# Civil Engineering Teaching Materials for Grades 6-8

| Activity Title | Activity Description | Area | Topic | Grade | Source | Required Time | Special Materials |
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| **Under Pressure** | Learn about water pressure and how the pressure at the top of a dam compares to the pressure at the bottom of it. | Hydraulic, Hydrology & Water Resources | Water Pressure | 5-8 | Building Big | 30 min. | Acrylic caulk |
| **Engineer a Dam** | Build a dam in a trough that completely holds back the water and also find a way of executing a controlled release. | Hydraulic, Hydrology & Water Resources | Dams | 5-8 | Try Engineering | 45 min. | |
| **Flood!** | Construct a model of a river system with levees. | Hydraulic, Hydrology & Water Resources | Dams - Levees | 6-8 | NOVA | 45 min. | Large container, Modeling clay |
| **River & Environment** | Learn how water flow changes environemnt and vice versa. | Hydraulic, Hydrology & Water Resources | Water flow | 6-8 | See below (The River Model) | n/a | The river model should be built in advance. |
| **Hydropower!** | Build a water turbine and explore dams and hydroelectric power. | Hydraulic, Hydrology & Water Resources | Hydroelectric power | 7-8 | ASCEville | 45 min. | |
| **Underwater Dream Machine** | Build your own submarine and make it neutrally buoyant in a diving tank | Hydraulic, Hydrology & Water Resources | Buoyancy | 6-8 | NOVA | n/a | Dishwashing liquid |
| **How Green is My Roof?** | Design and build a section of a green roof for a house. | Environmental | Green building | 5-8 | Salvadori Center | Two 45-min. sessions, a couple months apart | Plants, Soil |
| **Landfill in a Box** | Create a landfill system and investigate how it works over the course of a year. | Environmental | Landfills | 5-8 | ASCEville | several sessions, over a year | Soil, Sand, Gravel, Wooden block, Non-fusible interfacing fabric, Fish tank tubing |
| **Don't Runoff!** | Redesign a city and control stormwater runoff. | Environmental | Stormwater runoff | 6-8 | EiE | n/a | |
| **Iron Glove Experiment** | Understand the concepts of effective stress by observing how a rubber glove full of sand becomes rock-hard when subjected to vacuum pressure | Geotechnical | Effective Stress in Soils | 6-8 | See below (Soil Magic I) | n/a | Soil, Sand, Gravel |
| **Which Sand Pile Falls Sooner?** | Learn about rock bolting and soil reinforcement mechanisms. | Geotechnical | Reinforced soil effectiveness | 6-8 | See below (Soil Magic II) | n/a | Soil, Sand, Gravel |
| **Magic Powder** | Learn about viscousity of soils by playing with a water-corn starch mixture. | Geotechnical | Dilatancy Principle | 6-8 | See below (Soil Magic III) | n/a | |
| **Shallow & Deep Foundations** | Learn differences between shallow and deep foundations by testing a cardboard box test bed composed of layers of pebbles, soil and sand. | Geotechnical | Foundations | 6-8 | Teach Engineering | 50 min. | Soil, Sand, Gravel |
| **Car of the Future** | How to decrease the carbon footprint of your city's public transportation system through the use of various new technologies and/or alternative fuels? | Transportation | Traffic Emissions | 6-8 | NOVA | Four class periods | |
| **Daredevils of the Sky** | Experiment with the size, shape, angle of the wings, rudder position and weight of a paper airplane | Transportation | Airplanes | 6-8 | NOVA | n/a | |
| **Asphalt** | Learn about time-sensetive loading properties of asphalt cement. | Transportation | Pavement | 6-8 | See below | n/a | Asphalt cement |
| **Beam Bridge** | Build a beam bridge using a flat eraser or a small sponge, and see what happens when a load pushes down on a beam bridge. | Structural & Construction | Bridges | 5-8 | NOVA | 30 min. | |
| **Popsicle Bridge** | Design and build your own bridge out of up to 200 popsicle sticks and glue. | Structural & Construction | Bridges | 5-8 | Try Engineering | 3 45-min. sessions | |
| **Paper Bridge** | Build a bridge that holds 100 pennies, using 1 sheet of paper and up to 5 paper clips. | Structural & Construction | Bridges | 5-8 | Building Big | 30 min | |
| **Spaghetti Bridge** | Make a truss bridge out of spaghetti. | Structural & Construction | Bridges, Truss | 6-8 | Teach Engineering | 2 hours | |
| **Straw Bridge** | Create truss beam bridges using straws. | Structural & Construction | Bridges, Truss | 6-8 | Teach Engineering | 50 min. | |
| **Suspension Bridge** | Make a model suspension bridge using straws. | Structural & Construction | Bridges | 5-8 | Building Big | 30 min | |
| **Tension and Suspense!** | **Build a suspension bridge with chairs, cardboard, and string.** | Structural & Construction | Bridges | 7-8 | ASCEville | 45 min. | |

