MIFACE Investigation Report: #12MI121

SUBJECT: Pipefitter Dies When Excavation Wall Collapses, Causing Water Tank to Rotate and Pin Him Against Excavation Wall

Summary

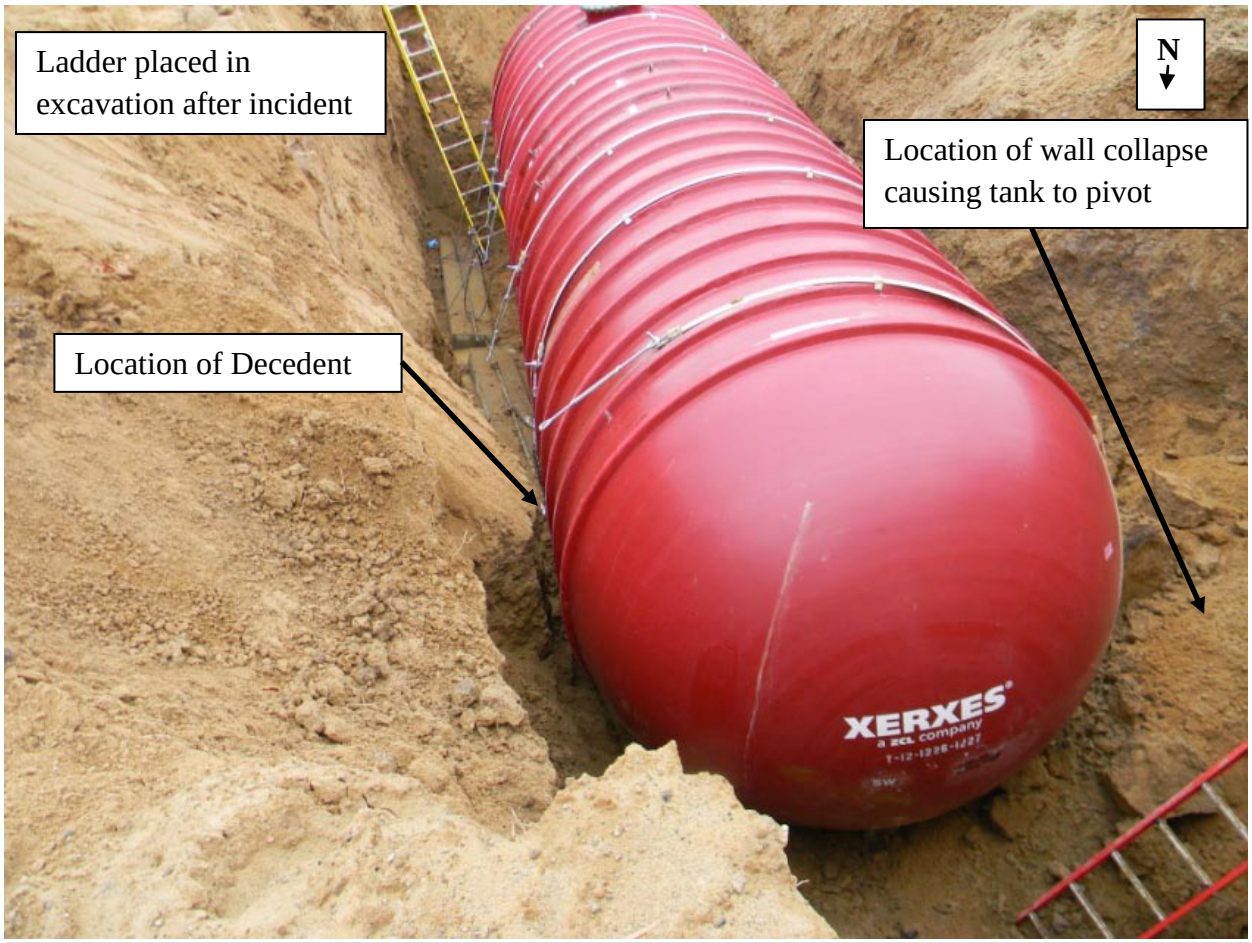


Figure 1. Position of water tank in excavation after trench wall collapse.

