Civil Engineering

This session will present participants with an overview of the civil engineering discipline as well as the opportunity to conduct a short, fun experiment that is related to civil engineering.

CATEGORY

- Engineering
- Civil Engineering

OBJECTIVES

By the end of this session participants will be able to:

- Define civil engineering.
- Understand what civil engineers do.
- Demonstrate key engineering concepts.

SUPPLIES

- Cardboard or poster board squares, approximately 8 inches by 12 inches (one per team of two)
- Newspaper
- Ice cube trays (one per team of two)
- Plaster of paris, measuring cup, a large bucket or mixing container, and stirrer
- Safety glasses and a mask
- Sandpaper
- Glue

PREPARATION

- Prepare plaster of paris cubes for the hands-on activity at least 12 hours in advance.
- Suggested website: United States Bureau of Labor Statistics Occupational Outlook Handbook, Architecture and Engineering Occupations: http://www.bls.gov/ooh/architecture-and-engineering/home.htm

ADVISOR NOTE: Text in italics should be read aloud to participants. As you engage your post in activities each week, please include comments, discussions, and feedback to the group relating to **Character, Leadership,** and **Ethics**. These are important attributes that make a difference in the success of youth in the workplace and in life.

ACTIVITIES

Introduction: What Civil Engineers Do

(The information that follows in the introduction and activities 1 and 2 is from the Bureau of Labor Statistics. Source: http://www.bls.gov/ooh/architecture-and-engineering/civil-engineers.htm.)

Tell participants: *Civil engineers design, build, supervise, operate, and maintain construction projects and systems in the public and private sector, including roads, buildings, airports, tunnels, dams, bridges, and systems for water supply and sewage treatment. Many civil engineers work in design, construction, research, and education.*

ACTIVITY 1

Duties: Civil engineers typically do the following:

- Analyze long range plans, survey reports, maps, and other data in order to plan projects.
- Consider construction costs, government regulations, potential environmental hazards, and other factors in planning the stages of, and risk analysis for, a project.
- Compile and submit permit applications to local, state, and federal agencies, verifying that projects comply with various regulations.
- Perform or oversee soil testing to determine the adequacy and strength of foundations.
- Test building materials, such as concrete, asphalt, or steel, for use in particular projects.
- Provide cost estimates for materials, equipment, or labor to determine a project's economic feasibility.
- Use design software to plan and design transportation systems, hydraulic systems, and structures in line with industry and government standards.
- Perform or oversee surveying operations in order to establish reference points, grades, and elevations to guide construction.
- Present their findings to the public on topics such as bid proposals, environmental impact statements, or descriptions of property.
- Manage the repair, maintenance, and replacement of public and private infrastructure.

Civil engineers work on complex projects, so they usually specialize in one of several areas.

- **Construction Engineers** manage construction projects, ensuring that they are scheduled and built in accordance with plans and specifications. These engineers typically are responsible for the design and safety of temporary structures used during construction.
- **Geotechnical Engineers** work to make sure that foundations are solid. They focus on how structures built by civil engineers, such as buildings and tunnels, interact with the earth (including soil and rock). In addition, they design and plan for slopes, retaining walls, and tunnels.
- **Structural Engineers** design and assess major projects, such as buildings, bridges, or dams, to ensure their strength and durability.
- **Transportation Engineers** plan, design, operate, and maintain everyday systems, such as streets and highways, but they also plan larger projects, such as airports, ship ports, mass transit systems, and harbors.

Work Environment

Civil engineers work in a variety of locations and conditions. When working on designs, civil engineers may spend most of their time indoors in offices. However, construction engineers may spend much of their time outdoors at construction sites monitoring operations or solving on-site problems. Some jobs may require frequent relocation to different areas and offices in job site trailers.

Civil engineers who function as project managers may work from cars or trucks as they move from site to site. Many civil engineers work for government agencies in government office buildings or facilities. Occasionally, civil engineers travel abroad to work on large engineering projects in other countries.

ACTIVITY 2

How to Become a Civil Engineer

Civil engineers need a bachelor's degree in civil engineering or in one of its specialties. Programs in civil engineering include coursework in math, statistics, engineering mechanics and systems, and fluid dynamics, among other courses, depending on the specialty. Courses include a mix of traditional classroom learning, work in laboratories, and fieldwork.

Important Qualities

- Decision-Making Skills: Civil engineers often balance multiple and frequently conflicting objectives, such as determining the feasibility of plans with regard to financial costs and safety concerns. Urban and regional planners often look to civil engineers for advice on these issues. Civil engineers must be able to make good decisions based on best practices, their own technical knowledge, and their own experience.
- Leadership Skills: Civil engineers take ultimate responsibility for the projects that they manage or research that they perform. Therefore, they must be able to lead planners, surveyors, construction managers, civil engineering technicians, civil engineering technologists, and others in implementing their project plan.
- Math Skills: Civil engineers use the principles of calculus, trigonometry, and other advanced topics in mathematics for analysis, design, and troubleshooting in their work.
- Organizational Skills: Only licensed civil engineers can sign the design documents for infrastructure projects. This requirement makes it imperative that civil engineers be able to monitor and evaluate the work at the jobsite as a project progresses. That way, they can ensure compliance with the design documents. Civil engineers also often manage several projects at the same time, and thus must be able to balance time needs and to effectively allocate resources.
- Problem-Solving Skills: Civil engineers work at the highest level of the planning, design, construction, and operation of multifaceted projects or research. The many variables involved require that they possess the ability to identify and evaluate complex problems. They must be able to then utilize their skill and training to develop cost-effective, safe, and efficient solutions.