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| **Arch Bridge** | Build a cardboard arch bridge amd see how the abutments support an arch bridge. | Structural & Construction | Bridges | 5-8 | NOVA | 45 min. | |
| **Build a Bridge** | Build four basic types of bridges and compare design vs. material in bridge strength. | Structural & Construction | Bridges | 5-8 | PBS | 2 90-min. periods | |
| **Bridge Types: Tensile and Compressive Forces** | Locate different tensile and compressive forces acting on various types of bridges. | Structural & Construction | Bridges | 6-8 | Teach Engineering | 45 min. | |
| **Construction Technologies: Create the Strongest Bridge** | Build 3 simple types of bridges (beam, arch, suspension), and test them under loads. | Structural & Construction | Bridges | 6-8 | Teach Engineering | 2 hours | |
| **Tasty Arch** | Build an arch that supports itself with no mortar. | Structural & Construction | Arches | 5-8 | NOVA | 45 min. | |
| **Load It Up!** | Test the maximum load that bridge piers can withstand. | Structural & Construction | Columns | 6-8 | Teach Engineering | 50 min. | |
| **Super Bridge** | Can you build strong bridge piers out of Spaghetti? | Structural & Construction | Columns | 5-8 | NOVA | 1 hour | |
| **Can a toilet paper tube support your weight?** | Demonstrate the differences between solid and hollow columns. | Structural & Construction | Columns | 5-8 | Building Big | 30 min. | |
| **Hang In There!** | Design the strongest cable that can support large hanging loads. | Structural & Construction | Cables | 5-8 | Building Big | 30 min. | |
| **Reel Distances** | Discover how to use pulleys to change the direction of force. | Structural & Construction | Pulleys | 6-8 | NOVA | n/a | |
| **Straw Shapes: Which one is more stable, a triangle or square?** | Test the stability of a triangle and a square made with straws by standing them on a table and pressing on them. | Structural & Construction | Shapes & Strength | 5-8 | Building Big | 30 min. | |
| **Shapes That Make Structures Strong** | Study the various shapes (triangles, arches, domes, etc.) engineers choose to make structures strong. | Structural & Construction | Shapes & Strength | 6-8 | PBS | Three 45-min. sessions | |
| **The Squeeze is On!** | Construct structures that can support the weight of a cinder block for 30 seconds. Learn about the force of compression nd how it acts on structural components. | Structural & Construction | Forces & Loads | 6-8 | Teach Engineering | 100 min. | |
| **Critical Load** | Learn how to reinforce the design of a structure to hold more weight. | Structural & Construction | Forces & Loads | 5-8 | Try Engineering | 45 min. | |
| **Leaning Tower of Pasta** | Use spaghetti and marshmallows to understand the effects that compression and tension forces have on structures. | Structural & Construction | Forces & Loads | 7-9 | Teach Engineering | 45 min. | |
| **Tug-Push-Twist-O'War** | Find out which materials can best withstand different forces. | Structural & Construction | Loads and Materials | 5-8 | Building Big | 30 min. | |
| **Shake It Up!** | Design and build shake tables to test the ability of buildings to withstand earthquakes. | Structural & Construction | Earthquakes | 6-8 | Teach Engineering | 100 min. | |
| **The Day the Earth Shook** | Explore different structural designs to discver some of the features that minimize the effects on a building when the earth shakes. | Structural & Construction | Earthquakes | 6-8 | NOVA | n/a | |
| **Killer Quake!** | Construct an earthquake-proof building. | Structural & Construction | Earthquakes | 6-8 | NOVA | n/a | An electric fan |
| **Meeting in the Middle:** How good are your directions in building a tunnel? | Describe the location of a tunnel opening on one side of a piece of cardboard to your partner, who will try to recreate it on the other side. | Structural & Construction | Tunnels | 5-8 | Building Big | 30 min. | |
| **Tunnel Through!** | Build a model tunnel through a clay mountain such that it simulates the principles behind real-life engineering design and can withstand a certain load. | Structural & Construction | Tunnels | 6-8 | Teach Engineering | 100 min. | |
| **Balsa Towers** | Build a tower with balsa wood and glue. | Structural & Construction | Towers | 6-8 | Teach Engineering: | 2 hours | |
| **High Rise** | Build a tower that can support a tennis ball at least 18 inches off the ground while withstanding the wind from a fan. | Structural & Construction | Towers | 5-8 | Design Squad | 45 min. | An electric fan |

