipment vendors, and consultants (12)
- *Excavation industry trade association representatives* (5, in addition to trainers from this group included above)
- *Excavation industry employer representatives* from four private companies and one public utility (5, in addition to the trainers from this group)
- *Safety experts and researchers* from universities and government agencies (5, in addition to the trainers from this group)
- *Union representatives* (4, in addition to the trainers from this group)
- *Cal/OSHA enforcement staff* – two district managers (both industrial hygienists) and one safety engineer (3)

The authors conducted the interviews mostly by telephone, using interview guides developed for each of the categories listed above. Participants were asked questions about their understanding of barriers to trench safety and recommendations for improving safety, as well as questions related to their areas of expertise (such as training). To encourage openness and comply with research subject confidentiality requirements, those interviewed were told that their names would not be published. Although the authors sought a broad range of viewpoints on the excavation industry and trenching safety, the study does not claim to be an accurate statistical sampling of the field. (The interview guides can be obtained by contacting Barbara A. Plog, at [bplog@berkeley.edu](mailto:bplog@berkeley.edu); 510-643-7203.)

### Barriers to safe trench work

The participants' comments on barriers to safe trench work can be categorized as follows: attitude, lack of training, insufficient enforcement, and costs.

#### *Attitude*

Many of those interviewed cited a casual attitude toward safety, on the part of both employers and workers, as one of the main barriers to ensuring safe trench work: many workers believe a cave-in will not happen to them, simply because they have never experienced or witnessed one. Because they believe cave-ins rarely occur, they are willing to enter an unprotected trench for a short time. Also, many workers believe they can outrun a cave-in, said one safety specialist (*see box*). Several of those interviewed said management's attitude toward safety plays a key role.

## Near-Misses and Cave-Ins Described by Interview Participants

“The cave-in happened when I was 22 on a jobsite in Dallas. We were laying a large-diameter pipe in a lot of different soils that were layered. There were two of us in a 20-foot deep trench that had no protection. The top 10 feet of soil was black clay, the bottom of the trench was solid rock, and in between the two layers was a wet spring. The operators had cut almost-vertical walls with some layback. We were worried about collapse, but went ahead doing 8-foot sections of pipe at a time. When I noticed a sidewall starting to shift, I pushed my buddy about 15-16 feet up the ramp. I did not make it out. I was covered up to my neck with my arms raised above my head. I do not remember anything after that except that when they pulled me out, my jeans and boots did not come out with me. They were pulled off and left in the hole as the workers grabbed my arms and pulled me out of the cave-in. After that we made a lot more demands for safety.”

\*\*\*\*\*

“In a large excavation, we were using a huge trench box. The sides of the excavation started to cave in. The chunks of falling soil were as big as a Volkswagen bug. The trench box functioned as it was supposed to and protected the employees. I now use this as a training example.”

\*\*\*\*\*

“When I was working as a safety person, there was a worker who was removing a pipe. They had dug through a hill (18-20 feet deep) that created a 12-foot vertical wall of soil. The worker was down in the trench with no protection. At first, I thought I would go get the worker’s foreman and have the foreman see the situation and let him get the worker out of the trench. I felt that this would be an opportunity for the foreman to learn something about trench safety and that having a foreman say something to the worker would have more impact than a safety person doing it. But as I started to go get the foreman I thought, this soil is sandy and really crappy, so I went directly to the worker and told him to come out of the trench. As soon as I got him out, a huge four-foot section of soil fell in and covered the worker’s shovel and gloves. This illustrated to me that you have to take corrective action immediately. Had I gone to the foreman first, the worker would have been killed.”

\*\*\*\*\*

“I was a general contractor who got my excavation licenses and started specializing in excavation work. About 20 years ago, I was putting in a pipe at my home. It was starting to get dark and I wanted to get done so I did not take the time to put shoring into the hole. I was on my hands and knees in the bottom of the 12-foot-deep trench, gluing the pipe ends, when the trench caved in. The impact of the falling soil knocked me into a fetal position with the open end of the pipe near my face. I thought I was just buried for a few minutes. I lost consciousness. Afterwards, they told me that I was buried under six feet of dirt and that I was there for almost an hour before they rescued me. Somehow I survived the burial without a broken bone and without major injuries. It was very scary. The first thing I remember seeing once they got me out and revived me was the body bag they had out ready for me. Because of this, I became very interested in trench safety.”

