The Civil Engineering Alphabet

By: Seth Chalmers, PE

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Dedication

To my grandsons,

Weston and Grant

Preface

I am a father and now am a grandfather to my young grandsons, Weston and Grant. It's amazing to watch them grow and learn—they are so eagerly curious. This is the reason I'm a civil engineer. I love to know how things work. I love to study and solve problems to make things better. I am eagerly curious in a childlike way, just like my grandsons.

The main reason I was inspired to write this book was to share my lifelong journey of becoming a civil engineer with them. My journey began as a young boy as I built dirt roads with my Tonka bulldozer and dump truck. Later, I got to operate a real bulldozer and dump truck doing road maintenance and "public works" projects at the Boy Scouts' Camp Geronimo. Also, engineering runs in my family—my father and grandfather were electrical engineers; my other grandfather was in the U.S. Army Corps of Engineers; my brothers became mechanical and mining engineers; and my uncles were aeronautical, chemical, and construction engineers. These experiences fed my curiosity and led me to become a civil engineer.

The inspiration for this book's format and content comes from the *ABCs of Engineering* by Chris Ferrie and Dr. Sarah Kaiser, published by Sourcebooks eXplore. I have greatly enjoyed reading this book with my grandsons. It presents engineering concepts on different levels, which not only makes the book interesting for children of different ages but is also educational for adults who might be reading the book with the child. What a brilliant way to introduce engineering topics in simple and approachable ways! Some people may be intimidated by engineering or STEM concepts because they believe they aren't smart or techy enough to get it. I am proof that you don't have to be good at math to become an engineer! What matters most is nurturing that childlike eager curiosity.

In looking at other children's books about engineering or STEM concepts, I found that they either didn't broadly cover civil engineering or hold my grandsons' attention. When we found Weston looking at the *ABCs of Engineering* on his own, it inspired me to write a book focused on the ABCs of civil engineering. I hope this book makes civil engineering available to everyone who is eagerly curious to learn and wants to make the world a better place for everyone.

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—to my grandsons, Weston and Grant, for their inspiration to engage in eager curiosity. I dedicate this book to them with my secret but non-binding ambition that they someday become civil engineers.

A is for **Applied Science**.

Applied sciences use math and science to solve problems.

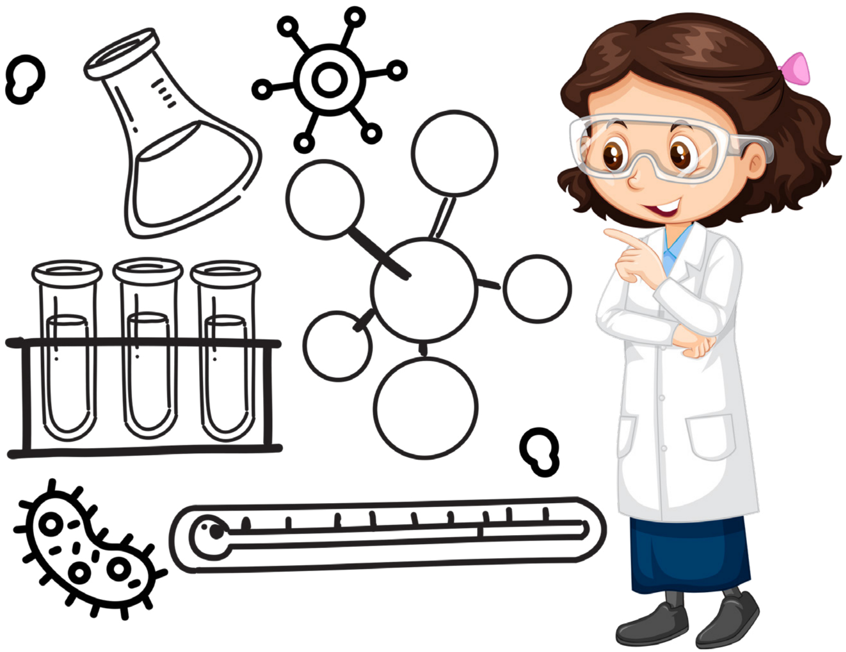
Applied sciences use math, chemistry, and physics to define and solve problems. This in turn helps make the world a better place to live. Applied sciences are also called STEM (science, technology, engineering, and mathematics). Civil engineering is an applied science. Other types of engineering include electrical, mechanical, mining, geotechnical, nuclear, chemical, industrial, materials, environmental, software, and aerospace engineering.

B is for **Biology**.

