CENTER OF EXCELLENCE FOR AIRPORT TECHNOLOGY

Mc4West Bridge Investigation

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Mc4 WEST

ILLINOIS

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Types of Bridges

- There are three major types of bridges:
  - The **beam bridge**
  - The **arch bridge**
  - The **suspension bridge**

- What governs which type of bridge you use?

Which Bridge Type Do You Use?

- The biggest difference between the three is the distances they can cross in a single span:
  - Modern **beam bridges** are likely to span a distance of up to 200 feet
  - Modern **arch bridges** can safely span up to 800 or 1,000 feet
  - **Suspension bridges**, the pinnacle of bridge technology, are capable of spanning up to 7,000 feet

Why the Differences in Span?

- What allows an arch bridge to span greater distances than a beam bridge, or a suspension bridge to span a distance seven times that of an arch bridge?

- The answer lies in how the bridge dissipates the forces (loading due to traffic, weather, etc) acting on it into **itself** and then transfers the force **through the abutment** into the earth.

Tension versus Compression

- **Compression** is a force that acts to compress or shorten the thing it is acting on
- **Tension** is a force that acts to expand or lengthen the thing it is acting on

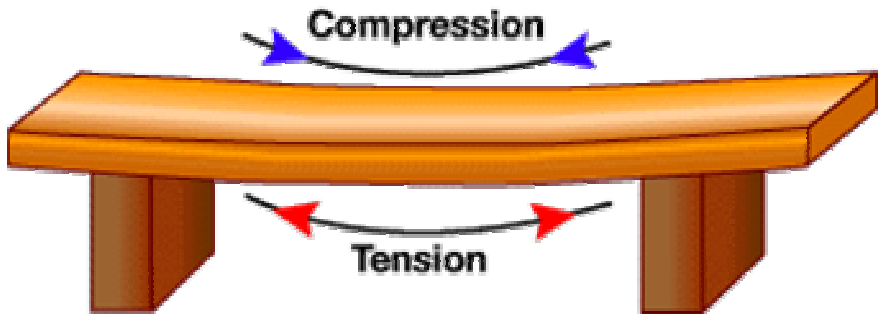
- Think about imposing compression or tension on a spring

Other Mechanical Issues

- **Buckling** is what happens when the force of compression overcomes an object's ability to handle compression
- **Snapping** is what happens when the force of tension overcomes an object's ability to handle tension
- To **dissipate** force is to spread it out over a greater area, so that no one spot has to bear the brunt of the concentrated force
- To **transfer** force is to move it from an area of weakness to an area of strength, an area designed to handle the force

Example Of Tension/Compression

- The top side is under compression and the bottom side is under tension. If you keep adding weight, eventually the two-by-four will break. Actually, the top side will buckle and the bottom side will snap.



BEAM BRIDGES

SPAN: Up to 200 feet

DESCRIPTION: A rigid horizontal structure that is resting on two piers

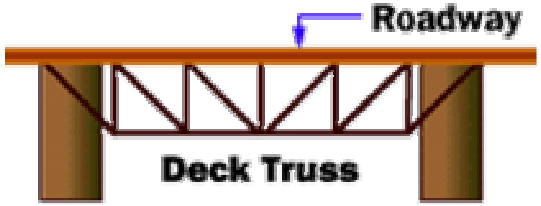
LOAD: Travels directly down

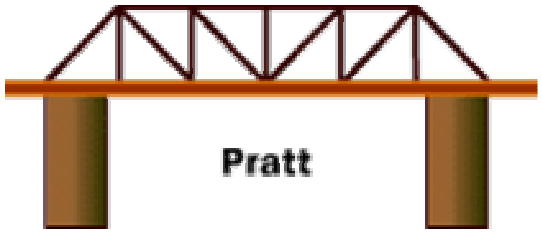
Truss Strength

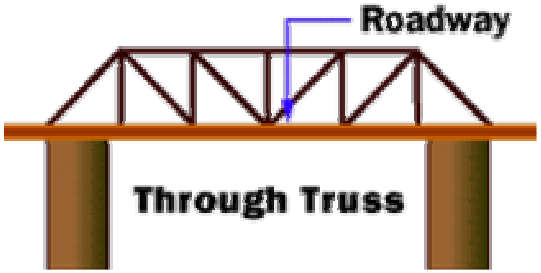
- If a beam were designed so that there was more material on the top and bottom, and less in the middle, it would be better able to handle the forces of compression and tension. (For this reason, I-beams are more rigid than simple rectangular beams with less material)

- A truss system takes this concept one step further.
  - Think of one side of a truss bridge as a single beam. We can see that the top and bottom of the beam contain more material than its center (corrugated cardboard is very stiff for this reason).
  - Another reason why a truss is more rigid than a single beam: A truss has the ability to dissipate a load through the truss work.

