Western Engineering Outreach

Tall Tower Challenge

Grade 6-8

Meet Today's ENG HERO!

Girma Bitsuamlak - Associate Professor with Western Engineering

Girma Bitsuamlak is an Associate Professor in Civil and Environmental Engineering at Western University. He is also the Associate director at the WindEEE Research Institute. Dr.Bitsuamlak has a long term goal of contributing towards optimal resiliency of the built environment under sustainability constraints. His research interests lie in the area of multi-scale, multi-physics experimental and computational modeling of wind effects on the built-environment. For more information about Dr.Bitsuamlak, please visit: https://www.eng.uwo.ca/civil/faculty/bitsuamlak_g/index.html

Learning Goals:

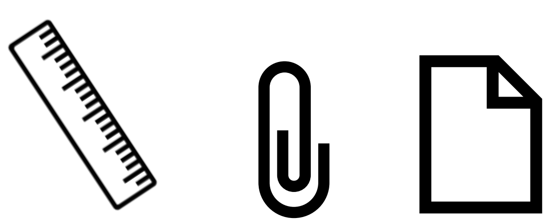
- Grade 6 2.2 use scientific inquiry/experimentation skills to investigate the properties of air (e.g., air takes up space, has mass, can be compressed)
- Grade 7: 2. design and construct a variety of structures, and investigate the relationship between the design and function of these structures and the forces that act on them
- Grade 8: 3. demonstrate an understanding of different types of systems and the factors that contribute to their safe and efficient operation.

Materials:

- 20 Plastic Straws
- 1 Sheet of Paper
- 10 Pipe Cleaners
- 10 Paper Clips
- Measuring Tape or Ruler

For testing

- One Golf Ball (can substitute this with any other similar weight)



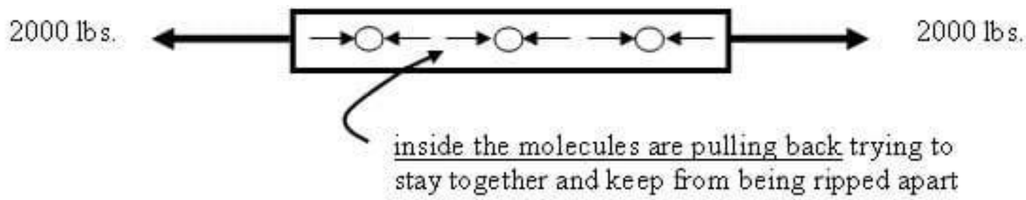
Engineering and Science Connections:

Background:

The five types of loads that can act on a structure are tension, compression, shear, bending and torsion.

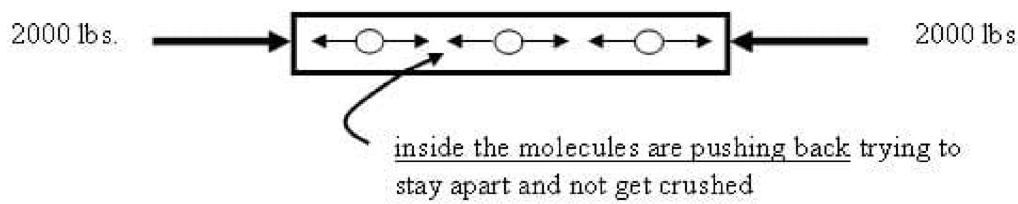
Tension: Two pulling (opposing) forces that stretch an object trying to pull it apart (for example, pulling on a rope, a car towing another car with a chain – the rope and the chain are in tension or are "being subjected to a tensile load").

Figure 1. Tension.



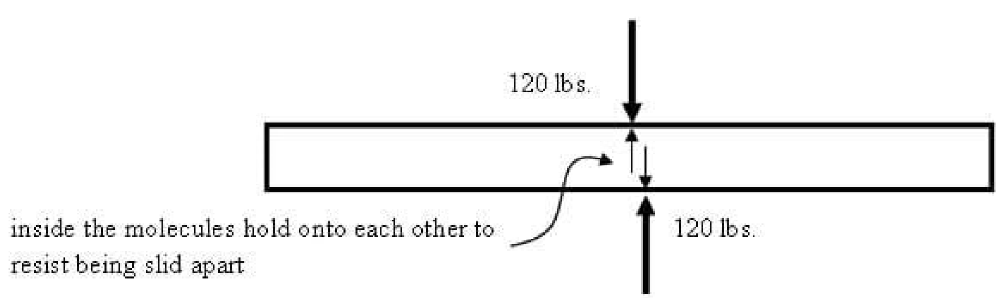
Compression: Two pushing (opposing) forces that squeeze an object trying to compress it (for example, standing on a soda can, squeezing a piece of wood in a vise – both the can and the wood are in compression or are "being subjected to a compressive load").

