March 6, 2009
Lowell High School

University of Massachusetts Lowell
UMASS

Introduction to Engineering

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Outline

- What is Engineering?
- Scope and Process of Engineering
- Great Engineering Achievements in the 20th Century
- Example of Engineering Design
- Engineering Research Approach
- Summary

What is Engineering?

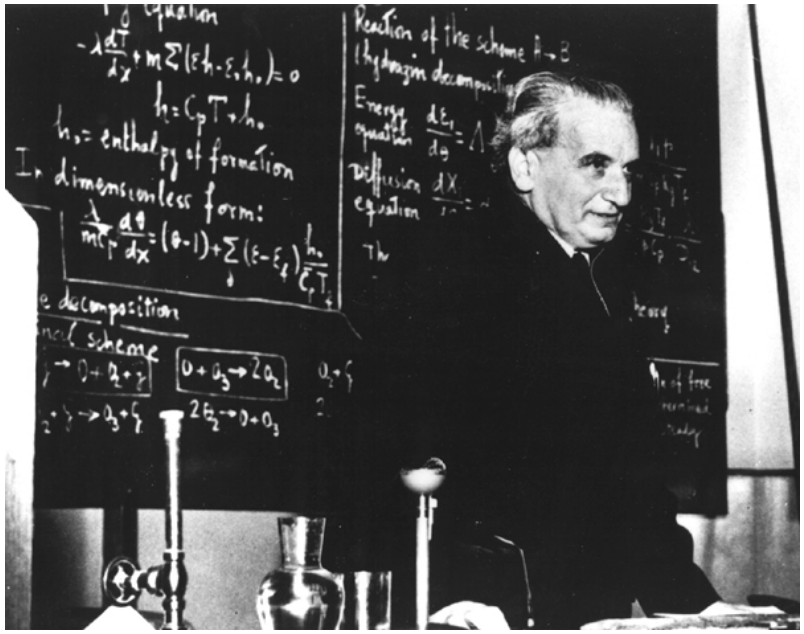
- If it is **green**, it is biology.
- If it **stinks**, it is chemistry.
- If it doesn't work, it is physics.
- If it works but no one knows why, it is **engineering**.

– Anonymous

What is Engineering?

- "The scientist explains that which exists; the engineer creates that which never was."

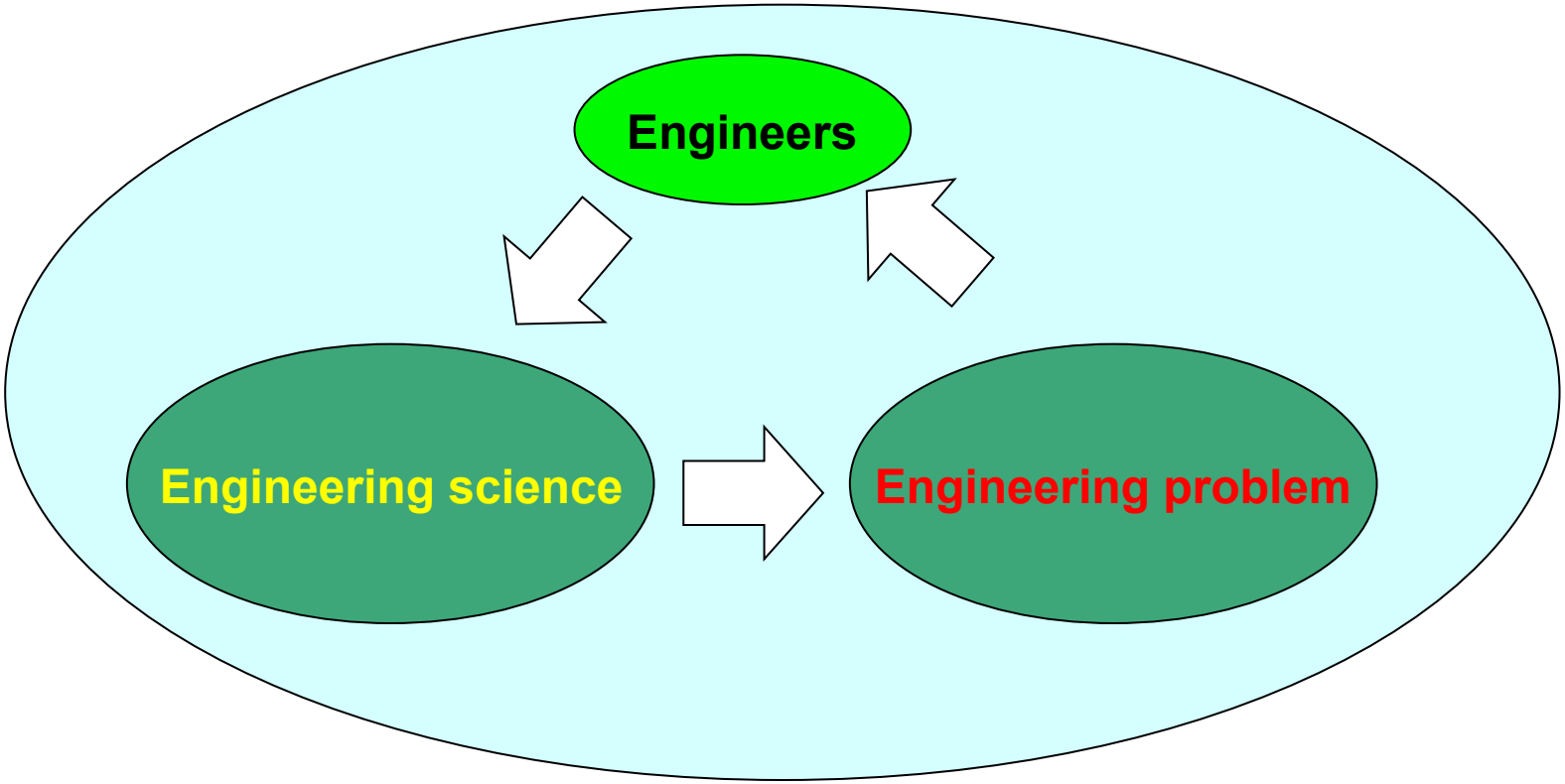
  — Theodore von Karman (1881~1963), a Hungarian-German-American engineer and physicist who was active primarily in the fields of aeronautics and astronautics



