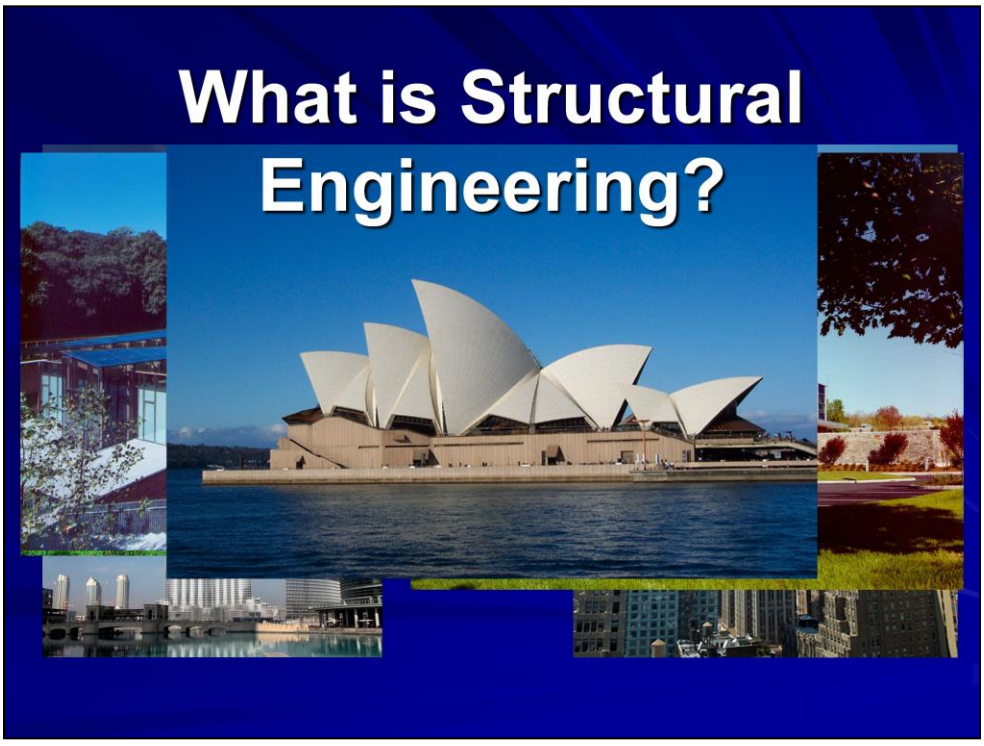
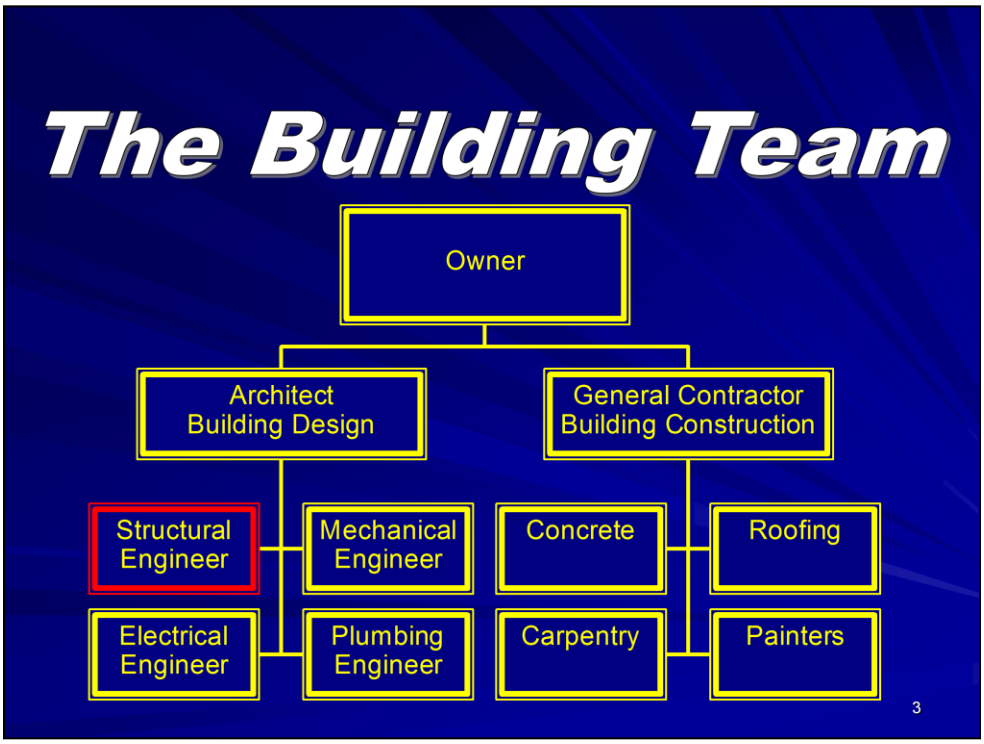
Introduction to Structural Engineering