Biology is the science of living things.

Biology focuses on living organisms and how life is sustained. In civil engineering, bacteria can be used to purify water and get rid of waste. This makes the water clean enough to water the ground and be released into larger bodies of water—and even for you to drink!

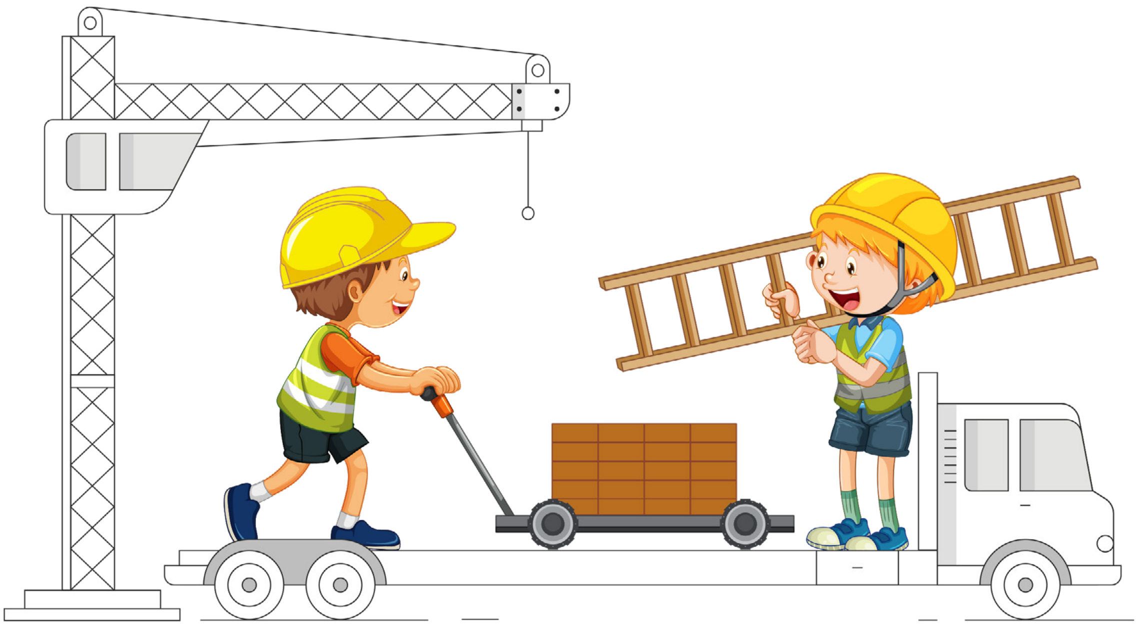
Protecting wildlife, providing landscaping, and protecting and restoring lands and waters are other aspects of biology that are involved in civil engineering. The goal is to minimize impacts to plants, animals, and ecosystems.



C is for **Construction**.

Construction is all about building projects.

Good construction builds safe projects that follow all requirements and last a long time. It is also important for projects not to take too long or cost too much money. Civil engineers who specialize in construction must know all about the project being built, like how to build a road, bridge, dam, wall, house, or park. They have to figure out how many workers and what types of equipment they need. They also have to estimate how much the project will cost, how long it will take, what materials are needed, and many other details. Construction is a very involved process.



D is for **Design**.

Design is a process used to develop a plan to achieve a goal.

Engineers design projects using known principles, methods, and standards. They design solutions that can solve problems with reliable outcomes. Designs usually go through several peer reviews by other engineers to ensure they are correct and look at the project from all perspectives.

A good design includes the work and costs to keep the project in a state of good repair so it lasts a long time, and to fix it if it is damaged or breaks. Some Roman roads are more than 2,000 years old and are still used today. Now, that's a good design!

E is for **Equity**.

Equity means making fair decisions.

Everyone deserves to have access to better infrastructure and opportunities. Engineers use STEM principles to figure out how to solve problems equitably (or fairly). In the past, however, engineering projects haven't always been done fairly. For example, sometimes nicer public projects were constructed in richer neighborhoods. Much of the Interstate Highway System and other public works projects in the 1960s and 1970s were built in poor neighborhoods to get rid of them or isolate them. Equity makes sure that projects benefit everyone, regardless of how old they are, where they live, how much money they have, what race they are, or if they have a disability.

F is for **Family**.

Civil engineering benefits families.