von Karman at the California Institute of Technology

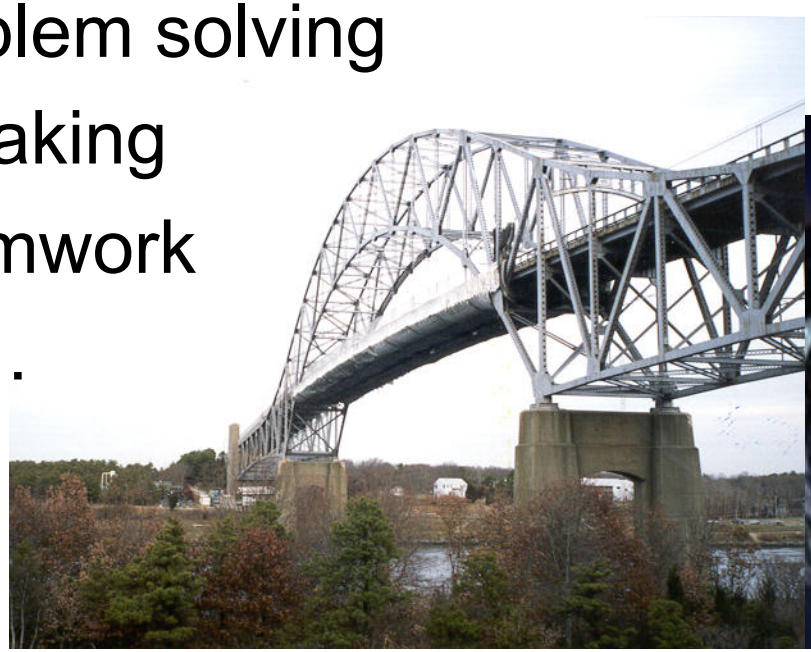
Vortex

What is Engineering?



What is Engineering?

- Engineering involves:
  - Science
  - Math
  - Writing
  - Problem solving
  - Speaking
  - Teamwork
  - etc…



What is Engineering?

- Engineer, as a noun, is from French “to contrive”.
- Engineers: “One who contrives, designs, or invents; an author, designer (const. *of*); also *absol.* an inventor, a plotter, a layer of snares.”

— Oxford English Dictionary

Scope of Engineering

- If Engineering = Problem Solving,
  - Does this mean any problem?
  - or only problems dealing with a technology component?

Process of Engineering

- Invention
- Research
- Design
- Development
- Production/Realization

Cost Cycle

Risk Mitigation

I-35 Minneapolis Bridge Collapse, MN (2007)

Great Engineering Achievements in the 20th Century

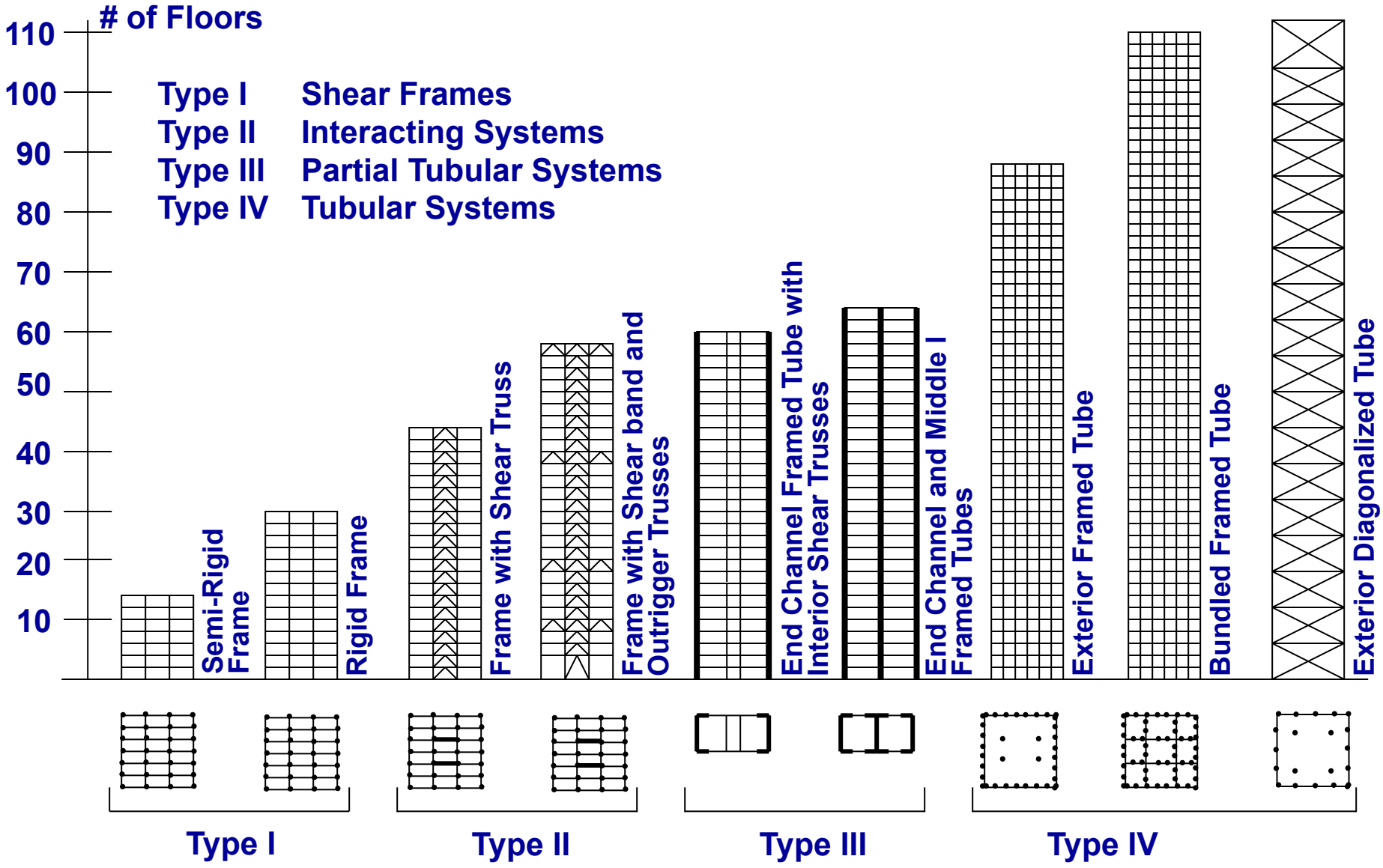
- Electrification
- Automobile
- Airplane
- Safe and abundant water
- Electronics
- Radio and TV
- Agricultural Mechanization
- Computers
- Telephone
- Air Conditioning and Refrigeration
- Interstate Highways
- Space Exploration
- Internet
- Imaging Technologies
- Household Appliance
- Health Technologies
- Petroleum and Gas Technologies
- Laser and Fiber Optics
- Nuclear Technologies
- High Performance Materials

Example of Engineering Design – Design of High-rise Buildings

- A clear classification of high-rise buildings with respect to their structural system is difficult.
- A rough classification can be made with respect to effectiveness in resisting lateral loads.

