Implementation of the New AASHTO Guide Specifications for Accelerated Bridge Construction

Module 1: NCHRP Project 12-102

This investigation is sponsored by TRB under the NCHRP Program. Data reported is work in progress. The contents of this presentation has not been reviewed by the project panel or NCHRP, nor do they constitute a standard, specification, or regulation.

Acknowledgements

- Project Team
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  - Dennis Mertz

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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

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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
  - Final Report is in for Publication

Technology Readiness

- Evaluation
  - Level of testing and research
  - Existing Specifications
  - Implementation
  - Durability
  - Parameters and weight factors worked out with project panel
**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
    1. Introduction
    2. Temporary Works
    3. Fabrication and Assembly Planning
    4. Layout and Tolerances
    5. Concrete Structures
    6. Steel Structures
    7. Geosynthetic Reinforced Soil / Integrated Bridge System

**A little Grammar to start**

- This document should not be considered a full specification
- Users of this document should exercise engineering judgement in conjunction with the provisions in the document.
- The document makes use of the terms “shall”, “should”, “may”, and “recommended”.
  - The term “shall” denotes a requirement for compliance with these specifications.
  - The term “should” indicates a strong preference for a given criterion.
  - The term “may” indicates a criterion that is usable, but other local and suitably documented, verified, and approved criterion may also be used in a manner consistent with the LRFD approach to bridge design.
  - The term “recommended” is used to give guidance based on past experiences.

**Reference Documents**

- This is not a stand-alone design specification.
- This document is intended to supplement the AASHTO LRFD Bridge Design Specifications and the AASHTO LRFD Bridge Construction Specifications
- In many cases, provisions will refer to other AASHTO documents
  - Not by article number
  - By article Title
  - Why?

**Other References**

- NCHRP Project 12-98
  - 2018 Guidelines on Prefab Tolerances
  - 2018 Guidelines on Dynamics
    - Including SPMTs and Lateral Sliding
  - Want to know more?
    - RII ABC Webinar Archives recordings
    - They are free!

**Current Status**

- The guide specification was completed late 2016
- Forwarded to the AASHTO T-4 Construction Committee for consideration
  - Home of ABC at AASHTO
- Reviewed by AASHTO Committees over the winter of 2017
- Minor revisions were made based on reviews
- Balloted for adoption in June 2017
- Passed
- Several Committees still have issues
  - T-4 is working with them to resolve some issues prior to publication
- Publication by AASHTO in late 2017, early 2018

**Design Specification Overview**

- Design Specification
  - Section 1: Introduction
  - Section 2: General Design Provisions
    - Shipping and Handling Provisions
    - Load Combinations for SPMT and Lateral Slide
Design Specification Overview

- Design Specification
  - Section 3: Design of Prefabricated Elements
  - Majority of specs are based on emulation
  - Significant seismic provisions
  - Major Provisions that vary from LRFD
    - Lapped hooked and headed bars
    - UHPC connections
    - Type 2 Mechanical Connectors
    - Corrugated Metal Pipe Sockets and corrugated precast sockets
    - Link slabs

- Design Specification Overview

- Construction Specification
  - Section 4: Detailing Requirements
    - Tolerances and layout of precast elements
    - Reference to NCHRP Project 12-98 guidelines
  - Section 5: Durability of ABC Technologies
    - Detailing recommendations for durability

- Key Definitions

  Accelerated Bridge Construction
  Bridge construction that uses innovative planning, design, materials, and construction methods in a safe and cost-effective manner to reduce the onsite construction time that occurs when building new bridges or replacing and rehabilitating existing bridges.

- Key Definitions

  Conventional Bridge Construction
  Bridge construction that does not significantly reduce the onsite construction time that is needed to build, replace or rehabilitate a bridge. Prefabrication is typically limited to beams and girders in this form of construction.

Definitions

- Definitions are included in Section 1 of the Design Section
- Based on FHWA and AASHTO T-4 Committee
Prefabricated Bridge Elements and Systems (PBES)
Structural components of a bridge that are built offsite or near the site that include features that reduce the on-site construction time that occurs with conventional bridge construction.

Prefabricated Bridge Elements (PBE)
A category of PBES which comprise a single structural component of a bridge. Prefabricated Bridge Elements can be made of any approved structural material.

Prefabricated System
A category of PBES that consists of an entire superstructure, an entire superstructure and substructure, or a total bridge that is procured in a modular manner such that traffic operations can be allowed to resume after placement. A Prefabricated system is rolled, launched, slid, lifted, or otherwise transported into place, having the deck and preferably the railing in place such that no separate construction phase is required after placement.

Self-Propelled Modular Transporters (SPMTs)
A high capacity transport device that can lift and move prefabricated elements and systems with a high degree of precision and maneuverability in all three directional axes without the aid of a tractor for propulsion.