- Special thanks to:
  - SEAOI
  - NCSEA
  - SEAONC
  - ISE

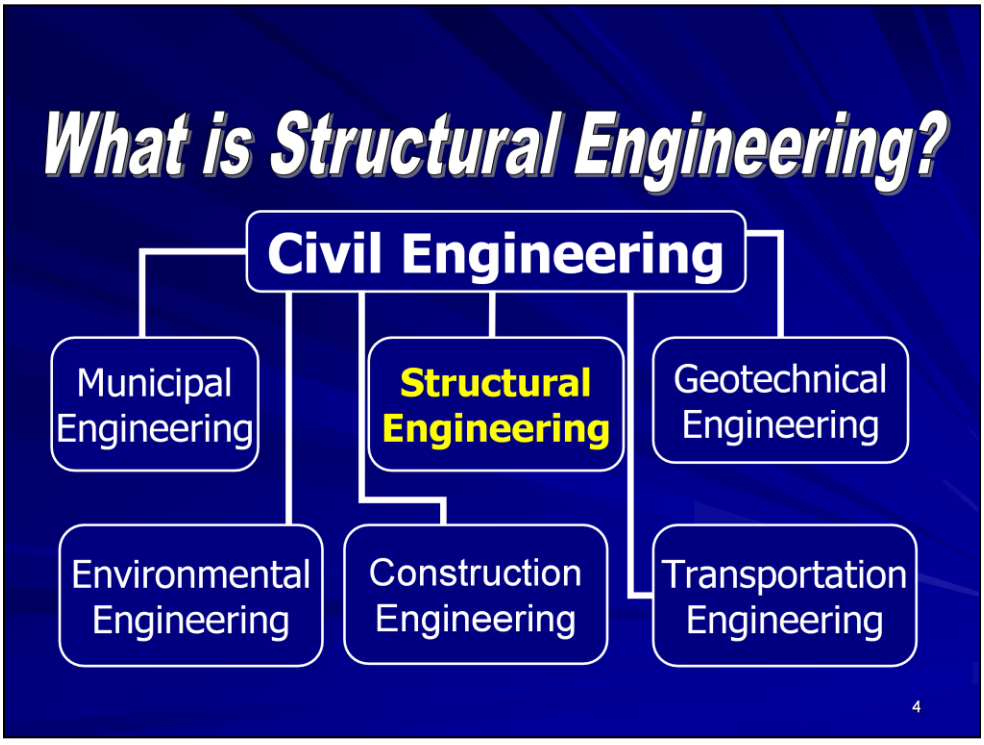


Ken Nizamuddin is a Senior Project Engineer with Rubinos & Mesia Engineers, Inc. He has worked in the Structural Engineering field for over 22 years, and holds a PE license in 11 states. He has served as the President of DAPC, and is a Past-Presdient of CBC, SEC, and SEAOI. He is a director for NCSEA and a structural member of C&S.



Structural engineers are part of a team that builds or retrofits a building or bridge. The top of the team is the building or bridge owner. Directly below is the architect. In many projects, the structural engineer works for the architect, providing their expertise with regards to the structure. The contractor is also directly under the owner. All of the various construction workers work for the contractor. Building a building is a collaborative effort that requires communication and team building skills.

The project structure is sometimes different from this. For many repair, retrofit, or reports when structural engineering expertise is necessary, the structural engineer will work directly for the owner.



Civil engineering is a professional engineering discipline that deals with the design, construction and maintenance of the physical and natural built environment, including works such as bridges, roads, canals, dams and buildings. Civil engineering is the oldest engineering discipline after military engineering, and it was defined to distinguish it from military engineering. It is traditionally broken into several sub-disciplines including municipal engineering, environmental engineering, geotechnical engineering, structural engineering, transportation engineering, materials engineering, coastal engineering, surveying, and construction engineering.

What is Structural Engineering?

The science and art of designing and making, with economy and elegance, buildings, bridges, frameworks and other similar structures so that they can safely resist the forces to which they may be subjected.

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Why do we need Structural Engineers?

Because Mother Nature is tough, that's why!

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Buildings must be designed to resist...

HURRICANES

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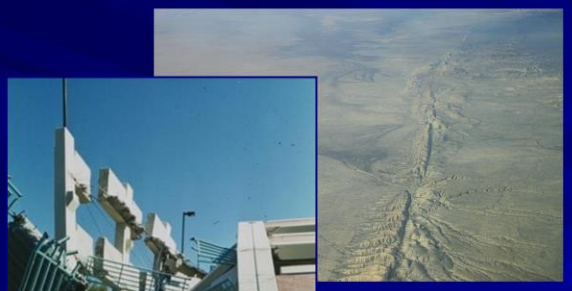
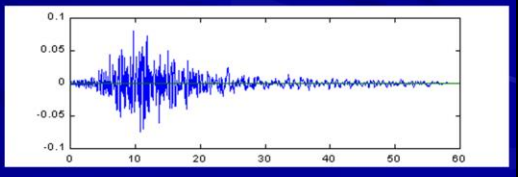
Buildings must be designed to resist...

SNOW STORMS

8

Buildings must be designed to resist...





EARTHQUAKES

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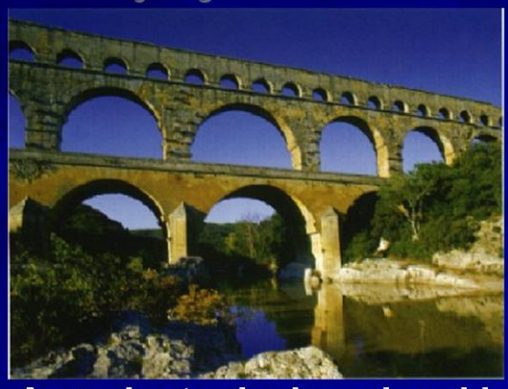
Some of history's greatest structures still stand...