In fall 2012, a male sprinkler fitter/pipe fitter in his 40s died when he was struck by and pinned against the wall of an excavation by a water tank which had pivoted due to an excavation wall collapse (Figure 1). The excavation was dug by another contractor, who was the designated competent person. The soil was water saturated clay. Two feet of fill sand was atop the clay. The excavation had been partially completed the day prior to the incident and completed the day of the incident. The excavation was approximately 40 feet long by 14 feet wide by 14 feet deep. The excavation walls were nearly vertical and were not shielded or shored against collapse. It rained the night prior to the incident. On the day of the incident, the excavator operator

lowered an empty 20,000-gallon, 10-foot-wide by 37-foot-long by 8-foot-high water tank that weighed approximately 5,700 pounds onto a one-foot-deep sand base. The tank was anchored via tie down straps to concrete deadman anchors. The decedent and another coworker were on the east side of the excavation getting ready to exit when the northwest corner of the excavation collapsed into the excavation causing the tank to pivot in a clockwise direction. The decedent was pinned by the tank against the east wall of the excavation. The excavator operator moved the tank to the west, freeing the decedent. Coworkers administered CPR while emergency responders were enroute. Emergency responders entered the excavation and continued resuscitative efforts. The decedent was declared dead at the scene.

Factors:

- Excavation walls inadequately sloped/shored
- Qualified person and employee training inadequate
- Soil conditions

RECOMMENDATIONS

- Employers should ensure when employees are working in excavations that require a supporting system that a supporting system is implemented in accordance with MIOSHA standards.

- Employers should ensure that a qualified person inspects the excavation, adjacent areas, and supporting systems on an ongoing basis and that the qualified person takes the appropriate measures necessary to protect workers.

- Construction employers should design, develop, and implement an Accident Prevention Program (APP). If employees enter the trench/excavation, the AAP should include sections on Trench/Excavation Safety and Confined Space.

- Employers should provide workers with training in the recognition and avoidance of unsafe conditions and the required safe work practices that apply to their work environments.

- General Contractor jobsite superintendents, who are the controlling employer on the multi-employer worksite, should have adequate training to recognize safety hazards and initiate any necessary controls.

- Employers should ensure that a safe means of egress, such as a ladder is in excavations so that no worker has to travel more than 25 feet lateral distance.

- Employers should develop a trench emergency action plan that describes rescue and medical duties and ensure that all employees are knowledgeable of those procedures.

- The employers of law enforcement and EMS personnel should develop standard trench rescue protocol and train their employees never to enter an unprotected trench during an emergency rescue operation.

BACKGROUND

In fall 2012, a male sprinkler fitter/pipe fitter in his 40s died when he was struck by and pinned against the wall of an excavation by a water tank which had pivoted due to an excavation wall collapse. MIFACE was informed of the incident by the MIOSHA 24-hour hotline report. The MIFACE investigator interviewed the firm owner at the company headquarters. The MIOSHA investigation file, death certificate, Sheriff and Medical Examiner reports were reviewed during the writing of this report. Incident scene pictures are courtesy of the responding sheriff department.

The firm has been in business for 20+ years. The firm designs, fabricates, installs, inspects, and services automatic fire protection systems, including installation of fire protection water tanks and reservoirs. The firm owner indicated that he employed 100 individuals; of the 100 individuals, 60 individuals worked in the field. The decedent's job title was sprinkler fitter. He worked full time and had 26 years of experience, 25 of which had been at a competitive firm that had been acquired by his current employer approximately one year ago.

The employees were not represented by a union. The firm did not have a health and safety committee. The employer had a written accident prevention program (APP) dated January 1999. The APP had written safety rules and procedures in place for the specific task being performed by the decedent. The firm's accident prevention program included the following topics: Safety and Health Policy, Safety and Health Objectives, Job Site Inspections, Contractor Safety Administrator, Personal Protective Equipment, Safety Rules/Standards, Job Safety Training, Safety Discipline, Power Lockout Procedure, Written Hazard Communication Program, Confined Space Entry, and General Confined Space Entry Procedure.