\*\*\*\*\*

“My uncle was doing excavation work in South Dakota. He was working in a trench that was 10 feet deep and had no shoring or other protective system in place. It collapsed while my uncle was in it. They dug him out and took him to a hospital where he died two weeks later from the injuries.”

They noted that companies lacking a commitment to safety fail to conduct a proper job hazard analysis and are ill-prepared to address hazards when they open a trench.

### *Lack of training*

The safety experts in particular cited lack of appropriate safety training for competent persons and workers as a major barrier to trench safety. Untrained, poorly trained, or inexperienced competent persons and workers are unable to recognize hazards and therefore do not know how to work safely in a trench. Many of those interviewed, including training providers and excavation company representatives, said there was a pressing need to provide more safety training in Spanish to accommodate the Hispanic workers who make up the largest part of their workforce. Also, many construction workers move from one employer to another, making it hard for workers to receive training on a regular basis.

In addition to inadequately trained workers, the Cal/OSHA staffers referred to contractors who are inexperienced and ignorant about trenching hazards. While contractors may know that some kind of cave-in protection is required, they may lack information about the specific protection needed, where to get it, or the fact that it may be rented. The problem is particularly acute among contracting companies that employ fewer than 10 workers. Such employers fail to provide adequate safety training and have the worst safety records, according to many respondents. One researcher noted that almost all the technical issues involved in using trench protective systems have been solved, and that having no shielding caused the vast majority of deaths.

### *Insufficient enforcement*

There was general agreement among those interviewed that OSHA enforcement is not adequate to motivate all employers to follow safe trenching practices. Many of the stakeholders interviewed said that they believed the OSHA excavation standard contained all of the elements necessary to ensure protection of trenching workers, but that OSHA needs to increase enforcement of the standard proactively, for instance, through targeted inspections.

Cal/OSHA staffers agreed with this assessment, but noted that restricted budgets limit the number of safety inspections that can be performed. They said also that limited resources mean the agency cannot always afford to hire engineering experts to counter the experts representing employers who appeal safety citations. This makes it difficult for Cal/OSHA to prevail in such cases.

### *Costs*

The cost of implementing safety measures was frequently mentioned as a barrier. Many contractors believe that the costs of trench protective equipment, as well as its transportation, installation, and storage, are excessive and affect company profits. The pressure on contractors to make competitive bids means they may cut corners on safety-related expenditures. Bidding procedures often do not specifically require trench protections or take into account a company's safety record. Representatives of public sector unions noted it is particularly difficult to get proper safety equipment or comprehensive safety training when municipalities experience budget shortages.

### *Other barriers*

The following barriers to trenching safety were also mentioned:

- Overly complicated regulations
- Lack of certification or a training standard for competent-person training providers
- The workers' compensation insurance system(s), for not providing adequate financial incentives for employers to create exemplary safety programs; also for not holding employers financially responsible for unsafe conditions resulting in serious injury or death, for instance, through substantially higher premiums.

### **Suggestions for improving trench safety**

The interviewed stakeholders offered recommendations centering on improved training and outreach on trenching hazards, as well as increased regulatory actions and advances in technology. (The authors have incorporated many of these suggestions in the recommendations; *see* page 12.)

### *Training and outreach*

Those interviewed generally agreed that the best way to prevent trenching injuries is to provide adequate training in trench safety, aimed at both workers and employers. Training providers, employer representatives, and trade association representatives alike emphasized the need to train employers on the requirements of the OSHA excavation standard as well as the reasons for using the protective equipment. They said employers also need information about available trench shielding methods. A union representative stressed letting companies know that trench box rental is less expensive than they may realize.

Managers need trench safety training because they make the decisions about renting or purchasing trench protective systems, said a company representative. According to a training instructor, such training is also needed for project designers responsible for specifying what safety equipment is used onsite.

