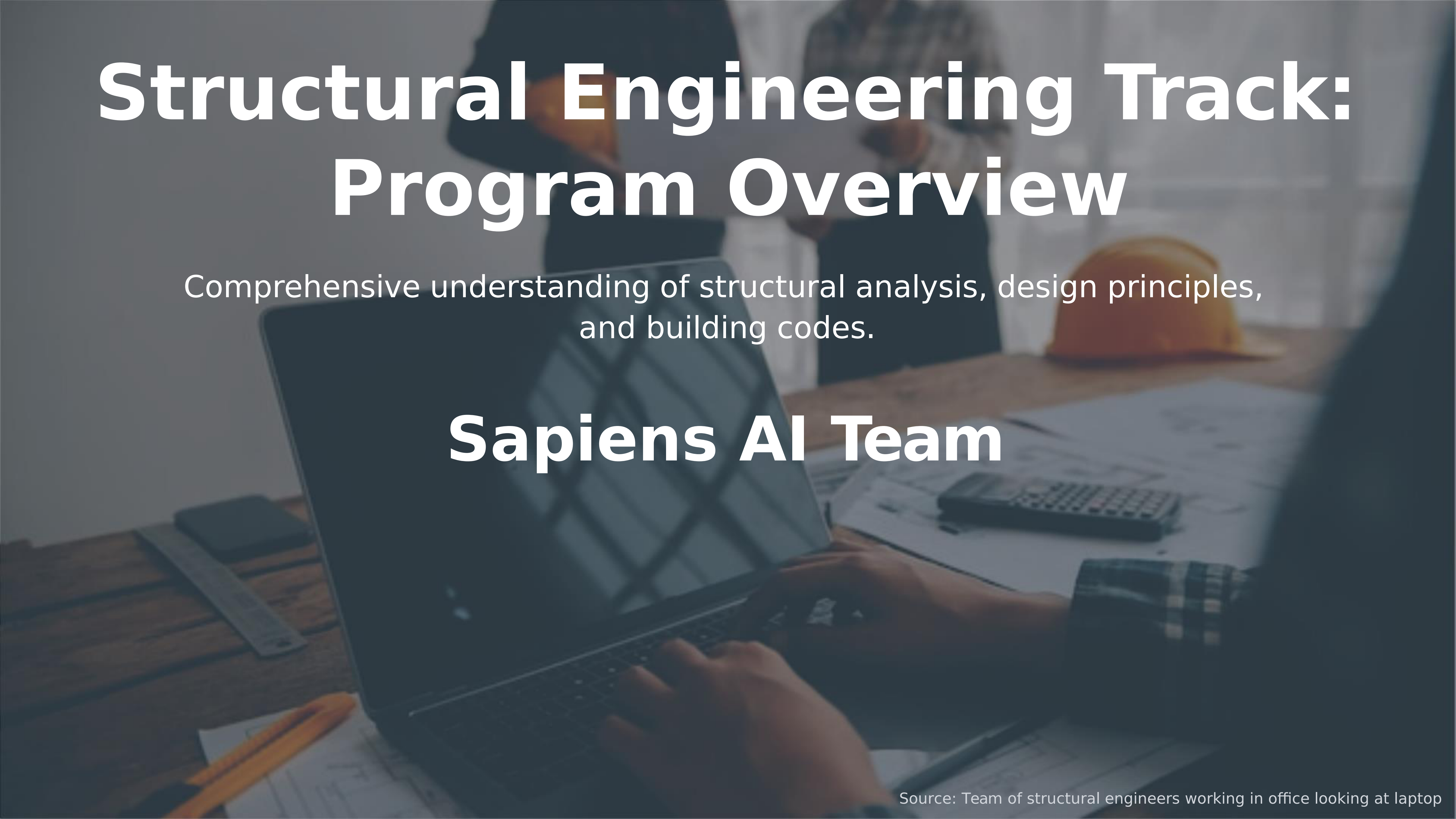
Structural Engineering Track: Program Overview

Comprehensive understanding of structural analysis, design principles, and building codes.

