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Selecting the Right Bridge Type

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Module 1: Introduction

Learning Objectives

By the end of this section, you will be able to:

- **Identify** the primary drivers and constraints that dictate bridge type selection.
- **Evaluate** how owner preferences and environmental commitments influence span arrangements.
- **Analyze** the impact of existing site constraints, such as railroads and roadways, on cost-effective design.

Executive Summary: Selecting the most appropriate bridge type for a specific site is the most critical decision a designer makes to ensure the structure is cost-effective. This choice is rarely straightforward and must balance owner desires, navigational requirements, environmental impacts, and existing physical constraints.

Required Span Lengths

Bridge superstructures must be selected based on their efficiency for specific span arrangements. Designers must navigate various technical and non-technical reasons when determining these lengths.

Owner Desires

In many projects, the selection of bridge type is driven directly by the owner's objectives.

- **Material Preference:** Some owners push for the shortest spans possible to allow for a wider choice of materials or to favor a specific material type.
- **Public Influence:** For long-span bridges, public opinion often weighs heavily on the final selection.
- **Prestige and Signature Structures:** Occasionally, an owner will prescribe a bridge type for perceived prestige, aiming for a record span length or a unique "signature" structure that hasn't been implemented in their jurisdiction before.

Hard Requirements

Certain requirements act as non-negotiable controllers of span length.

- **Navigational Clearance:** For water crossings, the U.S. Coast Guard typically acts as the controlling agency for required span lengths over navigable inland waterways.
- **Environmental Commitments:** Increased sensitivity to adverse environmental impacts has led to many cases where span arrangements are set strictly to meet environmental mandates.



💡 **Design Tip:** While minimizing spans often reduces material costs, always check for "Hard Requirements" early in the process, as navigational or environmental mandates can override simple economic optimizations.

Existing Constraints

Physical features at the site often dictate the span arrangement for new structures.

- **Existing Infrastructure:** When constructing near existing interchanges, features that must be retained or used for staging during construction can control span lengths.
- **Surface Roadways:** While it is sometimes cost-effective to move a roadway to accommodate a bridge, this is rarely feasible in congested urban environments.
- **Railroad Coordination:** Moving tracks or interrupting rail service is extremely costly. Railroads are highly protective of their facilities to maintain profitability; therefore, increasing span lengths to minimize railroad impacts is often the most beneficial approach.

Other Constraints

- **Site Access:** In wide, deep valleys, increasing span lengths to eliminate the need for costly piers can improve project economy.
- **Structural Economy:** Under specific site constraints, deck structures such as **trusses** or **arches** may become the most economical solution.
- **Construction Schedule:** If the owner requires a short construction duration, designers must select structure types that lend themselves to rapid deployment.
- **Regional Expertise:** The selection is often affected by local contractor experience. For instance, segmental structures are common in the Southeast but rare in the Northeast. Using a structure type that local contractors are unfamiliar with often results in high construction costs or the need for out-of-state bidders.



Checkpoint Quiz

1. Which agency typically controls the required span lengths for navigable inland waterways in the U.S.?

- a) Department of Transportation (DOT)
- b) Environmental Protection Agency (EPA)
- c) U.S. Coast Guard
- d) Federal Highway Administration (FHWA)

Answer: (c). The U.S. Coast Guard is the primary controlling agency regarding navigational clearance and required span lengths for navigable inland waterways.

2. Why might a designer choose to increase span lengths when crossing a railroad?

- a) To utilize segmental construction techniques
- b) To minimize high costs and service interruptions associated with moving tracks
- c) To follow AASHTO material preferences
- d) To reduce the prestige of the structure

Answer: (b). Moving tracks or interrupting rail service involves significant costs and logistical challenges; increasing span lengths helps minimize these impacts.

Module 2: Bridge Types

Learning Objectives

By the end of this section, you will be able to:

- **Select** the most appropriate bridge type based on span length and site-specific constraints.
- **Evaluate** the economic and structural trade-offs between rolled beams, plate girders, trusses, arches, and cable-suspended systems.
- **Analyze** the geometric and assembly requirements for complex structures like cable-stayed and suspension bridges.

Executive Summary: Current bridge construction utilizes a variety of structural systems, each optimized for specific span ranges. While rolled beams and plate girders dominate shorter spans, trusses, arches, and cable-suspended structures offer viable solutions for long-span crossings. Designers must account for fracture criticality, erection complexity, and maintenance requirements when selecting a bridge type.

Rolled Beam Bridges

Rolled beam bridges utilizing W-shapes are typically deployed for simple spans up to approximately 100 feet or continuous spans up to 120 feet.

- **Composite Action:** These beams are generally designed to act compositely with the bridge deck.
- **Unit Weight vs. Cost:** While rolled shapes result in higher unit weights of steel compared to plate girders, their **unit cost is significantly lower** due to simpler fabrication processes.
- **Detailing:** Fabrication is less expensive as transverse stiffeners are usually unnecessary. Diaphragms typically consist of rolled channel shapes.
- **Economy:** Limited welding and simplified diaphragm details often make rolled beams more economical than plate girders in short span ranges.

Welded Plate Girder Bridges

Deck plate girders are the most prevalent type of steel bridge structure.

Design Evolution and Fracture Criticality

- **Historic Systems:** Older designs often used two girders with transverse floorbeams and longitudinal stringers.
- **Fracture Concerns:** Concerns over **fracture criticality** (where a single girder failure could cause total collapse) led many agencies to move away from two-girder systems.

Through Girder Systems

- **Application:** Used primarily for sites with **severe superstructure depth restrictions**.
- **Configuration:** Features two main girders near the deck edges with shallow floorbeams connecting the bottom flanges.
- **Disadvantages:** These systems are fracture critical, cannot be made composite with the deck, and require additional steel in the top flanges due to limited bracing points.



Figure 1: Photo of a typical multi girder system with x-type intermediate cross frames and stay-in-place formwork used for constructing the deck slab

Multi-Girder and Composite Design

- **Composite Action:** Standard multi-girder bridges allow designers to account for the deck's strength in the girder's section properties.
- **Stability:** The top flanges in positive moment regions are fully braced by the deck in the final condition.
- **Optimization:** Designs are typically optimized for spans exceeding 125 feet with girder spacing between 11 and 14 feet.

Erection and Constraints

- **Falsework:** Plate girders generally require minimal falsework for spans under 200 feet.
- **Lateral Bracing:** May be required for spans exceeding 300 feet or in very high-wind environments.



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