NCHRP 12-102
Project Overview

Guide Specification Development
  • Significant synthesis project
  • No new research involved
  • Technology readiness evaluation done for each technology

Approach:
  • Not a stand-alone document
  • Supplement to:
    • AASHTO LRFD Bridge Design Specifications
    • AASHTO Bridge Construction Specifications
    • Separate Design and Construction Parts

Project Status
  • Complete
NCHRP 12-102
Project Overview

Sources of provisions
- Significant technology synthesis
- Dozens of past research projects on ABC
- NCHRP Research
- State DOT Research
- International Research
- Private research
- Questionnaire to Each State DOT
  - What are they using?
  - What is working? What is not?
  - Lessons Learned

Specification Overview

Guide Specification Contents

Part 1: ABC Design Guide Specifications
1. Introduction
2. General Design Provisions
3. Design of Prefabricated Elements
4. Detailing Requirements
5. Durability of ABC Technologies

Part 2: ABC Construction Guide Specifications
6. Introduction
7. Temporary Works
8. Fabrication and Assembly Planning
9. Layout and Tolerances
10. Concrete Structures
11. Steel Structures
12. Geosynthetic Reinforced Soil / Integrated Bridge System

Link slab specifications reside here
Key Definitions

Modular Deck Beam (MDB)
An element that is fabricated with beams combined with an integral composite reinforced concrete deck to form a modular unit. MDBs can be made with steel or prestressed concrete beams. A MDB is typically made with two or three beam elements.

Key Definitions

Closure Joint
A gap between two elements or systems that is filled with materials to form a connection. The joint may or may not include reinforcing. The width of the closure joint can vary based on the type of material used to fill the joint and the reinforcing within the joint. This feature is also referred to as a “closure pour” by some agencies.
Key Definitions

Link Slab

Links slabs are a transverse deck level connection at piers between the decks of two adjacent spans, providing a \textit{jointless bridge without continuity}. The deck is made continuous across the pier, but the supporting beams or girders are not connected.

Most Common uses of Steel in ABC

SPMT and Lateral Slide Installations

- Steel Superstructures
- Less weight = fewer axle lines & lighter temp. works = less cost
- Can handle negative moments better than concrete

Modular Deck Beams

- Less weight for cranes and transport
- Can accommodate any geometric configuration
Most Common uses of Steel in ABC

Modular Deck Beams

- Less weight when compared to concrete
- Weekend superstructure replacements are feasible
- Spans up to 135’ +/-

Modular Deck Beam Design

3.5.2.2—Modular Decked Beams

The design of modular decked beams shall follow the provisions in the AASHTO LRFD Bridge Design Specifications for beams with a CIP concrete deck. The deck level connections between the adjacent deck beams shall be designed as reinforced moment connections. The provisions for maximum skew of primary reinforcement are applicable to modular deck beams.

Primary reinforcement and distribution reinforcement are typically designed using the Strip Method as specified under the “Alternate Methods of Analysis” article in Chapter 4 of the AASHTO LRFD Bridge Design Specifications. Designers shall also design the deck for serviceability and deck overhang reinforcement.

C3.5.2.2

Modular decked beams (MDB) are also referred to as Prefabricated Bridge Units (PBUs) in some states. Modular steel decked beams consist of two or more steel beams that are connected to a concrete deck which is cast in a fabrication facility (off-site or near site). This forms a modular unit that is similar to a precast double tee beam. The most common modular decked beam has been made with steel beams. It is also possible to make a MDB with concrete beams. The provisions contained in this article would still be applicable to a MDB made with concrete beams. It is also possible to use an orthotropic steel deck connected to the top of a steel beam. This steel deck option is a specialized system that is not well documented, therefore this article focuses on the concrete deck option.

The behavior of an integral deck on steel beams is akin to a cast-in-place deck on independent beams.
3.6.9 LINK SLABS

In general, link slabs can be designed and detailed with normal deck concrete.

The detailing of link slabs involves the de-bonding of a portion of the bridge deck at the ends of the spans. Designers need to verify the design of the beam in this zone based on non-composite action.

The skew of the bridge may be neglected in link slab design.

Link Slab Connections

3.6.9.1 Primary Reinforcement

The primary reinforcement shall be designed and detailed to resist dead load and live load forces as specified in the AASHTO LRFD Bridge Design Specifications including the provisions for deck overhangs.

In a typical bridge with longitudinal beams or girders, the primary reinforcement runs transversely across the bridge deck. The design of this transverse reinforcement is not different than the design of normal deck reinforcement. The design of the transverse reinforcement must account for the overhang forces including barrier impacts.

A link slab still needs to support wheel loads
Link Slab Connections

3.6.9.2 Link Slab Reinforcement

Longitudinal link slab reinforcement shall be designed to resist the induced rotations in the adjacent beams.

Links slabs shall not be assumed to provide any continuity of composite dead loads or live loads.

The link slab shall be detailed as non-composite over its entire length through the use of a physical bond breaker between the link slab and the supporting beam. The minimum recommended length of the link slab shall be equal to the total of 5 percent of each span length that is connected to the link slab, measured from the end of the supporting beams.

C3.6.9.2

Link slab reinforcement is not designed for typical live load forces. Instead, it is designed to accommodate the beam end rotations. The rotation of the beams leads to forces that are result of the stiffness of the link slab.

