Structural Engineering

What is a structure?

- **Structure** – something that is constructed, or built
- Joining parts to meet a certain need or perform a specific task

Types of Structures

- Natural Structures
- -spider webs
- -birds nest
- -wasp nest

Types of Struct

- Human Structures
- -houses
- -buildings
- -bridges

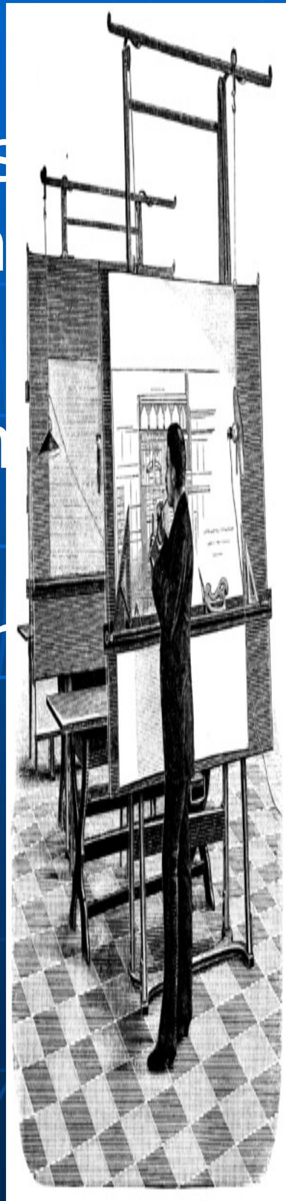
http://www.smh.com

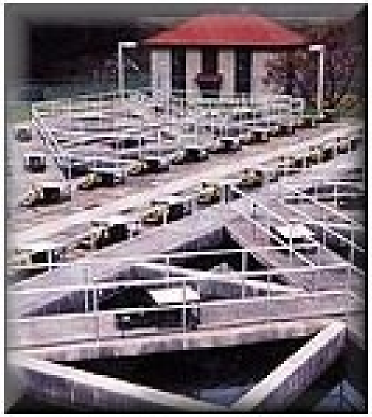
Design

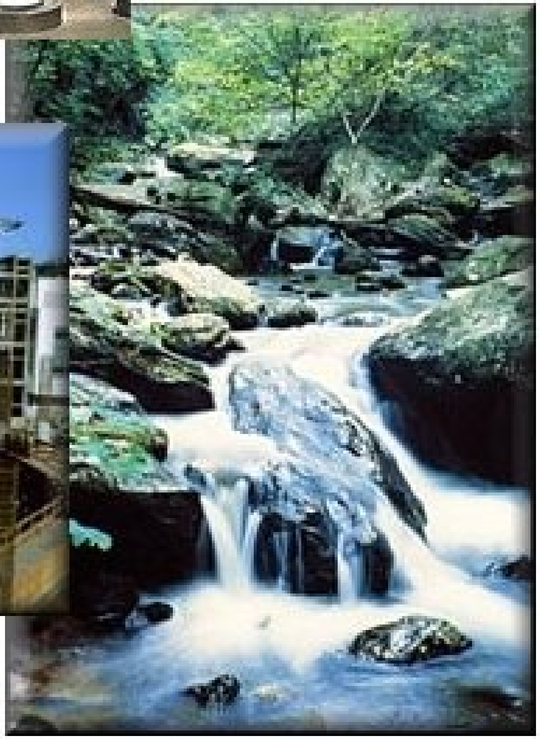
- Design depends o
- -dam must be str
- -tower to transmit signals must be ta
- -houses built for c
- -factories and offic

Who Designs Structures?

- **Civil Engineers** – design and supervis the building of structures that serve th public
- -most work on roads, water system sewers, and public structures
- **Structural Engineers** – civil engineer that focus on load-bearing structures
- **Architect** – designs buildings and oversees construction





Who Designs Structures?