Civil engineering helps families live long, healthy, and happy lives in their communities. Civil engineering helps provide clean water to use, transportation so we can go places, safe buildings to live and work in, and systems to take away waste. Engineering also helps us recover from natural disasters like storms, floods, tsunamis, and wildfires, or from disasters caused by humans. Civil engineers make sure that projects are resilient to a changing world climate.

G is for **Geology**.

Geology is the science of the earth.

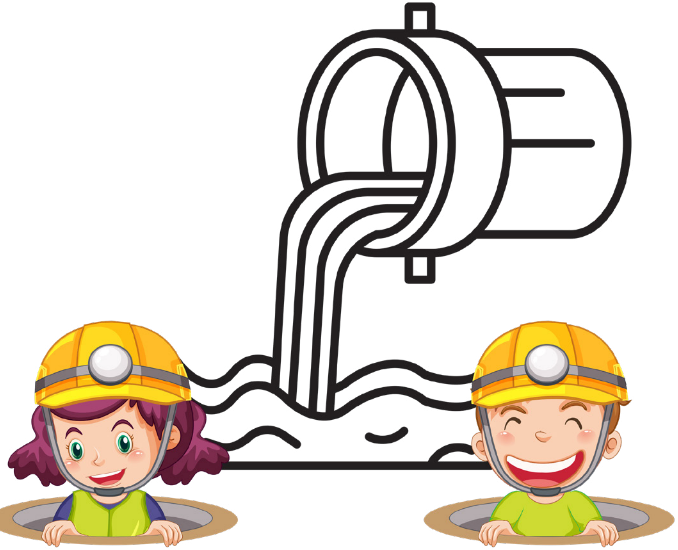
Geology is the study of the earth's materials—soil, rocks, and everything in between. Geology is important because it tells how the foundation of a building, bridge, dam, or road can withstand soil conditions.

If the soil conditions aren't considered, the building or road could sink, bend, or lean (like the Leaning Tower of Pisa in Italy)! One field of civil engineering is called geotechnical engineering. It uses applied earth sciences to solve engineering problems.

H is for **Hydrology** & **Hydraulics**.

Hydrology and hydraulics are about collecting and moving water.

Hydrology and hydraulics are the foundation of civilization because we all need water to survive. Hydrology is the study of the properties, distribution, and effects and amount of water in the atmosphere (rain, snow, and gas) on the earth's surface and underground.



Hydraulics is the study of the movement and flow of water using both gravity and pressure. Hydraulics makes sure that water goes where it needs to so it can be used for irrigation or purified so it's safe to drink. Hydraulics also makes sure that wastewater is treated so it doesn't cause disease or pollution. This includes storing water in the ground, lakes, or tanks to make sure we have enough water to use and to prevent flooding.

I is for **Infrastructure**.

Infrastructure is the “backbone” of society.

Civil engineers are responsible for planning, designing, operating, and maintaining all aspects of infrastructure. Every few years, the American Society of Civil Engineers (ASCE) does a report card on America’s infrastructure. Some of the areas include roads, bridges, airports, dams, drinking water, wastewater, stormwater, parks, railroads, and schools.

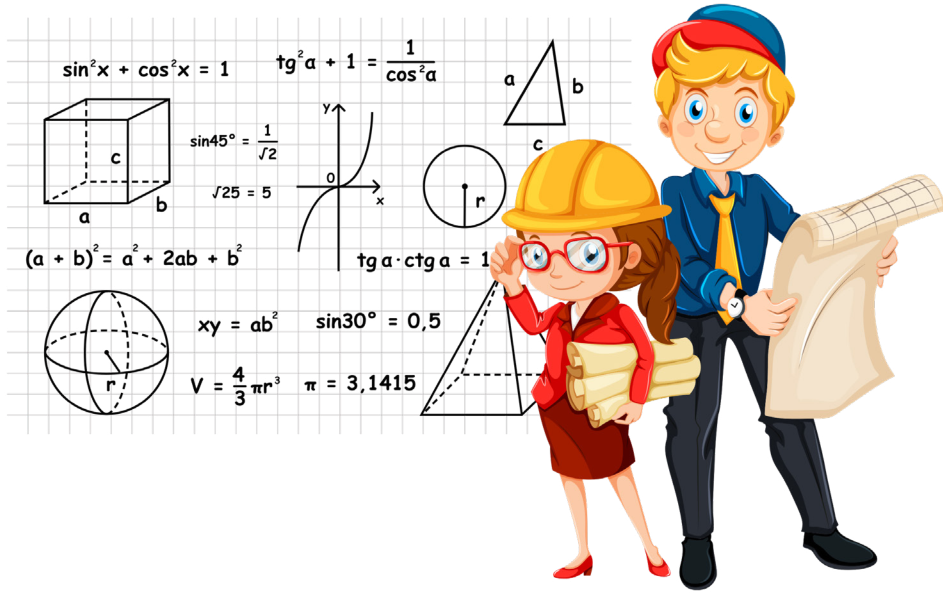
America’s grade is currently a C-. This is not a very good grade! We need more civil engineers and resources to help improve our infrastructure so we can get a better grade.