Lateral Slide
A method of moving a bridge system built adjacent to the final bridge location using hydraulic jacks or cable winches while supported on sliding materials or rollers. The bridge is typically built parallel to its final alignment, facilitating the installation.

Geosynthetic Reinforced Soil Integrated Bridge System (GRS/IBS)
A bridge that is directly supported on a GRS abutment that blends the roadway into the superstructure to create a jointless interface between the superstructure and the approach embankment.
**Key Definitions**

**Assembly Plan**
A package of plans, specifications and calculations developed by the contractor that describes the process for the assembly of prefabricated elements. The assembly plan may include handling and erection plans, materials specifications, details and calculations for bridge temporary works, and construction scheduling.

**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.

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

**Emulation**
A type of design where the bridge and its elements are designed to resist forces in the same manner as a bridge built with conventional construction.

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**Guide Specification Format**

**Standard AASHTO Format**
- Specifications on Left
- Commentary on Right
  - There is significant commentary
  - Includes Notation definitions
  - Includes references
- This is not an ABC Manual
  - Limited to Design and Construction “Specifications”
- Not a cookbook
  - You need to use engineering knowledge and judgement

**Questions?**

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Implementation of the New AASHTO Guide Specifications for Accelerated Bridge Construction

• Module 2: General Design Provisions

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Design Responsibilities - PBEs

1.4.1 DESIGNER

The designer is responsible for the design of all elements and connections according to the AASHTO LRFD Bridge Design Specifications as supplemented in this Guide Specification.

Examples of this approach include but are not limited to:

- Load and stress analysis
- Material selection
- Seismic design
- Fire safety

The designer shall be familiar with the design requirements of the Guide Specifications and shall be prepared to address any questions or concerns related to the design.

1.4.2 Establishing of Fabrication and Erection Guidelines

The designer shall establish guidelines for the fabrication and erection of the bridge structure. These guidelines shall include:

- Material specifications
- Fabrication tolerances
- Erection procedures
- Quality control

The designer shall be responsible for ensuring that the fabricated and erected structure meets the design requirements.

1.4.3 Specification of Special Materials

The designer is responsible for the specification of specialized materials to be used in precast concrete construction. Examples include:

- High-strength concrete
- High-performance polyurethane
- Post-tensioning tendons

The designer shall be familiar with the technical requirements and performance criteria for these materials.

1.4.4.1 Designer's Role in Shipping and Handling of Elements

The designer shall be responsible for ensuring that the fabricated elements are shipped and handled in accordance with the design requirements. This includes:

- Shipping arrangements
- Loading and unloading
- Staging and storage

The designer shall work with the fabricator to ensure that the elements are shipped and handled in a safe and efficient manner.

Design Responsibilities - PBEs

Note

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Design Responsibilities - PBEs

14.2 CONTRACTOR

In general, the contractor’s role is the design of precast elements in liaison with suppliers and manufacturers.

The Contractor may be requested to conduct the final design of the structure or components if agreed on the contract plans.

See Article 13.4 for examples of this approach.

Other Responsibilities

Designer Responsibilities - SPMTs

15.1 DESIGNER

The designer shall be responsible for the design of the entire bridge construction. The bridge can be constructed within the proposed work zone and other requirements of the contract documents.

15.1.1 Bridge Design

The designer shall make arrangements for the movement of the bridge using SPMTs. The designer shall be responsible for the design of the system as follows:

- The designer shall ensure that the SPMTs are used in accordance with the conditions described in the contract.
- The bridge shall be designed to accommodate the movement of the SPMTs.

The designer shall consider all aspects of the movement, including the location of the SPMTs and the movement of the bridge.

15.1.2 Bridge Analysis

The designer shall be responsible for the design of the bridge in terms of the movement of the SPMTs. The designer shall consider the following aspects of the design:

- The movement of the SPMTs shall be designed to accommodate the movement of the bridge.
- The bridge shall be designed to accommodate the movement of the SPMTs.

The designer shall be responsible for the design of the bridge in terms of the movement of the SPMTs.

Designer Responsibilities - SPMTs

15.1.3 Analysis of Traffic Beneath

The designer shall analyze the traffic beneath the bridge to determine the impact of the movement of the bridge. The designer shall consider the following aspects of the analysis:

- The movement of the traffic beneath the bridge shall be designed to accommodate the movement of the SPMTs.
- The designer shall be responsible for the design of the bridge in terms of the movement of the SPMTs.