Within the Job Site Inspections section, the safety plan stated "The safety administrator or other designated person will tour each job site each day and observe potential safety/health hazards including the potential hazards of confined spaces and dangerous wild animals or reptiles and develop a plan for safeguarding this organization's workers which may include the following…"

Within the Safety Rules section, the safety plan stated "Trenches over five feet deep must be shored or sloped as required. Keep out of trenches or cuts that have not been properly shored or sloped. Excavated or other material shall not be stored nearer than two feet from the edge of the excavation. Excavations less than five feet may also require cave-in protection in some instances."

Safety meetings were scheduled monthly and attendance records were maintained. The firm required all employees to watch a video regarding underground storage tank installation. The

video included instruction and training on proper sloping of excavation and various soil types. Two months before the incident, the decedent's employer conducted an excavation toolbox talk with all employees; the toolbox talk included written and verbal instruction as to proper angling of excavation sides among various soil types.

The company owner was responsible for the administration of the safety program and delegated field site safety to the foreman of each job. The decedent was the foreman at the site and thus responsible for site safety.

Firm Remediation

The firm updated their Health and Safety Program, to include soil type/shoring requirements after the incident.

The MIOSHA Construction Safety and Health Division issued the following serious citations at the conclusion of its investigation.

Serious: GENERAL RULES, PART 1, Rule 114(2)(d): Instructions were not provided to each employee in the recognition and avoidance of hazards and the regulations applicable to his or her work environment to control or eliminate any hazards or exposure to illness or injury.

Employer's Accident Prevention Program was deficient in identification and instruction on different types of soil conditions and/or the proper angle of repose for the soil conditions present at the jobsite. Employees were working in an improperly sloped excavation engaged in installing a 20,000 gallon water tank.

Serious: EXCAVATION, TRENCHING, AND SHORING, PART 9

- RULE 932(5): An ongoing inspection of an excavation or trench was not made by a qualified person.

An ongoing inspection of an excavation was not being conducted. Employees were working in the excavation, installing a 20,000 gallon water tank, when the northwest side of the excavation collapsed and one employee was crushed between the tank and the opposing side of the excavation, resulting in fatal injuries to the employee.

- RULE 941(1): The side of an excavation more than 5 feet deep was not sloped as prescribed in Table 1, unless supported as prescribed in this part.

Employees of this contractor entered and were working in an excavation that was approximately 40 feet long, 14 feet wide, and 11 feet deep, excavated by another employer. The employees were installing a 20,000 gallon water tank, when the northwest side of the excavation collapsed, pinning one employee between the tank and the opposing side of the excavation, resulting in fatal injuries to the employee. The west side of the excavation was

sloped to approximately 74 degrees, the east side was sloped to approximately 78 degrees, and the south side was sloped to approximately 73 degrees. Soil conditions were saturated, stiff clay with approximately 2 feet of sand fill at the top.

INVESTIGATION

The fire protection company hired another company (Company 1) to dig the excavation. The excavation was partially completed the day prior to the incident in the late afternoon. The same evening and early the next day (incident day), 0.77 inches of rain fell (National Climatic Data Center). The excavation was completed on the incident day. There were standing puddles of water in the excavation, which were removed when the excavation was completed to establish the sub-grade for setting the concrete deadman anchors and installing the 12" on sand cushion below the tank.

The completed 14-foot deep excavation was oriented north/south and was approximately 40 feet long by 16 feet at the top and 14 feet wide at the base. The owner of the excavation company, who was also the excavator operator, was designated as the competent, qualified person, as required by MIOSHA Construction Safety Standard, Part 9. The excavator operator informed the MIOSHA compliance officer that he had not received formal training with regard to excavation angle of repose calculations but that he had been doing the work activity for approximately 21 years and had "lots of experience in dealing with excavations". (Angle of repose is a safe angle from which the trench wall will not fail.)

The excavator operator had not taken any soil density readings in the excavation or performed any calculations with regard to the correct angle of repose. The west side of the excavation was sloped to approximately 74 degrees, the east side was sloped to approximately 78 degrees, the south side was sloped to approximately 73 degrees, and the north side, per incident scene pictures, appeared to be nearly 90 degrees. Soil conditions were saturated stiff clay with approximately two feet of sand fill at the top. The excavation walls were not protected from collapse by any approved method, such as shielding or shoring.