- Speaking Skills: Civil engineers must present reports and plans to audiences of people with a wide range of backgrounds and technical knowledge. This requires the ability to speak clearly and to converse with people in various settings, and to translate engineering and scientific information into easy-to-understand concepts.
- Writing Skills: Civil engineers must be able to communicate with others, such as architects, landscape architects, and urban and regional planners. They also must be able to explain projects to elected officials and citizens. This means that civil engineers must be able to write reports that are clear, concise, and understandable to those with little or no technical or scientific background.

Pay

The median annual wage for civil engineers was $82,050 in May 2014. The median wage is the wage at which half the workers in an occupation earned more than that amount and half earned less. The lowest 10 percent earned less than $52,570, and the highest 10 percent earned more than $128,110. Civil engineers typically work full time, and about 1 in 4 worked more than 40 hours per week in 2014. Engineers who direct projects may need to work extra hours in order to monitor progress on projects, to ensure that designs meet requirements, and to guarantee that deadlines are met.

ACTIVITY 3
Hands-on Project: Build a Roman Arch

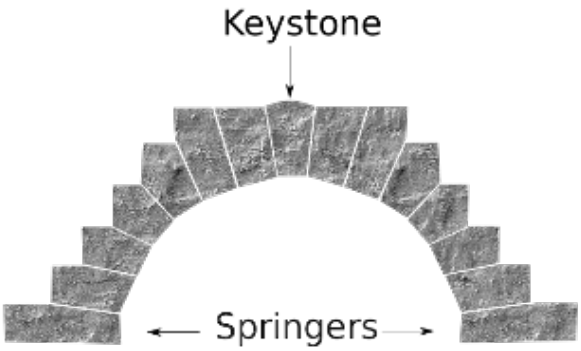
One of the most common and important features in construction is the arch. More than two thousand years ago, the Romans were the first to widely use arches to support structures above ground. Before that time, a number of cultures had used arches in building underground tunnels and vaults, where they benefited from the built-in support of the surrounding earth. The Romans introduced the concept of the keystone and began incorporating the arch in a wider range of structures. The keystone is a wedge-shaped stone placed at the highest point of the arch, also known as its apex. Use of a keystone distributes stress to the voussoirs, the other wedge-shaped stones that comprise the arch.

Glossary

Voussoir	A wedge-shaped element, typically a stone, used in building an arch.
Keystone	The wedge-shaped stone piece at the apex of a masonry arch, which is the final piece placed during construction and locks all the stones into position, allowing the arch to bear weight.
Springer	The lowermost voussoir, located where the curve of the arch springs from the vertical support of the arch or wall.

(Sources:: https://en.wikipedia.org/wiki/Keystone_(architecture); https://en.wikipedia.org/wiki/Voussoir)

In the image below, each stone is an example of a voussoir.



(Credit: Jhbdel/https://commons.wikimedia.org/wiki/File:Arch_voussoirs.svg)

Explorers are going to build their own arches using cubes of plaster of paris.

Procedures

1. As mentioned in the preparation section, prepare the plaster of paris cubes 12 hours in advance of the session. The amount of plaster of paris needed will depend on the size of the post. Each team of two Explorers will receive twelve "stones." Wearing safety glasses and a mask for protection, follow the directions on the plaster of paris packaging.

2. Carefully pour plaster of paris into the ice cube trays in order to create blocks of approximately the same size. Avoid pouring too much of the mixture into each space to keep blocks separate. When the blocks are completely dry, gently remove them from the tray and store them for the activity.

*Clean-up tip: Do not rinse plaster of paris in the sink. Allow the mixture to harden and then scrape it from the bowl into the trash.

3. At the start of the activity, have Explorers get in teams of two, and give each team the following materials: one cardboard or poster board square to serve as a base, twelve cubes to serve as voussoirs, and sandpaper to gently smooth the shapes if needed. Remind participants that each member of the team should contribute to the creation of the arch.

4. Tell Explorers they will have 10 minutes to build an arch that can stand alone without additional support. Encourage them to test different options for the number and placement of the blocks (slightly taller, slightly wider base, etc.) to see how the changes impact the strength. Explorers will find that the two blocks at the base might need to be sanded and turned to provide the best support. The arch must be

tall enough to slide a small bathroom-size cup (or similar-sized object) beneath it.

5. At the end of the 10 minutes, have Explorers share their arches and take turns placing small objects on top of the arches to test their strength. Begin with very small items, such as a coin, and increase the size and weight of the items.

NOTES: If many groups are having trouble getting structures to stand, you might choose to allow each group a small amount of glue to help hold the blocks together. This activity could also work with ice cubes, though a towel would need to be used as the base to absorb water as the structure melts.

ADVISOR NOTE

Some sample questions are below. They are designed to help the participants apply what they have learned to their own interests. You are welcome to use these questions or develop your own questions that relate to your post or specific focus area.

REFLECTION

Focusing Questions	▪ *What was the purpose of these activities? Why did we do them?* ▪ *Which parts of today's session did you most enjoy?* ▪ *What new things did you learn?*
Analysis Questions	▪ *How did you use engineering concepts and skills to build your arch?* ▪ *How did you overcome challenges while designing and building your arch?* ▪ *Why could working on a team be a benefit for engineers?*
Generalization Questions	▪ *What aspects of civil engineering would you like to learn more about?* ▪ *What subjects in school do you believe you will need mechanical engineering?*