J is for **Judgment.**

Engineers need good judgment when making designs.

Engineers base their designs on calculations, data analysis, and applied scientific principles. However, sometimes math and science don't give them all the answers, so they have to use engineering judgment for designs.

Engineering judgment means using your experience, common sense, and creativity to solve problems and come to sensible conclusions. This sometimes results in innovative (or new) ways to do things. Sometimes, engineers test out their new ideas using a smaller research or pilot project or experiment before applying the new idea to a big project. This helps reduce risk.

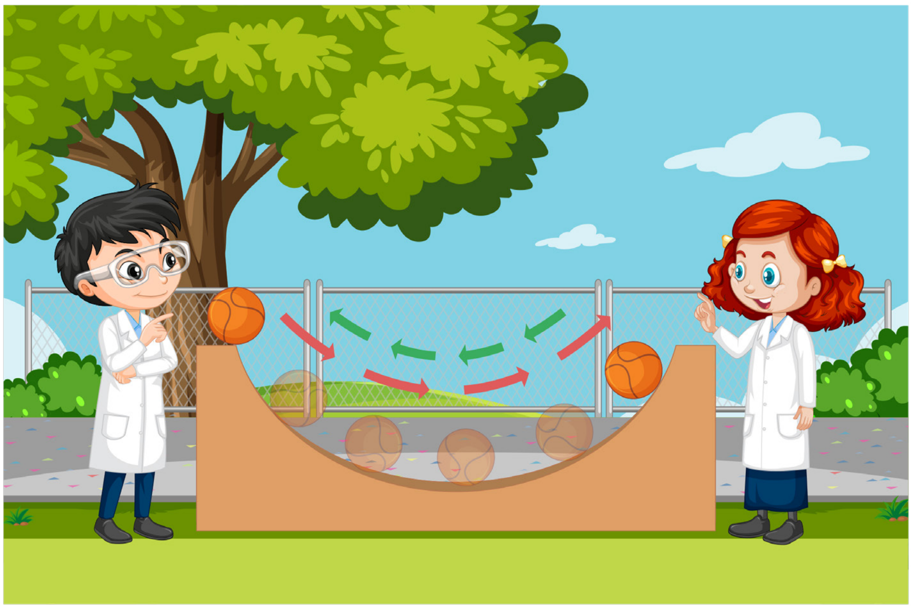


K is for **Kinetics**.

Kinetics is the study of forces and motion.

Every day, structures and materials experience loads, forces, and stresses. Kinetics is the use of physics and math to understand their properties and how much stress they can withstand. Civil engineers usually study materials in a static condition so these materials are designed to withstand all the loads and forces that are applied to them (such as wind, water flow, and earthquakes).

If these materials do move, it is within an acceptable range that they can withstand. This includes structures like bridges, buildings, pipes, light poles, power poles, and cell phone towers.



L is for **Licensing**.

Engineers need to be licensed to do work.

To become a civil engineer, the first step is to learn a lot about math, physics, and construction in college to earn a civil engineering degree. Then you take the Fundamentals of Engineering exam to become an engineer-in-training (EIT). Then you start working on projects and gaining experience.

After you take an exam to show how much you've learned, you become a licensed professional engineer (PE)! Licensed engineers are held to a high standard of responsibility for their design work and can be held accountable if they make big mistakes. Both professional engineers and engineering companies have to obtain a license with the technical board in their state.

M is for **Materials**.

It is important to use strong and durable materials for projects.

Different materials have different uses in projects. Knowing the strength of materials is extremely important in civil engineering. Steel is a very strong material that is used for tall buildings like skyscrapers, while wood is used for small buildings like houses. Concrete is a very strong mix of materials (cement, sand, water, and gravel) that is strong enough to bind walls together.