…because of structural engineering

Roman Aqueducts designed and built by Roman Centurions trained in structural engineering (Circa 300 BC)

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Great Pyramids of Egypt (c. 5000 BC)

11

The Pantheon (c. 125 AD)

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The Brooklyn Bridge (1883)

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The Eiffel Tower (1889)

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The Empire State Building (1931)

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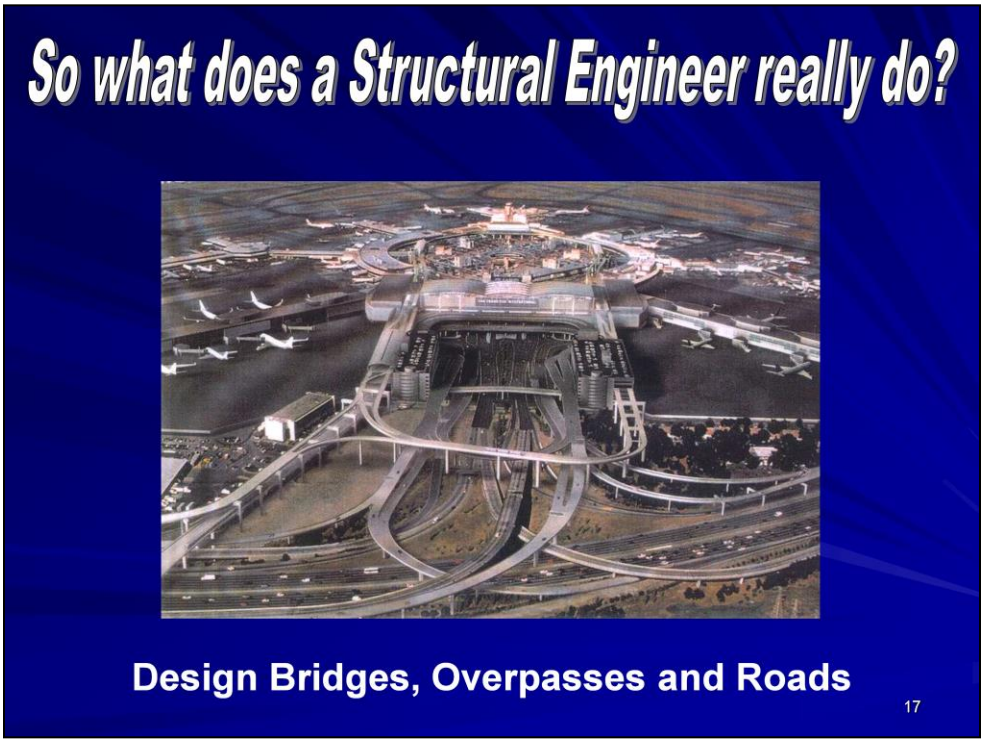
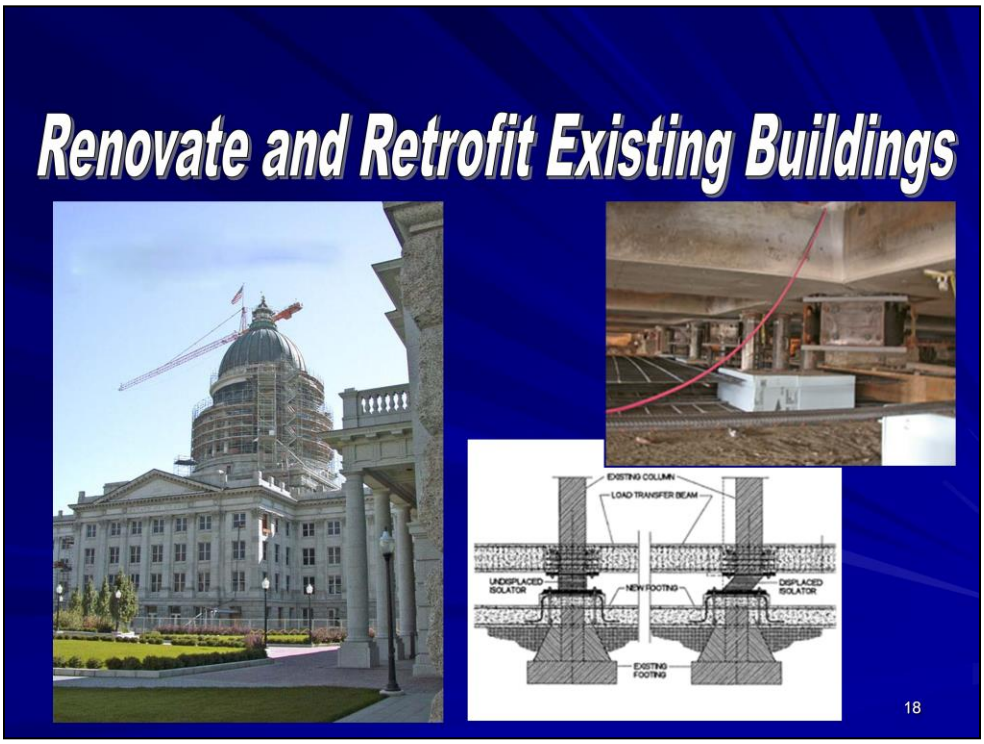
Designs bridges, overpasses and roads to safely handle the millions of vehicles that need to get from one place to another.



