SAFETY AND HEALTH PROGRAM

EXCAVATION SAFETY PROGRAM

1.0 PURPOSE

The purpose of this program is to prevent injuries and accidents from occurring during excavation work that Office of Physical Plant (OPP) performs. This policy will set forth the official practices required for excavations made by the OPP employees on property owned by Penn State University.

2.0 SCOPE

This program applies to any and all OPP employees who perform excavation type work, or who work around utility construction job sites.

3.0 DEFINITIONS

Shoring (shoring system) - A structure such as a metal hydraulic, mechanical, or timber shoring system that supports the sides of an excavation and is designed to prevent cave-ins.

Sloping (sloping system) - A method of protecting employees from cave-ins by excavating to form the sides of a trench that are inclined away from the excavation so as to prevent cave-ins. The angle of incline varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

Aluminum air shoring - An engineered shoring system comprised of aluminum air cylinders (crossbraces), used in conjunction with vertical rails (uprights) or horizontal rails (walers). Such a system is designed specifically to support the sidewalls of an excavation and prevent cave-ins.

Shield (shield system) - A structure that is able to withstand the forces imposed on it by a cave-in and has the ability to protect employees within the structure. Shields can be a permanent structure or can be designed to be portable and moved along as work progresses. Also known as trench box or trench shield.

Benching - A method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

Cave-in - The separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.
**Competent person** - One who is capable of identifying existing and predictable hazards in the surroundings, or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them. All competent persons must complete the 8-hour Physical Plant trenching and shoring class, successfully pass the exam, and be certified for successful completion of the class. A competent person should have and be able to demonstrate the following:

Training, experience, and knowledge of soil analysis, the use of protective systems, and the requirements of OSHA 29 CFR 1926 Subpart P. A Competent Person must also have the ability to recognize the following:

1. Conditions that could result in cave-ins,
2. Failures in protective systems,
3. Hazardous atmospheres
4. Other hazards including those associated with working in confined spaces.

**A Competent Person must have training and expertise and be able to exercise authority to take prompt corrective measures to eliminate existing and predictable hazards and to stop work when required.**

**Excavation** - Any man-made cut, cavity, trench, or depression in the earth’s surface, formed by earth removal.

**Registered professional engineer** - A person who is registered as a professional engineer.

**Trench (trench excavation)** - A narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench is not greater than 15 feet. If forms or other structures are installed or constructed in an excavation as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet or less, the excavation is also considered to be a trench.

### 4.0 Hazard Identification, Evaluation, and Control

During the course of routine maintenance activities, renovation, construction and research, OPP personnel may be required to work in or around excavations. Potential health and safety hazards that may be associated with these excavations include:

- Surface encumbrances including structures, fencing, piping, dirt, debris piles or stored material (spoil) and vegetation;
- Limited means of egress;
- Surface and subsurface utilities including water, sewer, electric, gas, cable, steam, telephone and fiber optics;
- Overhead utilities (power lines);
- Vehicle and equipment traffic in the vicinity or around the excavation;
- Falling loads from digging or lifting equipment;
- Water accumulation in the excavation;
- Hazardous atmospheres (i.e., oxygen deficiency, flammable gases, toxic fumes, etc.) which may occur in the excavation;
- Cave-in of loose soil and rock from the excavation face; and,
- Falling or driving into unprotected or unmarked excavations.
Prior to excavation activities, the site will be evaluated for potential health and safety concerns and an appropriate, site-specific plan of action will be prepared

When working under or in the vicinity of overhead power lines, a minimum distance of 10 feet shall be maintained or the lines will be de-energized. De-energizing, protecting, and/or removal of overhead power lines shall be coordinated with and completed by the OPP Utilities High Voltage crew. The qualified person shall be responsible for maintaining the required minimum distance of 10 feet throughout the course of the work.

5.0 SPECIFIC EXCAVATION REQUIREMENTS

5.1 Competent Person and Training Requirements

A competent person, as defined above, shall be at the excavation site while excavation activities are being performed. To be classified as a competent person, an individual must have attended an approved excavation safety course and received a certificate and/or card indicating successful completion of the course. For employees, who will be performing work in and around an excavation, under the supervision of the competent person, it will be required that they attend an approved excavation safety awareness course.

A competent person must demonstrate training, experience and understanding of the excavation standard, 29 CFR 1926 Subpart P, soil analysis and the use of protective systems. The competent person must have the authority to stop work and take corrective action to eliminate hazards that exist or might exist.