The designer shall be responsible for the design of the bridge in terms of the movement of the SPMTs.
**Designer Responsibilities - SPMTs**

Other Designer Responsibilities
- Staging area
- Show locations of temporary abutments
- Recommend a foundation type for temporary abutments
- Show support locations
- Travel Path
- Check for clearances
- Geometry checks (flatness)
- Bridge site geometry
  - Check for vertical issues (crowns, cross slopes, etc.)

**Contractor Responsibilities - SPMTs**

Other Contractor Responsibilities
- Staging area
- Design of Temporary Abutments
- Travel Path
- Final configuration of SPMTs
- Travel Path geometry analysis
- Monitoring system (to verify designer specified twist limits)
**Contractor Responsibilities - SPMTs**

12.3.4 Bridge Loading

A detailed analysis of the bridge structure by the contractor may be required prior to placing the first SPMT load and thereafter prior to the design and construction of any subsequent loads. The contractor may perform this analysis in a manner similar to the following:

- The contractor shall provide a design load to the manufacturer for each SPMT load.
- The design load shall be used to determine the performance of the SPMT

12.3.6 Lifting

The lifting of the bridge or plant from the ground in stages shall be performed in accordance with the manufacturer’s recommendations.

- The project team shall work with the manufacturer to provide a lifting plan.
- The lifting plan shall be approved by the project team.
- The lifting plan shall include:
  - The lifting sequence
  - The lifting capacity of the SPMT
  - The lifting equipment

12.3.8 Other

- The project team shall provide a safe working environment for all personnel.
- The project team shall ensure that all personnel are trained and qualified.
- The project team shall ensure that all equipment is inspected and maintained.

**Designer Responsibilities - Lateral Slides**

1.6.1.2 Preliminary Jacking Forces and Jacking Locations

The designer shall consider the acceptable jack loading locations on the bridge. This is typically determined by a preliminary jack loading analysis. The designer shall determine the jack loading forces and the jack loading locations for the sliding devices.

- The preliminary jack loading locations and associated forces shall be shown on the plans.
- The designer shall consider the effects of the jack loading on the structure.

1.6.4.1 Resolution of Sliding Forces

The approach to the preliminary forces of the sliding system shall consider the following:

- The forces shall be resolved into horizontal and vertical components.
- The forces shall be resolved into translation and rotation components.
- The forces shall be resolved into shear and moment components.

1.6.4.2 Foundation

In this section, the designer shall consider the following:

- The foundation type shall be selected to resist the sliding forces.
- The foundation shall be designed to resist the sliding forces.
- The foundation shall be designed to resist the overturning forces.

- The foundation shall be designed to resist the uplift forces.

**Other Designer Responsibilities**

- Geotechnical Design
  - Recommend foundation type for temporary supports
- Jacking Forces
  - Schematic layout of slide system
- Design for estimated temporary forces acting on substructure and superstructure
- Specifications
  - Require jacking plan submission
  - Allowance for alternate jacking systems and supports
**Contractor Responsibilities**

- Design of falsework
- Design of sliding system
- Determine final jacking forces
- Detailing of slide system

**Loads and Load Combinations**

2.4 LOADS AND LOAD COMBINATIONS

The following loads shall be included in all design analyses:

- Vertical loads
- Horizontal loads
- Wind loads
- Earthquake loads

The requirements of this article are based on the exception design process where the elements are designed and connected to behave as a structure built using conventional construction methods.

**Loads and Load Combinations**

2.4.3.3 Sliding and Jacking Loads

All sliding and jacking elements shall be designed for sliding and jacking forces during fabrication, shipment, and erection. The following loads shall be considered for sliding and jacking calculations:

- Static load on expansion joint
- Static load on bridge deck
- Dynamic load on expansion joint

The following loads for (1) are recommended:

- Longitudinal: 1.5
- Transverse: 1.0

**Loads and Load Combinations**

2.4.4 Loads and Load Combinations for the Bridge

The following loads shall be included in the analysis of the bridge:

- Dead load
- Live load
- Wind load
- Earthquake load

**Loads and Load Combinations**

C4.4.6 Structural Load Combination for the Bridge

The following loads shall be included in the analysis of the bridge:

- Dead load
- Live load
- Wind load
- Earthquake load

**Loads and Load Combinations**

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**Loads and Load Combinations**

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**Loads and Load Combinations**

C4.4.6 Structural Load Combination for the Bridge

The following loads shall be included in the analysis of the bridge:

- Dead load
- Live load
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- Earthquake load
Loads and Load Combinations

12.3.4.2 Load Combinations for Pavement and Hauling

The loads and load combinations shall be subjected according to the ACI 209.9 R-91 Load Design for Pavement and Hauling (1991). The following load combinations shall be subject to the loads shown in Table 12.3.4.2.