The crew was installing a 20,000-gallon, 10-foot-wide by 37-foot-long by 8-foot high water tank weighing approximately 5,700 pounds to provide water for fire suppression for a new building. The installation specifications for the tank called for a narrow dig to permit proper backfill. The work crew had been onsite for approximately four hours on the day of the incident.

The decedent and Coworker 1 arrived at approximately 7:45 a.m. The water tank and tank tie down straps were onsite, but the approximately 18-inch-wide by 9-inch-high by 8-foot-long precast concrete deadman anchors used to anchor and secure the tank in the excavation were not on site.

The crew unloaded the water tank and waited for the concrete anchors to arrive (Figure 2). Coworker 2 arrived at approximately 9:30 a.m. Coworker 2 called the company office to find out when the anchors would arrive; he was told they would be onsite between 10:00 a.m-10:30 a.m. The anchors should have been delivered the previous day or to have been on site no later than 8:00 a.m. on the day of the incident.

Figure 2. Concrete deadman anchors used on east and west sides of trench

While waiting for the deadman anchors to arrive, the crew went through the parts and assembled the cable tie downs. They found that they did not have enough cable clamps, so Coworker 2 went to a local hardware store to purchase more clamps.

At approximately 11:00 a.m., the deadman anchors arrived and using the excavator, the decedent and Coworker 1 and the excavator operator unloaded the truck and set the anchors in an area 40-50 feet away from the excavation. Using the excavator, the anchors were set in the excavation along the entire western and eastern edges. Coworker 1 indicated to the MIOSHA compliance officer that the sides of the excavation were crumbling and that the excavator had to remove dirt several times while placing the anchors. Approximately one foot of sand was hand shoveled and leveled by the excavator between the anchors for the water tank to rest on.

When Coworker 2 arrived back to the job site, the dead man had been positioned and the sand was in the process of being leveled. The decedent indicated to him that that the anchor connection points were not at the proper locations for the tie down straps. The crew discussed this issue and two approaches were developed to solve the issue. The first was to use three concrete deadman anchors per side (instead of four). The second approach was using steel pipe and sliding the steel pipe through the pickup points of the anchors, using the pipe as attachment points for the cable tie downs. Coworker 2 left the site and obtained piping from another worksite.

When Coworker 2 returned with the pipes, the decedent and his two coworkers entered the unprotected excavation, threaded the pipe through the anchor lift points, and installed the ¾-inch cable tie down straps to the anchors on west side. The crew threw the straps up and out of the excavation onto the west bank of the excavation. The tank was then placed into the excavation with the tank placed tight to the west wall of the excavation to allow for room for the workers to install the straps over the tank and onto the anchors on the eastern edge.

While installing the tie downs on the west side of the excavation, they realized that there was only enough cable for 2 of the 6 straps to be connected and installed on the east side of the excavation. It began to rain.

Figure 3. Concrete deadman anchor, steel rod and tie down straps on southeast end of water tank.

Coworker 2 exited the excavation via a 26-foot extension ladder located at the northwestern edge to grab another tie down strap. After obtaining the strap, standing near the ladder location, he threw it over the top of the tank and down the east side of the tank to the decedent and his coworker still in the excavation. The installation of two tie down straps on the eastern side began at the southernmost point of the tank (Figure 3). Since they were short material to complete the installation of all the tie down points on the east side of the tank, they decided to use steel chain on the 5th strap from the south end to hold the tank down so it did not float the tank out of position if a lot of rain was received (Figure 4).

Figure 4. Tie down strap with steel chain at northeast corner of excavation near location of decedent when he was struck by the tank.

The crew had completed three tie down points on the eastern side, two at the south end of the tank using cable and one at the north end of the tank using the steel chain. Due to the rain, the decedent and his coworker in the excavation decided to exit the excavation. They had just finished sending up their tools when the incident occurred. The decedent was walking north on the east side of the excavation toward the ladder at the northwest corner when the northwest corner of the excavation gave way and a portion of the northwest bank fell into the excavation, causing the water tank to move and pivot clockwise (eastward) approximately three to four feet (Figure 5). The decedent was pinned by the tank against the east wall of the excavation.