Types of Beam Bridges







ARCH BRIDGES

SPAN: Up to 1,000 feet

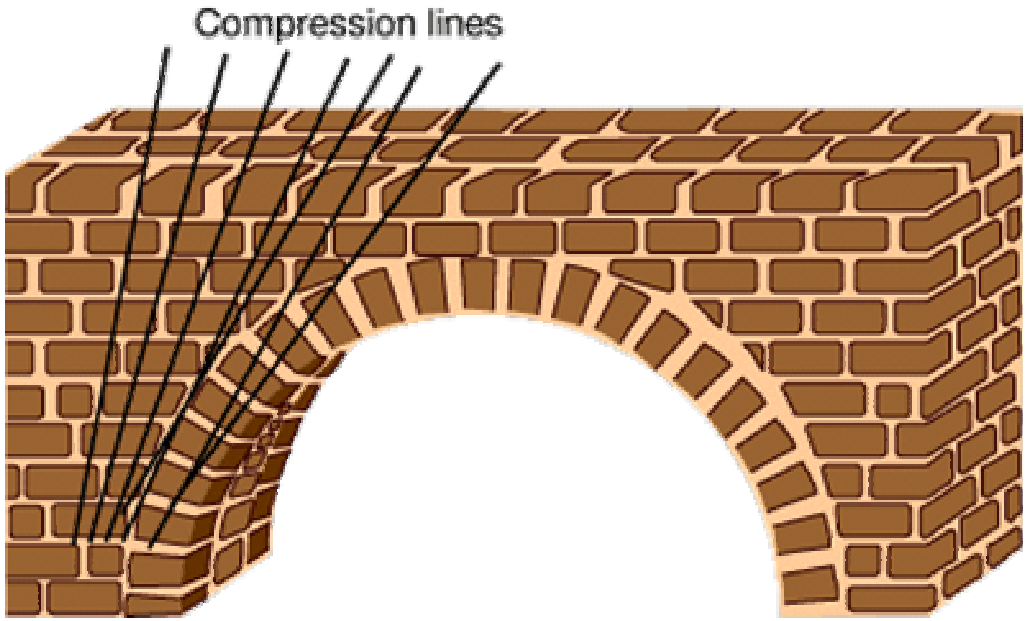
DESCRIPTION: Arch shape naturally diverts weight from deck to abutments

LOAD: Travels around arch (no tension)

Arch Bridges

- An arch bridge is a semicircular structure with abutments on each end. The design of the arch, the semicircle, naturally diverts the weight from the bridge deck to the abutments.
- Arch bridges are always under compression. The force of compression is pushed outward along the curve of the arch toward the abutments.
- The tension in an arch is negligible. The natural curve of the arch and its ability to dissipate the force outward greatly reduces the effects of tension on the underside of the arch.