5.2 Staging and Surface Encumbrances

When leaving an excavation open and unattended measures shall be taken to prevent unauthorized access. When an excavation is unattended and in excess of one (1) foot in depth a barrier fence is required surrounding the excavation. When an excavation is less than a foot in depth, barricades are acceptable. Fencing is required for depressions left by the removal of trees unless the depression is backfilled at once. On farms, where field tilling projects or research activities may make fencing impractical, an equally effective means of notification or warning of an excavation shall be employed.

Any surface encumbrances, or impediments, that are located in a position that could create a hazard to employees in or around the excavation shall be removed or supported to safeguard employees. All soil and rock removed during the excavation shall be placed at least two (2) feet from the edge of the excavation.

6.0 PROCEDURES

Excavation workers are exposed to many different hazards, but the main hazard is danger of cave-ins. OPP requires that all employees working in and around trenches or excavations (greater than 5 feet deep or if the competent person determines protective systems are needed less than 5 feet deep) be protected from cave-ins by the following methods:

1. Sloping and Benching Requirements outlined in 1926.652(b)
2. Support Systems, Shields, Bracing/Shoring and Other Protective Systems as outlined in 1926.652(c)

Excavations or trenches 20 feet deep or greater must have a protective system designed by a registered professional engineer.

6.1 A competent person shall be assigned to all excavations 5 or more feet deep. Underground utilities must be located and marked before excavation begins. Employees are not permitted in the excavation while heavy equipment is working.

6.2 Inspections

The competent person shall conduct inspections:
- Daily and before the start of each shift.
- As dictated by the work being done in the trench.
- After every rain storm.
- After other events occur that could increase hazards or change conditions, such as snowstorm, windstorm, thaw, earthquake, dramatic change in weather, etc.
- When fissures, tension cracks, sloughing, undercutting, water seepage, bulging at the bottom, or other similar conditions occur.
- When there is a change in the size, location, or placement of the spoil pile.
- When there is any indication of change or movement in adjacent structures.

For excavations 5 feet or greater in depth, a trench inspection form shall be completed daily. The completed form must be forwarded to the OPP Safety Coordinator. (APPENDIX A)

6.3 SOIL CLASSIFICATIONS

Type A - Most stable: clay, silty clay, and hardpan (resists penetration). No soil is Type A if it is fissured, is subject to vibration of any type, has previously been disturbed, or has seeping water.

Type B - Medium stability: silt, sandy loam, medium clay and unstable dry rock; previously disturbed soils unless otherwise classified as Type C; soils that meet the requirements of Type A soil but are fissured or subject to vibration.

Type C - Least stable: gravel, loamy sand, soft clay, submerged soil or dense, heavy unstable rock, and soil from which water is freely seeping.

Layered geological stratifications – When soils are configured in layers) - The soil must be classified on the basis of the classification of the weakest layer. Each layer may be classified individually if a more stable layer lies below a less stable layer, i.e. where a Type C soil rests on top of stable rock.

Because most excavations on PSU property will be conducted in order to repair / replace existing pipelines or equipment (i.e. the soil has been previously disturbed), the protective systems shall be installed to meet the requirements for Type C soil. All PSU soil will be considered Type C unless tested and re-classified to class A or B. The competent person in charge of the excavation shall be responsible for any soil testing. Approval from OPP Safety Coordinator must be obtained to re-classify soil.
6.4 SPOIL and MATERIAL PLACEMENT

6.4.1 Temporary spoil shall be placed no closer than 2 feet from the surface edge of the excavation, measured from the nearest base of the spoil to the edge of the cut. This distance should not be measured from the crown of the spoil deposit. This distance requirement ensures that loose rock or soil from the temporary spoil will not fall on employees in the trench of affect the stability of the trench wall.

6.4.2 Permanent spoil should be placed in accordance with the Erosion & Sedimentation Plan for the job so that it channels rainwater and other run-off water away from the excavation. Spoil should be placed so that it cannot accidentally run, slide, or fall back into the excavation. Permanent spoil should be placed at least 2 feet from the edge of the excavation.

6.4.3 Job materials shall be placed at a safe distance not less than 2 feet from the trench so as not to create similar types of hazards. Job materials can include pipe, tools, or any other material that will be used in completion of the work.

6.5 SURFACE CROSSINGS

Surface crossings of trenches should not be made unless absolutely necessary. When necessary, they are only permitted under the following conditions:

- **Vehicle crossings** must be designed by and installed under the direction of a registered professional engineer.
- **Walkways or bridges** must:
  - have a minimum clear width of 40 inches,
  - be fitted with standard rails (32 inches high)
  - extend a minimum of 36 inches past each surface edge of the trench.

