Resources Available from the National Concrete Bridge Council

2021 Michigan Bridge Week

Virtual Presentation – March 17, 2021 8:40 AM – 10:15 AM

Reid W. Castrodale, PhD, PE
Expanded Shale, Clay and Slate Institute (ESCSI) / Castrodale Engrg Consultants, PC
Chicago, IL / Concord, NC

Gregg A. Freeby, PE
American Segmental Bridge Institute (ASBI)
Austin, TX

National Concrete Bridge Council (NCBC)

The National Concrete Bridge Council (NCBC) is a council of allied industry organizations dedicated to:

- **Promote quality in concrete bridge construction**
- **Gather and disseminate information on design, construction, and condition of concrete bridges**
- **Establish communication with federal and state departments of transportation, city and county public works departments, and consulting engineers**
- **Provide information on behalf of the concrete industries to codes and standards groups**

From NCBC website: www.nationalconcretebridge.org

Current NCBC Members

American Segmental Bridge Institute (ASBI)

Concrete Reinforcing Steel Institute (CRSI)

Epoxy Interest Group of CRSI (EIG)

Expanded Shale, Clay, and Slate Institute (ESCSI)

National Ready Mixed Concrete Association (NRMCA)

Portland Cement Association (PCA)

Precast/Prestressed Concrete Institute (PCI)

Post-Tensioning Institute (PTI)

Silica Fume Association (SFA)

Wire Reinforcement Institute (WRI)

History

NCBC was formed in 1987

First meeting with FHWA was September 15, 1988

Back row (L to R):
Stan Gordon – FHWA
Bob Nickerson – FHWA
Walter Podolny – FHWA
Basile Rabbat – PCA
John Dick – PCI
Ted Neff – CRSI

Seated:
Jim Rossberg - NRMCA

NCBC Activities

Meetings with FHWA twice a year

- **At Professor's Workshop in summer**
- **At FHWA in DC in fall – at FHWA's Turner Fairbank Lab in recent years**

PCA Professor's Workshop – now ACI Professor's Workshop

- **Summer meeting with various tracks, including bridges**

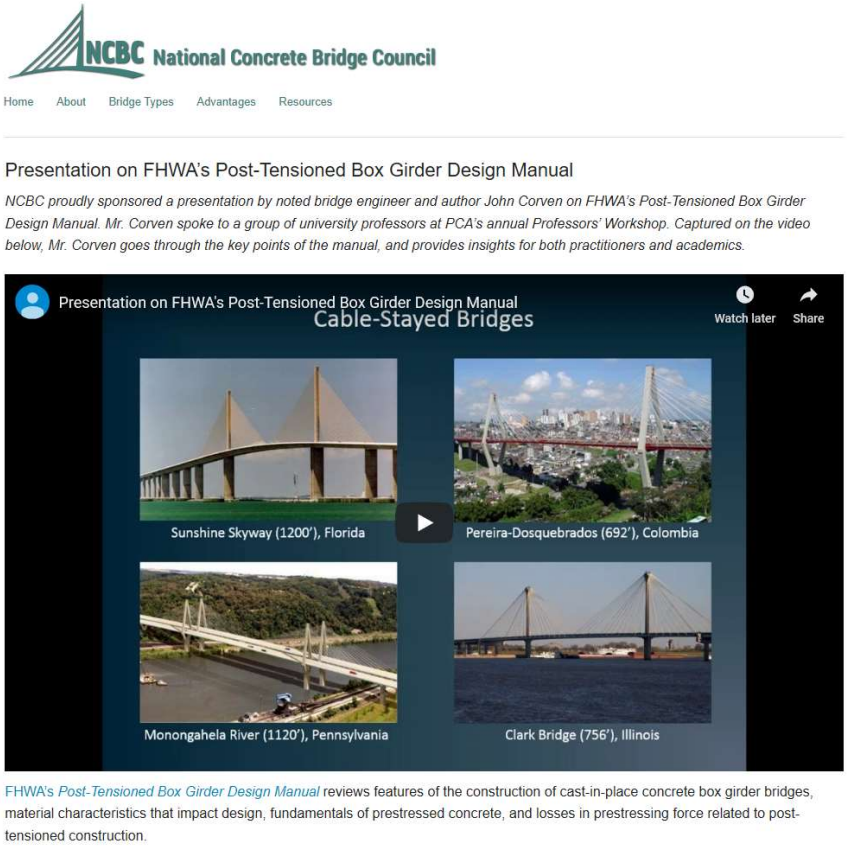
Informal support for AASHTO Technical Committees

- **Especially Concrete Design (T-10)**
- **Joint meetings of T-10 and the PCI Committee on Bridges began in mid-1990s**
- **Joint meetings of T-10 at the ASBI Convention started some time later**

NCBC Activities

Website

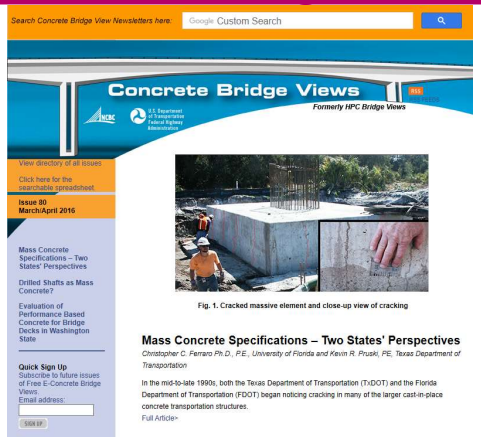
- www.nationalconcretebridge.org
- **Front page currently has a web training video on FHWA's *Post-Tensioned Box Girder Design Manual*.**



NCBC Activities

HPC BridgeViews / Concrete BridgeViews

- Cooperative newsletter with FHWA
- First issue was Jan./Feb. 1999
- Last issue was #80 – March/April 2016
- Issues are still available
  - www.concretebridgeviews.com



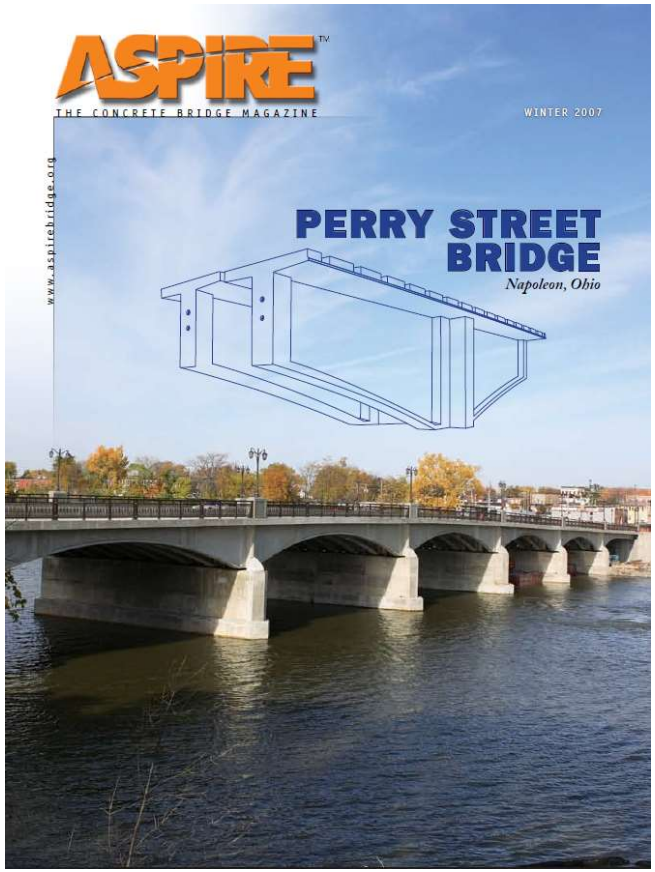
First issue

NCBC Activities

***ASPIRE*, the concrete bridge magazine**

- **About all types of concrete bridges**
- **First issue was Winter 2007**
- **All issues are available online**
  - **www.aspirebridge.org**
  - **Can search an issue or across all issues**
- **Free subscription**
- **Supported by several members of NCBC**

Let us know if you have projects or topics



First issue

NCBC Activities

Resources for Concrete Bridge Design and Construction

- **Intended to be a catalog or "bookshelf" of important resources for the design and construction of concrete bridges**
- **The list is not exhaustive**
- **Other documents may be included that will be useful for the practitioner such as research reports, journal articles, or other publications**
- **First draft is available on conference website with this presentation**

This document was the impetus for this presentation

Resources for Concrete Bridge Design and Construction

Table of Contents

Resources for Concrete Bridge Design and Construction

For each organization

ORGANIZATION DESCRIPTION

A brief description of the organization's mission.

MANUALS OF PRACTICE & SPECIFICATIONS

Industry-developed manuals of practice and guide or standard specifications

REFERENCES

Reference documents produced by the organization or relevant to the organization's products and processes

TRAINING

Available training related to the organization's products and processes

CERTIFICATIONS

Certifications available for the organization's products and processes as well as industry certifications for plants and personnel involved with production of products

Resources Available from the National Concrete Bridge Council

2021 Michigan Bridge Week

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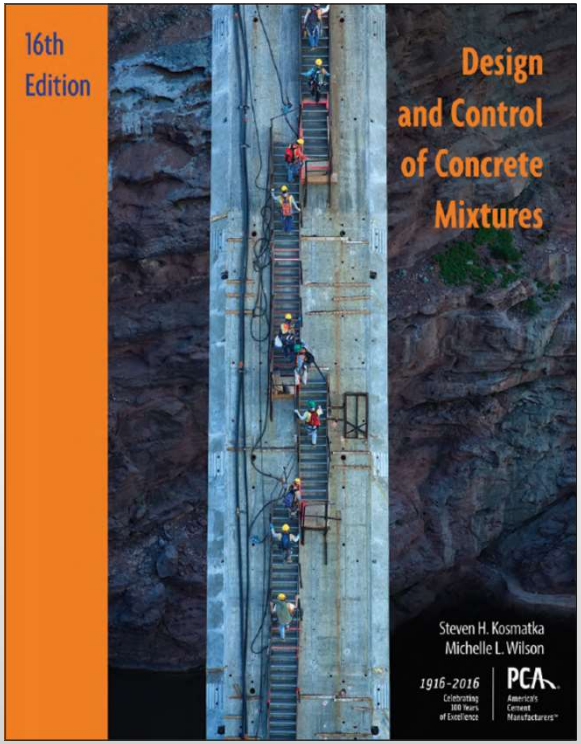
PCA Since 1916
America's Cement Manufacturers™

Portland Cement Association

- National trade association founded in 1916
- Headquarters in Alexandria, Virginia
- Members represent 91% of U.S. cement production capacity
- Members have facilities in all 50 states
- The PCA mission is to "improve and expand the uses of cement and concrete" through:
  - Market development
  - Education
  - Research
  - Technical services
  - Government affairs

PCA Since 1916
America's Cement Manufacturers™

Design and Control of Concrete Mixtures



REFERENCE:

Kosmatka, Steven H. and Wilson, Michelle L.,
Design and Control of Concrete Mixtures, EB001, 16th edition, Portland Cement Association, Skokie, Illinois, USA, 2016, 632 pages.