Figure 2. Compression.



Shear: Two pushing or pulling adjacent forces, acting close together but not directly opposing each other. A shearing load cuts or rips an object by sliding its molecules apart sideways (for example, pruning shears cutting through a branch, paper-cutter cutting paper - the branch and paper are "subjected to a shear loading").

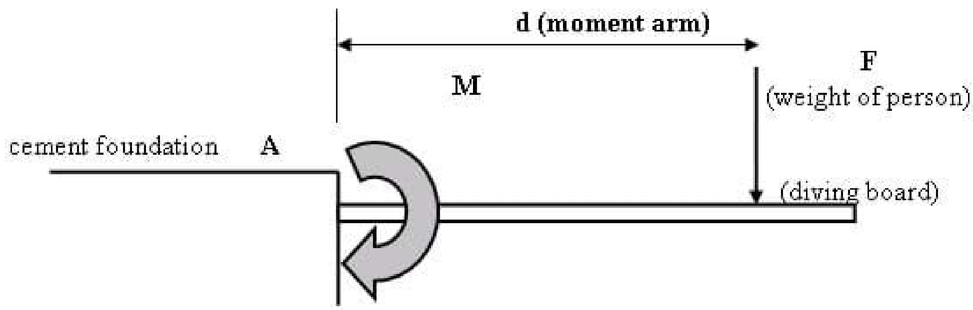
Figure 3. Shear.



A Moment of a Force

Understanding a moment of a force is key to understanding the last two types of loads. A moment is a "turning force" caused by a force acting on an object at some distance from a fixed point. Consider the diving board sketch in Figure 4. The heavier the person (force), and the farther s/he walks out on the board (distance), the greater the "turning force," which acts on the concrete foundation (fixed point).

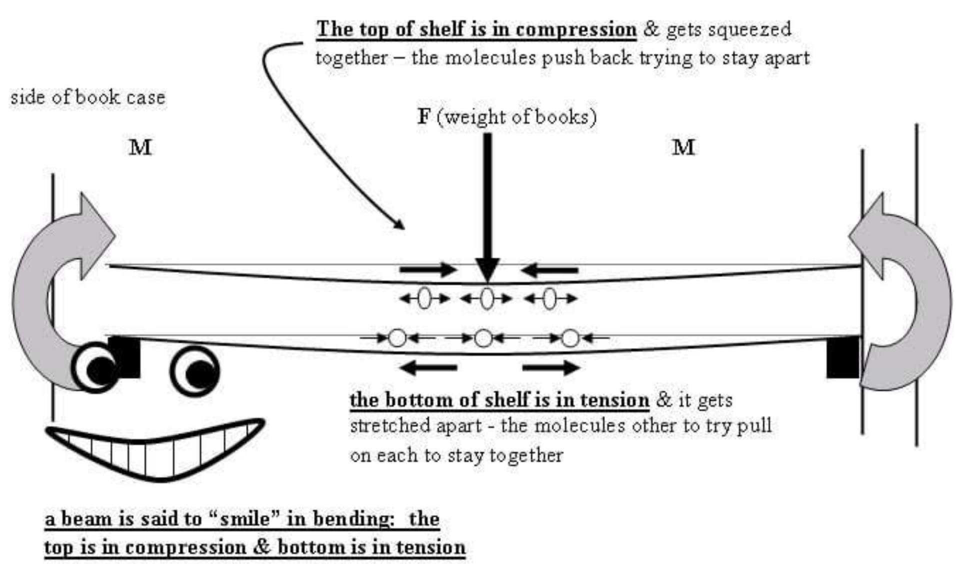
Figure 4. Moment of a force.



The force (F) produces a moment or "turning force" (M) that tries to rotate the diving board around a fixed point (A). In this case, the moment bends the diving board.
The stronger the force, and the greater the distance at which it acts, the larger the moment or "turning force" it will produce.