The general contractor's job superintendent was standing close by, next to the excavator when the incident took place. The operator of the excavator was on the excavator facing away from the excavation. The jobsite superintendent heard the cry for help. He instructed the excavator

operator to bring the excavator over to the excavation. The excavator operator was able to push the tank a little to the west, which allowed the decedent to fall to the ground.

Coworker 1, who was in the excavation at the time of the incident, was positioned more toward the southeast side of the excavation so when the tank pivoted in a clockwise direction, the tank moved away from him. Coworker 2, who had previously exited the excavation and the excavator operator found a ladder but it wasn't long enough to get Coworker 1 out of the excavation. A roofer's ladder was found, and placed in the southeast corner of the excavation, permitting the decedent's coworker to climb out of the excavation and the job superintendent and Coworker 2 to climb into the excavation.

Figure 5. Collapsed soil in northwest corner causing tank to pivot to the east trench wall

The jobsite superintendent and Coworker 2 began CPR inside the excavation while awaiting emergency responder arrival. First on scene were police department personnel, and the officer entered the excavation to assist while awaiting the ambulance. Another police officer arrived and entered the excavation to assist with CPR: one used an ambu-bag while the other hooked up the AED. After emergency responders' arrival, the decedent was declared dead at the scene. Fire department personnel entered the excavation, and the decedent was extracted using a backboard attached to the excavator bucket.

CAUSE OF DEATH

The cause of death as listed on the death certificate was massive trauma. Toxicological tests were negative for alcohol and illegal drugs and prescription medication.

RECOMMENDATIONS/DISCUSSION

- Employers should ensure when employees are working in excavations that require a supporting system that a supporting system is implemented in accordance with MIOSHA standards.

The MIOSHA Construction Safety Standard Part 9, Excavation, Trenching and Shoring R408.40925 defines an excavation as any man-made cavity or depression in the earth's surface, including its sides, walls or faces, formed by earth removal. Part 9, Excavation, Trenching and

Shoring R408.40926 defines a supporting system as the total system necessary to restrain the sides of an excavation from moving.

When earth is removed from the ground, the walls are left unsupported and pressures are generated at the face of the excavation. Where the soil can no longer withstand the pressure, the wall will shear and break away. One cubic foot of soil can weigh 100 pounds or more, depending on the soil's composition. Each cubic yard of soil may weigh more than one ton (2,500 pounds), producing a crushing injury to anyone caught in the wall collapse. A cubic yard of soil weighs nearly the same amount as a mid-size automobile.

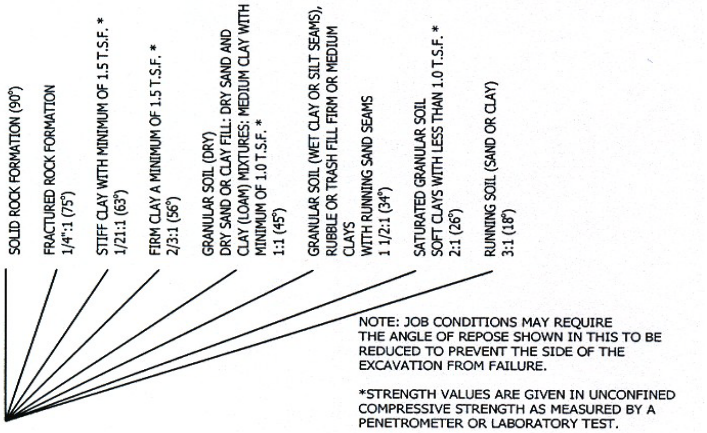
There are many factors and conditions that must be considered when determining the correct soil type. The OSHA Technical Manual, Chapter 5, Section 2- Excavations: Hazard Recognition in Trenching and Shoring provides construction employers with information about soil mechanics, how to classify soil and determine its classification, and based on the classification, select employee protection methods. Section 2 also identifies Special Health and Safety Considerations that should be evaluated for the trench/excavation. Unless the soil is evaluated and shown to be another soil classification, construction contractors should assume the soil is Type C - the worst case scenario - and slope or shore accordingly. In this case, clay with the rain is likely Type C.