6.6 TRENCH EGRESS

- Trenches 4 feet or more in depth shall be provided with a fixed means of egress.
- Spacing between ladders or other means of egress must be such that a worker will not have to travel more than 25 feet laterally to the nearest means of egress.
- Ladders must be secured and extend a minimum of 36 inches above the landing. Metal ladders should not be used when electric utilities are present in the trench.

6.7 PROTECTION FROM VEHICULAR TRAFFIC

- Employees exposed to vehicular traffic shall be provided with and required to wear vests or other suitable garments marked with or made of reflective or high-visibility materials.
- Only personnel who have been trained in Work Zone and Traffic Control procedures shall be permitted to control traffic by use of flags, barricades and other traffic control devices.
6.8 EXCAVATION SAFETY REQUIREMENTS

- Employees are not permitted to work under loads being lifted or moved by heavy equipment.
- Employees are required to stand away from equipment that is being loaded or unloaded to avoid being struck by falling materials or spillage.
- Equipment operators or truck drivers may remain in their equipment during loading and unloading if the equipment is properly equipped with a cab shield or adequate canopy.
- Barricades must be installed where necessary.
- Hand or mechanical signals must be used as required.
- Trenches left open overnight shall be fenced and barricaded.
- Employees shall not be permitted to work in hazardous and/or toxic atmospheres. Such atmospheres include those with less than 19.5% oxygen, greater than 23.5% oxygen a combustible gas concentration greater than 10% of the lower flammable limit, or concentrations of hazardous substance that exceed those specified in the Threshold Limit Values for airborne contaminants established by the ACGIH or the OSHA Permissible Exposure Limits.
- When the excavation operation approaches the estimated location of underground utility installations, the exact location of the installation shall be determined by safe and acceptable means (such as hand digging).

When the excavation is open, underground utility installations shall be protected, supported, or removed as necessary to safeguard employees.

6.9 ATMOSPHERIC TESTING

- If there is any possibility that the trench or excavation could contain a hazardous atmosphere, atmospheric testing must be conducted prior to entry. Conditions that might warrant atmospheric testing would be if the excavation was made in a landfill area or if the excavation was crossed by, was adjacent to, or contained pipelines containing a hazardous material (for example, natural gas lines).
- Testing should be conducted before employees enter the trench and should be done regularly to ensure that the trench remains safe at all times. The frequency of testing should be increased if equipment is operating in the trench.
- Testing frequency should also be increased if welding, cutting, or burning is done in the trench.
- Employees required to wear respiratory protection must be trained, fit-tested, and enrolled in the OPP Respiratory Protection Program.
- Some trenches qualify as confined spaces. When this occurs, compliance with the OPP Confined Space Program is also required.

6.10 STANDING WATER

Methods for controlling standing water and water accumulation must be provided and should consist of the following if employees must work in the excavation:

- Use of special support or shield systems approved by a registered professional engineer.
• Water removal equipment, such as pumps, must be used and monitored by a competent person. Equipment with internal combustion engines should be located as far from the trench as possible. Recommended distance is 50 feet.
• Employees are not permitted to work in or around the trench during rainstorms if such storm compromises the integrity of the trench wall condition.
• Trenches are to be carefully inspected by a competent person after each rain and before employees are permitted to re-enter the trench.

6.11 EXCAVATIONS AROUND FOUNDATIONS

• Excavations under the base of footing of a foundation or wall requires a support system designed by a registered professional engineer.
• Sidewalks and pavement shall not be undermined unless a support system or another method of protection is provided to protect employees from their possible collapse.

6.12 BENCHING

There are two basic types of benching, single and multiple, which can be used in conjunction with sloping. In Type B soil, the vertical height of the benches must not exceed 4 feet. Benches must be below the maximum allowable slope for that soil type. In other words, a 10-foot deep trench in Type B soil must be benched back 10 feet in each direction, with the maximum of a 45-degree angle.