17th Edition coming in 2021!

PCA Since 1916
America's Cement Manufacturers™

Premier Reference on Concrete Technology

- Backed by over 100 years of research by PCA.
- Reflects the latest information on standards, specifications, and test methods:
  - *ASTM International (ASTM)*
  - *American Association of State Highway and Transportation Officials (AASHTO)*
  - *American Concrete Institute (ACI)*

PCA Since 1916
America's Cement Manufacturers™

Design and Control of Concrete Mixtures

Abstract

- Fresh and hardened properties of concrete, such as workability, strength, volume change, and durability, are presented.
- All concrete ingredients (cementing materials, water, aggregates, chemical admixtures, and fibers) are reviewed for their optimal use in designing and proportioning concrete mixtures.
- The use of concrete from design to batching, mixing, transporting, placing, consolidating, finishing, and curing is addressed.
- Concrete pavements and structures along with sustainability and high-performance concretes, are also reviewed.

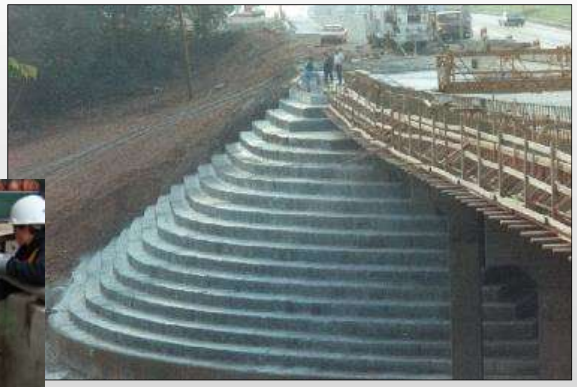
PCA Since 1916
America's Cement Manufacturers™

Lightweight Cellular Concrete

Lightweight cellular concrete (LCC) is a mix of portland cement, water, and air that can act as a lightweight, strong, durable, and inexpensive soil or fill replacement for geotechnical applications including retaining wall backfill and bridge abutments.

California Nevada Cement Association

Aerix Industries

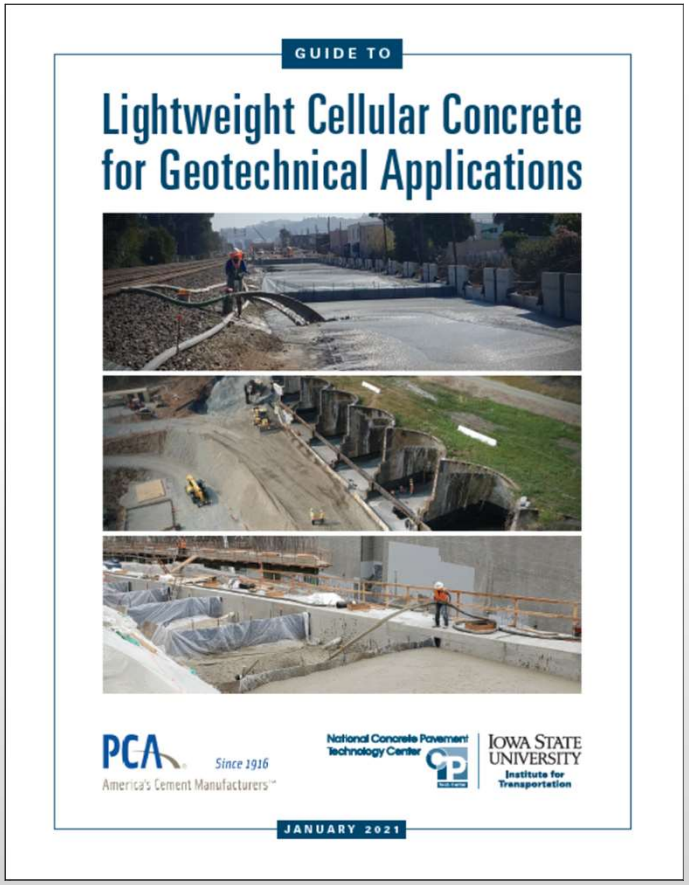


©1993 Elastizell Corporation of America

PCA Since 1916
America's Cement Manufacturers™

New LCC Guide

- Information on common uses and conceptual guidance, as well as design guidelines, for construction professionals and design engineers
  - Chapter 1 – Introduction
  - Chapter 2 – Physical Properties
  - Chapter 3 – Geotechnical Design Considerations
  - Chapter 4 – Mixture Design
  - Chapter 5 – Construction
  - Chapter 6 – Inspection, Testing, and Maintenance
- Appendix with guide specifications for the construction of LCC fill



PCA Since 1916
America's Cement Manufacturers™

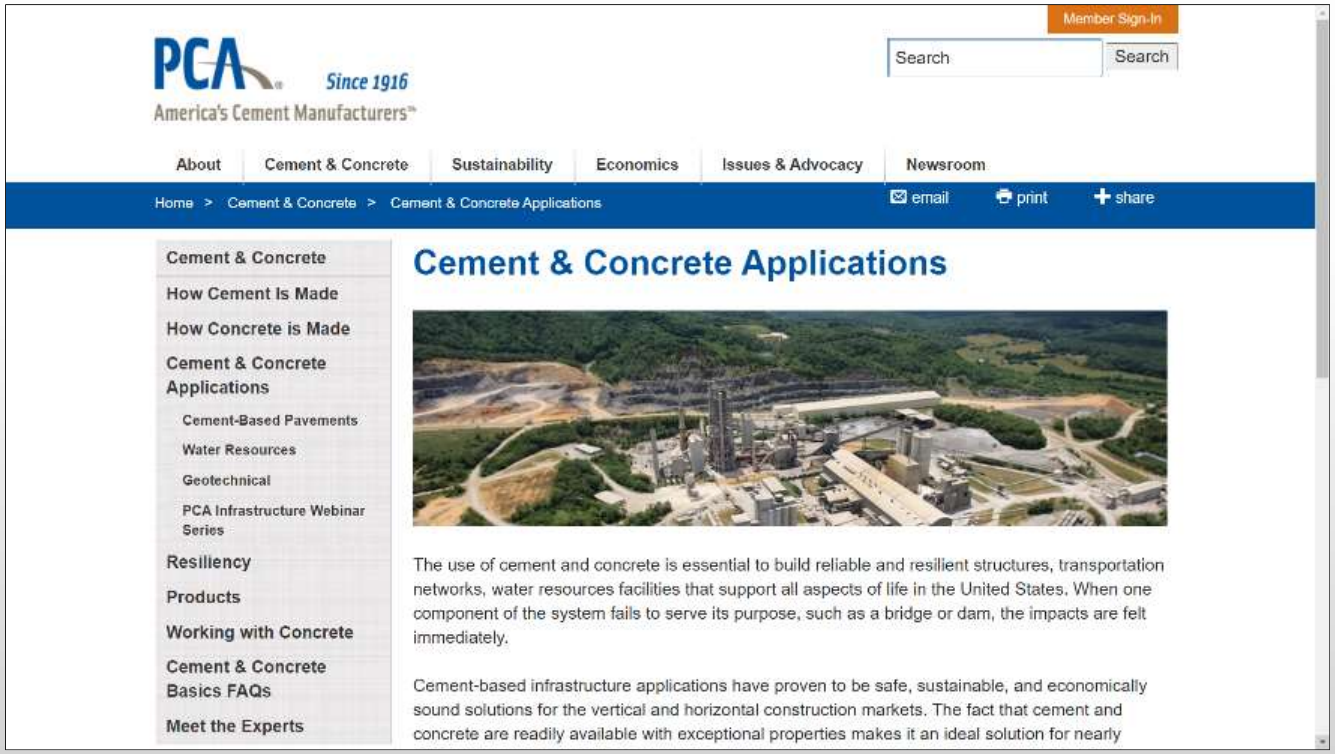
PCA 2021 Infrastructure Webinar Series

- Integrated Pavement Solutions with Portland Cement (April 28)
- Cement Modification and Stabilization of Soils (May 5)
- Sustainable Pavements with Full-Depth Reclamation (May 12)
- Design of Cement-Stabilized Bases (May 19)
- Roller-Compacted Concrete for Pavements (May 26)
- Geotechnical Solutions with
  Lightweight Cellular Concrete (June 2)
- Sustainability of Cement and Concrete (June 16)
- Cement-Based Water Resources Applications (June 30)
- Applications of Roller-Compacted Concrete for Dams (July 7)
- Design and Testing of Roller-Compacted Concrete (July 14)

Registration information coming soon!

PCA Since 1916
America's Cement Manufacturers™

www.cement.org



Resources Available from the National Concrete Bridge Council

2021 Michigan Bridge Week

Virtual Presentation – March 17, 2021 8:40 AM – 10:15 AM

The Silica Fume Association (SFA)

2021 Michigan Bridge Week

Virtual Presentation – March 17, 2021 8:40 AM – 10:15 AM

Jim Wolsiefer

Presented by Reid W. Castrodale, PhD, PE

www.silicafume.org


Silica Fume
User's Manual
U.S. Department of Transportation
Federal Highway Administration
SFA
SILICA FUME ASSOCIATION
Impermeability
High Strength
Sustainability
Durability
Viscosity