To protect workers from the danger of wall collapse, the MIOSHA Excavation, Trenching and Shoring Standard requires that an excavation, five feet or more in depth (unless soil conditions mandate protection in excavations less than five feet) be protected from cave-in. Rule 942 of the Excavation standard details what must be evaluated during an excavation to protect workers inside the excavation. The angle of repose and the design of the supporting system for a side of an excavation shall be based on the evaluation of all of the following factors: (a) depth of cut and type of soil, (b) possible variation in the water content of the material while the excavation is open, (c) anticipated changes in the material due to exposure to air, sun, water, or freezing, (d) load imposed by structures, equipment, overlying material, or stored material, (e) vibration from traffic, equipment, or blasting.

The selection of preventative measures is based on this evaluation. Methods such as angle of repose, sloping and benching, tight sheeting/sheet piling, or trench boxes and shields may be used to protect personnel in the excavation. In this incident, the installation instructions required a narrow excavation to ensure proper backfill. Thus, the option of using sloping/benching (positioning the soil away from an excavation at an angle that would prevent the soil from caving into the excavation) was limited. Due to the size of the tank, the use of a trench box may have been problematic. A professionally engineers shoring system would have been the option of choice to protect the workers in the excavation.

Employers should consult Table 1 in the MIOSHA Excavation Standard that details the maximum allowable angle of repose for the side of an excavation in excess of five-foot depth that is required depending upon the type of soil and environmental conditions present at the site. Employers can consult with manufacturers of protective systems to obtain detailed guidance for the appropriate use of these products. The Appendix in Part 9 has examples of good engineering practices based on the rules of Part 9.

TABLE 1
MAXIMUM ALLOWABLE ANGLE OF REPOSE FOR THE SIDE OF AN EXCAVATION IN EXCESS OF 5' DEPTH



- Employers should ensure that a qualified person inspects the excavation, adjacent areas, and supporting systems on an ongoing basis and that the qualified person takes the appropriate measures necessary to protect workers.

Part 9, Rule 932(5) defines a qualified person as a person, who by possession of a recognized degree or certificate of professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work.

In this incident, the excavator operator was the designated qualified person. Additionally, the decedent, who was the foreman on the site, also inspected the trench. Neither of these two individuals determined that the inadequately sloped excavation should not have been entered until it was either adequately sloped or a shoring system/trench box used. If the inspection had been carried out in compliance with MIOSHA regulations, unsafe conditions should have been recognized and the workers would not have entered the excavation until necessary safety precautions had been taken.

- Construction employers should design, develop, and implement an Accident Prevention Program (APP). If employees enter a trench/excavation, the AAP should include sections on Trench/Excavation Safety and Confined Space.

MIOSHA R408.40114(2)(d) requires that the employer have an accident prevention program that provides instruction to each employee in the recognition and avoidance of hazards. A comprehensive safety program should address all aspects of safety related to specific tasks that employees are required to perform. Written plans or procedures should be developed, implemented, and enforced for work operations located in and around trenches and other

excavations. These plans should be reviewed by supervisors and employees on a regular basis and should be made available at the work site as needed. Corrective action and retraining should be provided to employees if noncompliance of written plans and procedures are observed. If any special conditions exist that might present unfamiliar hazards, additional safety procedures and training should be developed to reduce or eliminate the hazard exposure to employees.

The firm was in the process of updating its accident prevention program (APP) at the time of the incident. Although a toolbox talk covering excavations, including written and verbal instruction as to proper angling of excavation sides among various soil types, it did not, nor did the AAP provide sufficient information regarding *the identification and instruction on different types of soil conditions or proper angle of repose for the soil conditions present* at the jobsite. *(emphasis added).*

There are many trenching/excavation checklists examples available on the Internet. The federal OSHA Construction e-tool has a Guide for Daily Inspection of Trenches and Excavations to assist supervisors and workers in identifying and evaluating potential trench/excavation hazards, such as cave ins, falls, falling loads, hazardous atmospheres, and incidents involving mobile equipment. MIFACE recommends employers include a checklist as part of their Health and Safety program and make the checklist available to supervisors/employees on site to use as required by the safety and health program/Part 9.