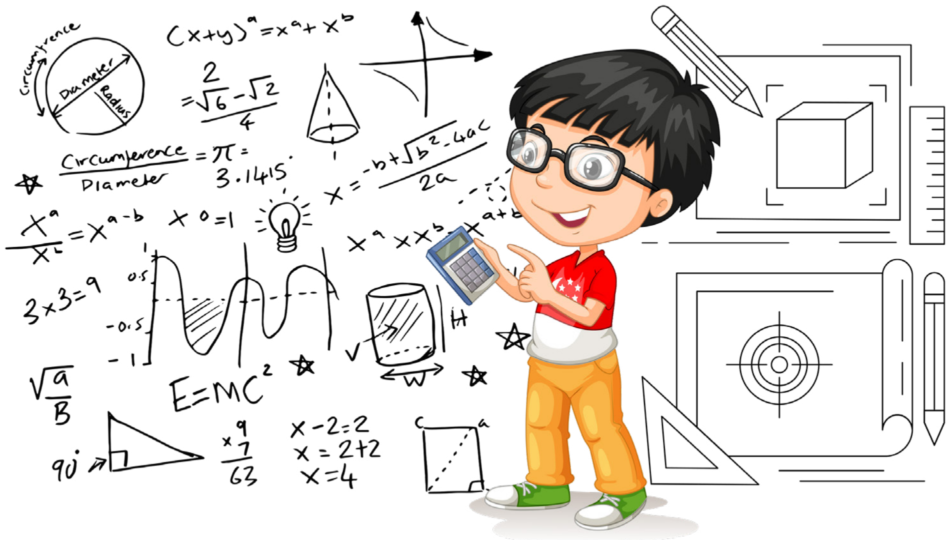
A special organization, ASTM International, was formed in 1898 to help set specifications and testing methods for materials under certain conditions. ASTM and similar organizations like the American Concrete Institute (ACI) and American Institute of Steel Construction (AISC) have played an essential role in making infrastructure better and safer in the United States.

N is for **Numerical Analysis**.

Numerical analysis is applying math to solve problems.

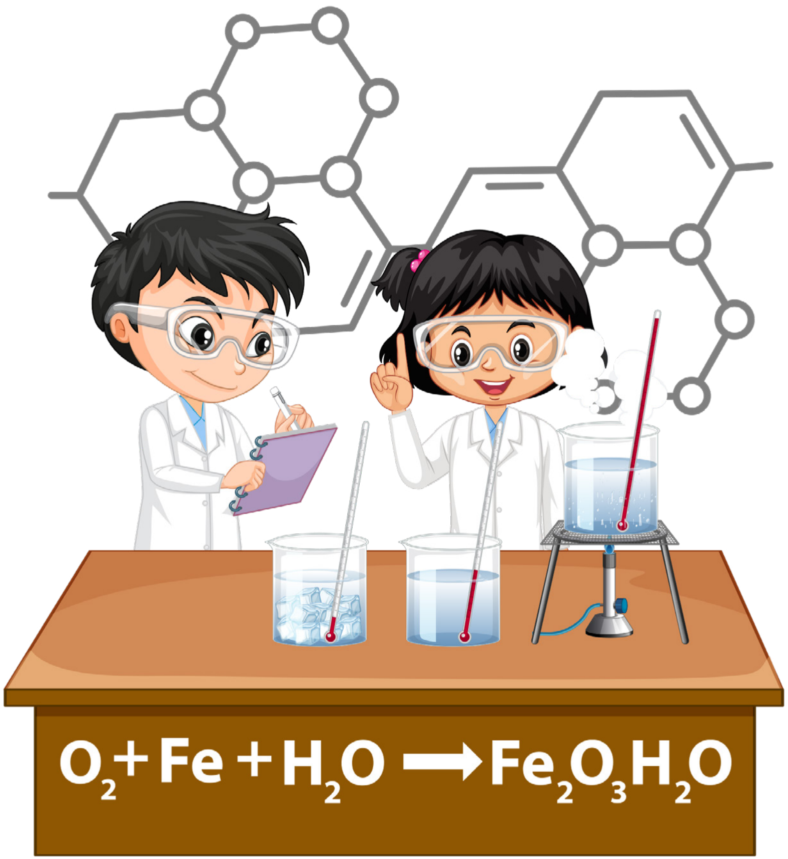
Numerical analysis became faster and more accurate when computers were invented. Computers allow software to be developed and written to provide engineering computations. Before computers, calculations could take weeks or even months to complete!

Now, engineers can quickly use Excel spreadsheets to make computations with very little error. Computer-aided design (CAD) is the primary numerical analysis tool for drawings. Engineers also use geographic information systems (GIS), which show where the project is located in the world.



O is for **Oxidation**.