Sapiens AI Team

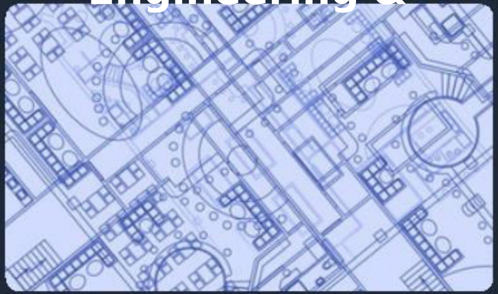


Source: Team of structural engineers working in office looking at laptop

Phase 1: Foundational & Core Concepts - Month 1

Week 1

Introduction to Structural Engineering &



- **Core Principles:** Understanding fundamental concepts and real-world applications.
- **Structural Behavior:** Overview of how structures behave under different conditions.
- **Design Process:** Introduction to the iterative process of structural design.

Week 2

Types of Loads & Load Combinations

- **Load Classification:** Identifying various loads (Dead, Live, Wind, Seismic).
- **Code Compliance:** Determining loads as per industry-standard building codes.
- **Load Combinations:** Combining loads to ensure structural safety and integrity.

Week 3

Analysis of Beams - Shear Force & Bending Moment

- **Beam Fundamentals:** Understanding beam types and their structural roles.
- **SFD & BMD:** Derivation and application of Shear/Bending Moment Diagrams.
- **Internal Forces:** Analyzing stresses within beams under various loads.

Week 4

Analysis of Trusses & Software Introduction

- **Truss Principles:** Understanding the mechanics and stability of truss structures.
- **Analysis Methods:** Introduction to methods for analyzing forces in truss members.
- **Software Overview:** Exposure to industry-standard structural analysis software.

Structural Fundamentals & Basic Analysis

Role of the Structural Engineer

Structural engineers are pivotal in ensuring the **safety, stability, and integrity** of structures against various loads and environmental conditions.

- **Design & Analysis:** Applying mechanics to design elements that can withstand anticipated loads.
- **Load Determination:** Assessing dead, live, wind, and seismic forces per building codes.
- **Material Selection:** Advising on materials like reinforced concrete and steel.
- **Code Compliance:** Ensuring designs

Common Structural Types

Structures vary widely, each engineered for specific purposes. Understanding these types is fundamental to design.

- **Buildings:** Residential, commercial, and industrial structures using beam-column systems.
- **Bridges:** Structures like beam, arch, and truss bridges designed to span obstacles.
- **Dams & Retaining Walls:** Massive structures holding back water or earth, often using reinforced concrete.
- **Industrial Structures:** Specialized frameworks, towers, and tanks for industrial processes.

Fundamental Mechanics & Behavior

Basic Mechanics Principles

- **Stress (σ):** Internal force per unit area.
- **Strain (ε):** Deformation per unit length.
- **Modulus of Elasticity (E):** Material's stiffness, ratio of stress to strain.

Structural Determinacy & Stability

- **Determinacy:** If forces can be found using static equilibrium equations.
- **Stability:** Ability to resist collapse and maintain geometric configuration.

Loads and Load Combinations

Understanding Dead Loads (DL)

Dead loads are permanent, static forces from the structure's own weight and fixed components.

- **Characteristics:** Constant magnitude and location.
- **Examples:** Weight of walls, floors, roofs, and fixed equipment.

Permanent | Static | Self-Weight

Understanding Live Loads (LL)

Live loads are variable, movable forces from occupancy, furniture, and non-fixed equipment.

- **Characteristics:** Dynamic, varying with use.
- **Examples:** People, movable partitions, vehicles, and stored materials.

Variable | Movable | Occupancy

Environmental Loads: Wind & Seismic

Wind Loads

Forces from moving air, causing pressure and suction. Critical for tall or exposed structures.

Seismic Loads

Inertial forces from ground motion during earthquakes, dependent on mass and stiffness.

Load Combinations (ASCE 7)

Engineers use standardized load combinations from codes like ASCE 7 to find the worst-case scenario for design, applying load factors to ensure safety against various simultaneous forces.

Critical Scenarios | ASCE 7 | Load Factors

Practical Application: Load Calculation & Combination

Example for an office building floor using ASCE 7 Strength Design combinations:

Nominal Loads (Calculated/Specified)

- Dead Load (DL): **180 psf**
- Live Load (LL): **50 psf**

Example Load Combinations (Factored)

- `1.2D + 1.6L`: 1.2(180) + 1.6(50) = **296 psf**
- `1.2D + 1.6S + 0.5L`: 1.2(180) + 1.6(30) + 0.5(50) = **289 psf**

Analysis of Beams & Trusses

Beam Analysis: SFD & BMD

Beam Types & Support Reactions

- **Beam Types:** Simply Supported (pin/roller), Cantilever (fixed/free), and Fixed-End (high stiffness).
- **Support Reactions:** Forces maintaining equilibrium. A roller has 1 reaction, a pin has 2, and a fixed support has 3 (two forces and a moment).