Example of Arch Bridge



Another Civil Engineering Arch

SUSPENSION BRIDGES

SPAN: Up to 7,000+ feet

DESCRIPTION: Cables strung across a obstacle (river) to support deck

LOAD: Travels through cables to towers and abutment

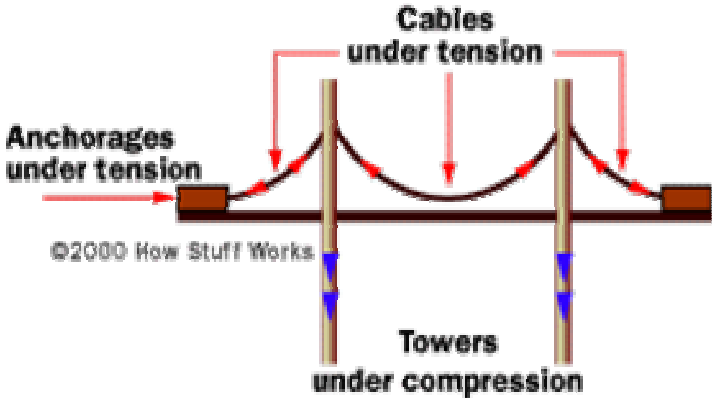
The Suspension Bridge

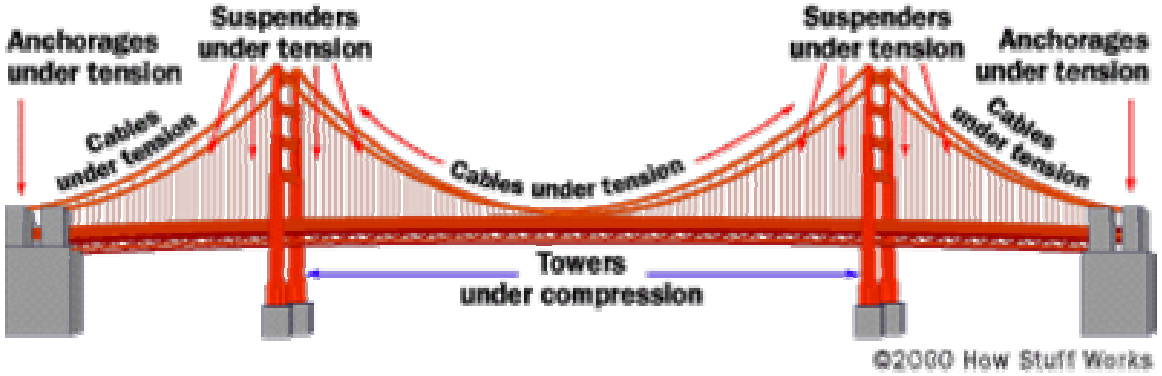
- A suspension bridge is one where cables (or ropes or chains) are strung across the river (or whatever the obstacle happens to be) and the deck is suspended from these cables.
- Modern suspension bridges have two tall towers through which the cables are strung. Thus, the towers are supporting the majority of the roadway's weight.

The Suspension Bridge

- The force of compression pushes down on the suspension bridge's deck, but because it is a suspended roadway, the cables transfer the compression to the towers, which dissipate the compression directly into the earth where they are firmly entrenched.
- The supporting cables, running between the two anchorages, are the lucky recipients of the tension forces. The cables are literally stretched from the weight of the bridge and its traffic as they run from anchorage to anchorage. The anchorages are also under tension, but since they, like the towers, are held firmly to the earth, the tension they experience is dissipated.

Examples of Suspensions Bridges





A NEW SUSPENSION BRIDGE: CABLE STAY BRIDGES

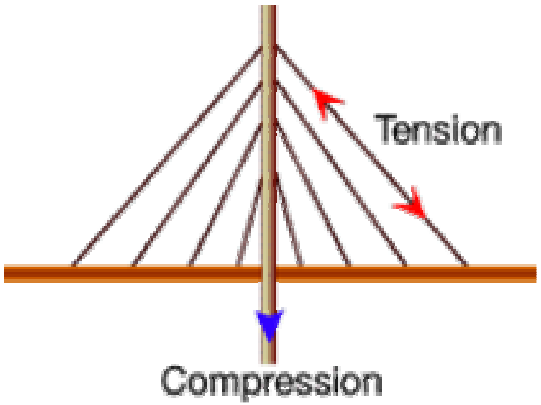
SPAN: Is there a limit?

DESCRIPTION: Cables strung across a obstacle (river) to support deck

LOAD: Travels through cables to towers

The Cable Stay Suspension Bridge

- The cable-stayed bridge does not require two towers and four anchorages as does the suspension bridge. Instead, the cables are run from the roadway up to a single tower where they are secured.



The Cable Stay Suspension Bridge

- Due to symmetry of the bridge, equilibrium is met and there is no need for outside support.
- Is there a limit to the length a bridge such as this can span?
- Still a new technology, but China is building a cable stay spanning 3,600 feet.

BRIDGE QUIZ

The following 5 slides contain pictures of bridges.

Name the type and win a prize.

What type of bridge is this?

What type of bridge is this?

What type of bridge is this?

What type of bridge is this?

What type of bridge is this?

BRIDGES IN CHICAGO

Bridge Facts for Chicago

- Chicago's central business community is more dependent on (and surrounded by) movable bridges than any other city in the world, including Paris, London, and Venice
- 37 city bridges
- Annual budget of $18 million
- Renovation projects that can run as high as $30 million per bridge

Bridge Facts for Chicago

- Chicago's oldest bridge is the Kinzie Street unit which was built in 1911 and rehabbed in 1998

Bridge Facts for Chicago

- Which are the most unusual?
  - Vertical lift bridges (that raise like a guillotine) on south Canal and on Torrance Avenue

Bridge Facts for Chicago

- Which are the most unusual?
  - Scherer Rolling Lift model at Cermak Road, which rolls back like a rocking chair on tracks

  - All three of these have dramatic, highly visible concrete counterweights dangling above street level

Another Unusual Chicago Bridge

- Swing Bridge, Calumet River

References

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