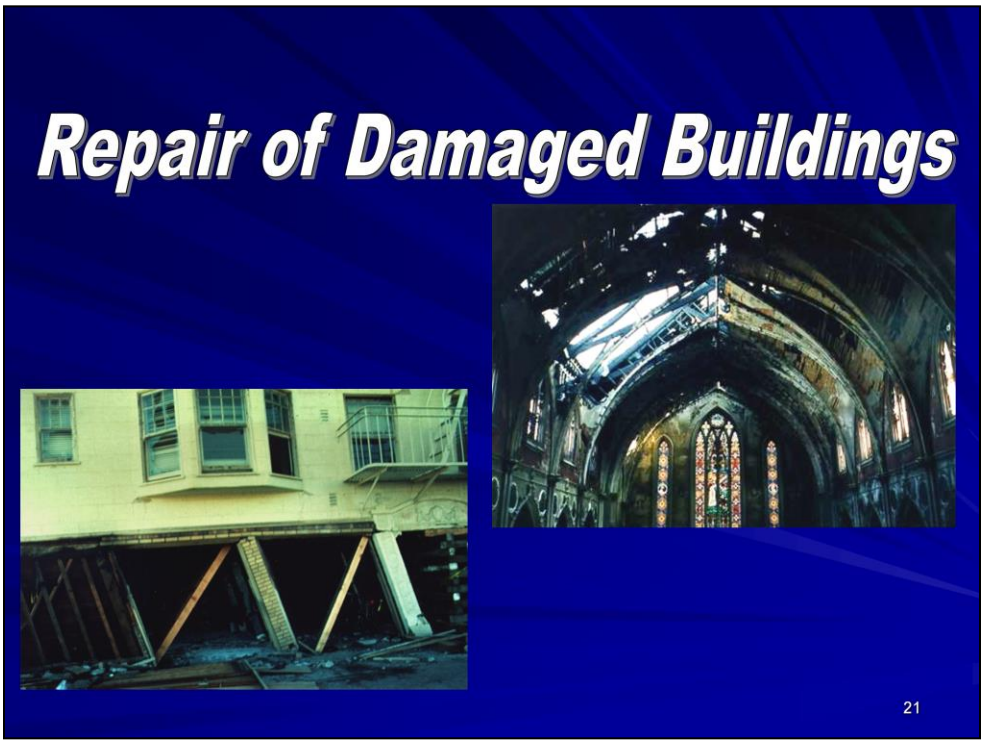
Designs new buildings that are safe, comfortable, functional, useful, and environmentally friendly



Retrofit and restore old buildings and historic structures to make them safe, attractive, and habitable.

One of the most challenging retrofit jobs is the strengthening of an historic building. Some buildings, like this older ornate church, have expensive and detailed finishes. They may have detailed tile mosaics or marble finishes on the walls. The structural engineers who do historic preservation have to introduce new structure that will protect the church in an earthquake but will not disturb the beautiful finishes of the building.

When a new building is constructed, it might need a deep basement or foundation. This is typical of new high rises that will have underground parking. Some structural engineers specialize in shoring. They design the structure that will hold back the soil around the location of the new foundation or basement. Some of these shoring structures can get very deep as you can see in the middle picture.