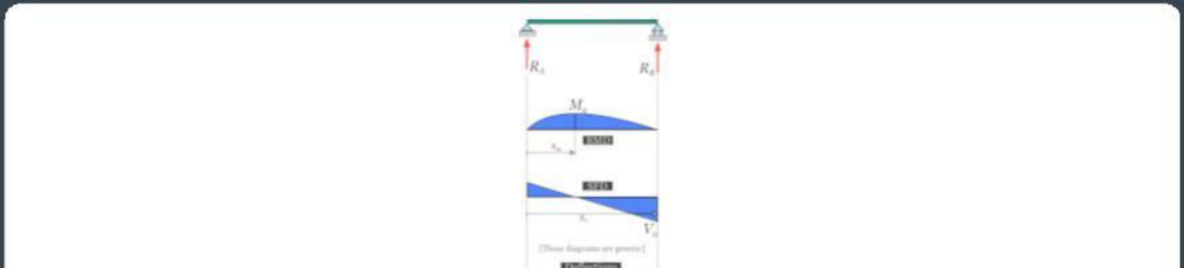
Simply Supported | Cantilever | Fixed | Reactions

Constructing SFD/BMD

Graphical plots of internal shear forces and bending moments, critical for locating maximum stress points for design.

- **SFD:** Varies with applied loads, showing shear distribution.
- **BMD:** Its slope is the shear force. Maximum moment often occurs where shear is zero.

Shear | Moment | Design



Truss Analysis: Joints & Sections

Truss Assumptions & Types

Assumptions include pin-connected joints and loads applied only at joints, resulting in members acting purely in tension or compression.

- **Common Types:** Pratt (efficient for bridges), Howe (for roofs), and Warren (equilateral triangles).

Axial Forces | Pratt | Howe | Warren

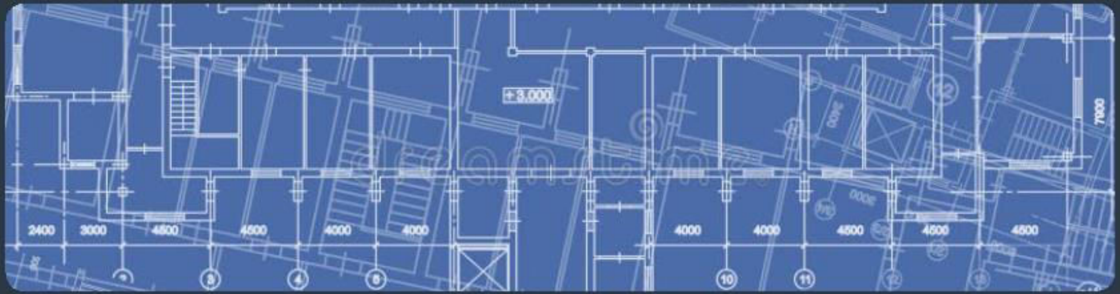
Methods for Force Calculation

- **Method of Joints:** Solves equilibrium (ΣFx=0, ΣFy=0) at each joint. Ideal for finding forces in all members.
- **Method of Sections:** Cuts the truss and uses equilibrium equations on the section. Efficient for finding forces in specific members.

Tension | Compression | Equilibrium

Phase 1: Foundational & Core Concepts - Month 2

Week 5: Analysis of Frames



Focus on indeterminate frames, exploring classical and modern methods for analyzing these complex, rigidly connected systems common in buildings.

- **Indeterminacy:** Understand structures where basic equilibrium is insufficient.
- **Classical Methods:** Intro to Slope-Deflection & Moment Distribution.
- **Matrix Methods:** Conceptual basis for computer-based analysis.

Indeterminate · Slope-Deflection · Moment-Distribution

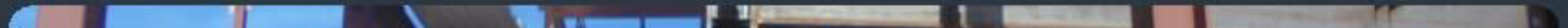
Week 6: Design of RC Structures

Dive into designing with reinforced concrete, a composite material leveraging concrete's compression strength and steel's tension strength.