Table 12.3.4.2

<table>
<thead>
<tr>
<th>Load Combination</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1</td>
<td>Truck Load in the Pavement and Hauling (ACI 209.9 R-91)</td>
</tr>
<tr>
<td>J2</td>
<td>Wind Load in the Pavement and Hauling (ACI 209.9 R-91)</td>
</tr>
<tr>
<td>J3</td>
<td>Water Load in the Pavement and Hauling (ACI 209.9 R-91)</td>
</tr>
</tbody>
</table>

Questions?

SPMT Installations
Implementation of the New AASHTO Guide Specifications for Accelerated Bridge Construction

Module 3: Design of Prefabricated Elements

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Section 3: Design of PBEs

Largest Section in the Guide Specification

- 85 pages

Seismic combined with non-seismic provisions

- The team originally considered a separate seismic section
- Panel decided that a combined section was preferred
- Many details and connections are applicable to both (avoid duplication of provisions)
- Consistent with the AASHTO LRFD Bridge Design Specifications
- This presentation will focus on non-seismic details
  - Stuart Brennan will cover seismic in the next module

Couplers and Design

Couplers have a minor impact on the design

- Concrete Cover on noncoupler designs
- Design section based on required cover
- Detail bars accordingly
- Coupler Designs
  - The diameter of the coupler is larger than the bar
  - There are multiple coupler manufacturers and each has different dimensions (diameter)
  - In order to maintain cover over the coupler, the designer needs to:
    - Move the bar cage for design
    - The distance has to be bracket all manufacturers (more on this in Module 6

PCFD Deck Panel Design

The core concept design approach: The panel coupling multiple deck panels has been based on some generalization for use of core concepts. The deck panels are an example of the core concept. The design of the panel coupling by the LRFD bridge design method of traditional truss/beam joint detail is the constant, the core concept is the variable. There is a need for new panel coupling design. The design of the panel coupling has to be in agreement with the traditional core concept of typical bridge design. The panel coupling has to be designed based on the earthquake resistance requirement and the geometry of the bridge.
PCFD Deck Panel Design

Precast concrete deck panels can be a form of precast concrete used for various purposes in construction. They are precast using molds and then cast into a specific shape, allowing for precise control over the final product. Precast concrete deck panels offer several advantages, including faster construction times, reduced material waste, and improved durability. They are commonly used in bridge construction, where they provide a strong and stable foundation. The panels can be customized to fit specific structural requirements, making them a versatile option for various projects. Additionally, precast concrete deck panels can be more cost-effective than traditional on-site construction methods, as they eliminate the need for labor-intensive on-site casting. The panels are typically delivered to the site and then assembled, ensuring a significant reduction in the overall project timeline.
Connection Design

To ensure the proper development of concrete compression elements, it is essential to design the connection in a manner that minimizes the width of the concrete member. This can be achieved by designing the connection so that the concrete is not subjected to tensile stresses. The connection should be designed to transfer the forces in a manner that minimizes the development length of the concrete member.

Connections shall be designed for dead weight and seismic loads. The connection shall be designed for the dead weight and seismic loads that may be applied to the concrete member. The connection shall be designed to transfer the forces in a manner that minimizes the development length of the concrete member.

Substructures can also affect the stiffness of the concrete member. The stiffness of the substructure shall be considered in the design of the connection to ensure that the connection is not subjected to excessive forces.

Connection Details

Reinforcement Details

Figure 2.12.21: Detail shown of the connection

The developed length shall not be less than the required length based on the design load and the strength of the concrete member.

Figure 2.12.21: Detail shown of the connection

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The developed length shall not be less than the required length based on the design load and the strength of the concrete member.
Mechanical Connectors

This remains a controversial subject with seismic states.
This is subject to change.
More information on the use of Type 2 Connectors in the next module.

Integral Abutment Connections

In the analysis, we constructed a jointed-alternate grade. All joints were assumed to be perfectly continuous. The jointed-alternate grade was analyzed to check the distribution of stresses and strains in the abutment. The results showed that the jointed-alternate grade provides a more accurate representation of the true behavior of the abutment. The jointed-alternate grade was used to analyze the behavior of the abutment under seismic loads.

Integral Abutment Connections

In the integral abutment, the jointed-alternate grade was used to analyze the behavior of the abutment under seismic loads. The jointed-alternate grade was used to analyze the distribution of stresses and strains in the abutment. The results showed that the jointed-alternate grade provides a more accurate representation of the true behavior of the abutment. The jointed-alternate grade was used to analyze the behavior of the abutment under seismic loads.

Link Slab Connections

3.6.1 Primary Reinforcement
The primary reinforcing bars shall be placed in the slab and the slab forms and shall be specified in the model code. The reinforcing bars shall be placed in the slab and the slab forms and shall be specified in the model code. The reinforcing bars shall be placed in the slab and the slab forms and shall be specified in the model code.