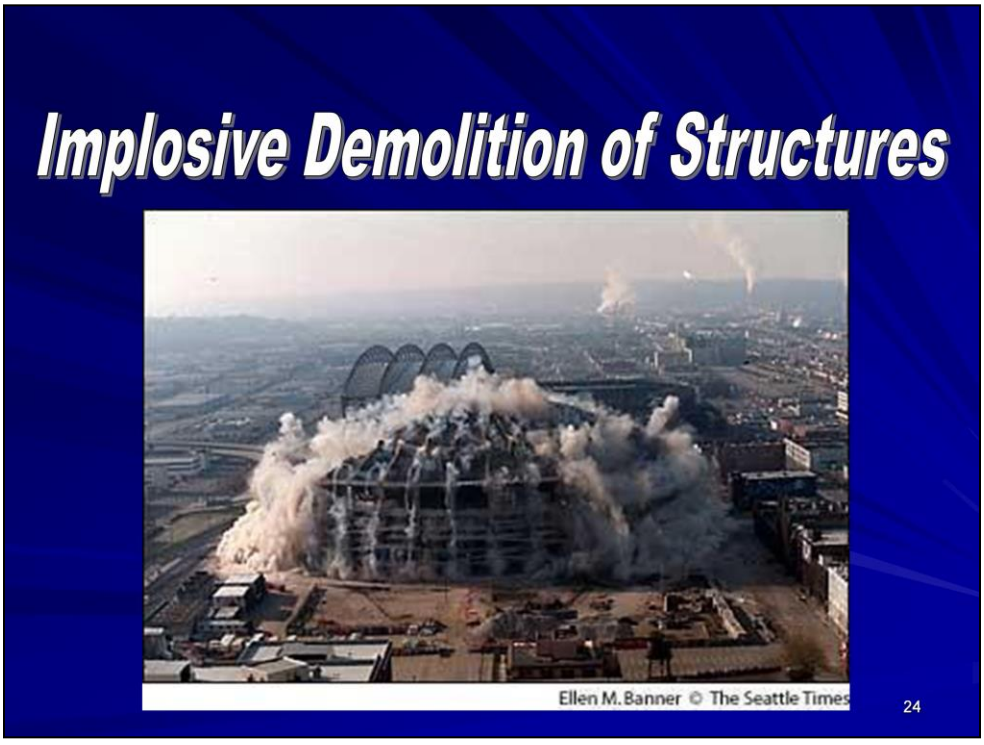


Following an earthquake, structural engineers are needed to help building owners make repairs. The building on the left was damaged in the 1989 earthquake. The first floor was seriously damaged but the top floors did OK. A structural engineer may work with a contractor to design a system for shifting the building back into place and repairing and strengthening the structure.

The building on the right is a church that was damaged by fire. A structural engineer worked with the owner, an architect, and a contractor to repair the building and to save the church.

The structural engineers sees that the design is properly implemented by the contractor, and actively participates in construction quality control programs.

Forensic engineering or building failure assessment is assessment of buildings which are under distress.



Explosive demolition of buildings and other structures. To safely and efficiently blow a building down, structural engineers have to figure out how it was put together so they can take it down in a matter of seconds.

Offshore Drilling Platforms exist because structural engineers have designed them to withstand some of the worst conditions that Mother Nature can dish out.

How Do We Design?

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Phase 1 – Concept or Scheme Design

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Phase 1 – Concept or Scheme Design

Lots of options is the norm:

- via a number of sketches / options in parallel with simple calculations
- There is rarely one solution, and often must assess options against some criteria



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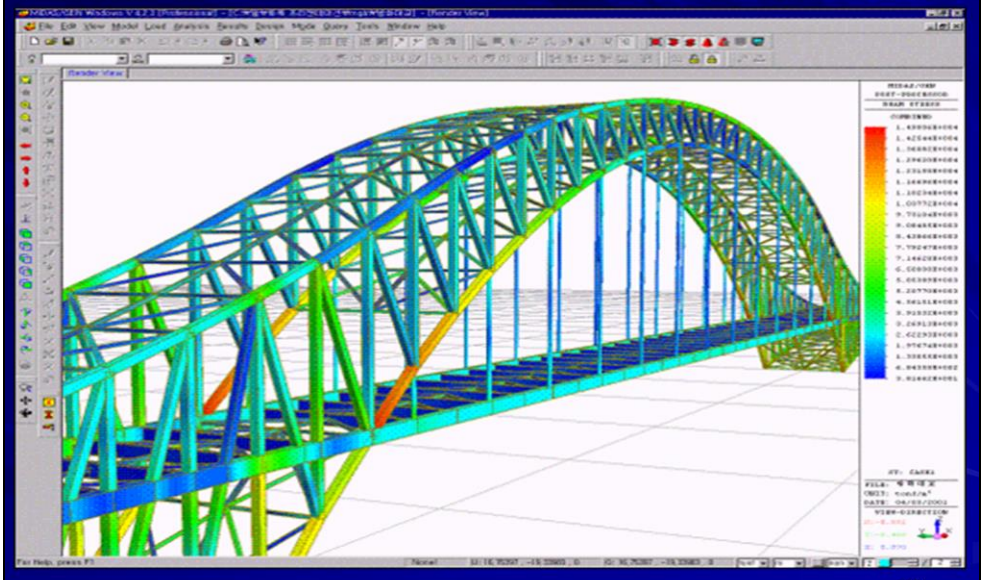
Phase 2 – Detailed Calculations



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We Design with Teamwork

- Structural Engineers do not work in isolation
- We are part of a larger project team and need to coordinate with:
  - Clients
  - Architects
  - Building Services Engineers
  - Civil & Geotechnical
  - Contractors

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Basic Structural Engineering concepts

TENSION- Giving things a stretch…

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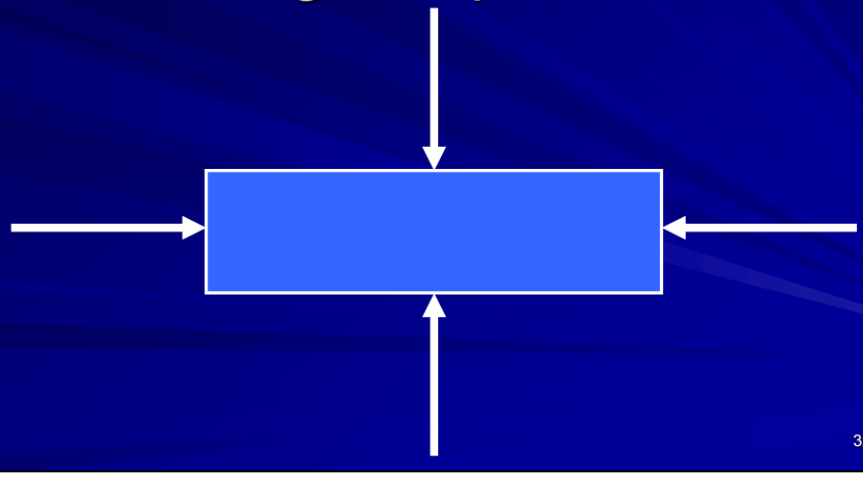
Basic Structural Engineering concepts