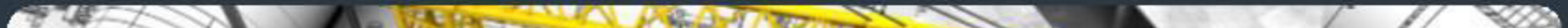
- **Material Properties:** Behavior of concrete and steel reinforcement.
- **Strength Design:** Apply Limit State Design (LRFD) for ultimate capacity.
- **Serviceability:** Control deflection and crack widths for durability.

Concrete · Rebar · Flexure · Shear

Week 7: Design of Steel Structures



Week 8: Dynamics & Building Codes



Frame Analysis & Material Design Basics

Determinate Frame Analysis

Types of Frames & Support Reactions

Determinate Frames: Unknown forces can be found using only static equilibrium equations ($\Sigma F_x=0$, $\Sigma F_y=0$, $\Sigma M=0$).

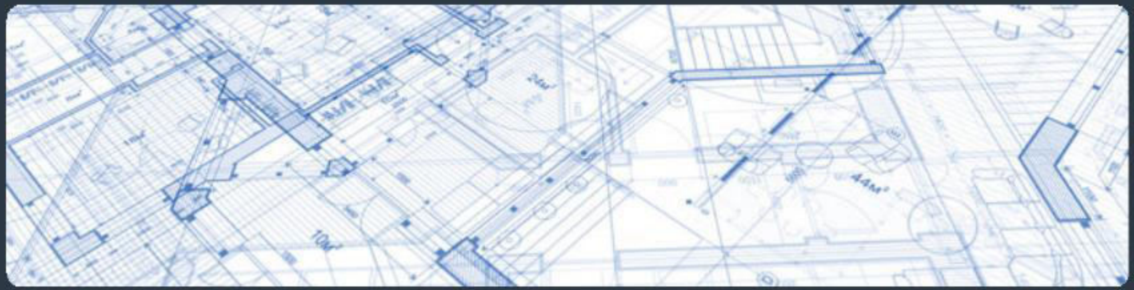
Support Reactions: Understanding reactions from Roller (1), Pin (2), and Fixed (3) supports is crucial.

SFD & BMD for Determinate Frames

The principles for Shear Force Diagrams (SFD) and Bending Moment Diagrams (BMD) extend to individual frame members.

These diagrams are essential for locating points of maximum stress, which dictates design requirements.

Determinate Equilibrium Reactions Shear Moment Internal Forces



Introduction to RC & Steel Design

Reinforced Concrete (RC)

A composite where concrete resists compression and steel rebar resists tension.

Flexural design (Strength Method) ensures the beam's capacity exceeds factored design loads.

Structural Steel

Known for its high strength-to-weight ratio and ductility.

Design considers failure modes like yielding, fracture (for tension), and buckling (for compression/flexure).

Concrete Rebar Tension Compression Ultimate Strength Ductility Yielding Buckling

Comparative Material Strengths for Design

Understanding characteristic strengths is foundational for effective design. This chart highlights typical values used in engineering for concrete's compressive strength (f'c) and steel's yield strength (Fy).

Structural Dynamics & Building Codes

Structural Dynamics

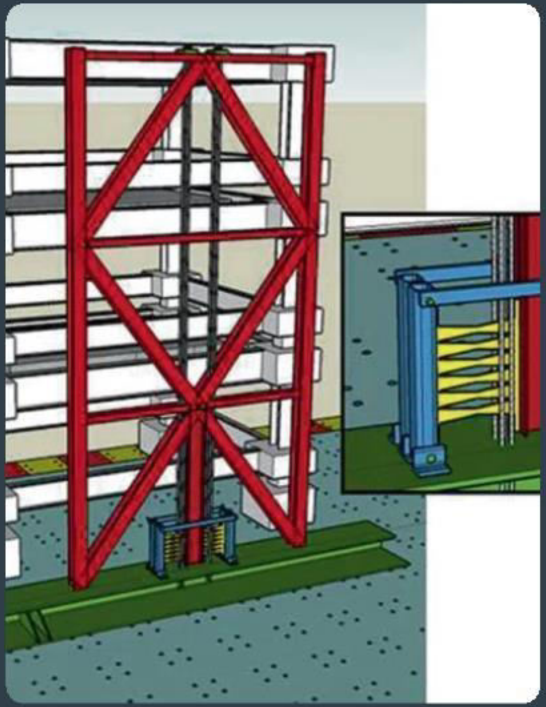
Examines the behavior of structures subjected to time-varying loads, considering inertial forces and vibrational characteristics.