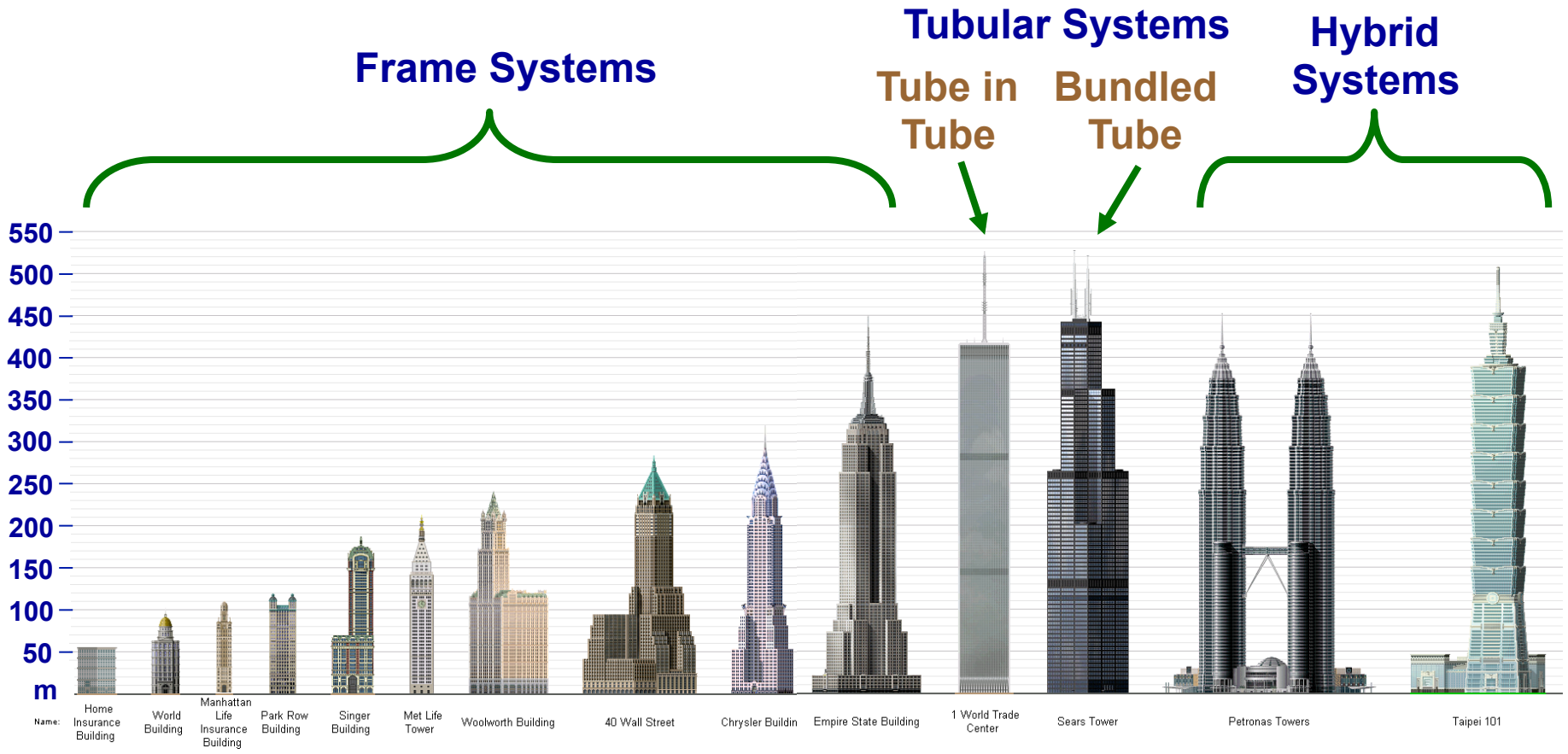
Structural Systems:

- Moment resisting frame systems
- Braced frame, shear wall systems
- Core and outrigger systems
- Tubular systems
  - Framed tubes
  - Trussed tubes
  - Bundled tubes
- Hybrid systems


# of Floors
110
100
90
80
70
60
50
40
30
20
10
Type I Shear Frames
Type II Interacting Systems
Type III Partial Tubular Systems
Type IV Tubular Systems
Semi-Rigid Frame
Rigid Frame
Frame with Shear Truss
Frame with Shear band and Outrigger Trusses
End Channel Framed Tube with Interior Shear Trusses
End Channel and Middle I Framed Tubes
Exterior Framed Tube
Bundled Framed Tube
Exterior Diagonalized Tube
Type I
Type II
Type III
Type IV

