Chapter 2

INTRODUCTION

2.1 Structural Engineering

1 Structural engineers are responsible for the detailed analysis and design of:

Architectural structures: Buildings, houses, factories. They must work in close cooperation with an architect who will ultimately be responsible for the design.

Civil Infrastructures: Bridges, dams, pipelines, offshore structures. They work with transportation, hydraulic, nuclear and other engineers. For those structures they play the leading role.

Aerospace, Mechanical, Naval structures: aeroplanes, spacecrafts, cars, ships, submarines to ensure the structural safety of those important structures.

2.2 Structures and their Surroundings

2 Structural design is affected by various environmental constraints:

1. Major movements: For example, elevator shafts are usually shear walls good at resisting lateral load (wind, earthquake).
2. Sound and structure interact:
   - A **dome** roof will concentrate the sound
   - A **dish** roof will diffuse the sound
3. Natural light:
   - A flat roof in a building may not provide adequate light.
   - A Folded plate will provide adequate lighting (analysis more complex).
   - A bearing and shear wall building may not have enough openings for daylight.
   - A Frame design will allow more light in (analysis more complex).
4. Conduits for cables (electric, telephone, computer), HVAC ducts, may dictate type of floor system.
5. Net clearance between columns (unobstructed surface) will dictate type of framing.

2.6 Structural Analysis

12 Given an **existing** structure subjected to a certain load determine internal forces (axial, shear, flexural, torsional; or stresses), deflections, and verify that no unstable failure can occur.

13 Thus the basic structural requirements are:

Strength: stresses should not exceed critical values: $\sigma < \sigma_f$

Stiffness: deflections should be controlled: $\Delta < \Delta_{max}$

Stability: buckling or cracking should also be prevented

2.7 Structural Design

14 Given a set of forces, **dimension** the structural element.

Steel/wood Structures Select appropriate section.

Reinforced Concrete: Determine dimensions of the element and internal reinforcement (number and sizes of reinforcing bars).

15 For **new structures**, **iterative** process between analysis and design. A preliminary design is made using **rules of thumbs** (best known to Engineers with design experience) and analyzed. Following design, we check for

Serviceability: deflections, crack widths under the applied load. Compare with acceptable values specified in the design code.

Failure: and compare the failure load with the applied load times the appropriate factors of safety.

If the design is found not to be acceptable, then it must be modified and reanalyzed.

16 For **existing structures rehabilitation**, or verification of an old infrastructure, analysis is the most important component.

17 In summary, analysis is always required.

2.8 Load Transfer Elements

18 From Strength of Materials, Fig. 2.1

Axial: cables, truss elements, arches, membrane, shells

Flexural: Beams, frames, grids, plates

Torsional: Grids, 3D frames

Shear: Frames, grids, shear walls.