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| **Newspaper Tower** | What's the tallest tower you can build using only two sheets of newspaper? You can bend, fold, or tear the paper, but no tape, no staples, no glue! | Structural & Construction | Towers | 5-8 | Building Big | 45 min. | |
| **Tall Tower Challenge** | Engineer the tallest tower you can build that can support the weight of a golf ball for 2 minutes, using just straws, pipe cleaners, and paperclips. | Structural & Construction | Towers | 5-8 | Try Engineering | 1 hour | |
| **Tower Investigation and the Egg** | Design and build 3 types of towers that can hold an egg one foot high for 15 seconds. | Structural & Construction | Towers | 6-8 | Teach Engineering | 1 hour | |
| **K'NEX Tower and Skyscrapers** | Build bridges and skyscrapers using K'NEX kits. | Structural & Construction | Towers | 6-8 | K'NEX kits | n/a | |
| **Geodesic Domes** | Build the strongest dome you can out of newspaper. | Structural & Construction | Domes | 5-8 | Building Big | 45 min. | |
| **Build a Big One!** | Build a large scale geodesic dome. | Structural & Construction | Domes | 5-8 | Building Big | 60-90 min. | |
| **A Great Lodge!** | Build two roofs, one with a truss and one without, and compare their strength. | Structural & Construction | Trusses, Roof | 6-8 | PBS/Great Lodges | 1 hour | |
| **Speedy Shelter** | Invent an emergency shelter that can fit a person and is sturdy and quick to build. | Structural & Construction | General Construction | 5-8 | Design Squad | 45 min. | |
| **Paper Table** | Build a table out of newspaper tubes that can hold a heavy book. | Structural & Construction | General Construction | 5-8 | Design Squad | 45 min. | |
| **Kinetic Sculpture** | Make a sculpture at least 6 in. tall with parts that move in the wind, and is yet sturdy enough to stand up in the wind. | Structural & Construction | General Construction | 5-8 | Design Squad | 45 min. | An electric fan |
| **Mobile Forces** | Learn about gravity, convection air currents, and balancing forces by creating your own mobiles | Structural & Construction | General Construction | 6-8 | Teach Engineering | 1 hour | |

**Activity Descriptions:**

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| **Asphalt** | Students learn about the unique properties of asphalt cement, specifically, its time-sensitive loading properties: First, each student take a turn striking a pan of asphalt binder material (asphalt cement) with a hammer. After the students found the material very resistant to compression in this manner, they are then able to see, by slowly pressing a finger into the pan, that the material deforms under a lighter, but much longer, loading. | Original Source |