Development of Structural Systems

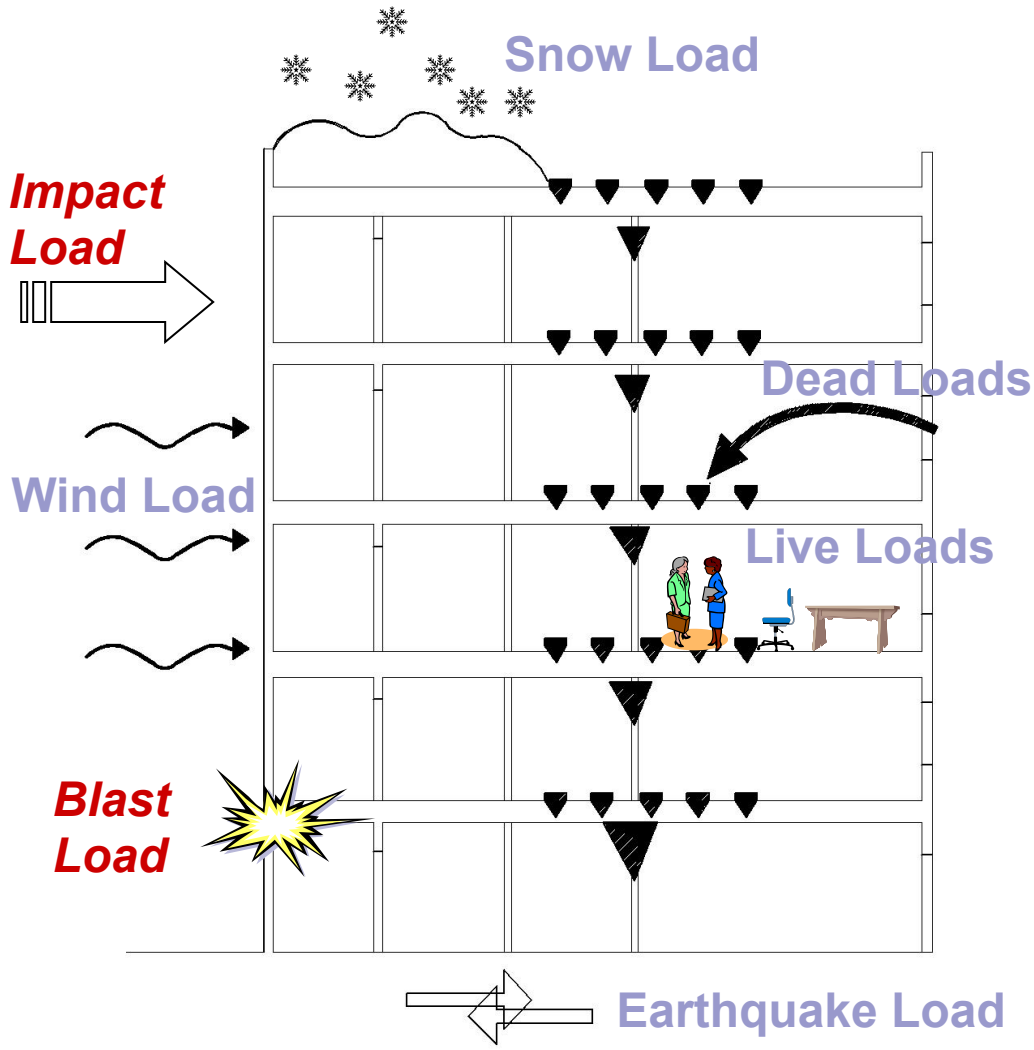
World's Tallest Buildings by Year



(Figure source: www.skyscrapers.com)

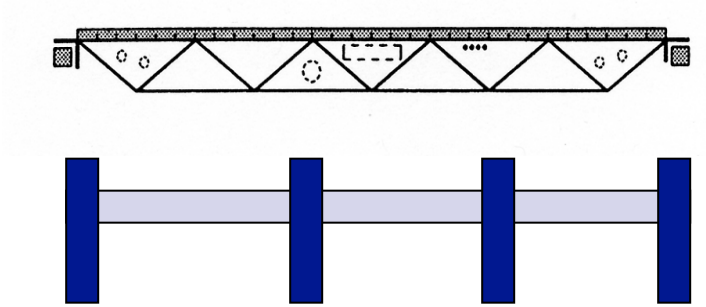
Structural Loads

- Gravity loads
  - Dead loads
  - Live loads
  - Snow loads
- Lateral loads
  - Wind loads
  - Seismic loads
- Special load cases
  - Impact loads
  - Blast loads



Gravity Loads

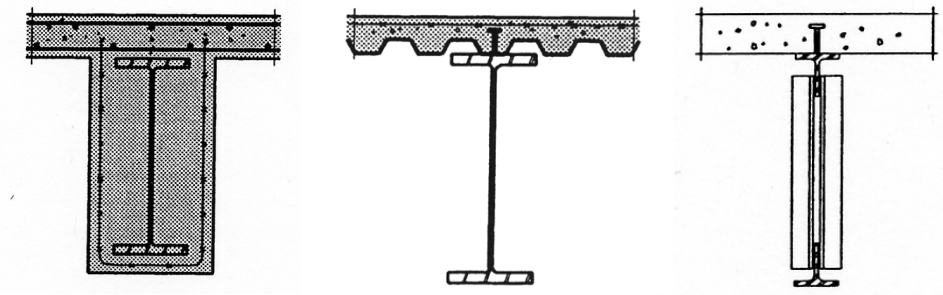
- Floor systems account for a major portion of the gravity loads
- Selection of the floor system may influence structural behavior and resistance
- Structural use plays a major role in selection of the floor system
  - Office buildings
    - large simply supported spans
  - Residential and hotel buildings
    - short continuous spans



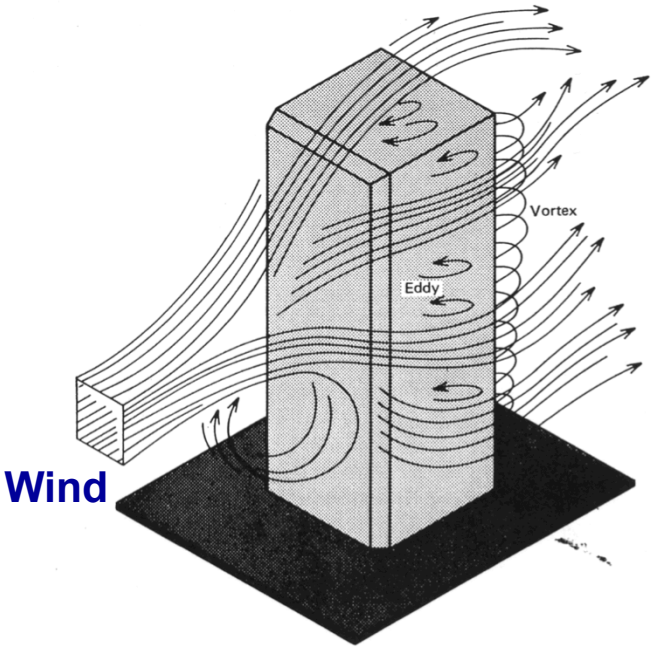
Types of floor systems

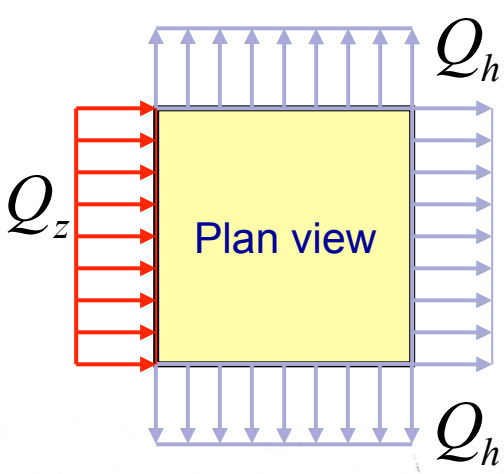
- Concrete
- Steel
- Composite
- Prestressed concrete