### *Other suggestions to improve training and outreach*

- Making free/low-cost training for workers, competent persons, and employers more widely available through partnerships
- Ensuring that the instructors have experience in excavation so they will have credibility with the audience
- Having a survivor of a trench collapse discuss what happened
- Using a video or other visual method to illustrate the rate of collapse
- Using case studies of trench collapses addressing "lessons learned"
- Combining classroom and field work, allowing trainees to gain hands-on experience and observe the complexities of trenching
- Developing interactive, web-based training on trench safety
- Disseminating practical checklists for trench inspection and other tools for hazard recognition
- Monitoring the work practices and performance of recently trained competent persons to ensure they are adequately prepared to assess and address hazards under a variety of conditions

- Developing and distributing a list of local training providers who offer competent-person training for trench safety
- Creating a web-based library of trenching-related photographs and videos for trainers to use
- Distributing trenching safety materials at places where contractors and others can easily find them, such as utility location services, permitting agencies, and fire departments
- Conducting public information campaigns using billboards, public service announcements, and a toll-free number for reporting unsafe conditions, to encourage workers and the public to recognize and report unsafe trenches.

### *Regulatory action*

The interview participants recommended the following regulatory actions for improving trenching safety:

- Increasing OSHA fines to demonstrate the seriousness of the violations and to motivate the industry to improve safety practices. A substantial initial fine would keep employers from becoming repeat offenders, said one respondent.
- Increasing enforcement of the OSHA multi-employer citation policy. This was suggested as a way to get general contractors more involved in day-to-day site safety management.
- Mandating that competent-person trainers be certified (for instance, by a state agency) to ensure that the training they provide is adequate
- Prosecuting willful violators of the excavation standard on criminal charges
- Making protective systems a bid item per linear foot in all public works project bids, as is done in Texas and Washington (Hinze and Walsh 1997)
- Linking revocation of contractor licenses to OSHA trenching violations.

### *Technology improvements*

Safety experts focused on technology as a means of improving trench safety. One expert said that developing lighter-weight shielding would help bring down the cost of transporting and installing it, increasing the likelihood that employers would use the shielding. Another safety specialist urged the use of trenchless technology, such as horizontal drilling, where appropriate. (A video, in Spanish and English, on horizontal drilling is at [www.elcosh.org](http://www.elcosh.org).) It was also suggested that employers use a competent engineer to design protective systems for complicated jobs.

## **Jobsite Visits**

The authors visited four jobsites to observe the use of “best practices” in trench safety and to become more familiar with trench protection equipment and techniques. The authors interviewed each jobsite’s competent person, as well as other laborers and operators (9 interviews). The participating companies were identified through the authors’ contacts. (The companies that agreed to the visits likely would believe they followed good safety practices. The sites observed were not necessarily typical of the industry, in which most construction companies employ fewer than 20 workers.)

The jobsites were operated by three companies; one ran two sites. Two companies were in the private sector, each employing more than 200 workers. The third was a public-sector utility with several thousand employees. All four sites employed union labor. The observed activities included replacing water lines and installing sewer lines and storm drains. The trenches ranged in

depth from 5 to 16 feet, and protective systems in use were aluminum hydraulic shoring, slide rail systems, and sloping. On each site, the interviewed laborers and operators (a total of 5) were able to identify the competent person. The workers appeared knowledgeable about trench safety issues, such as the requirements for protective systems, soil testing, and means of egress. All employees wore hard hats, safety glasses, work boots, and safety vests. All of the jobs appeared to be well-planned before the start of excavation work, as indicated by the fact that appropriate safety equipment (personal protective equipment, measurement devices, and trench protection equipment) was onsite for use as necessary.

## **Review of Media Coverage of Trenching Incidents**

The authors reviewed newspaper and television coverage of 18 excavation-related deaths that occurred throughout the United States during the project period (November 2003 through January 2005). Most reports were identified through the internet blog *Confined Space*, (<http://spewingforth.blogspot.com>). In most cases, the deaths resulted from suffocation or serious injury caused by trench collapses. The authors reviewed the coverage to assess its potential for raising public awareness about how these deaths may be prevented. In some cases the article clearly stated that the trench was five feet deep or greater and was unprotected, in violation of the OSHA standard. Sometimes a trench safety expert, such as an OSHA staff member, provided information on the proper use of trench protective systems, including in one case a drawing of a trench shield. Also, factors that increase the risk of cave-ins were discussed, such as waterlogged soil following a rainstorm.