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| **The River Model** | Construct a river model as a 20 in. wide by 48 in. long by 4 in. deep Plexiglass box filled with sand. The boxes are filled with a mixture of fine, medium, and coarse sand to allow the creation of three dimensional river systems. The flow through the model is accomplished by using a small submersible pump in a lower reservoir. For convenience and economics, the reservoir is simply a 20-gallon plastic storage container. Water is inserted into the upper portion of the modeling box through a small hose behind a diffuser. The diffuser slows the velocity of the water to resist excessive erosion at the point of entry. The box is set at a slight angle to facilitate flow through the river system. The water returns to the reservoir after leaving the model through a square notch in the end of the box. The water then recirculates through the system. The water needs to be occasionally exchanged because the unfiltered water becomes quite "muddy."<br><br>Students are asked to verbalize what they see and how water flowing through the system is changing the environment. The system allowed students to visualize various river processes including sediment transport, bank and bed erosion, river evolution, flooding, etc. The use of non-uniform sand allowed students to visualize the transport of different sediment sizes as would be encountered in nature. Depending on the velocity of the water, students could see smaller grains of sediment being transported, with larger grains settling onto the bottom.<br><br>Additionally, students have the opportunity to change their environment by adding scale features to the model such as boulders (using small rocks), gabions (using wired baskets filled with gravel), logs (cut dowel rods), and bank vegetation (using sponges anchored with toothpicks). The river model can easily be changed to incorporate these features and see how the river adapted to the changes. Finally, after students are given opportunities to alter the system, they are asked to construct a new river system and predict how it would react when water was added.<br><br>*Challenges:*<br><br>Patience - The students frequently wait long enough for the system to adapt to changes they had made<br><br>Maturity - This experiment is very similar to playing in a wet sand box and some of the students treated as such instead of a scientific learning experience. | Original Source |

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| | Students are initially asked to build simple structural shapes such as squares and triangles with K'NEX kits and to investigate what happens when they are "loaded." They then individually construct a simple pier bridge. By performing these experiments, they will be introduced to common terminology such loading, tension, compression, span, support, joint, connection, abutment, footing, etc. Once the students have background knowledge in the subject matter, they are split into teams and presented an engineering challenge with several restraints. The students then work as a team to complete their project using the materials contained in a single K'NEX kit. The challenge may involve a bridge or a skyscraper. The K'NEX kits include blueprints for constructing various types of bridges and the students are allowed to use these blueprints to simplify the construction process. | |

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| **K'NEX kits** | In the case of a bridge, the students are told to span a distance (14 in.) using a bridge design of their choice. Two prizes may be awarded: one for the most aesthetically pleasing/interesting bridge and another one for the strongest bridge. The strongest bridge will be judged by determining the number of science textbooks it can hold during a load test before collapsing (given lateral foundation support). A more interesting contest would have been a bridge weight to load weight ratio, but the students are usually more interested to see the ultimate load and failure. The strongest bridge will be a variation of an elevated train truss structure and supported more than 20 textbooks before collapsing. The student usually enjoy the catastrophic failure of their creations.<br>In the case of the skyscraper, students are given a rectangle of construction paper that represent a "city block" and that would be the maximum foundation footprint size for their building (i.e. in the final design, the K'NEX pieces at "ground level" must be contained by the border of the construction paper). Similar to the bridge assignment, students are presented with two challenges with prizes awarded: an award for the tallest constructed building that can withstand a hurricane load (box fan) without toppling, and an award for the most volumetric office space given the foundation size and specified amount of materials. | Original Source |

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| **Soil Magic I: Iron Glove Experiment** | Students are challenged to understand the concepts of effective stress by observing how a rubber glove full of sand becomes rock-hard when subjected to vacuum pressure (iron glove experiment). The concept of effective stress in soils may be revisited using a demonstration of a bag of potato chips under loaded conditions (with pin holes introduced to the bag over time). | Original Source |

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| **Soil Magic II: Which Sand Pile Falls Sooner?** | Rock bolting is demonstrated using a bucket of gravel that remained in place after tipping the bucket upside down. This behavior is achieved through the action of applied compressive forces through the rock mass with bolts. The effectiveness of reinforced soil is demonstrated by hiding paper discs within one pile of sand next to a "control" pile of sand, and the students will see that the reinforced sand pile (which appeared identical to the control pile) is able to hold substantially more weight before failing. The soil reinforcement demonstration is quite rapid because it has to be entirely set up ahead of time to maintain the element of surprise. | Original Source |

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| **Soil Magic III: Magic Powder** | Students make a water-corn starch mixture (termed "ooblech" by Elton) that maintains form as a ball as long as they keep moving it from hand to hand. However, if the action stops, the substance becomes viscous and runs down their hands and arms. | Original Source |