**Benching alone is not adequate protection in Class C soil.**

Maximum allowable slopes for excavations less than 20’ based on soil type and angle to the horizontal are as follows:

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Height/depth ratio</th>
<th>Slope angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type B</td>
<td>1:1</td>
<td>45 degrees</td>
</tr>
<tr>
<td>Type C</td>
<td>1 1/2:1</td>
<td>34 degrees</td>
</tr>
</tbody>
</table>

A 10-foot-deep trench in Type B soil would have to be sloped to a 45-degree angle, or sloped 10 feet back in both directions. Total distance across a 10-foot-deep trench would be 20 feet, plus the width of the bottom of the trench itself. In Type C soil, the trench would be sloped at a 34-degree angle, or 15 feet back in both directions for at least 30 feet across, plus the width of the bottom of the trench itself.
6.13 SLOPING

Sloping is a protective measure that cuts the walls of the excavation back at an angle from the floor to produce a stable slope. The slope angle is based on soil type. The flatter the angle of the slope, the greater the protection factor for the employee (see Figure 1).

- Type A Soil: The ratio is 3/4 ft. horizontal for every foot vertical (53° from the horizontal)
- Type B Soil: The ratio is 1 ft. horizontal for every foot vertical (45° from the horizontal)
- Type C Soil: The ratio is 1 1/2 ft. horizontal for every one foot vertical (34° from the horizontal)

Maximum allowable slopes and sloping configurations will be determined according to soil type as described in Appendix A and B of the OSHA excavation standard. See Example below.

<table>
<thead>
<tr>
<th>Slope Criteria</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>A simple slope excavation 20 feet or less in depth shall have a maximum allowable slope of 3/4:1.</td>
<td><img src="image1.png" alt="Type A Soil Simple Slope Excavation" /></td>
</tr>
<tr>
<td>A simple slope excavation 20 feet or less in depth shall have a maximum allowable slope of 1:1.</td>
<td><img src="image2.png" alt="Type B Soil Simple Slope Excavation" /></td>
</tr>
<tr>
<td>All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1 1/2:1.</td>
<td><img src="image3.png" alt="Type C Soil Simple Slope Excavation" /></td>
</tr>
</tbody>
</table>

6.14 SHORING

Shoring is used when the location or depth of the cut makes sloping back to the maximum allowable slope impractical. There are two basic types of shoring that OPP uses: Timber Shoring and Aluminum Air Shoring. Because the Physical Plant has aluminum air/hydraulic shores, they will be the focus of this section.

Air shoring provides a critical safety advantage over timber shoring because workers do not have to enter the trench to install them. They are also light enough to be installed by one worker; they are gauge-regulated to ensure even distribution of pressure along the trench line; and they can be adapted easily to various trench depths and widths. However, if timber shoring is used, it must meet the requirements of OSHA 29 CFR 1926.650, .651, and .652.
All shoring shall be installed from the top down and removed from the bottom up. Air shoring shall be checked at least once per shift for leaking hoses and/or cylinders, broken connections, cracked nipples, bent bases, and any other damaged or defective parts.

The top cylinder of air shoring shall be no more than 18 inches below the top of the excavation.

The bottom cylinder shall be no higher than four feet from the bottom of the excavation. (Two feet of trench wall may be exposed beneath the bottom of the rail or plywood sheeting, if used.)

Three vertical shores, evenly spaced, must be used to form a system.

Wales are installed no more than two feet from the top, no more than four feet from the bottom, and no more than four feet apart, vertically. Air shores must be installed in accordance with Table D – 1.2 and Table D - 1.3 in Type B soil.
### Table D-1.2
**Aluminum Hydraulic / Air Shoring**
*Vertical Shores for Soil Type B*

<table>
<thead>
<tr>
<th>DEPTH OF TRENCH (FEET)</th>
<th>MAXIMUM DEPTH OF TRENCH (FEET)</th>
<th>MAXIMUM HORIZONTAL SPACING (FEET)</th>
<th>MAXIMUM VERTICAL SPACING (FEET)</th>
<th>WIDTH OF TRENCH (FEET)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>UP TO 8</td>
<td>OVER 8</td>
<td>OVER 12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UP TO 12</td>
<td>UP TO 15</td>
<td></td>
</tr>
<tr>
<td>OVER 5</td>
<td>8</td>
<td></td>
<td>2-INCH</td>
<td></td>
</tr>
<tr>
<td>UP TO 10</td>
<td>6.5</td>
<td></td>
<td>2-INCH</td>
<td></td>
</tr>
<tr>
<td>OVER 10</td>
<td>5.5</td>
<td></td>
<td>3-INCH</td>
<td></td>
</tr>
<tr>
<td>UP TO 15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OVER 15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UP TO 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For applications other than those listed in the tables, refer to CR 1926.652(c)(2) for use of manufacturer’s tabulated data. For trench depths in excess of 20 feet, refer to CFR 1926.652(c)(2) and CFR 1926.652(c)(3).