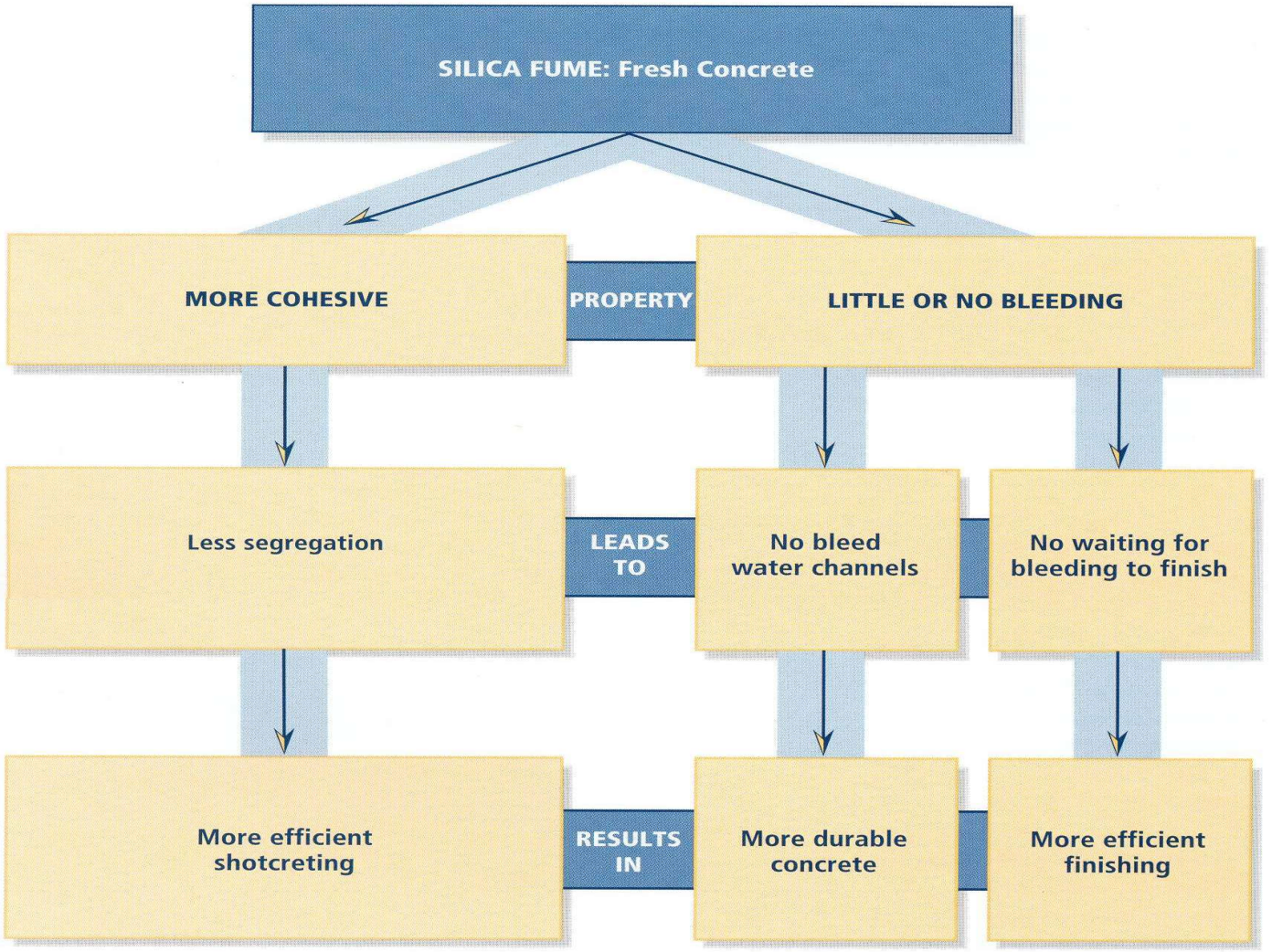
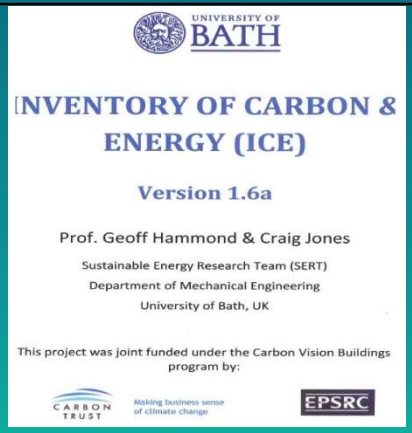

SILICA FUME: Fresh Concrete
MORE COHESIVE
PROPERTY
LITTLE OR NO BLEEDING
Less segregation
LEADS TO
No bleed water channels
No waiting for bleeding to finish
More efficient shotcreting
RESULTS IN
More durable concrete
More efficient finishing

FIGURE 4.4. Silica fume Standard Reference Material (SRM 2696) available from the National Institute for Standards and Technology. Check either the Silica Fume Association or NIST web sites, as listed in the text, for instructions on how to order this material.

RMC Environmental Impact & Energy Savings

Recovered Mineral Component	Fly Ash	Slag Cement	Silica Fume
	per pound:		
Avoided CO2 Emissions	0.318 lbs	0.304 lbs	0.318 lbs
Energy Savings	$ 0.059	$ 0.053	$ 0.411
	per kilogram:		
Avoided CO2 Emissions	0.70 kg	0.67 kg	0.70 kg
Energy Savings	$ 0.129	$ 0.116	$ 0.905

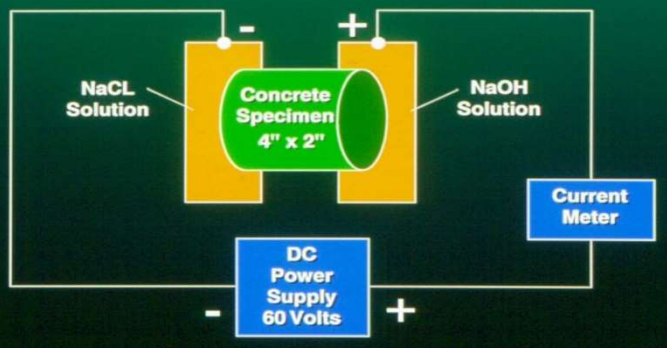


Carbon Footprint / per metric ton

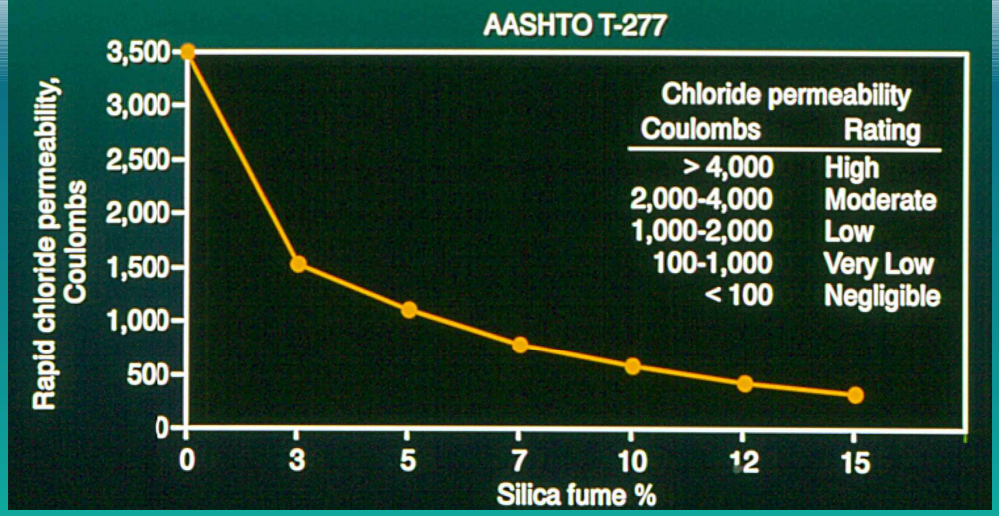
Portland Cement	Slag Cement	Fly Ash	Silica Fume
959 kg	155 kg	93 kg	14 kg

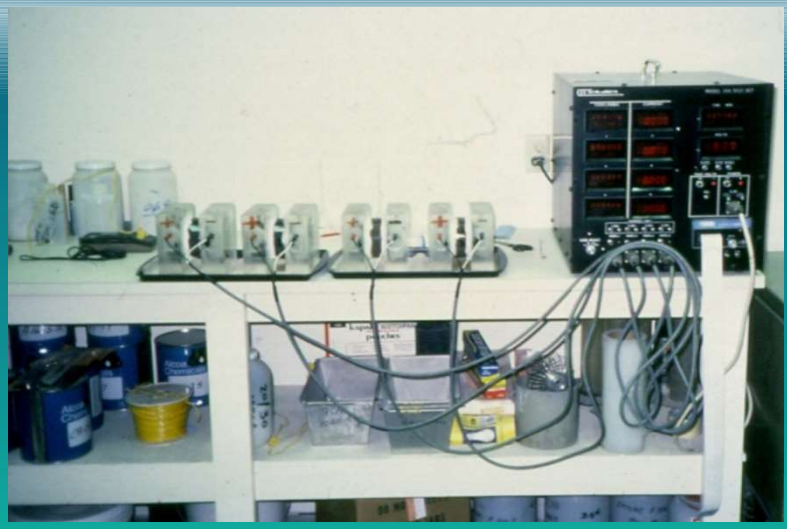
Low Permeability Concrete

RCP Aashto T-277 Test Apparatus



Rapid Chloride Permeability Test





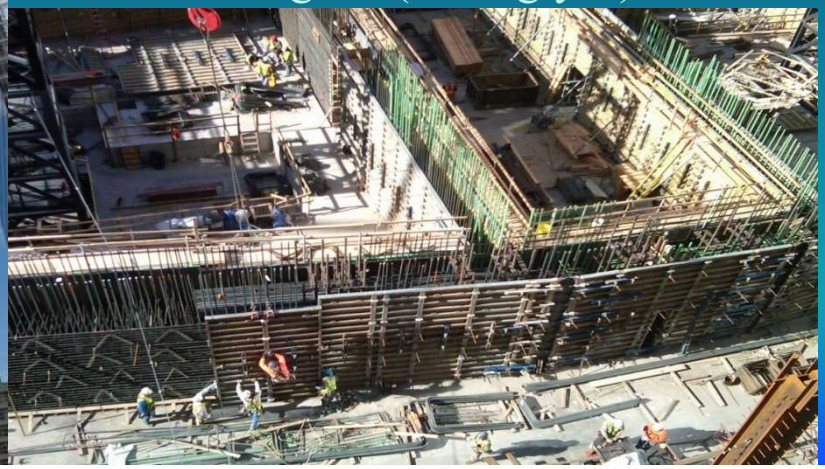
World Trade Center, NYC

Total Binder Content
518 kg/m^3 (873 lbs/yd^3)

55% Slag Cement / 3% Silica Fume
7% Fly Ash / 35% Portland Cement

16,160 psi (111MPa) @ 56 days
binder efficiency = 18.5 psi/lb

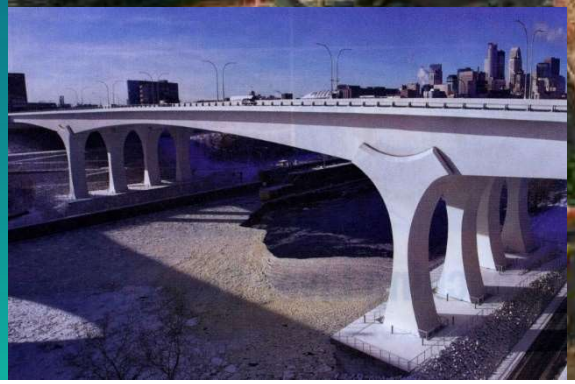
Carbon Footprint :
218 kg/m^3 (168 kg/yd^3)