Key Concepts

- **Mass:** Resists changes in motion.
- **Stiffness:** Resistance to deformation.
- **Damping:** Dissipates vibrational energy.

SDOF Systems

Simplifies a structure to a single mass-spring-dashpot system to understand fundamental behaviors like natural frequency and resonance.



Dynamic Loads | Inertia | Vibration | Frequency | Resonance

Building Codes & Safety Standards

Legal documents establishing minimum requirements to protect public health, safety, and welfare by translating engineering principles into regulations.

Role of Codes

- **Public Safety:** Prevent structural failures.
- **Uniformity:** Ensure consistent construction quality.
- **Resilience:** Resist extreme events.

Key Standards

- **IBC:** International Building Code (USA).
- **Eurocodes:** Harmonized rules for Europe.
- **IS Codes:** Indian Standards.

Safety | Regulations | IBC | Eurocodes | IS Codes | Compliance

Phase 2: Industry Immersion & Capstone Project

Week 9

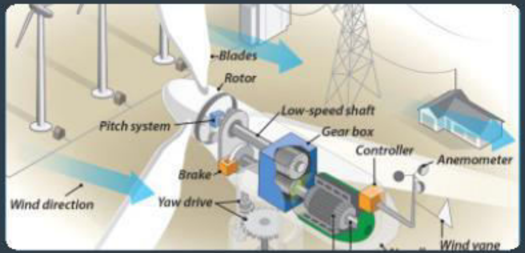
Project Kick-off & Load Calculation

This week initiates the capstone project, defining its scope and objectives. A critical first step involves detailed load calculation for the chosen structural system, applying parameters from building codes.

Scoping · Load Paths · Code Compliance

Week 10

Software-Based Analysis & Verification



This week focuses on advanced structural analysis using industry-standard software. It involves gaining hands-on experience and critically verifying software-generated results against manual checks to ensure accuracy.

FEA · Modeling · Simulation · Validation

Week 11

Structural Design & Code Checks

This week is dedicated to the practical structural design of components in RC or Steel, based on analysis results. It requires continuous adherence to building codes and material specifications for safety and constructability.

Sizing · Detailing · Materials · Durability

Week 12

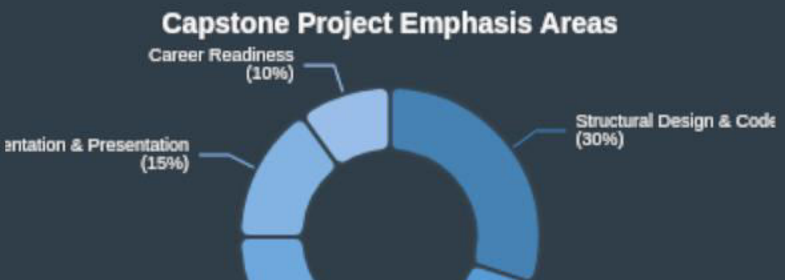
Documentation, Presentation & Career Prep

The final week focuses on compiling a comprehensive design report, delivering a professional technical presentation, and engaging in targeted career development workshops for resume building and interview skills.

Reporting · Communication · Licensure

Capstone Project: Holistic Focus Areas

The Capstone Project synthesizes all learned concepts, requiring a balanced allocation of effort across various critical areas to ensure a successful outcome and prepare for real-world engineering challenges. This breakdown illustrates the interconnected nature of project phases.



Capstone Mini Project & Career Development

Capstone Mini Project: Concept to Output

Comprehensive Design & Analysis

The capstone project culminates your learning, challenging you to undertake the comprehensive analysis and design of a simple beam or frame, applying knowledge of mechanics, loads, and material design.

Professional Deliverables: Reports & Drawings

A core component is preparing professional design reports and structural drawings, emphasizing clarity, accuracy, and industry best practices for all technical documentation.

Final Project Presentation: Showcasing Expertise

Showcase your design process and results in a final presentation, honing your ability to articulate complex engineering concepts effectively to a professional

Career Development: Launching Your Path

Resume Building & LinkedIn Optimization

Dedicated workshops will equip you to craft compelling resumes and optimize your LinkedIn profile to build a strong professional brand and attract employers.

Mock Interviews & Licensing Guidance

Gain confidence through interactive mock interviews with constructive feedback. Receive insights on preparing for professional certifications like the SE licensing exams.