COMPRESSION- Giving things a squash…



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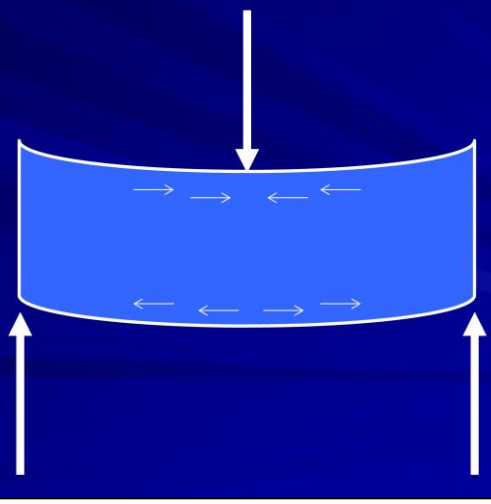
Basic Structural Engineering concepts

BENDING- A little of both…



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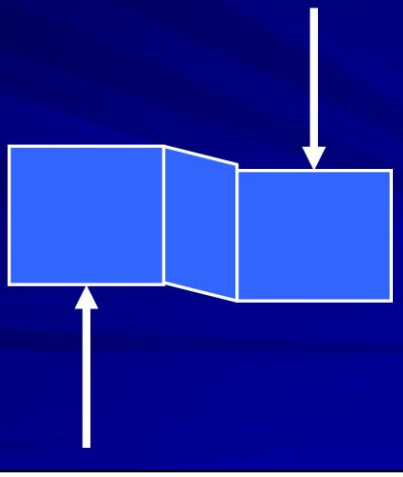
Basic Structural Engineering concepts

SHEAR- Break me off a piece…



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Basic Structural Engineering concepts

Triangles

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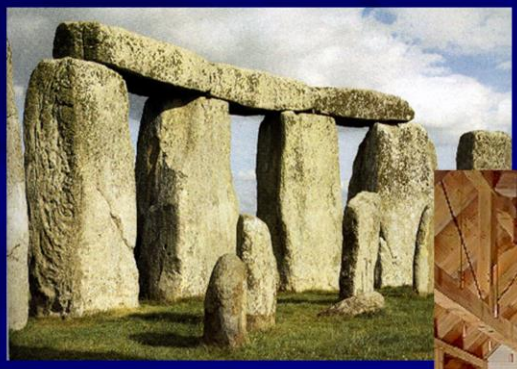
Basic Structural Engineering concepts

Arches

Basic Structural Engineering concepts



Post & Beam

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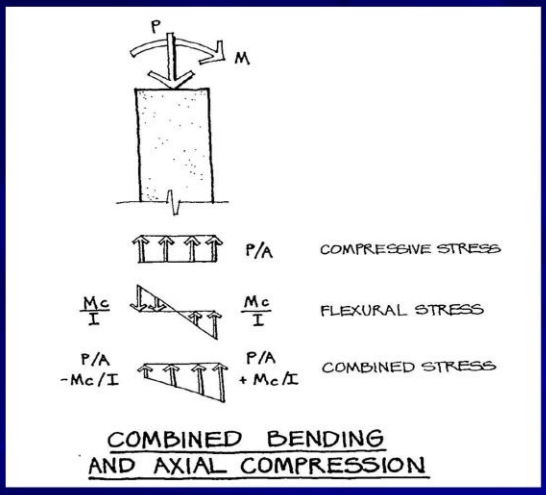
Structural Engineering Principles



COMBINED STRESSES

- Stress is additive
- Stress from different directions must be accounted
- Stress in opposite directions is subtracted

Axial (compression) + Bending (flexural) = Total Stress

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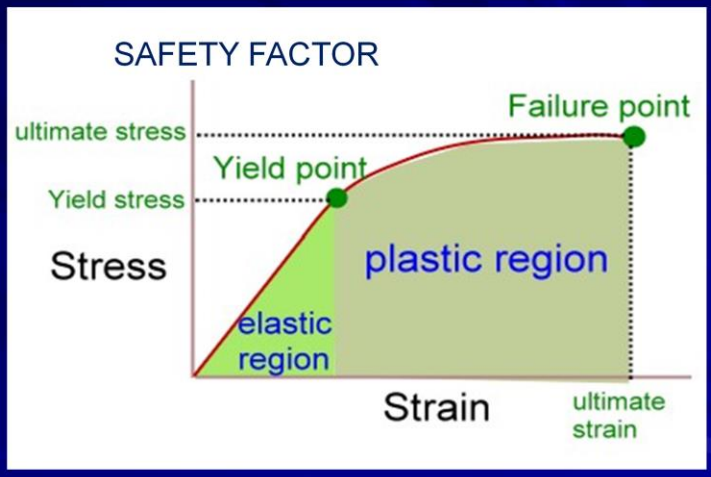
Structural Engineering Principles



- Yield Stress is the "Max Value" used for design.
- Safety Factors (SF) reduce the "Max Value" to account for unknown effects.