I-35 W
Minneapolis

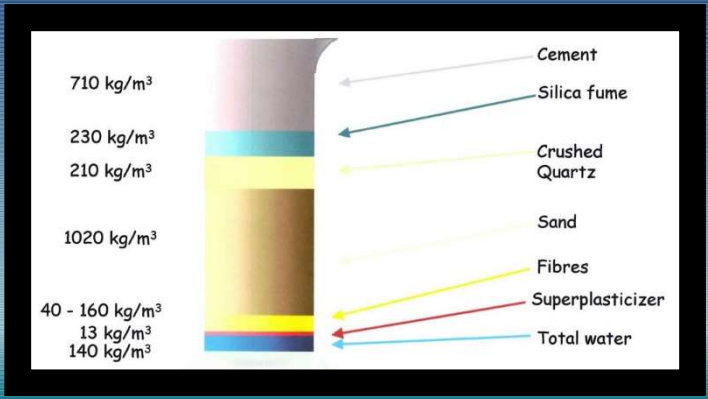
SUSTAINABLE :
slag cement
silica fume
& fly ash

O.P.C. as low as 15 %
RCPT = 250 coulombs @ 28 days
f'_c = 4,000 – 6,500 psi



Panama Canal 100 year design life

Ultra High Performance Concrete



Density	2500 kg/m 3
Compressive strength	150 - 180 MPa
Bending strength	32 MPa
Tensile strength	8 MPa
Young modulus	50 000 MPa
Poisson ratio	0.2
Shrinkage	0
Creep factor	0.15 - 0.3
Resistance to fatigue	> 10 millions cycles
Thermal expansion coefficient	12.10^{-6} m/m

Chlorine ion diffusion (AASHTOO T259)	$2.\ 10^{-14}$ m²
Carbonation (CEN standard)	nil
Gas permeability (Nitrogen)	$1.5\ 10^{-20}$ m²
Freeze thaw resistance (Young modulus after 300 cycles	100 %
Abrasion resistance (CNR test index)	1.1
Water porosity	1.9%
Tritium water diffusion	10^{-5} cm²/day

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The Expanded Shale, Clay and Slate Institute (ESCSI)

The Expanded Shale, Clay and Slate Institute (ESCSI) was founded in 1952 and is the international trade association for manufacturers of ESCS lightweight aggregate.

ESCSI sponsors limited research and development on applications of LWA. Results of research and other work is then developed and disseminated to all parts of the building industry.

ESCSI works closely with other technical organizations, ACI, ASTM, etc., to maintain product quality, life-safety, and professional integrity throughout the construction industry and related building code bodies.

ESCSI
Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate

What is Lightweight Aggregate?

ESCSI members manufacture lightweight aggregate (LWA) using rotary kilns where raw materials (shale, clay & slate) are expanded at temperatures of around 2000 deg. F

The LWA produced in this manner

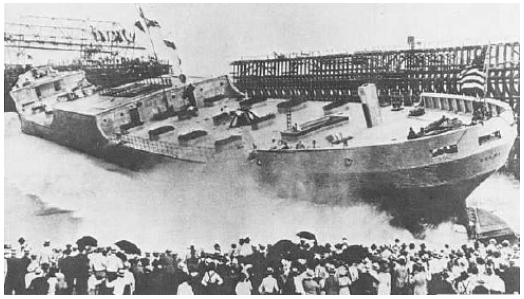
- is a vitrified ceramic
- is about as hard as quartz
- is about ½ as dense as NWA
- has 6-30% absorption

1 lb. of each aggregate

ESCSI
Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate

Uses for Lightweight Aggregate

- Structural lightweight aggregate (LWA) has been commercially manufactured in USA since 1920 – not a new material!
- It was immediately used to produce structural lightweight concrete (LWC)



USS Selma 1918

San Francisco Oakland Bay Bridge 1936

- Obvious benefit was reduced density
- Also found that the material was very durable

ESCSI
Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate

Uses for Lightweight Aggregate

- LWC used on San Francisco-Oakland Bay Bridge – built in 1936
- Used "all LWC" (95 pcf air dry) for upper deck of suspension spans
- Lower deck was reconfigured for highway traffic in 1958 using LWC
- Both decks are still in service today - protected by wearing surfaces

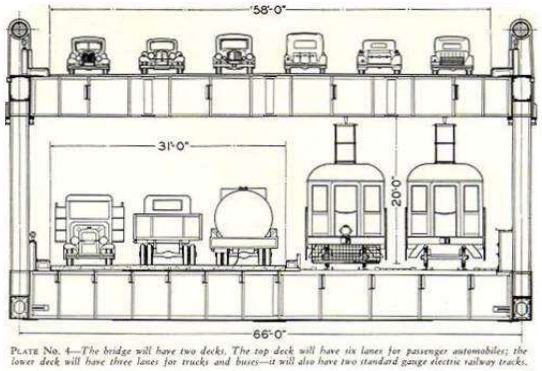
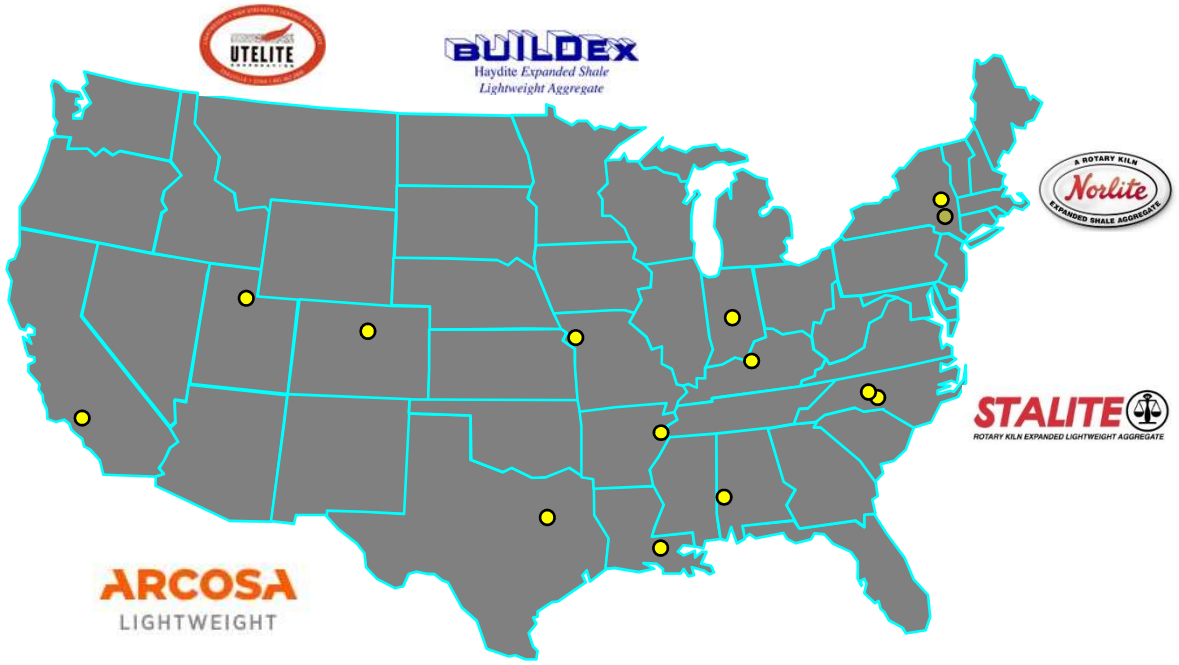


PLATE No. 4—The bridge will have two decks. The top deck will have six lanes for passenger automobiles; the lower deck will have three lanes for trucks and buses—it will also have two standard gauge electric railway tracks.

ESCS Plants in the US



14 plants in the US

See www.escsi.org for locations of member company plants

ESCSI
Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate

Applications of LWA for Transportation Facilities

- Structural Lightweight Concrete (LWC)
  - Cast-in-place concrete
  - Precast concrete
  - Prestressed concrete
- Internal Curing of Concrete
- Geotechnical
- Rain Gardens
- Water Treatment
- Asphalt Chip Seal






ESCSI
Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate

Lightweight Concrete Bridges

LWC has been successfully used for

- Decks
- Prestressed and post-tensioned concrete
- Other elements, especially when precast

Many examples are available

- Three are shown here

ESCSI
Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate

Beach Bridge in North Haven, ME

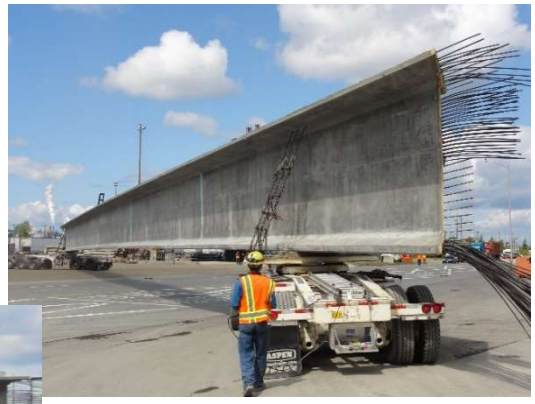
- Replace two-span bridge on island off coast of Maine
- Sand LWC used for NEXT D beams
  - Allowed re-use of existing pier
  - Avoided design & construction of a new foundation in difficult soil conditions
  - Bridge closure shortened by eliminating pier reconstruction
    - Bridge was only access to several homes, the local fishing wharf, and beach
  - Reduced beam weight for shipping and handling at remote location
- SCC LWC mix properties
  - Design f'_c = 6 ksi; max. plastic density = 120 lb/ft^3; spread of 22 to 28 in.