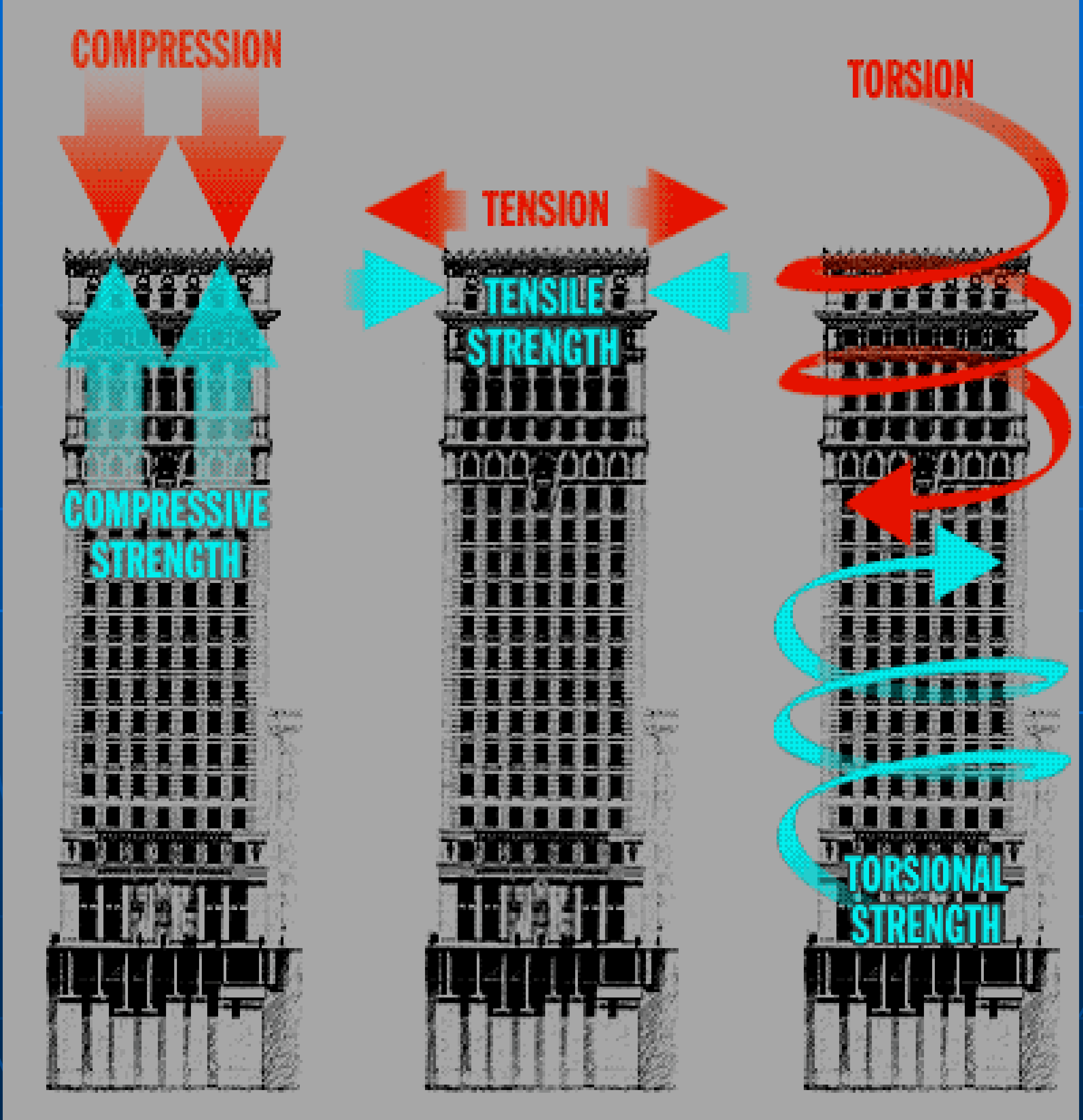
- Questions they might ask:
- -how many vehicles or pedestrians on bridge per day
- -how might skyscraper be affected by high winds
- -how to protect a st earthquake zone

Forces on Structures

- **Force** – push or pull that transfers energy to an object
- ***External force*** – come from outside, act upon the structure
- ***Internal force*** – force that parts exert on eachother, act within structure

Types of Forces

- 4 types: compression, tension, torsion, shear
- 1. Compression – shortens or crushes
- 2. Tension – stretches or pulls apart
- 3. Torsion – twists
- 4. Shear – pushes parts in opposite directions


COMPRESSION
COMPRESSIVE STRENGTH
TENSION
TENSILE STRENGTH
TORSION
TORSIONAL STRENGTH

- **2.3 Internal Forces Within Structures**
- ***Compression, Tension, and Shear***
- Compression forces crush a material by squeezing it together. Compressive strength measures the largest compression force the material can withstand before it loses its shape or fails.
- Tension forces stretch a material by pulling its ends apart Tensile strength measures the largest tension force the material can withstand before failing.
- Shear forces bend or tear a material by pressing different parts in opposite directions at the same time. Shear strength measures the largest shear force the material can withstand before it rips apart.
- Torsion forces twist a material by turning the ends in opposite directions. Torsion strength measures the largest torsion force the material can withstand and still spring back into its original shape.