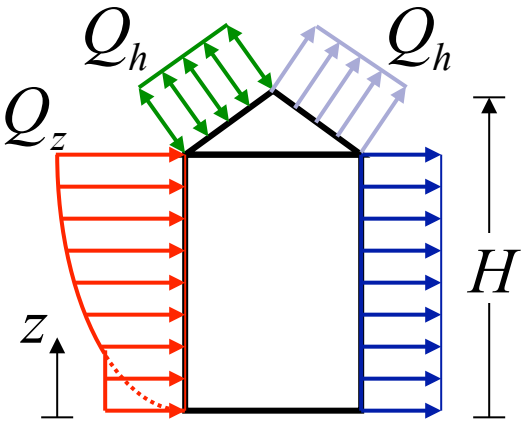
Composite floor systems



Wind Loads

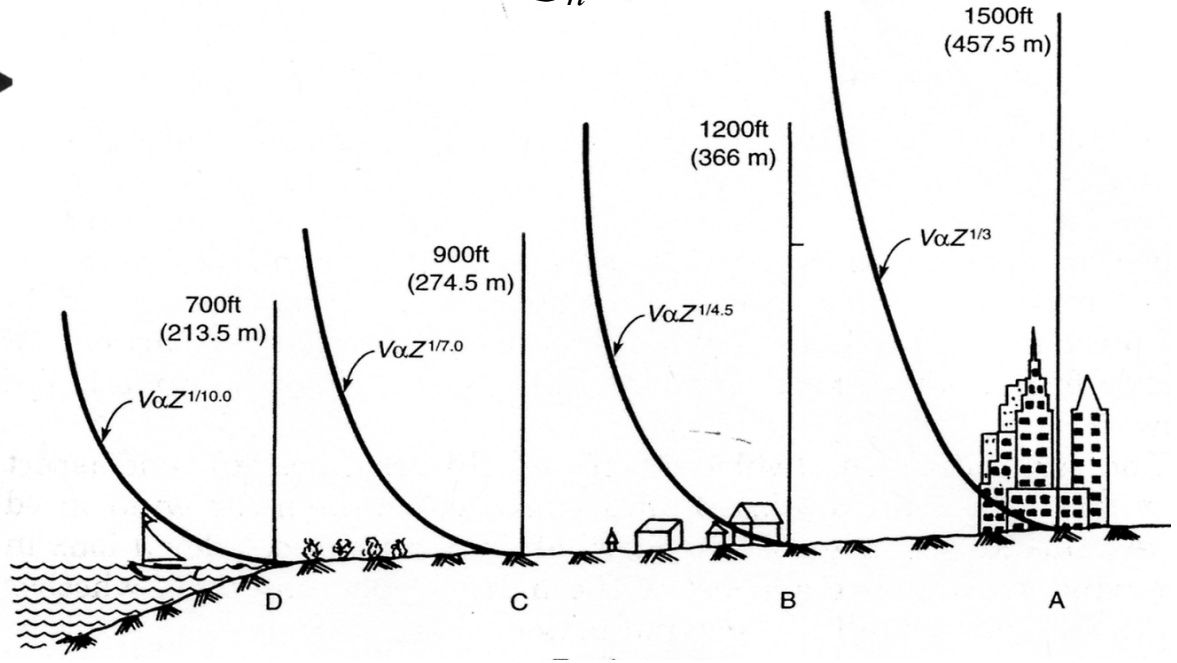




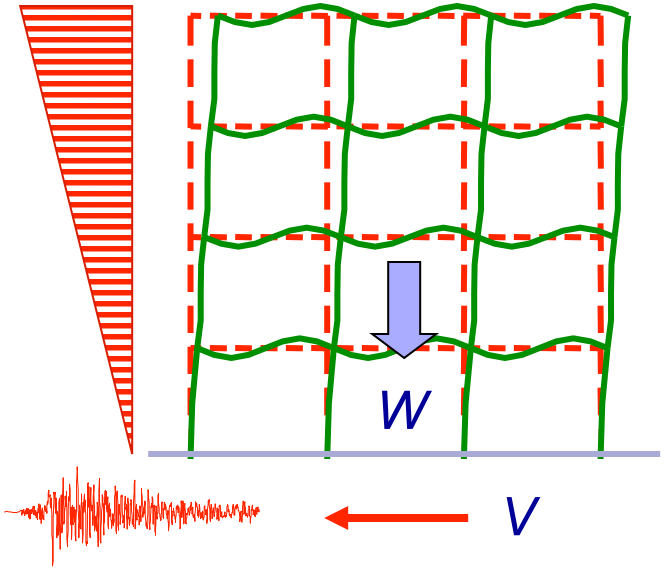


$$Q_z = KV^2I$$

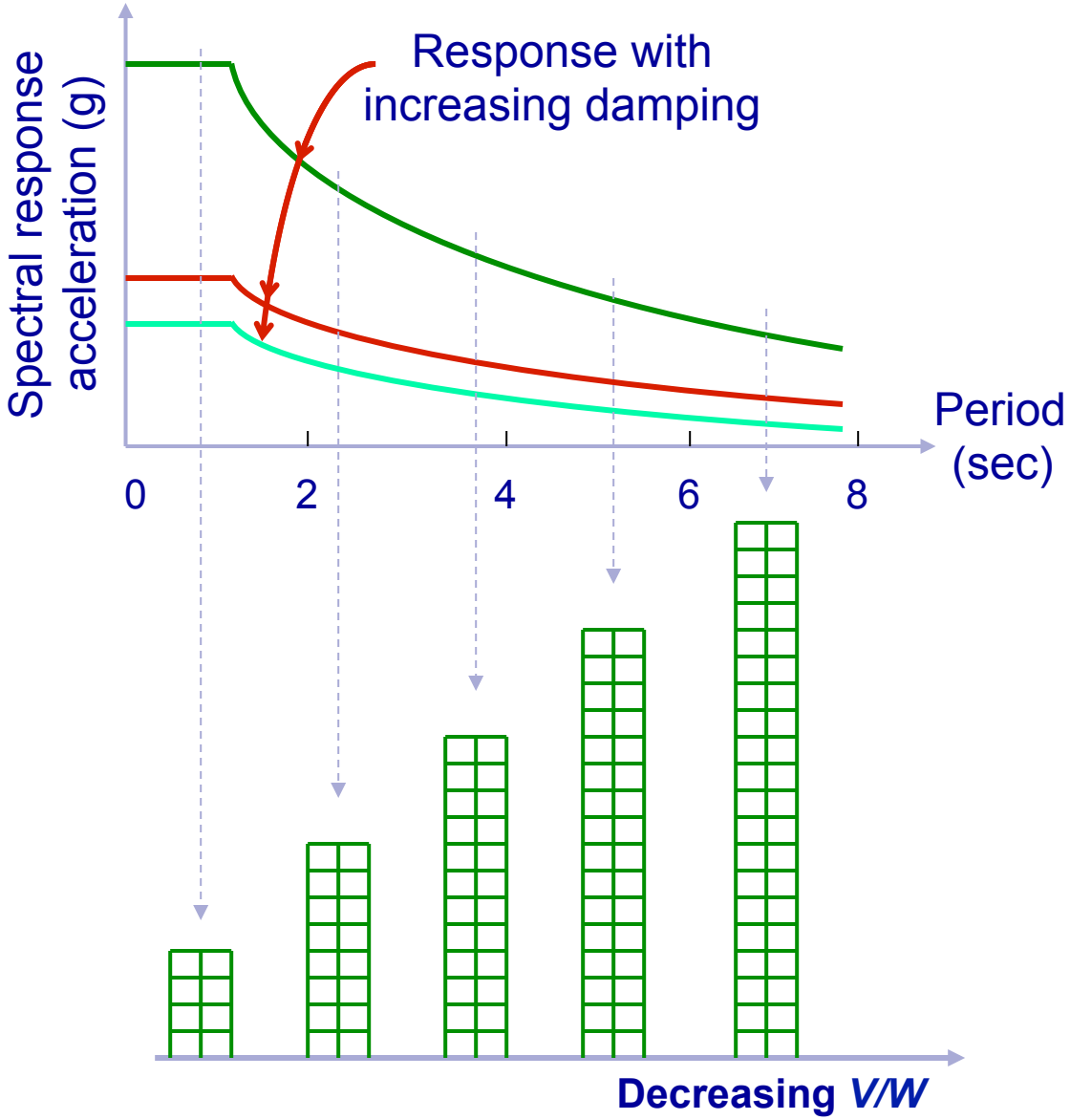
$$Q_h = Q_z\big|_{z=H}$$



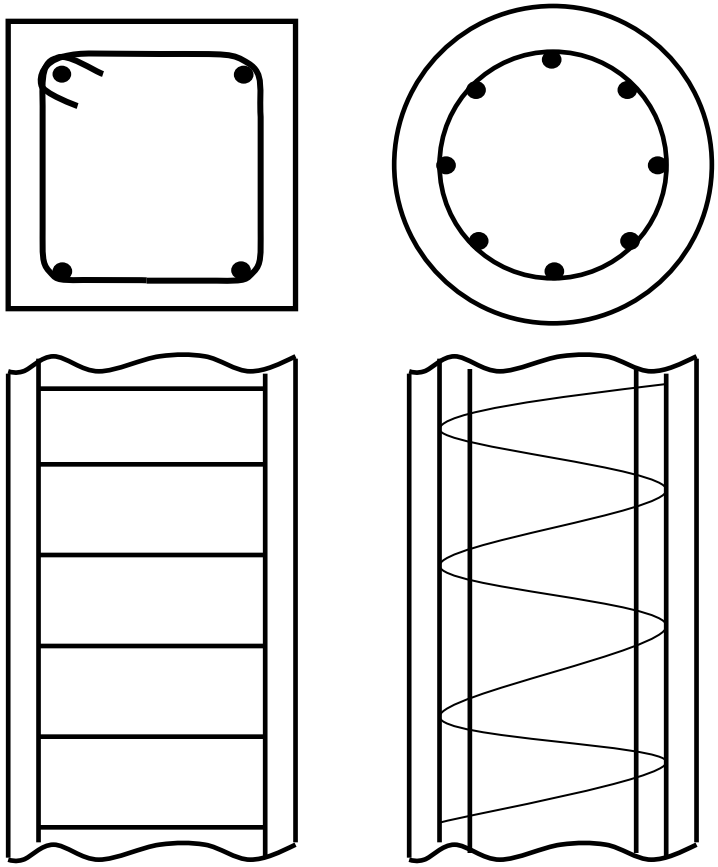
Seismic Loads

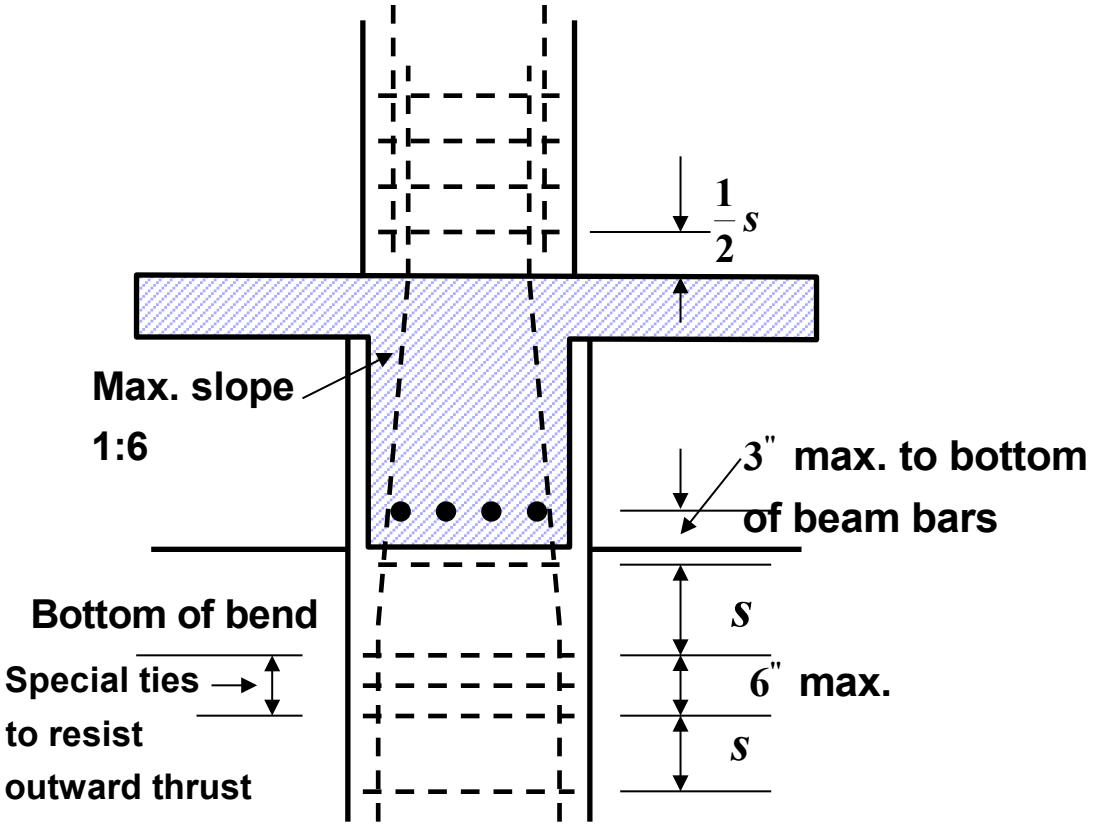


$$V = C_s \text{¥} W$$



Final Design –
Design of Member Dimensions





Construction – Before