Link Slab Connections

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Link Slab Connections

3.6.2 Link Slab Reinforcement
Link slab reinforcement shall be designed for the defined seismic forces in the link slab.

Link Slab Connections

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Link Slab Connections

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Link Slab Connections

Steel Beam Connections

Other Deck Beam Connections

GRS/IBS Design

Provisions are based on FHWA Implementation Guide
- There is some concern within the AASHTO Bridge Sub-committee
  - Under debate at this time
Questions?
NCHRP Project 12-102 Seismic

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BergerABAM / Seattle University

Review of New Guide Specifications for ABC

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

Construction Guide Specifications for ABC

DESIGN OF PREFABRICATED ELEMENTS

3.4 Seismic Design for Accelerated Bridge Construction
3.5 Prefabricated Element Design
3.6 Connection Design and Detailing
3.7 GRS IBs
3.8 Accelerated backfill

3.4 SEISMIC DESIGN FOR ABC

3.4.1 Seismic Analysis & Design Methods
3.4.2 Load Path
3.4.3 Seismic Systems, Elements, & Sub-Systems
3.4.4 Energy Dissipation
3.4.5 Capacity Protection

3.4 SEISMIC DESIGN FOR ABC CONT.

Seismic analysis and design of prefabricated elements shall be performed using either:
- Force-Based Design
  AASHTO LRFD Bridge (2014)
- Displacement-Based Design
  AASHTO Seismic GS (2011)

... set up to accommodate continuing research and advancements.

In high seismic areas inelastic ductility is required; thus clearly all members must have sufficient strength and ductility to form the intended structural plastic mechanism.

... ideal locations for ABC connections
3.4.1.2 AASHTO LRFD (2014)

The force-based seismic design methodology, as defined in AASHTO LRFD Bridge Design Specifications, is permitted when factors and prescriptive detailing for energy dissipating PBES and their connections have been shown through laboratory testing to provide acceptable performance. This document limits the application of force-based design procedures for some prefabricated connections in Zones 2 through 4 when detailed understanding of material behaviors is necessary.

3.4.1.3 AASHTO SEISMIC GS (2011)

Displacement-based design, as defined in AASHTO Guide Specifications for LRFD Seismic Bridge Design, shall be used to ensure proper performance of prefabricated elements and their connections in Seismic Design Categories (SDCs) B through D.

3.4 SEISMIC DESIGN FOR ABC CONT.

...Select a methodology and use it. Do not mix and match!

3.4.2 LOAD PATH

A continuous load path shall exist between the source of the seismic loads and the foundation. The load path shall enable the transfer of forces between the elements and connections through which it passes.

3.4.3 SEISMIC SYSTEMS, ELEMENTS, & SUBSYSTEMS

3.4.3.1 Earthquake-Resisting Systems (ERS)

3.4.3.2 Earthquake-Resisting Elements (ERE)

3.4.3.3 Earthquake-Resisting Sub-Systems (ERSS)

... Detailing is important!
3.4.3.2 DEFINING EREs W/ ABC

Determine what is different from CIP and make a plan for addressing it in the design.

3.6 CONNECTION DESIGN & DETAILING

3.6.1 General
3.6.2 CIP Concrete Closure Joints w/ Lapped Bars
3.6.3 Grout/Concrete Under Footings & Slabs
3.6.4 Mechanical Reinforcing Bar Connectors
3.6.5 Grouted Ducts
3.6.6 Pocket Connections

3.6 CONNECTION DESIGN & DETAILING

3.6.7 Socket Connections
3.6.8 Full Depth Precast Concrete Deck Panel Connections
3.6.9 Link Slabs
3.6.10 Steel Connections
3.6.11 Integral Substructure to Superstructure Connections
3.6.12 Deck Beam Connections

3.6.1 GENERAL CONNECTION DESIGN

Provisions in Section 3.6 are not intended to preclude the use of other preferred details as approved by the Owner and so long the designer can demonstrate adequate load transfer as well as consideration for compatibility of deformations and constitutive relations of materials.
3.6.4 MECHANICAL BAR CONNECTORS

- Viable option for connecting concrete elements
- Defined Type 1 and Type 2 Connectors

Defined in ACI-318-14 (Building Code) requirements for structural concrete (Special Moment Frames & Special Structural Walls)

Implied in AASHTO SG8 (2011) under “Splicing of Longitudinal Reinforcement in SDCs C & D

Type 1 mechanical connectors shall not be used to splice longitudinal column reinforcement within a distance equal to twice the maximum column dimension from the top of the footing or from the bottom of the pier cap, or at any other location where yielding of the reinforcement is likely to occur as a result of inelastic lateral displacements.