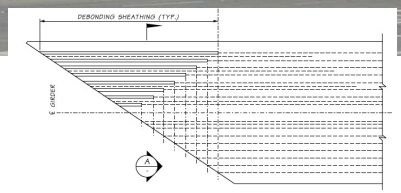
Benicia-Martinez Bridge, CA

- I-680 over the Carquinez Strait north of San Francisco (completed in 2008)
- Cast-in-place box girder
  - 82 ft wide deck
  - 658 ft max. spans
- LWC was used for the entire segmental box girder cross-section
  - LWC used for full length of 6500 ft bridge except for pier segments
  - Reduced seismic forces, foundations & cost
- If research on LWC ductility now completed was available at design, the bridge would probably have used LWC from the top of footing

Portland Ave/Puyallup River - Tacoma, WA

- New US record for the longest single piece PS girder
  - 223 ft long – plus severe skews (add 7 ft)
  - WF100G Mod – 8'-4" tall; 5'-1" wide top flange
  - Same LWC mix as I-5 over the Skagit River
  - LWC required to be able to truck girder to site





Internal Curing of Concrete with LWA

Replace a portion of the conventional sand in a concrete mixture with prewetted LWA to deliver curing water to the interior of concrete

- Reduces shrinkage and cracking
- Reduces permeability through better hydration of cement
- Slightly reduces density
- Does not affect w/cm since water comes out after concrete has set

NYS DOT now requires the use of internal curing for decks on continuous multi-span bridges because of success in using it

- Also reduce wet curing from 14 days to 7 days with internal curing

Internal Curing of Concrete with LWA

Example of internal curing in the field

Test pour for 10Mgal water storage tank - Highlands Ranch, CO

- Internal Curing vs. No Internal Curing
- Concrete placed at 92 deg F air temp. & 20% RH
- No conventional curing of any type was applied

Surface still moist

Surface is dry

ESCSI Resources - www.escsi.org

The ESCSI website has a section for Structural Applications

- Many references and reports are available here – all that are posted are available free of charge
- A few resources require purchase from the publishing organization.
- Check out these webpages for Structural Applications:
  - Technical Docs: https://www.escsi.org/tech-docs/
  - Latest Papers: https://www.escsi.org/structural-lightweight-concrete/latest-papers/
  - Training: https://www.escsi.org/videos/
    https://www.escsi.org/professional-courses/
  - Newsletter: https://www.escsi.org/news/

ESCSI
Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate

Slide 45

RC1 The videos listed in the slides that follow are not on the website - not that I can find!
Reid Castrodale, 3/10/2021

KH2 https://www.escsi.org/videos/
Ken Harmon, 3/10/2021

KH6 https://www.escsi.org/professional-courses/
Ken Harmon, 3/10/2021

RC2 I thought that this could be added, then we could skip/hide many of the detail slides that follow, as I have done.
Reid Castrodale, 3/10/2021

KH3 Yep, I agree
Ken Harmon, 3/10/2021

KH5 https://www.escsi.org/news/
Ken Harmon, 3/10/2021

RC3 Added this and will hide slide that follows. Removed item about finding suppliers since that is mentioned on the map slide.
Reid Castrodale, 3/10/2021

KH4 Yep, I agree
Ken Harmon, 3/10/2021

KH7 Ken Harmon, 3/10/2021

ESCSI Resources - www.escsi.org

Manuals & Specifications

- *ESCSI Reference Manual for the Properties and Applications of Expanded Shale, Clay and Slate Lightweight Aggregate*
  - Comprehensive document on production, properties and use of ESCS LWA for the wide range of applications
- *Guide Specification for Structural Lightweight Concrete (2001)*
- *Guide Specifications for Internally Cured Concrete (2012)*

ESCSI
Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate

ESCSI Resources - www.escsi.org

References – Selected titles shown

- *Cracking Tendency of Lightweight Concrete (2010)*
  - Report on testing three types of LWC using three types of LWA for a typical bridge deck mix
- *Effect of Lightweight Aggregate on Early-Age Cracking of Mass Concrete (2017)*
  - Report on tests of LWC to demonstrate reduction in cracking potential for mass concrete
- *Specified Density Concrete, (2005)*
  - Paper describing benefits of using a specified density concrete rather than the usual definitions of LWC based on constituents

ESCSI
Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate

ESCSI Resources - www.escsi.org

Training

A series of courses on internal curing presented by Dr. Jason Weiss of Oregon State Univ. in 2013 are available free of charge

- *Module 1: Improving the Performance of Concrete with Internal Curing*
- *Module 2: Internal Curing Concept, Proportioning and Aggregate*
- *Module 3: Internal Curing Shrinkage and Shrinkage Cracking*
- *Module 4: Internal Curing Mechanical and Transport Properties*
- *Module 5: Improving Sustainability with Internal Curing*

ESCSI
Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate

ESCSI Resources - www.escsi.org

Training

Four videos demonstrating test methods and field production procedures for internally cured concrete are available free of charge

- *Centrifuge Test for Internal Curing Lightweight Aggregate*
- *Internally Cured Concrete Part One: Lightweight Aggregate Preparation, Moisture Testing and Mix Design*
- *Internally Cured Concrete Part Two: Plant Charging and Batching Considerations*
- *Determining the Moisture Content of Lightweight Aggregate Using the Towel Dry Method*

ESCSI
Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate

ESCSI Resources - www.escsi.org

Training

A video that demonstrates proper test procedures for the Volumetric Air Meter is available free of charge

- *ASTM C173 Volumetric Air Meter Test Video*

ESCSI
Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate

ESCSI Resources – Lightweight Design eNews

Newsletter

Lightweight Design eNews is an electronic newsletter that provides article on recent projects that have used LWA or LWC

Most issues include at least one article related to bridges

Free subscription is available by using the "Quick Link" at the bottom of any page on the website, and select "Lightweight Design eNews"

ESCSI
Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate

ESCSI Resources - www.escsi.org

- Additional papers, reports, and promotional info are available on website
- Presentations from some past workshops are also available
- Recent publications on LWC include:
  - Service life extension with LWC
  - Reduced cracking in mass concrete
  - Mitigation of ASR
  - Internal curing of concrete with prewetted LWA
- Upcoming publications on LWC include:
  - LWC Primer for Bridges - FHWA

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Rotary Kiln Structural Lightweight Aggregate

Resources Available from the National Concrete Bridge Council

2021 Michigan Bridge Week

Virtual Presentation – March 17, 2021 8:40 AM – 10:15 AM

Overview

Matt Shergalis

Northeast Region Manager

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630-380-5867

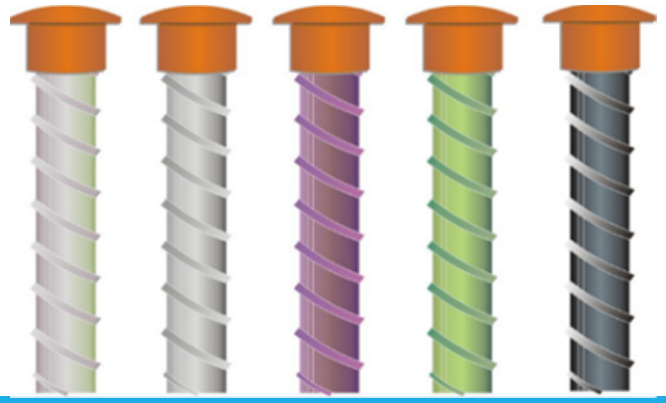
(Presented by Reid Castrodale)

CRSI Concrete Reinforcing Steel Institute

Concrete Reinforcing Steel Institute

Founded in 1924, the Concrete Reinforcing Steel Institute (CRSI) is a technical institute and Standards Developing Organization (SDO) that stands as the authoritative resource for information related to steel reinforced concrete construction. CRSI offers many industry-trusted technical publications, standards documents, design aids, reference materials, and educational opportunities.

CRSI members include manufacturers, fabricators, material suppliers, and placers of steel reinforcing bars and related products as well as professionals who are involved in the research, design, and construction of steel reinforced concrete structures and bridges.

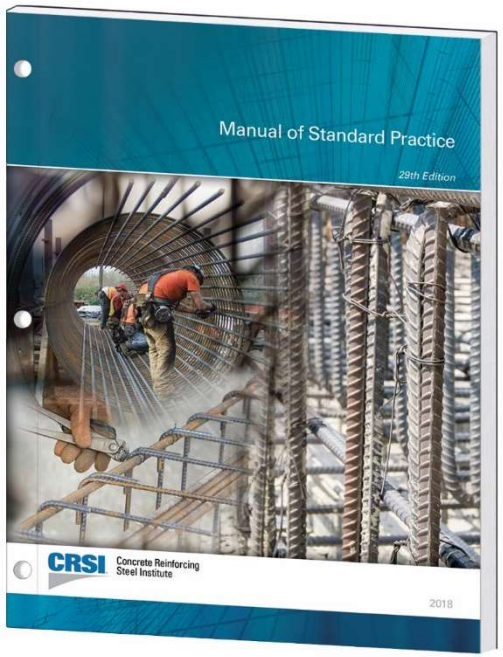


Resources

- Case Studies
- Design Guides
- Detailing Supplements
- Engineering Data Reports
- Research Reports
- Standard Documents
- Technical Notes

Manual of Standard Practice

- Recommended industry practices for estimating, detailing, fabricating, and placing reinforcing steel for reinforced concrete construction
- Includes suggested specifications for reinforcing steel



Research

- Use of High Strength Steel (Grades 80 & 100)
- Evaluation of End Anchors and Hooks
- Anchorages and Splices
- Harmonization of ASTM 615 and A706

Standards

- CRSI RB4.1 - Supports for Reinforcement Used in Concrete (2016)
- CRSI CG1.1 - Epoxy Coating Plant: Straight Bar Lines (2016)
- CRSI CG1.2 - Epoxy-Coated Facilities: Custom Lines (2016)
- CRSI CG2.1 - Epoxy-Coated Steel Reinforcing Bar Fabrication Facilities (2016)
- CRSI IPG4.1 - Stainless Steel Reinforcing Bar Fabrication Facilities (2016)

https://www.crsi.org/index.cfm/standards/standards_docs

Certification Programs

Independent Manufacturers Certification Committee (IMCC)

- Oversees Programs and Acts on Behalf of CRSI
- Responsible for policies and procedures for all issues
- Ensures that a quality system is established, implemented and maintained
- Develops certification programs
- Balanced Committee Structure of Users, Producers and General Interest

Certification Programs

Certification Administrator (CA)

- Oversees and manages the operation of certification programs

Independent Auditor (IA)

- ISO/IEC 17020 Accredited
- Review's quality control program and provides inspection services:
    - Unannounced annual inspections
    - Initial inspections
    - Random inspections
    - Re-inspections for critical non-conformances

Certification Programs

Types of Certifications

- Epoxy Coating of Straight Bars
- Epoxy Coating of Custom Bars
- Epoxy Coating of Fabricated Bars
- Stainless Steel Fabricated Bars

Total Number of Participating Plants: 34

e-Learning

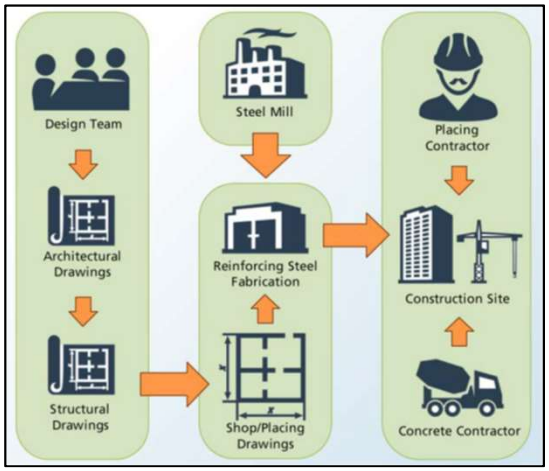
On-Demand Webinars

High-Strength Steel Reinforcement

REBAR U

www.crsi.org

Interactive Courses



Steel Reinforced Concrete: Essentials

Overview

Peter Fosnough

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(Presented by Reid Castrodale)

EIG CRSI

EPOXY INTEREST GROUP

What is EIG?