Oxidation is damage caused by oxygen.



We all need oxygen to survive. The air we breathe is approximately 21% oxygen. Even though oxygen is necessary for life, it can also cause damage to materials. For example, rust forms when oxygen and water touch iron.

Concrete, wood, metals, and other materials used to construct buildings, roads, and other infrastructure also oxidize. It is important to consider oxidation when making engineering designs. Sometimes, materials that have oxidized need to be repaired or replaced.

Galvanizing is the most cost-effective way to prevent oxidation. It involves coating steel or iron with zinc to protect it from rust.

P is for **Preservation**.

Preservation is taking good care of infrastructure.

Once something is built—like roads, bridges, and buildings—it needs attention to make sure it is maintained correctly. It is much better to fix small problems before they become bigger and more expensive problems. Oftentimes, infrastructure in the United States is not taken care of until it's too late.

Lots of potholes on a road are a sign that not enough money is being invested in pavement preservation. If preservation is not prioritized for bridges and buildings, they can collapse with tragic consequences.

Q is for **Quality**.

A good engineering design must have high quality.

All engineers are focused on quality. Quality is a fundamental of engineering. It means doing a project well so that it meets requirements and is safe for people to use. It is doing projects right the first time so they don't break or stop working properly. People could get hurt or killed if a project isn't done well.

Quality assurance is the processes and procedures to make a quality product that meets requirements. Quality control is reviewing designs to ensure they are correct and fix any errors.

R is for **Research**.

Research helps us improve engineering.

Research uses math and science to develop, study, and test new concepts, ideas, and theories. In 1863, President Abraham Lincoln signed an Act of Congress forming the National Academy of Sciences (NAS). The National Academy of Engineering (NAE) and National Academy of Medicine (NAM) also conduct research in different fields.

Many universities with engineering colleges conduct research. Much research is funded by NAS, federal or state governments, and the civil engineering industry. This research looks for new ways to apply engineering principles to projects. It looks for new techniques to make engineering designs safer, better, stronger, and less expensive.

S is for **Safety**.

Safety is the #1 goal of civil engineering.

Safety is about protecting people from harm. It is critical in all engineering steps—planning, design, construction, operation, and maintenance. There are many standards, guidelines, practices, and checklists for each engineering step to make projects as safe as possible.

When you drive across a bridge or fly on an airplane, you probably don't worry about getting to your destination safely. This is because engineers have done hundreds or thousands of checks during the design and building process. If something bad does happen, engineers look back at the design and/or construction to see what went wrong so they can learn from their mistakes.

T is for **Transportation...**

Transportation is about moving people and goods.