3.6.4.1 FORCED-BASE DESIGN

- Reduced modification factor $R_r$:
  $$ R_r = \gamma R $$

  - $0.8$ for $L_{MC} \leq 4 \, d_{bar}$
  - $0.5$ for $L_{MC} > 4 \, d_{bar}$

On-going research, but current research is limited to #8 bars and smaller. Revisions are expected until additional research is complete.

3.6.4.2 DISPLACEMENT-BASED DESIGN

The displacement capacity of each bridge bent shall be calculated using the “Nonlinear Static Procedure (NSP)” outlined in AASHTO Guide Specification for LRFD Seismic Design. Plastic moment capacity shall be based on the moment-curvature analysis of the column section with no mechanical connector and the analytical plastic hinge length shall be taken as the reduced analytical plastic hinge length given by:

$$ L_{pl} = L_p - \left(1 - \frac{2\,l_d}{L_p}\right)\beta L_{pl} \leq L_p $$

where:

- $L_p$ is the tension development length

3.6.4.5 DEBONDING OF COLUMN REINF.

Applicable in footing or pier cap when couplers are used. The minimum debonding length, $L_{deb}$, and anchorage length, $L_{ anch}$ in inches, shall satisfy:

$$ L_{deb} \geq \frac{D_c}{500\,d_y^2} \left(1 - \frac{D_c}{d_y} \right) $$

where:

- $D_c$ is the diameter of the column
- $d_y$ is the nominal yield strain of the column longitudinal reinforcement
- $l_d$ is the distance of column longitudinal bar

$$ L_{anch} \geq L_{deb} + L_d $$

where $L_{deb}$ is the tension development length.
3.6.5 GROUTED DUCTS

- Connect reinforcing bars that projects from one element into a corrugated ducts embedded in receiving member

\[ l_{ad} \geq 0.67 \frac{d_{lb} f_{ye}}{f_{c}} \]  

3.6.5.1 Minimum Development Length

The anchored length for column grade 60 bars developed into corrugated steel ducts shall satisfy

\[ l_{ad} \geq \frac{d_{lb} f_{ye}}{f_{c}} \]  

where:
- \( l_{ad} \): anchored length of longitudinal reinforcing bars into a pier cap or footing (in.)
- \( d_{lb} \): diameter of column longitudinal bar (in.)
- \( f_{ye} \): expected yield stress of the longitudinal reinforcement (ksi)
- \( f_{c} \): nominal compressive strength of grout (ksi)

In lieu of specific data it shall be permitted to use \( f_{ye} = 60 \) ksi for grade 60 reinforcement conforming to ASTM A706 or ASTM A615.

3.6.5.2 Splicing w/ Ductility Demands (ED) for SDCs C and D in Grounted Duct Connections

Where tensile force is transferred between reinforcing anchored into steel ducts using high-strength grout and bars adjacent to the duct, the splice length, \( l_{spa} \), shall be the larger of the anchorage length of the bar inside the duct or the splice length of the bars on the outside of the duct.

Transverse steel shall enclose both the duct and the bars outside the duct.

3.6.5.3 Debonding of Column Longitudinal Reinforcement in Grounted Duct Connections

3.6.5.4 Bedding Layer in Grounted Duct Connections

3.6.5.5 Development of Deformed Steel Bars in Corrugated Steel Ducts using UHPC

3.6.6 POCKET CONNECTIONS

- Column with projecting reinforcement and a receiving precast footing or pier cap with a corrugated steel-pipe-formed pocket

3.6.5 & 6 DEVELOPMENT LENGTH

3.6.5.1 Groouted Duct Development Length

\[ l_{ad} \geq \frac{0.67 d_{lb} f_{ye}}{f_{c}} \]

3.6.6.3 Pocket Connection Development Length
3.6.6 OTHER SECTIONS

- **3.6.6.5 Bedding Layer**
- **3.6.6.6 Abutment to Pile Pocket Connections**

Nominal shear transfer resistance, $V_n$, at the pocket to precast abutment interface and area of the pocket $A_{cp}$ shall be:

$$V_n = 0.12 \sqrt{f_{cp}} A_{cv}$$

$$A_{cv} = \pi dh bn$$

3.6.7 SOCKET CONNECTIONS

- **Embedment of precast column or pile into receiving element**
- **Socket can be:**

  a) Wet (cast-in-place)
  b) Formed (precast)

3.6.7.2 SOCKET IN CIP FOOTING

- $L_e = 1.0D$ Intentionally roughening (0.25") is required
- $C = 0$  

![Diagram](image1)

3.6.6.4 CORRUGATED PIPE THICKNESS

- For SDC B (Seismic Zone 2):

$$\rho_s = \min\left\{ \frac{V_{sh}}{V_{pl}} \left[ \frac{f_{cp}^\prime}{f_{yc}^h} \right] \right\}$$

- For SDCs C and D (Seismic Zones 3 and 4):

$$\rho_s = \frac{V_{sh}}{V_{pl}} \left[ \frac{f_{cp}^\prime}{f_{yc}^h} \right]$$

Additional prescriptive transverse reinforcement is also required, as described below:

$$\rho_s = \frac{V_{sh}}{V_{pl}}$$

$\rho_s$ shall be calculated as the minimum joint shear reinforcement ratio for SDC C and D in AASHTO Guide Specifications for LRFD Seismic Bridge Design.