EIG CRSI
EPOXY INTEREST GROUP

In 1991, CRSI initiated a Certified Plant Program for epoxy-coated bar producers and today there are 35 certified coating plants.

In March 2008, a new group was formed within CRSI. The Epoxy Interest Group (EIG) of CRSI operates within the charter of CRSI to promote and market epoxy-coated bars and is able to create awareness and interest in epoxy coated reinforcing steel (rebar) and its important benefits for DOT's, engineering specifiers and contractors.

The Epoxy Interest Group consists of 17 companies operating 28 coating operations and 5 powder manufacturing plants in North America.

Advantages of Epoxy

EPOXY INTEREST GROUP

- Optimum protection from de-icing salts.
- High speed coating—any steel
- Maxmum flexibility for fabrication
- Sustainability

  - Local sourcing, Recycled & Life Cycle (100+)

Meets or Exceeds:

ASTM A775

AASHTO M284

ASTM A884

AASHTO M254 for dowel bar

FHWA

www.epoxyinterestgroup.org

Resources

EPOXY INTEREST GROUP

- Publications
- Presentations
- Papers
- Research Reports
- Industry Practices
- Videos

www.epoxyinterestgroup.org

Research

EPOXY INTEREST GROUP

- Comparative Laboratory Study of Metallic Reinforcing Steel for Corrosion Protect (FHWA-HRT-15-078) - SK Lee
- Laboratory Evaluation of Corrosion Resistance of Various Metallic Dowel Bars (FHWA-HRT-15-079) – SK Lee
- Hot Dip (A767) vs Continuous Galvanized (A1094)

www.epoxyinterestgroup.org

New Technologies

EPOXY INTEREST GROUP

- Abrasion Resistant Coat
- Dual-Coated (A1055)
- Textured Coat
- Self-Healing

www.epoxyinterestgroup.org

Dual Coat

EIG CRSI
EPOXY INTEREST GROUP

- Greenbar+ powder designed for improved adhesion over Continuous Galvanized Rebar
- ASTM A1055 testing in Progress
- No change in IR signature; readily acceptable by DOTs owing to credibility of Greenbar (base formula)
- Ready plug-in on customer lines, same application
- Prof. Castaneda's (Texas A&M) research shows Epoxy over CGR is better than Stainless on several corrosion performance tests and will result in longer lifespan of the infrastructure project.

Textured Coat

EPOXY INTEREST GROUP

- High Performance Roughcoat powder for improved mechanical adhesion to concrete
- Exhibits superior damage tolerance, reduced microcracking & extends bridge life
- Significant possible code advantages in seismic and commercial building zones
- Reduced steel congestion for bridge piers and commercial buildings in high $/sq.ft.
- Increased traction of workers during installation, reducing workplace injuries
- Collaboration with several DOTs & Universities for independent evaluation

Resources Available from the National Concrete Bridge Council

2021 Michigan Bridge Week

Virtual Presentation – March 17, 2021 8:40 AM – 10:15 AM

Brian Killingsworth, P.E.

Executive Vice President

National Ready Mixed Concrete Association

bkillingsworth@nrmca.org

2021 Michigan Bridge Week

Virtual Presentation – March 17, 2021 8:40 AM – 10:15 AM

NRMCA

NCBC

What are we talking about?

- Plant & Truck Certifications and Personnel Accreditations
- Concrete Materials & Innovations
- Material Disclosures and Life Cycle Thinking
- Resiliency

National Ready Mixed Concrete Association

- Founded in 1930
- Represent the Ready Mixed Concrete Industry Through Activities:
  - Promotion
  - Education
  - Advocacy
  - Regulatory
  - Engineering
  - Safety, Operations, and Environmental
  - Work Force Development
- State Associations in All 50 States
- Represents Equipment Manufacturers Through Mixer and Truck Bureaus

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Certification Encouraged For Agencies & Suppliers

NRMCA Personnel Certifications:

- Concrete Exterior Flatwork Finisher Program
- Certified Concrete Sales Professional (CCSP)
- Certified Sustainability Professional
- Concrete Delivery Professional Certification
- Concrete Field Testing Technician Grade II
- Concrete Green Building Certification
- Concrete Sustainability Professional Certification
- Concrete Technologist Level 2 “Technical Short Course”
- Concrete Technologist Level 3
- Concrete Technologist Level 4 “Durability Course”
- Effective RMC Supervisor Certification
- Environmental Professional Certification for the Ready Mixed Concrete Industry
- Fleet Manager Certification
- NRMCA Safety Certification
- OSHA 10-Hour Safety Certification for General Industry
- Pervious Contractor Certification
- Plant Manager Certification
- Sales Manager Certification

NRMCA Plant Certifications:

- Quality: Plant and Truck Certification and/or Quality Certification Program
- Environmental Stewardship: Green-Star Certification Program
- Sustainability: Sustainable Concrete Plant Certification

Testing Agency Qualifications (ASTM and AASHTO):

- ASTM C1077 and ASTM E329 for Quality Assurance Testing
- Concrete Mixture Design: CCRL AASHTO Accreditation Program (AAP)

Testing Personnel Certifications:

- Field: ACI Concrete Field Testing Technician Grade 1 (according to ACI CP-1)
- Laboratory Technician: ACI certified Concrete Strength Testing Technician or Concrete Laboratory Testing Technician - Level I
- Laboratory Supervisor: ACI certified Concrete Laboratory Testing Technician - Level II

NRMCA Product Certifications:

- NRMCA Certified Environmental Product Declaration

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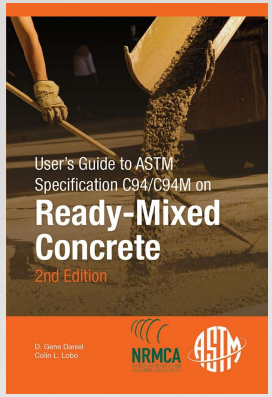
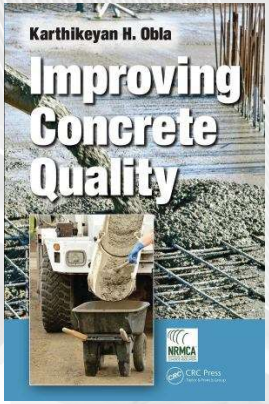
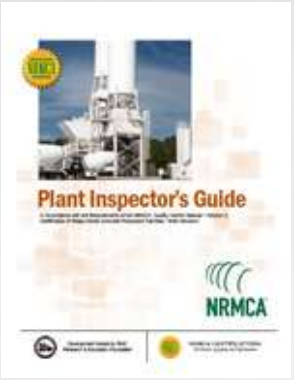
NRMCA Resources

- User's Guide to ASTM Specification C94 (Ready Mixed Concrete)
- Plant Inspector Guide & Qualification
- Improving Concrete Quality
- Guide to Improving Specifications for Ready Mixed Concrete
- Online Safety Series







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In Practice Series

Concrete in Practice Series (CIP)

- Dusting Concrete Surfaces
- Scaling Concrete Surfaces
- Crazing Concrete Surfaces
- Cracking Concrete Surfaces
- Plastic Shrinkage Cracking
- Joints in Concrete Slabs on Grade
- Cracks in Residential Basement Walls
- Discrepancies in Yield
- Low Concrete Cylinder Strength
- Strength of In-Place Concrete
- Curing In-Place Concrete

Concrete in Practice Series (CIP)

- Hot Weather Concreting
- Blisters on Concrete Slabs
- Finishing Concrete Flatwork
- Chemical Admixtures for Concrete
- Flexural Strength of Concrete
- Flowable Fill
- Radon Resistant Buildings
- Curling of Concrete Slabs
- Delamination of Troweled Concrete Surfaces
- Loss of Air Content in Pumped Concrete
- Grout

Concrete in Practice Series (CIP)

- Discoloration
- Synthetic Fibers for Concrete
- Corrosion of Steel in Concrete
- Jobsite Addition of Water
- Cold Weather Concreting
- Concrete Slab Moisture
- Vapor Retarders Under Slabs on Grade
- Supplementary Cementitious Materials
- Ordering Ready Mixed Concrete
- Concrete Pre-Construction Conference
- High Strength Concrete

Concrete in Practice Series (CIP)

- Making Concrete Cylinders in the Field
- Testing Compressive Strength of Concrete
- Structural Lightweight Concrete
- Self-Consolidating Concrete (SCC)
- Pervious Concrete
- Maturity Methods to Estimate Concrete Strength
- Aggregate Popouts
- Acceptance Testing of Concrete
- Thermal Cracking of Concrete
- Alkali Aggregate Reactions (AAR)
- Durability Requirements for Concrete

- Available in English and Spanish
- Digital Copies are Free
- Printed Copies for Purchase

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In Practice Series

Technology in Practice Series (TIP)

- Quantifying Concrete Quality
- Aggregate Sampling for Laboratory Tests
- Aggregate Sample Reduction for Laboratory Tests
- Capping Cylindrical Concrete Specimens with Sulfur Mortars and Unbonded Caps
- Aggregate Moisture and Making Adjustments to Concrete Mixtures
- Creating and Using Three Point Curves for Laboratory Trial Batches
- Concrete Yield
- Density of Structural Lightweight Concrete
- Mixing Water Quality for Concrete
- Testing Concrete Cores
- Slump Loss of Concrete

Technology in Practice Series (TIP)

- Chloride Limits in Concrete
- Time of Setting of Concrete Mixtures
- Estimating Concrete Strength Using Maturity
- Evaluating Strength Test Results
- Drying Shrinkage of Concrete
- Managing Concrete Temperature for Specified Requirements
- Reuse of Returned Concrete
- Understanding Variability of Test Methods—Precision Statements

Specification in Practice (SIP)

- Limits on Quantity of Supplementary Cementitious Materials
- Limits on Water-Cementitious Materials Ratio (w/cm)
- Minimum Cementitious Materials Content
- Restrictions on Type and Characteristics of Fly Ash
- Restrictions on Aggregate Grading

