Design for Constructibility

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Module 1: Introduction

Learning Objectives

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

- **Evaluate** the impact of modern material advancements on bridge span lengths.
- **Identify** critical stress conditions that occur during the erection phase versus the in-service condition.
- **Select** appropriate design considerations based on the stability requirements of partially completed structures.

Executive Summary: Technological advancements, specifically High-Performance Steels, have extended span capabilities but shifted critical design vulnerabilities to the construction phase, where unbraced lengths often create higher stress levels than the final in-service state.

Design Evolution and Material Impact

Technological progress and environmental considerations have pushed the boundaries of traditional bridge engineering, leading to significantly increased **maximum span lengths** for various bridge types.

- **High-Performance Steels (HPS):** Over the last decade, the introduction of HPS has made steel plate girder bridges the preferred choice for spans reaching up to **500 feet**.
- **Extended Span Challenges:** Utilizing higher-strength steels to achieve these lengths requires you to account for construction-related variables that were less critical in shorter, more rigid designs.

Erection vs. In-Service Stability

A common oversight in bridge engineering is focusing exclusively on the **in-service condition**—checking stability and member stress only after the entire superstructure is complete and braced.

- **Critical Stress Windows:** The most severe stresses in a component often occur during **erection**.
- **Unbraced Lengths:** During assembly, the partially completed structure may face large unbraced lengths that compromise stability.
- **Designer Responsibility:** You must determine which erection methods and procedures apply to your specific design to mitigate these risks.

💡 **Design Tip:** Always perform a secondary analysis for the "partially completed" state. Member capacities that appear adequate for the final braced structure may fail during the erection sequence due to lateral-torsional buckling or other stability issues.

Checkpoint Quiz

1. **Which factor has most significantly contributed to steel plate girder bridges being utilized for spans up to 500 feet?**
   a) New environmental regulations
   b) Introduction of High-Performance Steels (HPS)
   c) Advanced computer modeling of in-service loads
   d) Reduced bridge deck thickness

Answer: (b). HPS has provided the strength-to-weight ratio necessary to push span lengths to 500 feet.

2. **Why might the erection phase be more critical than the in-service phase for member stress?**
   a) The materials are not yet fully cured
   b) Permanent dead loads are higher during construction
   c) Large unbraced lengths affect the stability of the partially completed structure
   d) Wind loads are naturally higher during the construction year

Answer: (c). Stability is often compromised during erection because the structure lacks the bracing of the completed system, making unbraced length a critical design factor.

Module 2: Design Fundamentals

Learning Objectives

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

- **Select** appropriate crane types based on pick weight, site access, and mobility requirements.
- **Evaluate** different erection methods for I-girders, trusses, arches, and cable-supported structures.
- **Identify** site considerations that impact the cost-effectiveness and feasibility of bridge designs.

Executive Summary: Successful bridge erection relies on matching equipment capabilities and assembly methods to site-specific constraints; often, the most "material-efficient" design is less economical than one optimized for contractor access and rapid construction.

Equipment Fundamentals

Crane selection is driven by variables such as pick weight, radius, height, and site terrain.

Crane Types and Capabilities

- **Mobile Hydraulic Cranes:** Used for light- to medium-weight picks up to **650 tons**. They feature quick setup via telescoping outriggers and are ideal for accessible sites like grade separations.
- **Mobile Lattice Boom Cranes:** Suitable for picks up to **300 tons** at high elevations. While versatile in reach, they **cannot move** once the load is lifted.
- **Lattice Boom Crawler Cranes:** Rated up to **300 tons**, these are used on unfinished terrain and
- **Lattice Ringer Cranes:** Designed for heavy-duty picks up to **1,400 tons**. Often mounted on barges for river or bay projects to overcome their inherent immobility on land.
- **Tower Cranes:** Used for lightweight picks (up to **20 tons**) at extreme heights, such as bridge towers. They may require dedicated foundations and can feature self-jacking legs.

Figure 1: Photograph of a mobile hydraulic crane

Figure 2: Photograph of a mobile lattice boom crane

Figure 3: Photograph of a lattice boom crawler crane

Figure 4: Photograph of a lattice ringer crane

Figure 5: Photograph of a tower crane