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Structural Engineering Principles

Serviceability

- Deflection Limits
- Comfortability
- Vibration Limits
- Movement limit to prevent damage

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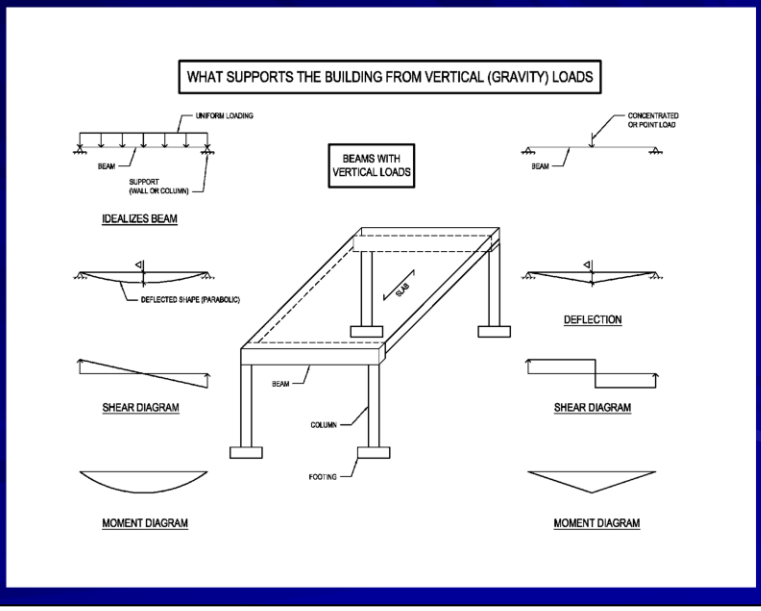
How do structures behave?



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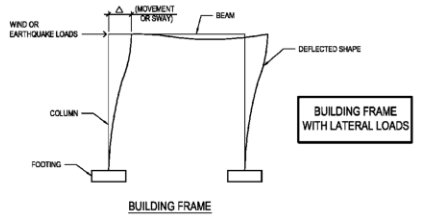
How do structures behave?

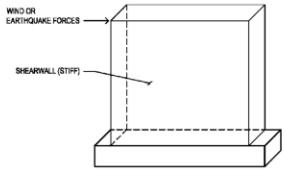
WHAT HOLDS UP THE BUILDING TO LATERAL FORCES



BUILDING FRAME WITH LATERAL LOADS

BUILDING FRAME

- BUILDING FRAME IS DESIGNED TO RESIST LATERAL LOADS
- SHEAR AND MOMENT DIAGRAMS SIMILAR TO BEAM DIAGRAMS ARE USED TO DESIGN THE BUILDING FRAME ELEMENTS



SHEARWALL WITH LATERAL LOADS

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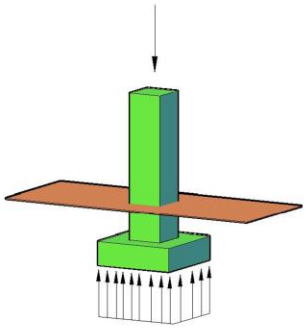
Type of Foundation Systems

COMMON FOUNDATION SYSTEMS



SPREAD FOOTING

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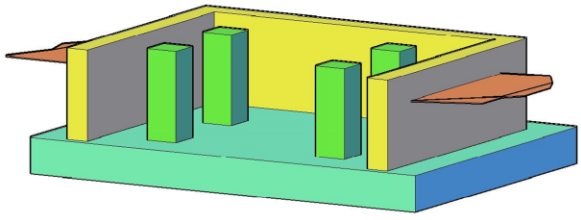
Type of Foundation Systems

COMMON FOUNDATION SYSTEMS



MAT FOOTING

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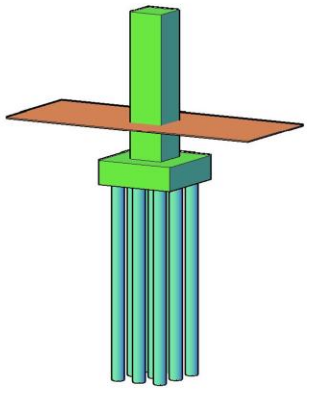
Type of Foundation Systems

COMMON FOUNDATION SYSTEMS



PILE FOUNDATIONS

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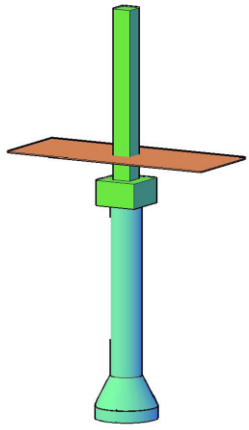
Type of Foundation Systems

COMMON FOUNDATION SYSTEMS



DRILLED PIERS / CAISSONS

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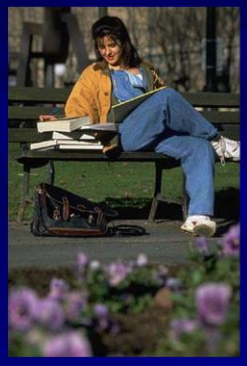
What education is required?