- Digital Copies are Free
- Printed Copies for Purchase

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Cement and Concrete Innovations

- Limestone cements – ASTM C595 or AASHTO M 240 - Type IL (5-15% interground limestone):
  - Manufactured for equivalent performance to ASTM C150 cements
- Natural pozzolans and ground glass pozzolans
- Mineral fillers – ASTM C1797 (ground calcium carbonate or aggregate mineral fillers)
- Workability retaining admixtures
- Crack reducing admixtures (besides shrinkage reducing)
- Nano-carbon fibers for improved durability (likely expensive)
- Integral water proofing admixtures for reduced permeability
- Latex Modified Concrete-Very Early Strength (w/sulfoaluminate cements - SAC):
  - e.g. bridge deck overlays reaching 3,500 psi in 24 hr
- Technology for consistent fresh properties:
  - in-transit water and admix adjustments
  - real time air monitoring

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Self-Cleaning Concrete

- Concrete made with titanium dioxide (TiO_2) cement
- TiO_2 breaks down harmful pollutants
- Reaction catalyzed by light…photocatalysis
- Intended for projects in urban centers
  - e.g. Nitrous dioxide (NO_2) produced by burning fuels in cars and trucks.
  - Responsible for acid rain, smog, respiratory problems and staining
  - Reaction with sunlight converts NO_2 to NO_3
  - A harmless salt which is dissolved by water

Courtesy of Lehigh Hanson

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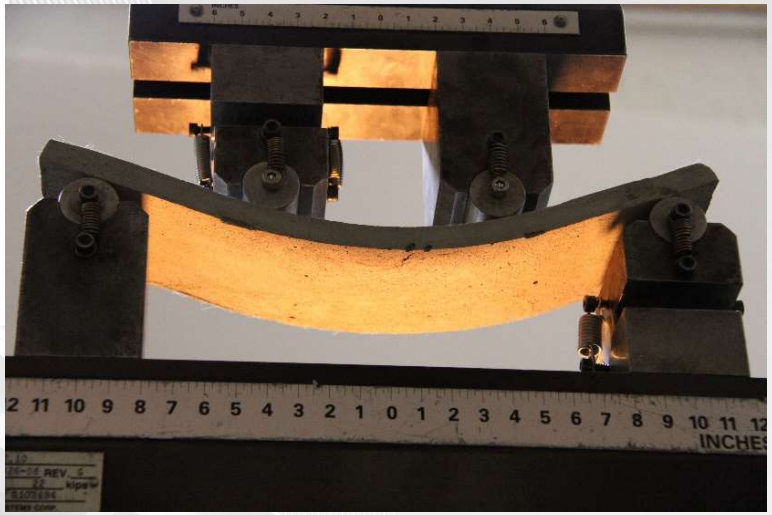
Bendable Concrete (aka Engineered Cementitious Composite)

- 300-500 times more tensile strain capacity than normal concrete
- Tiny fibers disbursed throughout
- Can absorb greater quantities of energy without being damaged
- Applications
  - Paved surfaces with repeated loading of heavy vehicles
  - Viaduct dampers
  - Earthquake resistance in tall buildings
- Self-healing capabilities
  - Keeps cracks relatively small
  - Natural reactions through carbon mineralization
  - Repairs the cracks and restores the durability
- Has been commercialized



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Ultra High Performance Concrete (UHPC)

- Manufacturer distributes the premix powder, fibers and admixtures to partners
- Can use high carbon metallic fibers, stainless fibers, poly-vinyl alcohol (PVA) fibers or glass fibers
- Improves strength and ductility
- Less porous than conventional concrete
- More resistant to chlorides, acids, and sulfates
- Has self-healing properties

NM 186 crossing the La Union Canal in Anthony, New Mexico
Courtesy of New Mexico State University

Courtesy of LafargeHolcim/Ductal®

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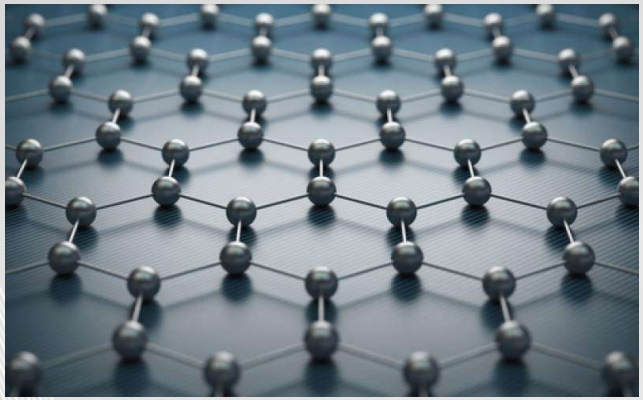
Graphene Concrete



- Graphene is single layer of carbon atoms
- Tightly bound in a hexagonal honeycomb lattice
- Layers of form graphite, naturally occurring, crystalline form of carbon
- Commonly used in pencils and lubricants
- Graphene is the thinnest, lightest and strongest compound discovered
- Over 100 times stronger than steel
- Graphene concrete is made with flakes of graphene
- Inexpensive, compatible with large scale manufacturing
- Improves strength and permeability
- Requires less cement to make concrete
- Electrically conductive
  - Underfloor heating
  - Clearing ice and snow from pavements
- Not yet commercialized

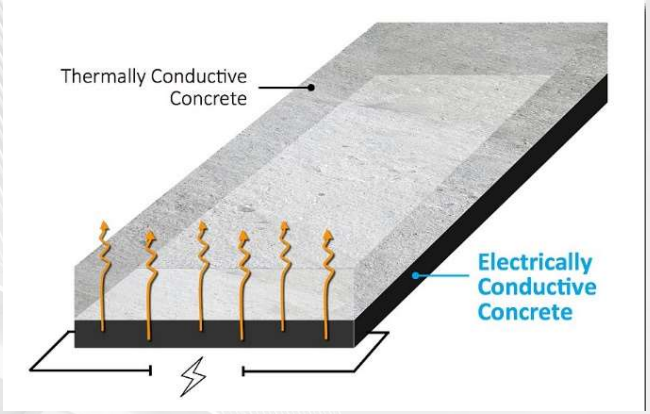


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Illustration by Stacy Smedley of Skanska

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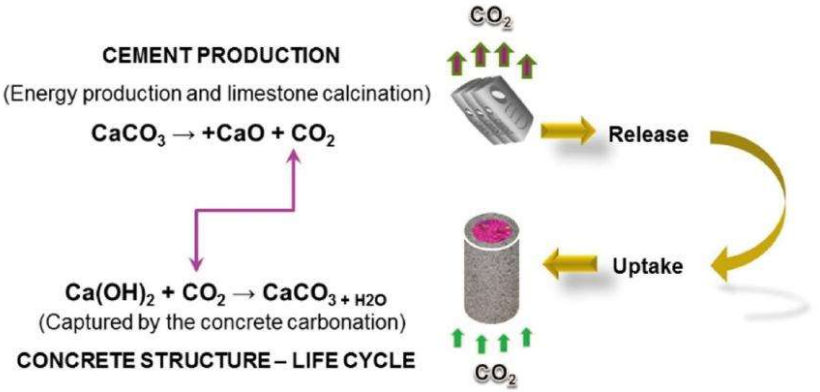
Carbon Capture

- Concrete is a carbon dioxide (CO_2) emitter
- Mainly due to the cement manufacturing process
- Carbonation: carbon dioxide (CO_2) penetrates the surface of hardened concrete and chemically reacts with cement hydration products to form carbonates
- For in-service concrete, slow process
- Given enough time and ideal conditions
  - all of the CO_2 emitted from calcination could be sequestered via carbonation.
  - Real world conditions are usually far from ideal
  - Estimates cumulative CO_2 sequestered in concrete is 4.5 Gt 1930-2013[1]
  - 43% of the CO_2 emissions from production of cement



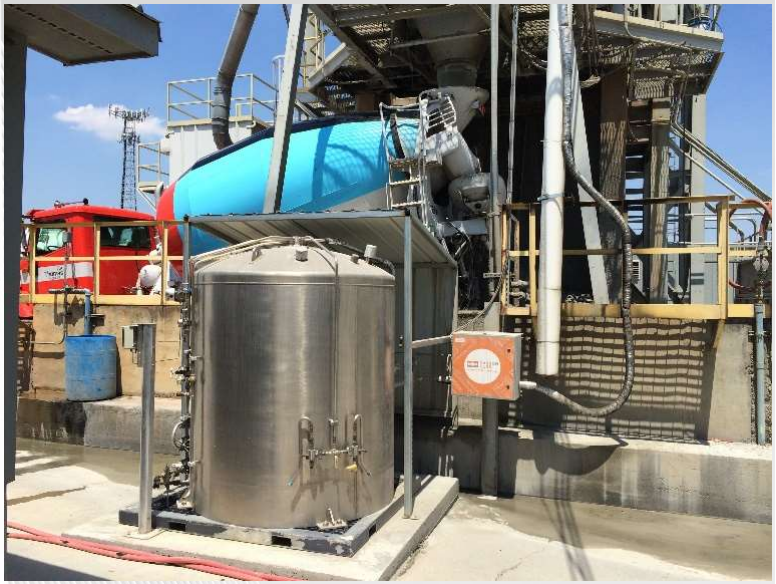
Carbonation depends on:

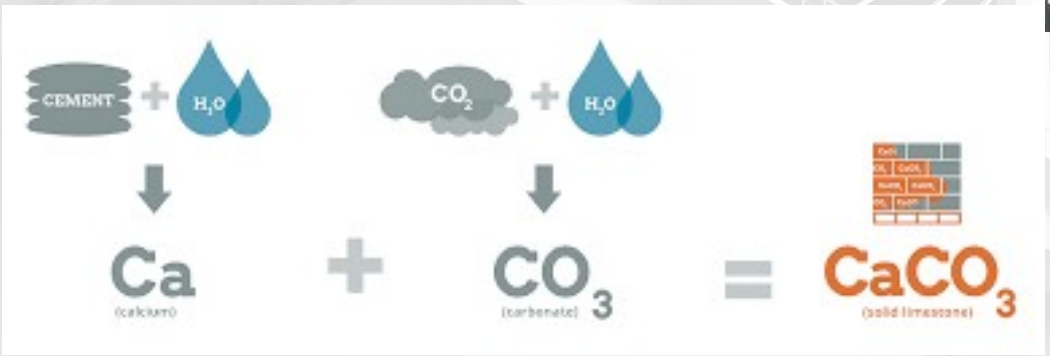
- Exposure to air
- Surface orientation
- Surface-to-volume ratio
- Binder constituents
- Surface treatment
- Porosity
- Strength
- Humidity
- Temperature
- Ambient CO_2 concentration