## **Discussion and Conclusions**

There is broad consensus among the experts cited in this report that consistently implementing the requirements of the OSHA excavation standard (Subpart P, Excavations, of 29 CFR Part 1926.650, .651, and .652) would prevent most trenching-related deaths and serious injuries. In particular, the experts emphasized the need for having a properly trained competent person at every trenching jobsite to assess the hazards and ensure the appropriate use of trench protective systems.

According to those interviewed for the project, employers' ignorance about the true hazards of trenching work and ignorance of the applicable OSHA requirements put many trenching workers at risk. Some employers do not know where to obtain the protective equipment or may be unaware that the equipment can be rented. Lack of adequate safety training for the competent person and other workers at the trenching site also poses serious risks. The greatest risk appears to exist among smaller companies, which lack the resources to employ safety professionals and which are less likely to provide adequate safety training for their employees.

There was a widespread feeling among those interviewed that OSHA enforcement in this industry is insufficient to motivate all employers to follow safe trenching practices. Weak enforcement is attributed to a combination of factors: limited resources, reductions in final penalties, and inability to target the companies most likely to be out of compliance.

The economic pressures faced by the construction industry—a result of intense competition, low profit margins, the common practice of awarding contracts to the lowest bidder without regard to safety record or practices, and production time pressures—all serve to work against implementation of safe trenching practices.

The authors remain convinced that effective training of competent persons and workers involved in trenching/excavation operations is an essential component of a trench safety program. This area of construction safety is very challenging to teach. The OSHA excavation standard is lengthy and complex, there are difficult concepts and skills to convey, such as soil classification and testing methods, and trainees must gain proficiency in a wide range of complex protective equipment (such as shoring, trench boxes, and sloping). Also, the trenching industry increasingly includes workers with limited education who speak little English.

The authors believe that competent-person training could be improved by increasing the use of effective adult learning methods, such as more hands-on exercises with equipment, effective visual aids that promote interactive discussion, and supporting written materials that incorporate clear graphic illustrations and minimize use of text (*see annex A*).

#### *Project limitation*

The authors were unable to contact or perform worksite visits at smaller companies that are prevalent in the industry. Because of limited resources and perhaps also lack of awareness, these companies are least likely to employ trench safety protections and to have adequately trained competent persons or excavation crews. These companies are the most difficult to reach because they are often not members of trade associations and may be reluctant to talk with university or government researchers.

## **Recommendations**

The authors suggest the following strategies for preventing trenching-related injuries and deaths:

- Target excavation companies and workers, especially small or inexperienced contractors and those already cited by OSHA, for a range of safety interventions through a network of people representing enforcement, trade associations, unions, and insurers.
- In California, pilot-test a partnership with Cal/OSHA and others to increase referrals of unprotected trenches for enforcement inspections. The authors propose forming a partnership with one or more Cal/OSHA District Offices, to pursue ways to increase such referrals, primarily by enlisting the support of fire departments, which are involved in trench rescues, and municipal building departments. The project would develop a short training curriculum, including simple tools for hazard recognition and guidance on when and how to refer an unsafe situation to Cal/OSHA.
- Increase public awareness of trench safety. Examples include placing no- or low-cost advertisements in local publications, making and disseminating public service announcements, and promoting widespread and in-depth media coverage of trenching-related injuries and trench safety issues.
- Develop and/or more widely disseminate tailgate training materials in English and Spanish that will assist small trenching-business owners to train their workers to recognize trenching hazards and to never enter an unprotected trench. Materials that minimize written text in



favor of clear visuals/graphics are recommended. (*See* annex A for more information on available training materials.)