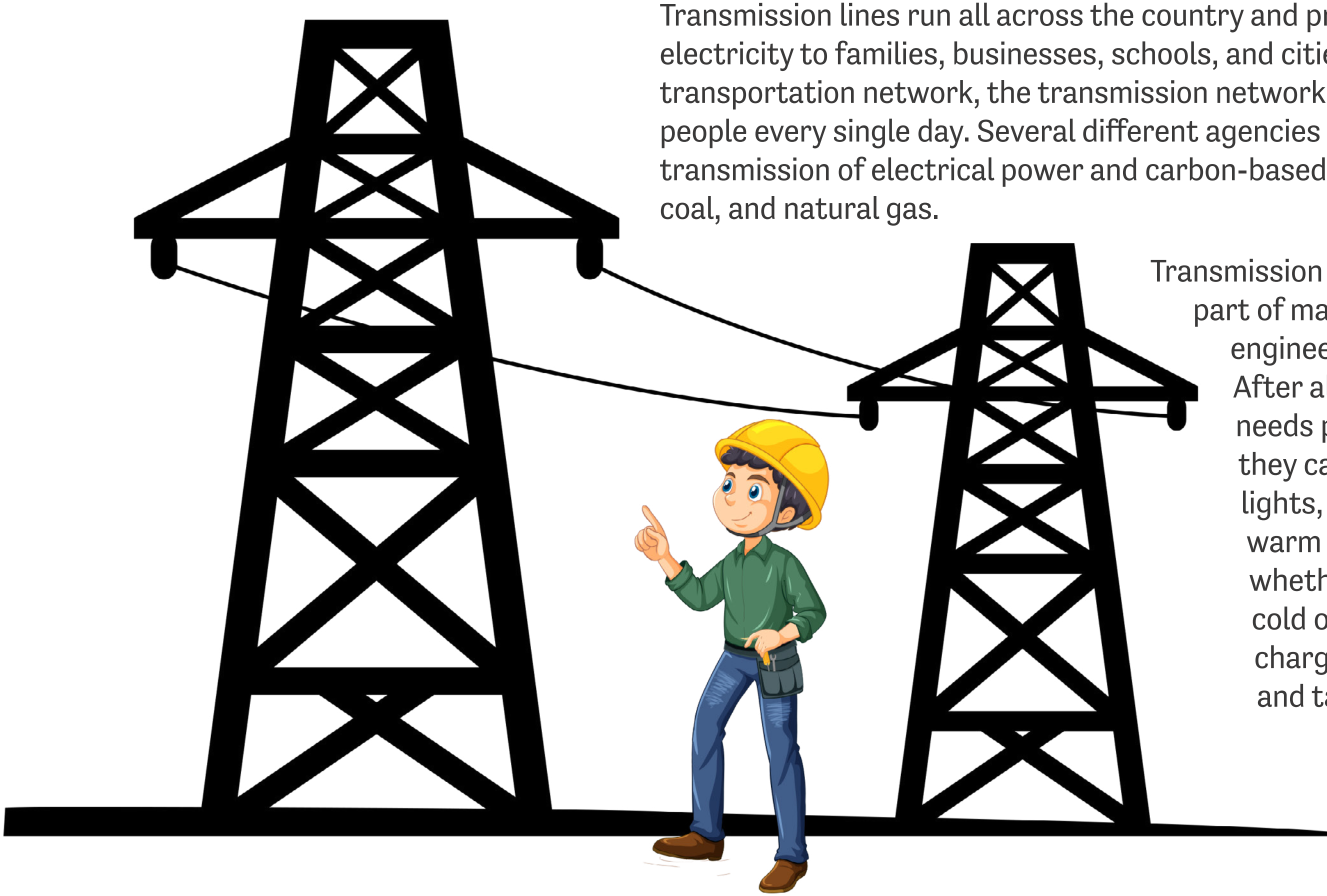
Transportation is all about going from one place to another, whether on the ground (roads and railroads), on the water (boats), or in the air (airports). Our country's transportation system serves the American people and economy 24 hours a day, 7 days a week, 365 days a year. The goal is to move people and goods safely, efficiently, and sustainably.

The United States Department of Transportation (USDOT) oversees transportation in the United States, along with other federal, state, local, and native nation governments. Many civil engineers focus on transportation.

...and **Transmission**.

Transmission lines provide power to keep the lights on.

Transmission lines run all across the country and provide electricity to families, businesses, schools, and cities. Like the transportation network, the transmission network serves people every single day. Several different agencies regulate the transmission of electrical power and carbon-based fuels like oil, coal, and natural gas.



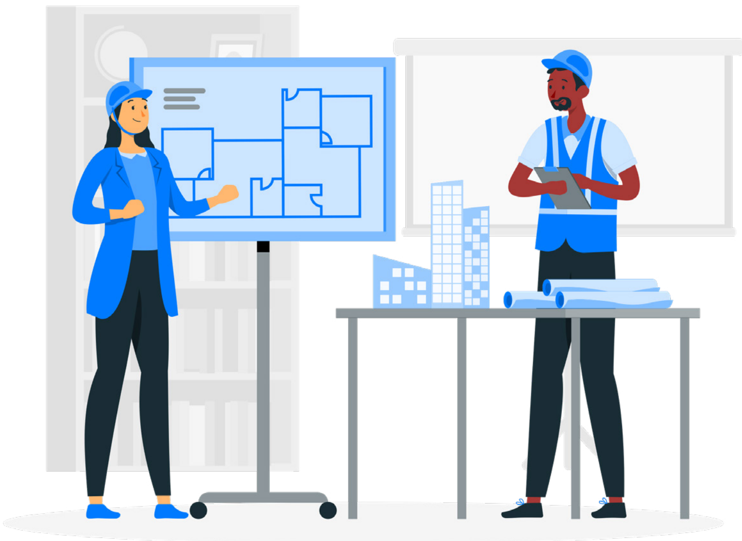
Transmission is an important part of many civil engineering projects. After all, everyone needs power so they can turn on the lights, stay cool or warm (depending on whether it's hot or cold outside), and charge their phones and tablets!

U is for the **Uniform Building Code**.

The Uniform Building Code holds projects to the same standard.

The Uniform Building Code (UBC) and other related codes have greatly helped civilization. The first version of the UBC was published in 1927. Other codes address accessibility, electrical, fire, gas/fuel, life safety, mechanical, and plumbing work.