**2-inch diameter cylinders, at this width, shall have structural steel tube (3.5 x 3.5 x 0.1875) oversleeves, or structural oversleeves of manufacturer's specification, extending the full, collapsed length.**

### Table D-1.3
**Aluminum Hydraulic / Air Shoring**
*Waler Systems for Soil Type B*

<table>
<thead>
<tr>
<th>DEPTH OF TRENCH SPACING (FEET)</th>
<th>WALE</th>
<th>HYDRAULIC CYLINDERS</th>
<th>TIMBER UPRIGHTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVER 5</td>
<td>3.5</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>UP TO 10</td>
<td>6.5</td>
<td>2.1-8</td>
<td></td>
</tr>
<tr>
<td>OVER 10</td>
<td>7</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>UP TO 15</td>
<td>9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>OVER 15</td>
<td>10</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>UP TO 20</td>
<td>12</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>OVER 20</td>
<td>14</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

*Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.*
Air shores must be installed with sheeting in accordance with Table D - 1.4 in Type C soil.

### Aluminum Hydraulic / Air Shoring

**Waler Systems for Soil Type C**

<table>
<thead>
<tr>
<th>DEPTH OF VERTICAL SPACING</th>
<th>WALES</th>
<th>HYDRAULIC CYLINDERS</th>
<th>TIMBER UPRIGHTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SECTION MODULUS (IN³)</strong></td>
<td></td>
<td>WIDTH OF TRENCH (FEET)</td>
<td>MAX. HORIZ. SPACING (ON CENTER)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UP TO 8</td>
<td>OVER 8 UP TO 12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HORIZ. SPACING</td>
<td>CYLINDER DIAMETER</td>
</tr>
<tr>
<td>OVER UP TO 4</td>
<td>3.5</td>
<td>6</td>
<td>2 IN.</td>
</tr>
<tr>
<td>OVER UP TO 4</td>
<td>7</td>
<td>6.5</td>
<td>2 IN.</td>
</tr>
<tr>
<td>OVER UP TO 4</td>
<td>14</td>
<td>10</td>
<td>3 IN.</td>
</tr>
<tr>
<td>OVER UP TO 4</td>
<td>3.5</td>
<td>4</td>
<td>2 IN.</td>
</tr>
<tr>
<td>OVER UP TO 4</td>
<td>7</td>
<td>5.5</td>
<td>3 IN.</td>
</tr>
<tr>
<td>OVER UP TO 4</td>
<td>14</td>
<td>8</td>
<td>3 IN.</td>
</tr>
<tr>
<td>OVER 20</td>
<td>3.5</td>
<td>3.5</td>
<td>2 IN.</td>
</tr>
<tr>
<td>OVER 20</td>
<td>7</td>
<td>5</td>
<td>3 IN.</td>
</tr>
<tr>
<td>OVER 20</td>
<td>14</td>
<td>6</td>
<td>3 IN.</td>
</tr>
</tbody>
</table>

For applications other than those listed in the tables, refer to CFR 1926.652(c)(2) for use of manufacturer’s tabulated data. For trench depths in excess of 20 feet, refer to CFR 1926.652(c)(2) and CFR 1926.652(c)(3).

* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

** 2-inch diameter cylinders, at this width, shall have structural steel tube (3.5 x 3.5 x 0.1875) oversleeves, or structural oversleeves of manufacturer’s specification, extending the full, collapsed length.
6.15 SHIELDING

- Trench shields or trench boxes are different from shoring because they are intended primarily to shield workers from cave-ins and similar incidents rather than support the walls from caving.
- The excavated area between the outside of the trench box and the face of the trench should be as small as possible. The space between the trench box and the excavation side must be backfilled to prevent lateral movement of the box. Shields may not be subjected to loads exceeding those which the system was designed to withstand.
- Trench boxes are generally used in open areas, but they also may be used in combination with sloping and benching.
- The trench box must extend at least 18 inches above the surrounding area if there is sloping toward the excavation. This can be accomplished by providing a benched area adjacent to the box.
- Any modifications to the shields must be approved by the manufacturer.
- Shields may ride two feet above the bottom of an excavation, provided they are calculated to support the full depth of the excavation and there is no caving under or behind the shield.
- Workers must enter and leave the shield in a protected manner, such as by a ladder or ramp.
- Workers shall not be permitted to remain in the shield while it is being moved.