- Develop and evaluate a training module for competent persons that teaches how to conduct effective tailgate trainings for trenching crew workers. This module could be incorporated into existing competent-person training curriculums, used in refresher trainings, or delivered as a stand-alone program.
- Encourage or mandate that those who contract for trenching work in public works projects require a separate bid item (such as per linear foot) for trench protection systems.
- Promote mentoring of smaller trenching/excavation companies by safety professionals in larger companies with well-established trench safety programs or others who have extensive experience in this industry. One approach might be for a trade association to encourage its members to each “adopt” a smaller company for the purpose of sharing safety expertise.
- Use partnerships to increase dissemination of effective training programs, materials, safety checklists, and “best practices” in trench safety training. For instance, place trenching safety materials at locations visited by contractors and others, including OSHA offices and local permitting agencies.

## References

- Arboleda, C.A., and D.M. Abraham. 2004. Fatalities in trenching operations – Analysis using models of accident causation. *Journal of Construction Engineering and Management*, American Society of Civil Engineers (ASCE). 130(2):273-280.
- BLS, Bureau of Labor Statistics, U.S. Department of Labor. 2003. Washington, DC. <http://www.bls.gov/iif/home.htm>
- . 2005a. Quarterly Census of Employment and Wages, 2003. Washington, DC.
- CFOI, Census of Fatal Occupational Injuries, microdata provided by the U.S. Bureau of Labor Statistics to the Center to Protect Workers' Rights.
- Deatherage, J.H., L.K. Furches, M. Radcliffe, W.R. Schriver, and J.P. Wagner. 2004. Neglecting safety precautions may lead to trenching fatalities. *American Journal of Industrial Medicine*, 45(6):522-7.
- Hinze, J.W. 2005. The use of trench boxes for worker protection. *Journal of Construction Engineering and Management*, American Society of Civil Engineers (ASCE), 131(4):494-500.
- Hinze, J.W., and K. Bren. 1997. The causes of trenching-related fatalities. Construction Congress V: Managing Engineered Construction in Expanding Global Markets. *Proceedings of the Congress*, sponsored by the American Society of Civil Engineers (ASCE). Minneapolis, MN, October 4-8, 1997:389-98.
- Hinze, J.W., and K. Walsh. 1997. Shoring as a bid item. Construction Congress V: Managing Engineered Construction in Expanding Global Markets. *Proceedings of the Congress*, sponsored by the American Society of Civil Engineers (ASCE). Minneapolis, MN, October 4-8, 1997:226-32.
- Irizarry, J., D.M. Abraham, R.D. Wirahadikusumah, and C. Arboleda. 2002. Analysis of Safety Issues in Trenching Operations. 10th Annual Symposium on Construction Innovation and Global Competitiveness, September 9-13, 2002. Construction Safety Alliance site: <https://engineering.purdue.edu/CSA/publications/trenching03>
- Lee, S., and D.W. Halpin. 2003. Predictive tool for estimating accident risk. *Journal of Construction Engineering and Management*, American Society of Civil Engineers (ASCE). 129(4):431-36.
- Lew, J., D.M. Abraham, R.D. Wirahadikusumah, J. Irizarry, and C.A. Arboleda. 2002. Excavation and trenching safety: Existing standards and challenges. *Proceedings of Triennial Conference CIH WO99 Implementation of Safety and Health on Construction Sites*, May 7-10, 2002, Hong Kong. Construction Safety Alliance site: <https://engineering.purdue.edu/CSA/publications/trenching02>

MMWR. 2004. Occupational fatalities during trenching and excavation work – United States, 1992-2001. *Morbidity and Mortality Weekly Report*, 53(15):311-14.

SOII, Survey of Occupational Injuries and Illnesses, microdata provided by the U.S. Bureau of Labor Statistics to the Center to Protect Workers' Rights.

U.S. Census Bureau, Department of Commerce. 2004a. Site Preparation Contractors: 2002, 2002 Economic Census, Construction Industry Series, December, Table 1.

<http://www.census.gov/prod/ec02/ec0223i238910t.pdf>

—. 2004b. Water and Sewer Line and Related Structures, Construction: 2002, 2002 Economic Census, Construction Industry Series, December, Table 1.

<http://www.census.gov/prod/ec02/ec0223i237110t.pdf>

## **Annex A. Review of Training Programs and Materials**

The authors attended and reviewed two 8-hour competent-person training programs for excavation safety, which were sponsored by safety or trade organizations. The authors also reviewed five written manuals designed for training of competent persons for trenching operations and other identified training materials.