The goal of these codes is to promote and standardize safety for infrastructure. They also give specifications (or instructions) for many topics. Knowing about and following codes is an important aspect of engineering design, operation, and maintenance.



V is for **Value.**

Good infrastructure brings a lot of value to our lives.

Well-planned, designed, constructed, operated, and maintained infrastructure brings tremendous value to our lives. It improves the places where we live, work, play, and go to school. However, this value is not free—it requires an investment (or money).

Most of the money to build new infrastructure, fix old infrastructure, and keep it working well comes from taxes and fees. Taxes are charged on people's income and property. Fees are charged on gasoline, water, trash and recycling pickup, and other services. The ASCE infrastructure report card tells us how our country's infrastructure is doing and what we need to do to preserve its value.

W is for **Water...**

Civil engineers design all aspects of water use and reuse.

Clean water (drinking or potable water) is needed for everyone's health and well-being. If people don't have clean water to drink and use, they can get sick or even die. Potable water is purified at water treatment plants and distributed through sanitary pipes or containers so people can use and drink it.

Water from storms or snowmelt needs to be collected and moved to prevent flooding. It can be used to irrigate crops or treated at water treatment plants so it is safe to drink.

...and **Waste.**

Waste has two basic forms, water and solid.

Wastewater happens when you use the bathroom or wash the dishes. Wastewater flows away in sewer pipes to wastewater treatment plants. After it is treated, the water is sometimes released into bodies of water, used for irrigation, or used to cool power plants. Sometimes rainwater or stormwater is included in a city's wastewater system in a combined sewer system. However, these systems are often separate, where a separate stormwater sewer system takes water to rivers, lakes, or the ocean so it does not cause flooding.

Solid waste or trash also needs to be collected and then disposed of properly in landfills, recycling centers, or incinerators, especially if it is considered hazardous. If solid waste and wastewater are not properly conveyed, treated, disposed of, or reused, our environment would experience much more pollution, poison, and disease. The U.S. Environmental Protection Agency's (EPA's) main mission is to make sure that waste in all forms is properly handled and disposed of to protect human health and the environment.

X is for **X is a useful shape**.

X is a very useful shape in engineering design.

A truss is a frame that provides structural support for bridges, buildings, roofs, and other structures. Trusses can come in all different shapes and forms, including the X-shape. The framework of trusses can support heavy loads and evenly distribute stresses without having to provide massive support walls, columns, or beams.

Skyscrapers sometime use trusses on the outside to make them taller and stronger. Trusses are also used in different kinds of machinery, such as cranes, and in airplane wings.

Y is for **Y-axis.**

The Y-axis tells you where you are on the planet.

The Cartesian coordinate system was invented in the 17th century. It allows everything on earth to be located. The X-axis and Y-axis are the horizontal coordinates that tell you where you are on the earth's surface using north, east, south, and west. The Z-axis tells you the elevation (how high something is), usually with reference to sea level. The X, Y, and Z axes are extremely important in survey, which locates and measures land and infrastructure.

They are used for CAD drawings when designing things. They are also the foundation of the Global Positioning System (GPS), which uses satellites to determine the location of vehicles, aircraft, phones, and other devices where position is important.

Z is for **zone.**

A zone is a specific area or region.

Zones are used to characterize areas or regions for different purposes. Examples of zones include seismic zones (which are at risk of earthquakes), flooding zones (where floods are caused by storms or sea level rise), and wildfire zones (where wildfires have occurred). Other zones include different soils, climates, and historic or hazardous (dangerous) conditions that must be considered when building infrastructure. Zoning is used in land development to refer to different types of urban (in the city) and rural (outside the city) development, such as residential, commercial, and industrial development. Civil engineers need to be aware of which zones apply when they are planning and designing infrastructure.

Conclusion

Civil engineering is all about solving problems to make life better for people and their communities.

Civil engineering is a very broad branch of engineering. It involves planning, designing, building, operating, and maintaining civilization so everyone can live healthy, productive lives. It impacts almost all aspects of our lives, including the buildings we live in and how we travel around. It helps make sure we have clean water to use and takes away waste to keep things clean.

Civil engineering is a great way to make a difference in the world. It is all about making people's lives better and safer—now and in the future.

Civil engineering is a great profession! If you would like to learn more about civil engineering, please visit the Dibble website at https://www.dibblecorp.com/insights/the-civil-engineering-alphabet for additional information on education and careers in civil engineering.