Types of Forces

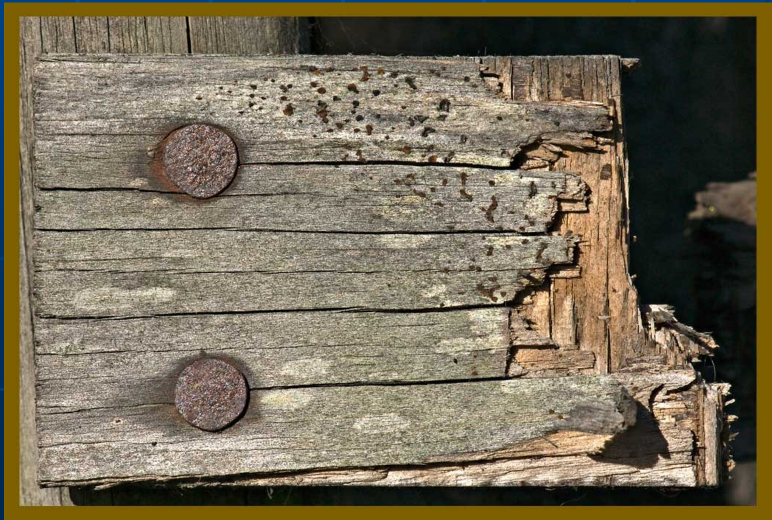
- **Load** – external force acting on an object, eg: weight, pressure from wind/water
- ***Static Load*** – change

Structural Materials

- Wood
- -one of the first materials used for structures
- -still the primary
production

Structural Materials

- Disadvantages of wood:
- -expands and contracts with changes in moisture
- -damaged by weather and insects
- -breaks down if not maintained



Engineered Wood

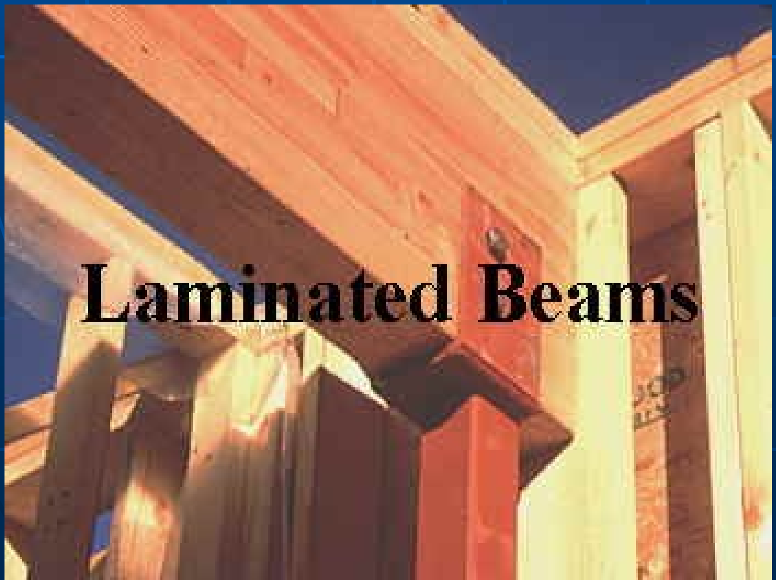
- -bonding wood strands, fibres, veneers with adhesive
- -can control strength and stability
- -formed into panels, laminated beams, I-joists
- -structural panels (plywood) most common
- -made by gluing together veneers
- -odd number of layers, alternating grains
- -less likely to shrink or expand (dimensional stability)

Structural Materials

- I-joists
- -laminated, used for floor construction in homes
- -light, available up to 60 ft, don't bow or twist
- -eliminate squeaky floors because don't shrink

Structural Materials

- Laminated Beams
- -glue together thin strips of wood
- -consistently strong, can be made very long



Steel

- -Steel is an alloy (metal made of different elements)
- -made from iron and carbon
- -may have chromium and nickel to resist rust
- -made into many shapes (I-beams, pipes, wires) and joined many ways (rivet, bolt, weld)
- -used as rebar or wires to strengthen concrete


Concrete

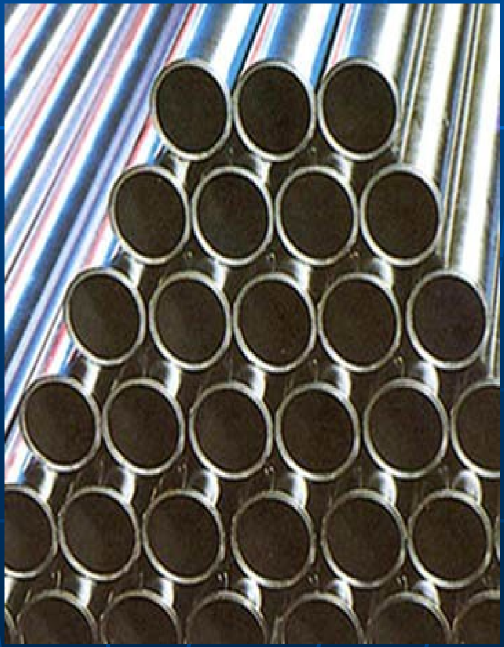
- -made by mixing cement, sand, gravel and water
- -hardens into strong material
- -examples?
- -very strong in compression
- -poured into forms to make almost any shape

Concrete

- -weak in tension
- -may be reinforced with steel bars to make ***reinforced concrete***
- -***pre-stressed*** concrete contains wires that are under tension all the time
- -produce beams, floors or bridges with a longer span than reinforced concrete
- -wires produce a compressive stress that offsets tensile stresses

Structural Members

- Structural Members:
- -building materials joined to make a structure’s frame
- Common shapes include:
- -I-beam
- -box-beam
- -angle-beam
- -pipe



Bridges

- Before a bridge is built:
- -soil samples
- -wind speed and direction
- -water levels and speed of water
- -models tested in lab or on computer
- -community hearings
- -planning takes several years and millions of dollars!