### **Competent-person training programs**

The instructors in both programs clearly had experience with the excavation industry, one as a safety director for a large general contractor and the other as a manager for an equipment rental company. Although their specific experience differed, their familiarity with the excavation industry allowed them to speak about trench safety based on personal experience and to appear knowledgeable and credible. Overall, both instructors appeared well-prepared and had a thorough knowledge of the OSHA excavation standard (Subpart P, Excavations, of 29 CFR Part 1926.650, .651, and .652). The classes were generally well organized, the material was presented clearly, and the instructors capably answered questions from the trainees. Both programs focused on the basics of the OSHA excavation standard.

Both programs relied on a traditional lecture format, and photographs were used to demonstrate hazards and controls. The only hands-on training was a demonstration of the pocket penetrometer and the torvane shear tools for analyzing the characteristics of soils.

The authors offer these recommendations for improving training:

- Increase participation of attendees.
- Present higher-quality visuals that make it easier to see what is happening and to determine the depth of trenches or the degree of slopes.
- Increase hands-on training and provide a demonstration trench and/or field component to teach soil analysis, hazard recognition, hazard control, and use of protective equipment.
- Ensure that follow-up classroom and on-the-job training is provided so that competent persons will become proficient under a wide variety of trenching conditions.

The authors acknowledge that it would be difficult to incorporate all of these training features into an 8-hour session, yet adding a half-day session might present a barrier to recruitment.

### **Written training materials**

The authors reviewed five written manuals used in trench safety training for competent persons; the manuals were provided by two trade associations, the Construction Safety Council, the OSHA Training Institute, and a private consultant. These manuals also serve as reference material for competent persons. The findings are summarized below:

- All five manuals included a copy of the OSHA excavation standard and appendices, and where applicable included the Cal/OSHA excavation standard (Title 8 California Code of Regulations Sections 1540, 1541, and 1541.1).

- *Managing Excavation Hazards Handbook* by the Construction Safety Council (1996), a 46-page handbook, is noteworthy for its readability and effective use of photographs illustrating hazards and protective systems. It also features exercises to test trainees' ability to apply the information presented.
- The graphics in the other manuals were limited mainly to photocopies of the diagrams showing protective systems that appear in the excavation standard.

The technical language contained in all five manuals is taken directly from the excavation standard and may not be easily understood by all users. The manuals should take into account the educational background and reading skills of the intended users and present the information in an appropriate non-technical format.

The manuals included some additional materials that could help competent persons perform their jobs more effectively, such as:

- A three-page "Excavation Checklist" to assist the competent person in conducting an inspection (National Utility Contractors Association's (NUCA) Competent Person Manual)
- A two-page "Soils Analysis Checklist" (NUCA Competent Person Manual)
- A one-page "Daily Trenching Log" for competent persons to document their daily inspections (NUCA Competent Person Manual)
- A four-page "Competent Person Field Guide" that reinforces the responsibilities of the competent person and provides summary technical information (provided by the Engineering and Utility Contractors Association, a NUCA regional chapter in California).

The Electronic Library of Construction Occupational Safety and Health (eLCOSH) website, [www.cdc.gov/elcosh/docs/hazard/safety\\_trenches.html](http://www.cdc.gov/elcosh/docs/hazard/safety_trenches.html), provides numerous links to articles, fatality narratives, and tailgate training materials that provide very useful information about the hazards associated with trenching/excavation work, causes of injuries, and the key points of the OSHA standard. Of particular note are two items, "Trenches and Excavation Training Guide" and "Trenches and Excavations Checklist," which provide a summary of trenching hazards in formats that can be used for tailgate trainings and competent-person inspections; both are also available in Spanish, produced by the Labor Occupational Health Program at the University of California at Berkeley. The eLCOSH website also includes a horizontal drilling video (in Spanish and English), which was not reviewed by the authors.