When principal tension stress in the joint is not calculated, $\rho_s$ in Equation (3.6.6.4-2) shall be taken as:

$$\rho_s = \frac{V_{sh}}{V_{pl}}$$

$\rho_s$ shall be calculated as the minimum joint shear reinforcement ratio for SDC C and D in AASHTO Guide Specifications for LRFD Seismic Bridge Design.

![Diagram](image2)
3.6.7.3 SOCKET IN SHAFT

Spiral/Hoops Requirement
\[ A_{sh} \geq \frac{k f_{ul} A_t}{2 \pi f_{ytr} t_s} \]

Location
- \( k = 0.5 \)
- \( k = 1.0 \)
- \( k = 2.0 \)

3.6.7.4 SOCKET IN PC ELEMENT

3.6.11 INTEGRAL CONNECTIONS

NCHRP Project 12-102

Questions?
Implementation of the New AASHTO Guide Specifications for Accelerated Bridge Construction

Module 5: Other Topics

This investigation is sponsored by TRB under the NCHRP Program. Data reported is work in progress. The contents of this presentation have not been reviewed by the project panel or NCHRP, nor do they constitute a standard, specification, or regulation.

Section 4: Detailing Requirements

Detailing of bridges for ABC and Prefabrication is not significantly different

- Designers still need to depict the construction and layout
- There are a few items that are applicable to ABC that need to be shown on the contract plans

Section 4: Detailing Requirements

5.4 Element and Structural Elements

The designer shall depict structural and structural elements on the plans or in the specifications. Element and structural elements shall be shown on the plans that are intended to be used on the contract.

Exciting plans are not required for all projects. Projects with similar elements and specifications may not include excelling plans. Structural and structural elements are not required for elements that can be used on the contract.

The designer should be responsible for detailing and specifying elements. The details in the drawing notes and specifications should be used to ensure that the elements are specified for the project.

Ordinary elements and structural elements shall be shown in the specifications. The designer should ensure that the elements are shown in the specifications.

Element and structural elements shall be shown in the specifications. The designer should ensure that the elements are shown in the specifications.
Lateral Slide Systems

Durability of ABC Technologies

No need to sacrifice durability with ABC and prefabrication
- Many good details have been developed that have proven to be very durable
- Utah DOT completes routine inspections on specific ABC details
  - Many of the provisions in this section are based on owner experiences

Durability of ABC Technologies

- Integral Abutments and Pilars
  - Integral dimensions and piers should be considered for ABC project feasibility

Durability of ABC Technologies

- Semi-Integral Abutments
  - Good solution for many ABC Technologies
  - Fast
  - Economical
  - Durable
Part 2: Construction Guide Specifications

Similar to AASHTO LRFD Bridge Construction Specifications
• Specification on left, Commentary on right
• Not as detailed as state project specifications
• There is no standard format for state specs
• State specs reference other state specs
• Focus is on guidance

Includes measurement and payment specifications where applicable

Section 2: Temporary Works

2.1 DESIGNER

The designer shall be responsible for the review of Contractor submissions regarding temporary works.

2.1.1 Bridge System

The bridge system shall include all temporary works for the construction of the bridge system. The temporary works shall be designed to ensure the safety of the construction workers, the public, and the environment.

2.1.2 Construction for Temporary Works

The construction of temporary works shall be in accordance with the requirements of the temporary works specification.

Section 2: Fabrication and Assembly Planning

Fabrication specification expanded beyond what is in the AASHTO LRFD BCS
• Some agencies are allowing contractor precasting and near site precasting

What is assembly planning?
• Bicycle analogy
• Step-by-step plan for assembling the bridge
• An enhanced erection plan
• Schedule is an important part
Fabrication

- Shop Drawings
  - Requirements for shop drawings

Fabrication Checklists
- Prepour Inspection
- Cast-in Inspection including curing
- Post-pour Inspection
- Final Inspection Prior to Shipping

Dry-fit of assemblies
- Can be used for complex structures
- Subassemblies can be used

Repairs of non-conformances
- Use PCI Manual for the Evaluation and Repair of Precast, Prestressed Concrete Bridge Products

Assembly Planning

- 3.5 Assembly of Prefabricated Bridge Elements

  The Contractor shall be responsible for the development of all procedures, specifications, and instructions necessary for the Contractor's fabricating, inspecting, and installing the bridge elements as specified in the Contract Documents.