Links slabs do not provide measurable resistance to negative bending moments, and their stiffness is significantly less than the adjacent composite beams, therefore the joint can be assumed to be a theoretical pinned connection. This approach is similar to the assumption made with the design of an integral abutment bridge.

Figure C3.6.9.2-1 shows a typical link slab debond zone.

![Link Slab Debond Zone](image)

**Figure C3.6.9.2-1 Links slab debond zone**

The design bending moment in the link slab per beam \( M_b \) shall be calculated as follows:

\[
M_b = 2E_b I_b \frac{\Delta o}{L_o} \tag{3.6.9.2-1}
\]

where:

- \( E_b \) = modulus of elasticity of the link slab (ksi)
- \( I_b \) = moment of inertia of the link slab using gross gross section properties (in\(^4\))

The design bending moment can be derived from the theory that the slab is fixed at each end of the link slab. A rotation is applied to the slab from either end resulting in a maximum bending moment at the fixed end. Figure C3.6.9.2-2 shows the free body diagram for this situation.

![Link Slab Free Body Diagram](image)

**Figure C3.6.9.2-2 Links slab free body diagram**

The moment of inertia of the link slab is calculated in the same plane as the adjacent girders. For an interior beam the calculation would be as follows:

\[
I_b = S \cdot d^2 / 12 \tag{C3.6.9.2-1}
\]

where:

- \( S \) = beam spacing (in.)
- \( d \) = gross section depth of the link slab (in.)

Similar calculations would be used for fascia beams accounting for the width of the overhang. The use of gross section properties is conservative since it results in a larger section property than a cracked section.

Designers should not increase the thickness of the link slab in order to provide a more robust connection. Increased thickness will lead to increased stiffness, which will develop more bending moment in the link slab, potentially leading to more cracking. Maintaining the same thickness as the adjacent span slab is recommended. Likewise, the use of higher strength concrete is not recommended since it will have a higher modulus of elasticity, which will lead to higher link slab moments.
Link Slab Connections

\[ O = \text{maximum girder end rotation applied to the link slab (rad.)} \]

The maximum girder end rotation is the largest end rotation that would be applied to the link slab zone after the casting and curing of the link slab region. Provisions for continuous spans may be used for the application of the vehicular live load.

\[ L_s = \text{total length of link slab (in.)} \]

The total length of the link slab shall be the debond zone as shown in Figure C3.4.9.2-1.

The link slab shall be designed to resist the induced bending moment. The section shall also be checked for serviceability using the "Control of Cracking by Distribution of Reinforcement" provisions in the AASHTO LRFD Bridge Design Specifications.

The loads factors used to calculate rotations need to be consistent with the design provisions being used (strength vs. service). These provisions will ensure that the crack width in the link slabs will provide a durable structure. The provisions for Class 2 exposure are recommended.

Free body diagram of system

Link slab flexing

Beam End Rotation due to live load

Impact of Link Slab at piers with expansion and fixed bearings
Impact of Link Slab at piers with expansion and fixed bearings

 Expansion beam translates with rotation of fixed beam

 Link slab flexing

 Beam End Rotation due to live load

 Idealized Expansion Bearing

 Idealized Fixed Bearing

 Impact of Link Slab at piers with two fixed bearings

 Shearing forces in bearing

 Tension in deck due to negative moments

 Force couple moment arm

 Live load negative moments due to force couple fixity

 Live load negative moments due to force couple fixity

 Idealized Fixed Bearings

 17

 18
Continuous Deck drives thermal movement to act as 3 span continuous structure
One Fixed Bearing at each pier

Impact of Link Slab on Multiple Spans with fixed Bearings

Link Slabs at piers (typ.)
Thermal movement at this bearing increases under this scenario, potentially overstressing the bearing
Significant Shear force at fixed bearings causing significant overturning forces on piers and potentially causing pier damage

Link Slab Durability

- MassDOT 93Fast14
  - Over 175,000 ADT
  - In service since 2011
  - No issues
Span-by-Span Efficiency

- Modern Steel Construction Article
  - September 2014
  - Cost comparison - Advantages

<table>
<thead>
<tr>
<th>Item</th>
<th>Continuous Span</th>
<th>Span-by-span</th>
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<tbody>
<tr>
<td>Structural Steel</td>
<td>Less steel required ✓</td>
<td></td>
</tr>
<tr>
<td>Bearings</td>
<td>Fewer Bearings at pier ✓</td>
<td></td>
</tr>
<tr>
<td>Bolted Splices</td>
<td>None required ✓</td>
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<tr>
<td>Construction Speed</td>
<td>Much faster ✓</td>
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<tr>
<td>Deck Reinforcing</td>
<td>Less long. Rebar ✓</td>
<td></td>
</tr>
<tr>
<td>Erection</td>
<td>Much easier ✓</td>
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- Result: Similar costs

Summary – Why Consider Steel for ABC?

Modular Deck Beams
- Less weight for cranes and transport
- Can accommodate any geometric configuration

Simplified and Durable Construction
- Span-by-span construction with link slabs – no deck joints

Efficiency
- Span-by-span construction can be competitive with continuous girder design when total costs are included