OSHA also has an e-tool available at:

<http://www.osha.gov/SLTC/etools/construction/trenching/mainpage.html>

### **Video, DVD/CD, and online materials**

Visual media, such as films and videos, offer many advantages for illustrating trenching hazards and controls, and may be used effectively within instructor-led training programs or in shorter, stand-alone venues for awareness-raising or refresher training. The authors provide brief reviews of visually-based training materials as follows:

- “Introduction to Trenching Hazards,” 27-minute video (Construction Safety Association of Ontario, Canada, 1991): Provides a comprehensive overview of excavation site hazards as well as the causes of cave-ins (particularly useful for introductory training). Video clips of excavation sites and graphics clearly illustrate trenching hazards and protective systems, supplementing a clear and understandable narrative. Soil types are described in a non-technical manner, using the terms “good,” “fairly good,” and “bad.” An accompanying manual contains additional detail. A disadvantage is that it presents Canadian rather than U.S. regulatory requirements.
- An untitled DVD containing material produced by the Chicago Laborers’ Training Fund, the Underground Contractors Association, and the National Utility Contractors Association (distributed by the Underground Contractors Association of Illinois 2003): Includes a 10-minute segment on trench shoring, featuring ten rules for using this method safely; includes construction site video footage and slides for a final review. The segment does not include information on how to determine proper spacing of shoring. The DVD also does not cover other types of protective systems or how to choose which system is best for any particular jobsite.
- Online trench safety training by ClickSafety (available at [www.clicksafety.com](http://www.clicksafety.com)): The online program includes four modules pertaining to trench safety, covering the OSHA excavation standard and how to apply it, as well as employers’ and employees’ responsibilities concerning the competent person. The training is self-paced and includes quizzes at the end of each section. The program uses animated graphics, photographs, and text, but not video clips. The primary disadvantage is that there is no opportunity for a trainee to ask questions or obtain clarification.
- Draft CD “Trench Protective Systems: Use and Cost Benefits,” under development by the NIOSH Research Laboratory in Spokane, Washington. The interactive CD is intended to support multiple learning styles through the use of text, pictures, interactive media, and video. The CD covers the types of trench collapse (described by a firefighter who conducts rescues), frequency and cost of trench collapse, soil types, general OSHA safety requirements, trench protective systems, practical examples, and conclusions. It uses graphics to illustrate, for instance, the types of trench collapses and presents economic arguments for using protective systems, information that could serve to motivate employers. Since different modules seem to be appropriate for different audiences (employers versus workers or competent persons), it would be helpful to provide more clarification on how to use this material. The version reviewed by the authors uses examples and regulations based on the Washington Administrative Code rather than the OSHA standard, which limits its usefulness in other locations. As of December 2005, this CD was still under development and evaluation by NIOSH staff. (Note: a website version of this product, entitled, “Trench Safety Awareness” will be posted on the NIOSH website at <http://www.cdc.gov/niosh/docs/2005-133c/> and on eLCOSH.)

In developing electronic training programs, the producers should take into account the diverse backgrounds of the intended audience, whose education, literacy level, and computer skills may vary widely. Producers should also consider the possibility that many employers, particularly small contracting companies, may not have ready access to the multimedia equipment (computers, internet, VCRs, or DVD players) required to run these training programs.

In September 2004, the OSHA Susan Harwood Grant program awarded three grants for educational materials development related to trench safety that will make available additional options for multimedia training products (when publicly available, these products can be accessed at <http://www.osha.gov/dcsp/ote/sharwood.html>):

- Construction Safety Council, Hillside, Illinois. The Council will develop a five-module interactive course for the Internet, CD, and DVD that covers Subpart P, excavation requirements, soil analysis, protective systems, and emergency response enhanced with video, graphics, and PowerPoint slides.
- Labor-Management Construction Safety Alliance, Boston, Massachusetts. The grantee will develop and evaluate a bilingual interactive DVD and computer-based training program on excavation and trenching hazards for instructor-led training. Materials will target various trades and address specific tasks that present the greatest risk of exposure.
- National Utility Contractors Association Foundation for Education and Research, Arlington, Virginia. NUCA will develop an employee orientation-level training program that will introduce hazards and employer responsibilities for protecting workers in excavation and trenching operations. A CD/DVD will include audio and video text in English and Spanish and will target workers with limited reading skills.