Many workplaces contain spaces that are considered to be "confined" because their configurations hinder the activities of employees who must enter into, work in or exit from them. A confined space has the following characteristics:

- Is large enough for an employee to enter fully and perform assigned work;
- Is not designed for continuous occupancy by the employee; and
- Has a limited or restricted means of entry or exit.

By definition, a permit-required confined space has one or more of these characteristics:

- Contains or has the potential to contain a hazardous atmosphere;
- Contains a material with the potential to engulf someone who enters the space;
- Has an internal configuration that might cause an entrant to be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross section; and/or
- Contains any other recognized serious safety or health hazards.

Any trench that's deeper than four feet meets the definition of a confined space and may meet the definition of a permit-required confined space. Employees who work a confined space, such as a trench or excavation also face increased risk of exposure to serious physical injury from hazards such as entrapment, engulfment and hazardous atmospheric conditions. MIFACE recommends that construction firms include a confined space topic and training requirement in

their Accident Prevention Program to detail the requirements for safe practices and procedures when entering a trench or excavation.

- Employers should provide workers with training in the recognition and avoidance of unsafe conditions and the required safe work practices that apply to their work environments.

Employees who work in or around excavations should receive as part of their safety training the hazards associated with working in and around trenches and other excavations. Training should include the hazards of water accumulation, vibration, heavy equipment operations, underground utilities, hazardous atmospheres, soil types, and stability of surrounding structures. Other elements of excavation training should include requirements regarding means of access and egress, emergency rescue equipment, inspections, competent persons, professional engineer services, and protection of employees by sloping, benching, and support systems.

Employers should also ensure that the training in recognizing and avoiding hazards is coupled with employer assessment that workers are competent in the recognition of hazards and safe work practices.

- General Contractor jobsite superintendents, who are the controlling employer on the multi-employer worksite, should have adequate training to recognize safety hazards and initiate any necessary controls.

The MIOSHA Multi-Employer Work Site Agency Instruction (MIOSHA-COM-04-1R3) defines a controlling employer as “An employer who has general supervisory authority over the work site, including the power to correct safety and health violations itself or require others to correct them. Control can be established by contract or, in the absence of explicit contractual provisions, by the exercise of control in practice.”

Additionally, the Instruction states that “A controlling employer must exercise reasonable care to prevent and detect violations on the site.” In evaluating whether a controlling employer has exercised reasonable care in preventing and discovering violations, the MIOSHA compliance officer should consider questions such as whether the controlling employer:

- Conducted periodic inspections of appropriate frequency;
- Implemented an effective system for promptly correcting hazards and
- Enforces the other employer's compliance with safety and health requirements with an effective, graduated system of enforcement and follow-up inspections.

Although the controlling employer is not normally required to have the same level of knowledge of the applicable standards or of trade expertise as the employer it has hired, MIFACE recommends that the general contractor employees on-site have a general knowledge of the safety and health hazards that could be found on the construction site. The General Contractor’s jobsite superintendent was

standing near the non-compliant trench and did not take correct the safety and health violation or require the decedent, who was the foreman to correct the hazard of the unshielded/unshored trench.

- Employers should ensure that a safe means of egress, such as a ladder is in excavations so that no worker has to travel more than 25 feet lateral distance.

The trench was 40 feet long, with only one means of egress – a ladder – on the northwest corner of the trench. This was in violation of the Part 9, Rule 933(4) - An excavation 48 or more inches in depth and occupied by an employee shall be provided with either a ladder extending not less than 3 feet above the top as a means of access or with a ramp meeting the requirements of subrule (5) of this rule. Lateral travel along the wall of a trench to a ladder or other means of egress shall not exceed 25 feet. Employers should ensure that a safe means of egress, such as a ladder is in excavations so that no worker has to travel more than 25 feet lateral distance.

- Employers should develop a trench emergency action plan that describes rescue and medical duties and ensure that all employees are knowledgeable of those procedures.