- High School
- College
- Graduate School (optional)

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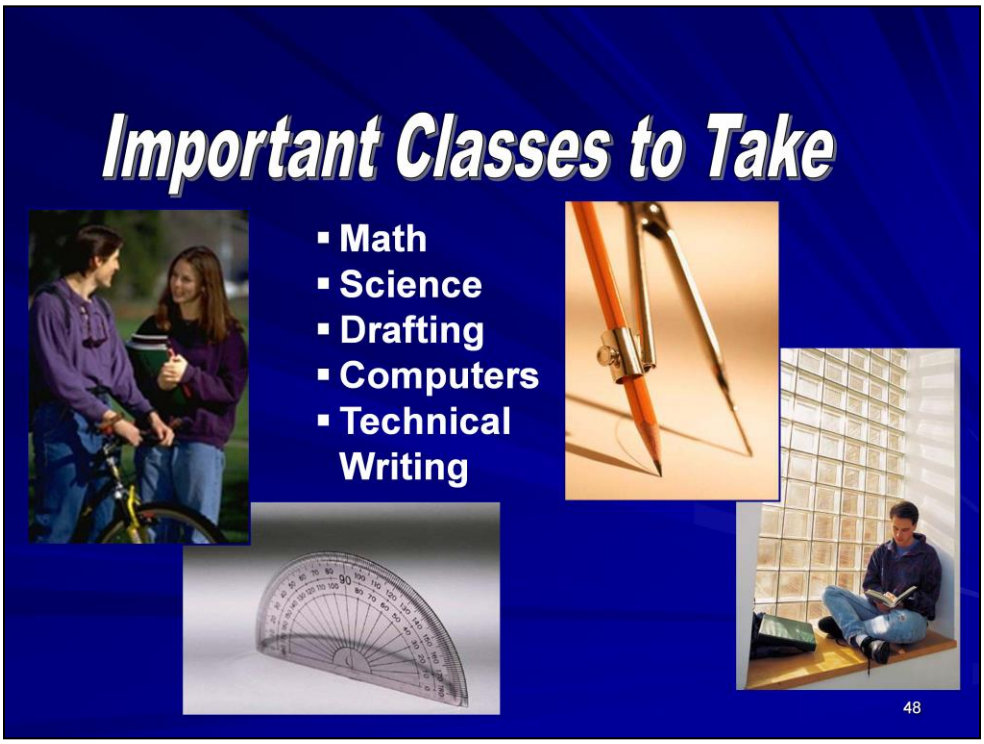

Math – trigonometry, calculus, geometry

Science - physics

1. Stable career – anticipated big demand in the future – significant overhaul of infrastructure required – many bridges in US are structurally deficient.

2. Dynamic industry – a lot of interaction with a variety of individuals on the design and construction teams

3. Sense of Accomplishment – you get to design a building and then see it through construction. For years to come, you can point to that building and say that you're the one who designed the systems that keep it standing. There are few professions outside the construction industry where the fruits of your labor have such a visible impact on society for such a long time.

What's a typical day for a structural engineer?

Calculations...

...Computers

Building Codes...

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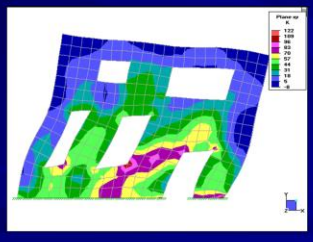
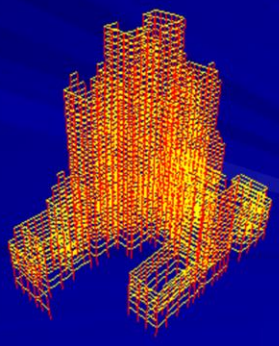
What's a typical day for a structural engineer?

Analysis...





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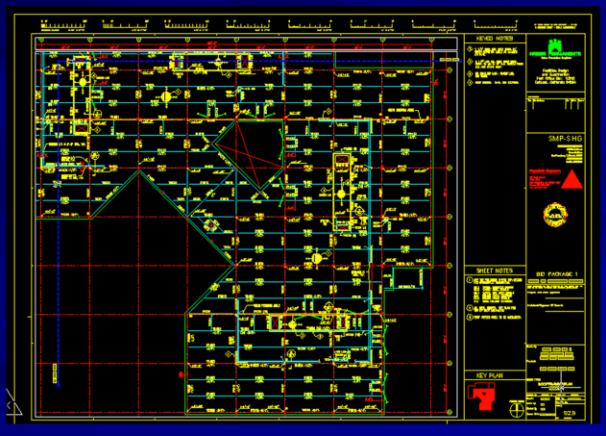
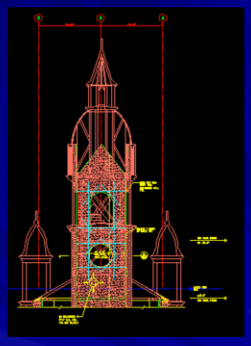
What's a typical day for a structural engineer?

Drawings...





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What's a typical day for a structural engineer?

At Work…

…In Meetings

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What's a typical day for a structural engineer?

At the

Job Site...

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Questions?

- **Special Thanks:**
  - SEAOI
  - NCSEA
  - SEAONC
  - ISE

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