

Introduction to Bridge Engineering

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Key concepts, typical bridge types, design process, and essential considerations

1. What Is Bridge Engineering?

- **Definition:** A sub-discipline of civil engineering focused on the planning, analysis, design, construction, maintenance, and rehabilitation of bridges.
- **Goals:**
 - Provide safe, reliable, and economical crossing over obstacles (roads, railways, water, valleys).
 - Minimize environmental impact and lifecycle costs.
 - Accommodate current and future traffic loads and service requirements.

2. Fundamental Forces & Loads

Load Type	Description	Typical Design Values
Dead Load	Weight of the bridge itself (superstructure, substructure, deck, utilities).	Calculated from material densities and geometry.
Live Load	Vehicles, pedestrians, trains, or temporary construction loads.	Highway: AASHTO HL-93, HS-20, etc.; Rail: Cooper E-80, etc.
Environmental Loads	Wind, seismic, thermal expansion, flood, ice, snow, water currents.	Code-specified spectra (e.g., ASCE 7 for wind, IBC/Eurocode for seismic).
Special Loads	Impact, blast, ship collision, ship impact, ship anchor, etc.	Project-specific, often based on risk assessments.

Load combinations are prescribed by design codes (AASHTO LRFD, Eurocode 1, etc.) to ensure safety under worst-case scenarios.

3. Common Bridge Types

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Type	Typical Span Range	Main Structural System	Typical Applications
Beam / Girder	< 30?m	Simple steel, concrete, or composite girders supporting a deck.	Highway overpasses, short river crossings.
Truss	30?–?150?m	Triangular web of members (steel or timber) that transfer loads axially.	Rail bridges, historic structures.
Arch	30?–?300?m	Compression arch (steel, concrete, masonry) with deck supported by hangers or spandrels.	Aesthetic crossings, deep valleys.
Cable?Stayed	100?–?2,500?m	One or more towers; deck supported by cables directly attached to towers.	Long?span highway/rail bridges, iconic landmarks.
Suspension	> 300?m (up to >?2? km)	Main cables draped over towers, vertical suspenders support the deck.	Very long spans, iconic bridges.
Movable (Bascule, Lift, Swing)	Varies	Mechanisms allow deck to open for marine traffic.	Navigation channels, ports.
Hybrid/Innovative	Varies	Combination of systems (e.g., arch ?cable, truss?cable).	Site?specific constraints, aesthetic goals.

4. Design Process Overview

1. Pre?Feasibility & Site Investigation

- Topography, geology, hydrology, environmental constraints.
- Traffic forecasts, clearance requirements, utility locations.

2. Conceptual Design

- Select bridge type based on span, site conditions, budget, aesthetics.

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- Rough sizing of main elements (e.g., girder depth, arch rise).

3. Preliminary Structural Analysis

- Simple hand calculations or spreadsheet models to verify feasibility.
- Evaluate load paths, estimate member forces.

4. Detailed Design & Analysis