Bridge Types

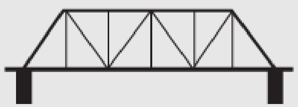
BRIDGE TYPES

The I-35W bridge that collapsed Wednesday in Minneapolis was designed as a "non-redundant" truss structure. Non-redundant bridges require less material and are cheaper to build but have no other pathways for loads to be disbursed in the event of a failure. That design has caused problems with some other bridges, including the Silver Bridge that collapsed into the Ohio River in 1967 at the height of rush hour, carrying 31 vehicles and 46 people with it. Experts says greater redundancy could prevent a progressive collapse of a bridge.

GIRDER BRIDGE

A girder or beam bridge is arguably the most basic bridge. A log across a creek is an example of a girder bridge in its simplest form. Modern steel girder bridges often use I-beams or box girders in their construction.

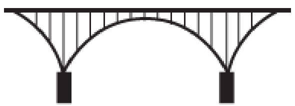
EXAMPLE: The 2,165 foot Poplar Streeet Bridge.



TRUSS BRIDGE

The truss is a simple skeletal structure. In theory, the individual parts of a simple truss are only subject to tension and compression forces but not bending forces. Trusses are made up of small beams that when put together can support large amounts of weight and also span great distances.

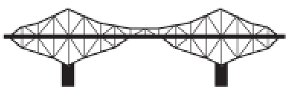
EXAMPLE: The Old Chain of Rocks Bridge is a one-mile-long truss bridge with a dramatic joint in the center.



ARCH BRIDGE

The second oldest bridge type, the arch doesn't require piers in the center. Arches use a curved structure. This provides high resistance to bending forces. Arches can only be used where the ground or foundation is solid and stable.

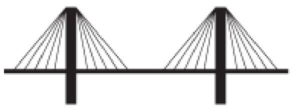
EXAMPLE: The Eads Bridge has a three-arch span that totals 1,647 feet.



CANTILEVER BRIDGE

A cantilever bridge is a modified form of beam bridge. The support is in the middle of a span, not the end. The advantage to a cantilever bridge is its ability to span wide spaces without the need of extensive and expensive support while under constuction.

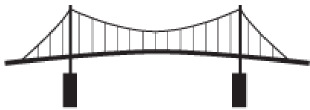
EXAMPLE: The Greater New Orleans Bridge over the Mississippi River.



CABLE-STAYED BRIDGE

A typical cable-stayed bridge is a continuous girder with one or more towers erected above piers in the middle of the span. Cables stretch down diagonally (usually to both sides) and support the girder from the towers.

EXAMPLE: The Clark Bridge crossing the Mississippi going to Alton.



SUSPENSION BRIDGE

The suspension bridge allows for the longest spans. A typical suspension bridge is a continuous girder with one or more towers erected above piers in the middle of the span.

EXAMPLE: The Golden Gate bridge in San Francisco.

SOURCES: Matsuo Bridge Co., Ltd., www.riverwebmuseums.org

Research by Mark Learman
Graphic by John D. Telford | Post-Dispatch

Skyscrapers

- History:
- -Great Pyramid of Giza in ancient Egypt, which was 146 metres (480 ft) tall and was built in the 26th century BC
- -Ancient Roman housing structures reached 10 stories
- -Medieval times: many towers built for defense
- -Leaning Tower of Pisa built in 1178

Skyscrapers

- -first “skyscraper” was Home Insurance Building in Chicago, 1885
- -10 stories
- -load-bearing steel frame instead of load-bearing walls
- -practical with the invention of the elevator (no more stairs!)

Skyscrapers

- -Current record = Taipei 101 @ 101 stories, 1,670 ft tall
- -has huge pendulums near top to counteract swaying

Skyscrapers

- -high quality steel beams bear immense weight
- -beams welded, bolted, or riveted together
- -most weight is transferred to vertical column, the spreads out at base and substructure
- -fire safety is a major concern

Wind Resistance

- -many tall buildings sway several feet in strong wind
- -structure is tightly constructed to stop movement
- -computers monitor sway and move huge concrete weights to compensate

Earthquake Resistance

- -ban construction along fault lines
- -many buildings built on layers of flexible rubber or a sliding surface