  Fabrication of bridge elements, or components of the bridge shall not commence until both the Fabrication Plan and the Assembly Plan are reviewed for adequacy.

  The Contractor shall coordinate the development of the Assembly Plan with the development of the Fabrication Plan to ensure adequate coordination.

  The Assembly Plan shall include, but are necessarily limited to the requirements set forth in this section.

Assembly Plan - PBES

- Assembly Sequence and Construction Methods
- Lifting and Handling Procedures and Details
- Geometry Control Plan
- Interim Material Strength
- Post-tensioning (if applicable)
- Assembly sequence for post-tensioned full-depth deck panels (if applicable)
- Assembly time schedule

Assembly Plan - Systems

- Assembly Sequence and Construction Methods
- Temporary Falsework Plans
- Lateral Slide Plan Requirements
- SPMT Installation Plan Requirements

Section 4: Layout and Tolerances

- Fabrication and Erection Tolerances
  - Should be included on the plans or in the specifications
  - If not specified—
    - Use “Guidelines for Prefabricated Bridge Elements and Systems Tolerances” (NCHRP 12-98 document)

- Structure Layout
  - Use of common horizontal datum
  - Use of common vertical datum
  - Use of working lines and working points
  - Geometry Control during construction
Section 5: Concrete Structures

- Performance based concrete specifications
- Minimum requirements
- Concrete Strength
- Allowable Cement Types
- Air Entrainment (if required)
- Permeability (if required)
**High Early Strength Concrete**

- Additional Requirements
  - Mix design development (by the contractor)
  - Use of maturity meters (allowed)
  - Confined shrinkage test (AASHTO Ring Test)
  - Field Trial Placement
  - Large scale confined shrinkage test
  - Includes recommended pass fall requirements

**Ultra-High Performance Concrete**

- Performance Specification
  - Developed by FHWA
  - General mix requirements

- Performance Testing

**Ultra-High Performance Concrete**

- Other requirements
  - Surface preparation
  - Exposed Aggregate Finish
  - SSD Conditions
  - Formwork for UHPC
  - Properly sealed
  - Use of top forms for sloped piers
  - Slight overfilling to provide slight pressure head
  - Mixing UHPC
  - Temperature monitoring
  - Mixing equipment

- Placing UHPC
  - Follow manufacturer's recommendations
  - No Vibration

- Finishing UHPC
  - Coat slightly higher than required
  - Three coats or self-levelling at.
  - Surface grinding
  - Heating and after set
  - Machining or other setup

- Cutting UHPC
  - Sealed forms
  - No freezing until strength reaches 10ksi
  - Live load may be applied when strength reaches 14ksi
Other Concrete Construction Specs

Surface Preparation for Concrete Connections
- Connections subjected to water
- Exposed aggregate finish or desired of balance
- Saturated Surface Dry Condition prior to casting

Grouted Joints and Keys
- Forming
- Limited use of backer rods
- Mockups for complex grouting

Other Concrete Construction Specs

Grouted Coupler Connections
- Materials
  - Prequalified lists
  - Certified Five Years
  - Grout supplied by coupler manufacturer
- Installation Methods
  - According to manufacturer
  - Includes recommended installation sequence
- Field testing
  - Grout cube testing

Other Concrete Construction Specs

Post-tensioned connections
- Closure Joints
  - Headed Reinforcing Bars
  - Precast Full Depth Deck Panel Shear connector blockouts on PS Girders
  - Link Slabs

Section 6: Steel Structures

Not a lot required for this specification
- Covered by AASHTO LRFD Bridge Construction Specifications

Items covered in minor detail
- Simple span bridges made continuous for live load
- Precast in shop for complex details
- Modular decked beams
  - Need for coordination between steel fabricator and precast fabricator
- Links slab beams
  - Need for surface smoothness in link slab regions

Section 7: GRS/IBS

Based on FHWA Implementation Guide
- This guide spec references the implementation guide for more details

Facing Blocks
- Higher level of quality for freezing environments
  - GRS Block (dry cast, freeze/thaw resistant, higher strength, lower maintenance absorption
  - Precast block (dry cast, facing allowed)
Section 7: GRS/IBS

Other material specifications
- Backfill and geosynthetic materials

Construction requirements
- Reinforced soil foundation
- Placement of backfill and compaction
- Placement of geosynthetic reinforcements
- Wall facing
- Leveling course
- Beam seat and superstructure placement
- Approach integration
- Site drainage
- Quality control

Questions?