Royal Albert Bridge, UK (1859)

Construction – Now

Lavant viaduct (Talubergang P19 Lavant), Austria (1985)

Steps in Engineering Research

- Observe
- Simplify
- Analyze
- Model
- Experiment

Engineering Research Approaches

- Theoretical investigation (e.g., formulation, derivation, proof)

$$S\left(\bar{r}_{s,j},t\right)=\frac{1}{R_{s,j}^{2}}\int_{\omega_c-\pi B}^{\omega_c+\pi B}d\omega\cdot\exp\left[i\omega t\right]$$

$$F\left(\xi,t-\frac{R_s}{t}\right)=C_{bp}\cdot\frac{\partial}{\partial t}D\left(\xi,t-\frac{R_s}{t}\right)$$

$$D\left(\xi,t-\frac{R_s}{t}\right)=\int_0^{R_s}d\bar{r}_j\int_0^{2\pi}d\phi_i\cdot G\left(\bar{r}_j,\phi_i\right)S\left(\bar{r}_{s,j},t\right)$$

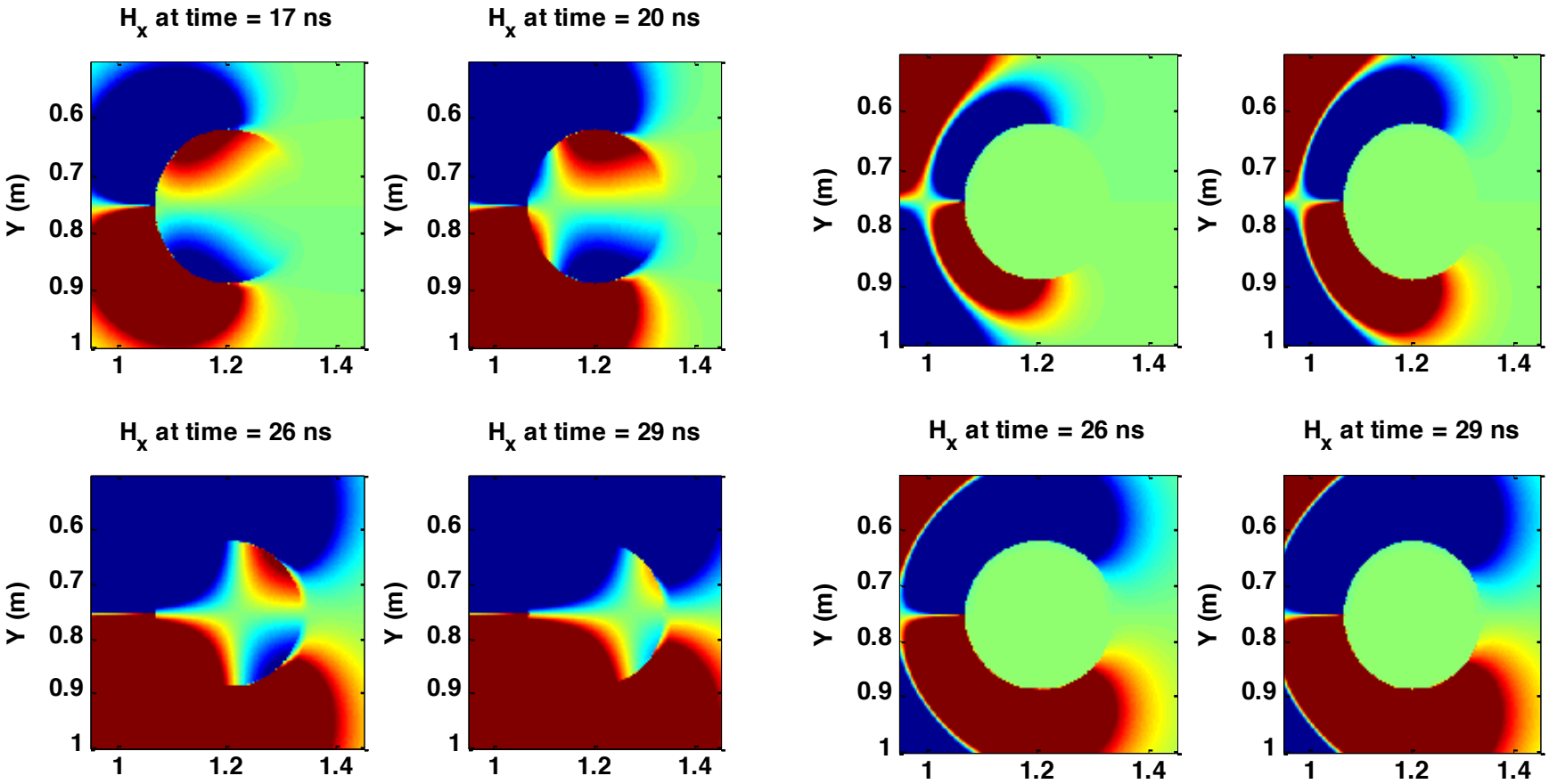
$$\frac{\partial}{\partial t}D\left(\xi,t-\frac{R_s}{t}\right)=\frac{\partial}{\partial t}\int_0^{t-\frac{R_s}{t}}dt'\cdot D\left(\xi,t-\frac{R_s}{t}\right)\cdot M\left(t-t'\right)$$