An excavation emergency action plan did not exist for the site. The work crew's first reaction was to come to the aid of their fellow worker. Their reactions were driven by emotion and when they entered the excavation, they put their own lives in danger. Thankfully, the excavation walls did not collapse further during their rescue attempt. Many injuries and deaths to rescuers, coworkers or emergency responders are the result of forging ahead without stopping and assessing the situation.

Following formal procedures in the event of an emergency situation such as this are essential in order to avoid further injury and to ensure that the lives of those performing the rescue are not also endangered. To the extent feasible and practical, the employer should analyze jobsites for all foreseeable emergencies. A plan based on specific events should be developed. The plan should describe what actions to take regarding rescue and/or first aid.

- The employers of law enforcement and EMS personnel should develop standard trench rescue protocol and train their employees never to enter an unprotected trench during an emergency rescue operation.

The police, fire and ambulance personnel entered the unsupported excavation to provide first aid. A police officer stood atop the excavation to "watch it" in case of further collapse. Emergency responders were concerned about the condition of the walls of the excavation. Rescue personnel should never, under any circumstances, enter a hazardous environment to attempt a rescue operation unless properly equipped and trained in the use of the equipment and methods required for rescue.

Only those persons trained in the requirements of *NFPA 1670: Standard on Operations and Training for Technical Search and Rescue Incidents* should attempt rescue operations after an excavation cave-in occurs. All persons at the incident site should follow the directions given by the Incident Commander or his/her designee in order to provide the most optimal circumstances for the safety of all persons on the site during rescue operations. Rescue attempts should be discontinued when rescue personnel are placed in imminent and immediately dangerous situations until proper shoring of excavations can be accomplished.

Key Words: Construction, Trench, Excavation, Wall Collapse, Water Tank

REFERENCES

MIOSHA standards cited in this report may be found at and downloaded from the MIOSHA, Michigan Department of Licensing and Regulatory Affairs (LARA) website at: www.michigan.gov/mioshastandards. MIOSHA standards are available for a fee by writing to: Michigan Department of Licensing and Regulatory Affairs (LARA), MIOSHA Standards Section, P.O. Box 30643, Lansing, Michigan 48909-8143 or calling (517) 322-1845.

- MIOSHA Construction Safety Standard, Excavation, Trenching and Shoring, Part 9
- MIOSHA Construction Safety Standard, General Rules, Part 1.
- MIOSHA Multi-Employer Work Site Agency Instruction MIOSHA-COM-04-1R3
- NFPA [1999]. NFPA 1670, Standard on operations and training for technical rescue incidents 1999 Edition, Chapter nine, trench and excavation. Quincy, MA; National Fire Protection Association.
- MIFACE Investigation Report #04MI160: Carpenter Dies When Eight-foot Trench Wall Collapses During Sewer Pipe Replacement. http://www.oem.msu.edu/MiFace/04MI160v1.pdf
- MIFACE Investigation Report #05MI084: Worker Dies in Trench Collapse. http://www.oem.msu.edu/MiFace/05MI084v1.pdf
- NIOSH Workplace Solutions: Trenching and Excavation http://www.cdc.gov/niosh/docs/wp-solutions/2011-208/pdfs/2011-208.pdf
- NIOSH in-house FACE Report 99-02. Youth Dies In Trench Collapse-Arizona
- Web-based Trench Safety Awareness (NIOSH) http://www.cdc.gov/niosh/docs/2006-133D/
- Electronic Library of Construction Occupational Safety and Health (eLCOSH). Trenches and Excavations web page. http://www.elcosh.org/en/index.php?module=Search&and_filters[]=24
- OSHA Fact Sheet Trenching http://www.osha.gov/OshDoc/data_Hurricane_Facts/trench_excavation_fs.pdf
- MIOSHA Construction Safety and Health Fact Sheets; Excavation and shoring: Protective Systems

- MIOSHA Fact Sheet Consultation Education & Training Division Excavation Training by the Numbers
- Oklahoma Case Report 05-OK-011-01: A Plumber Was Killed When a Skid-Steer Loader Tipped Forward and Struck Him in the Head. http://www.cdc.gov/niosh/face/stateface/ok/05ok011.html

 October 28, 2013