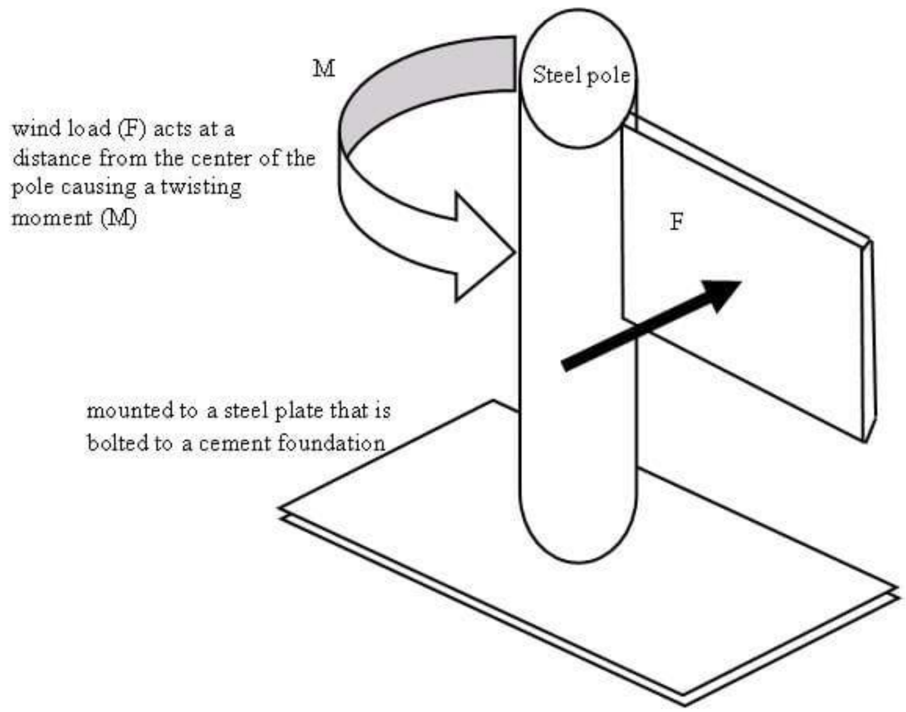
Bending: When a moment or "turning force" is applied to a structural member that is fixed on both ends, such as a pole beam, making it deflect or bend. A moment that causes bending is called a bending moment. Bending produces tension and compression inside a beam or a pole, causing it to "smile." The molecules on the top of the smile get squeezed together, while the molecules on the bottom of the smile get stretched out. A beam or pole in bending will fail in tension (break on the side that is being pulled apart) (for example, a shelf in a bookcase, and the earlier diving board scenario).

Figure 5. A bookcase example of bending.



Torsion (Twisting): Created when a moment or "turning force" is applied to a structural member (or piece of material) making it deflect at an angle (twist). A moment that causes twisting is called a twisting or torsional moment. Torsion produces shear stresses inside the material. A beam in torsion will fail in shear; the twisting action causes the molecules to be slid apart sideways (for example, a pole with a sign hanging off one side).

Figure 6. Torsion.



Activity:

Intro:

Have you ever wondered how really tall buildings stay up? Why do skyscrapers not fall down when wind hits them? Engineers work with architects and scientists to understand what makes materials break, and then use what they learn to design strong structures. Today, you will have the opportunity to figure out how to make a strong structure, too. Sometimes, engineers may be able to find very strong materials, but they cannot use them in a structure because the material are too expensive. Sometimes, engineers cannot use as much material as they might like due to budget or supply limitations. Just like an engineer, today you will be constrained; you can only use a limited amount of materials. Your job is to design and build a structure that is as tall and strong as possible, using only the limited number of materials provided (straws, pipe cleaners and paper clips, NO TAPE) .

Tall Tower Challenge

As you build, think about what forces will be acting upon your structure. Which parts will be pushed together – that is, which will experience compression – and which parts will be pulled apart – that is, which will be under tension. How will you design the tallest, strongest structure using limited resources?

The Leaning Tower of Pisa

Ever wondered about the Leaning Tower of Pisa? How does it stay up? How are engineers trying to straighten it over time? Watch the video below to find out!

Video Recommendation: https://www.youtube.com/watch?v=s_F_G_lhku0

Engineering Design Challenge:

1. The object of this activity is to build a tower as high AND as strong as you can using only a limited supply of materials. There are no step-by-step instructions for this project, only the constraints of limited resources! You can do whatever you want with the materials to try to build a structure as tall, stable and strong as possible.
2. The structure you build with have to hold the weight of a golf ball and optionally, withstand the force of wind from a hair dryer.
3. Draw a picture of the design you want to build before you start building!

What Did You Learn?

- About compression and tension forces and how they impact the stability of a structure
- Learning about how engineers take all forces into consideration when designing structures and choosing materials

Future Learning

- Which geometric shapes seemed the strongest for holding weight? Squares, circles, triangles? Why do you think that is?
- Investigate these further by learning about different stable structures in the world and about the tallest structures in the world.

Share your creations!

We would love to see what you made. Email as at discover@uwo.ca or tag us on social media.

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Thanks for discovering with us!