$$=\int_0^{t-\frac{R_s}{t}}dt'\cdot D\left(\xi,t-\frac{R_s}{t}\right)\cdot\frac{\partial}{\partial t}M\left(t-t'\right)$$

$$I\left(r,\phi\right)=\int_0^{R_s\theta_{\text{int}}}d\xi\cdot F\left(\xi,t-\frac{R_s}{t}\right)$$

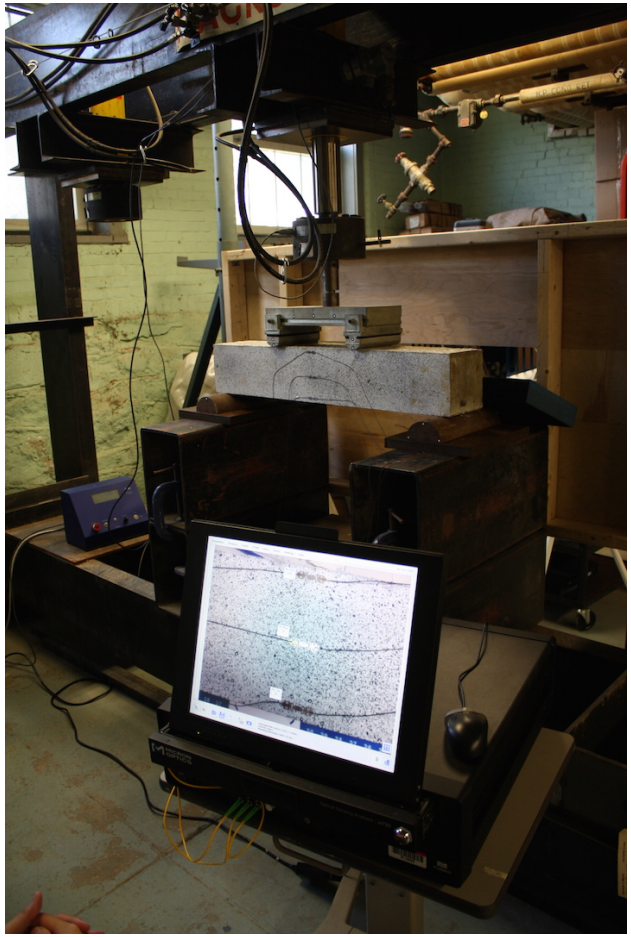
Engineering Research Approaches

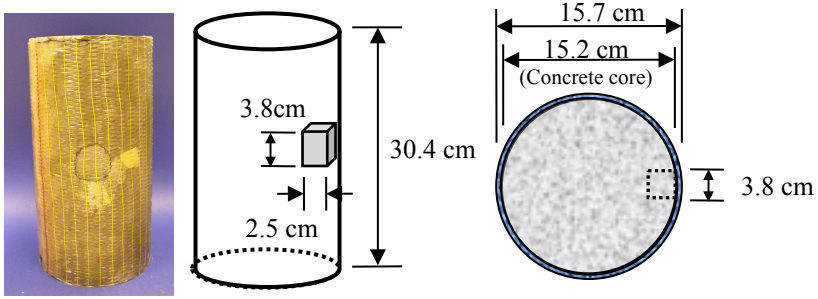
- Numerical Simulation

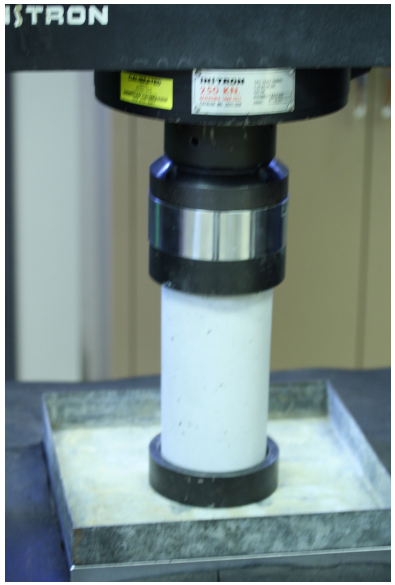


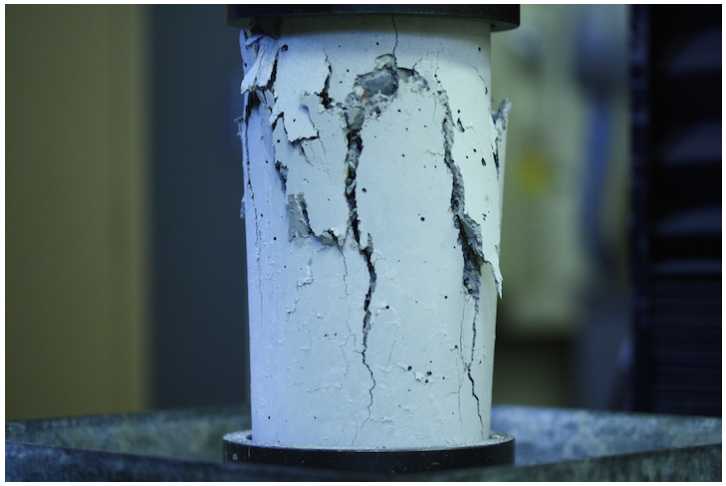
Engineering Research Approaches

- Experimentation









Summary

- Engineering is the backbone of every civilization.
- Engineering is an applied science.
- Engineering includes a number of very diverse disciplines. Each discipline usually includes several specialized areas. → *Engineers are differentiated by the material or the structure or the property they study.*
- Engineering is about how to make things or how to make things work, which is very practical.
- For whichever research topic engineers investigate, there must be a practical problem behind it.
- Good engineers must have learned from their practical experience.