[1]"Substantial Global Carbon Uptake by Cement Carbonation," Nature Geoscience

Enhanced Carbonation

- Inject CO_2 into concrete
- Creates artificial limestone CO_2
- Sequesters small amount of CO_2
- Enhances compressive strength
- Reduces cement content

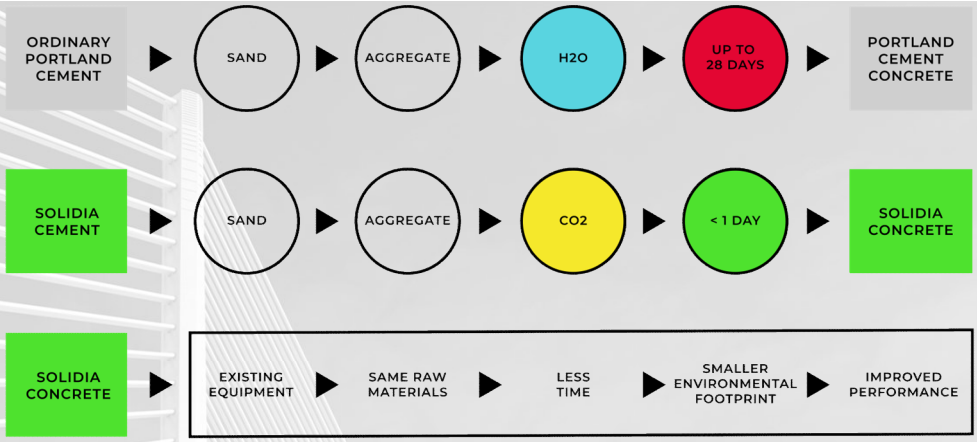




Courtesy of CarbonCure

Enhanced Carbonation

- Specially formulated cement
- Primarily in the precast concrete products industry
- About the same cost as portland cement
- Significantly reduces CO_2 emissions through reduced production energy
- Uses less limestone, fired at lower temperatures
- Produces 30% less greenhouse gases
- Concrete cures in contact with a CO_2 atmosphere in curing chamber under pressure
- Sequesters CO_2 equal to 5% of its weight
- Claims concrete's carbon footprint is reduced by 70%.



Courtesy Solidia Technologies

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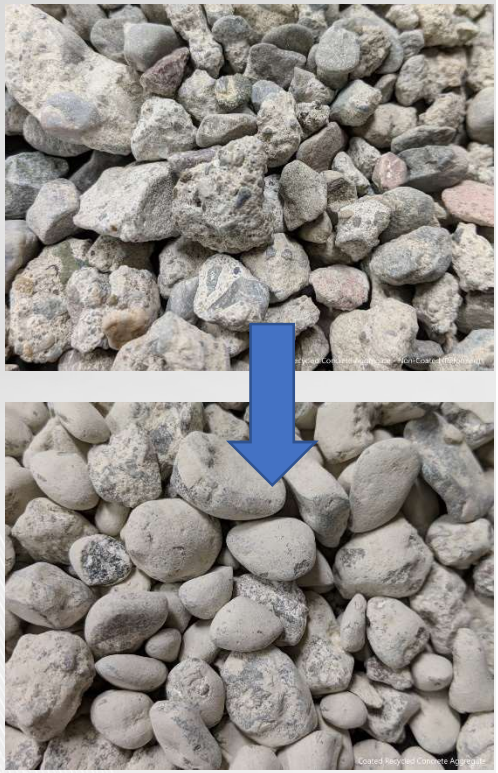
Enhanced Carbonation

- Another company combines industrial CO_2 emissions with metal oxides
- CO_2 sequestered construction aggregate (limestone)
- 44% by mass permanently sequestered CO_2
- Substrate is small rock particles or recycled concrete
- Carbon-negative concrete is achievable
  - One cubic yard of concrete contains 3,000 pounds of aggregate
  - 44% comprised of sequestered CO_2, roughly 1,320 pounds
  - Offsets more than the amount of CO_2 produced by cement
  - Roughly 600 pounds per cubic yard
- Used on Interim terminal at San Francisco International Airport
- Concrete met all necessary specifications



Courtesy of Blue Planet

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ISO 14040: Environmental Management and LCA

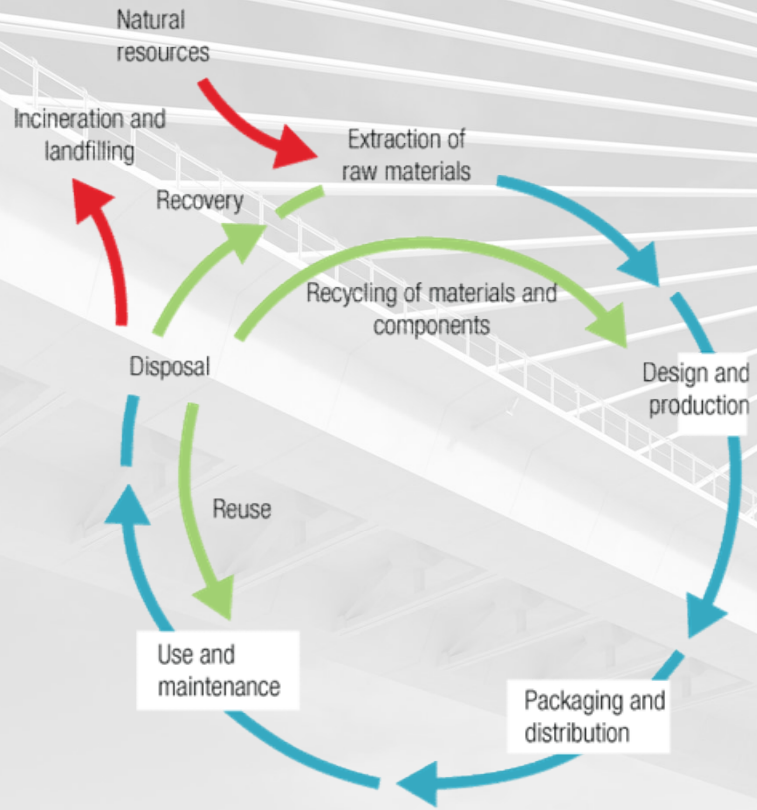
Material Disclosures (Cradle to Gate)

Life Cycle Impact Results (per m^3)

Declared Unit: 1 m^3 of 3,000 psi concrete

OPERATIONAL IMPACTS (per m^3)	*Residential Concrete*
Plant Operating Energy Consumption (MJ)	15.8
On-Site Plant Fuel Consumption (MJ)	172.9
Concrete Batch Water (m^3)	1.94E-01
Vehicle and Equipment Wash Water (m^3)	6.2E-01
On-Site Waste Disposed (kg)	0.68
ENVIRONMENTAL IMPACTS	
Total Primary Energy (MJ)	3,136
Climate Change (kg CO_2 eq)	364
Ozone Depletion (kg CFC11 eq)	1.34E-08
Acidification Air (kg SO_2 eq)	2.41
Eutrophication Air (kg N eq)	5.55
Photochemical Ozone Creation (kg O3 eq)	1.14

Life Cycle Thinking (LCT)



Life Cycle Initiative

The main goals of LCT are to reduce a product's resource use and emissions to the environment as well as improve its socio-economic performance through its life cycle.

Economic = Life Cycle Cost Analysis
Environment = Life Cycle Assessment

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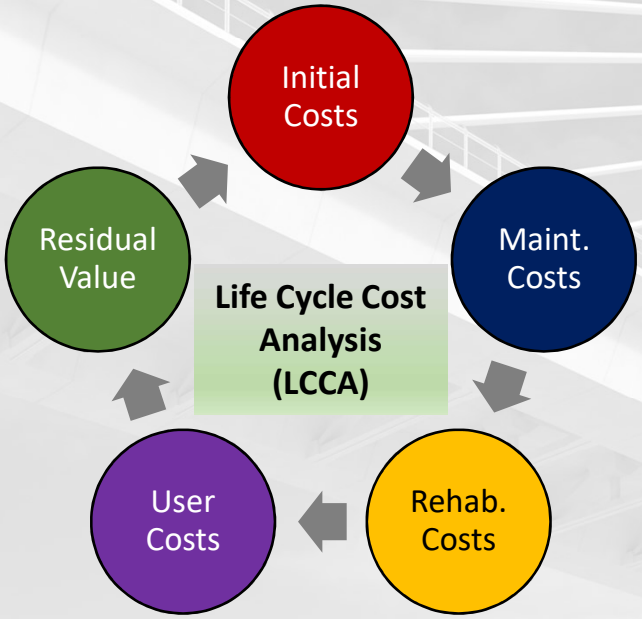
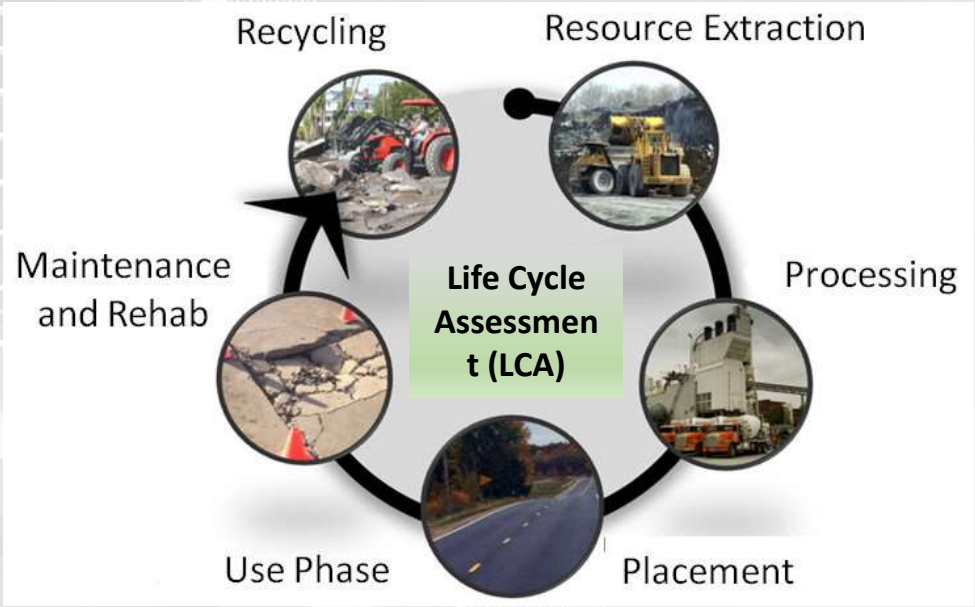
Life Cycle Thinking (LCCA/LCA)

Economic Considerations



Environmental Considerations



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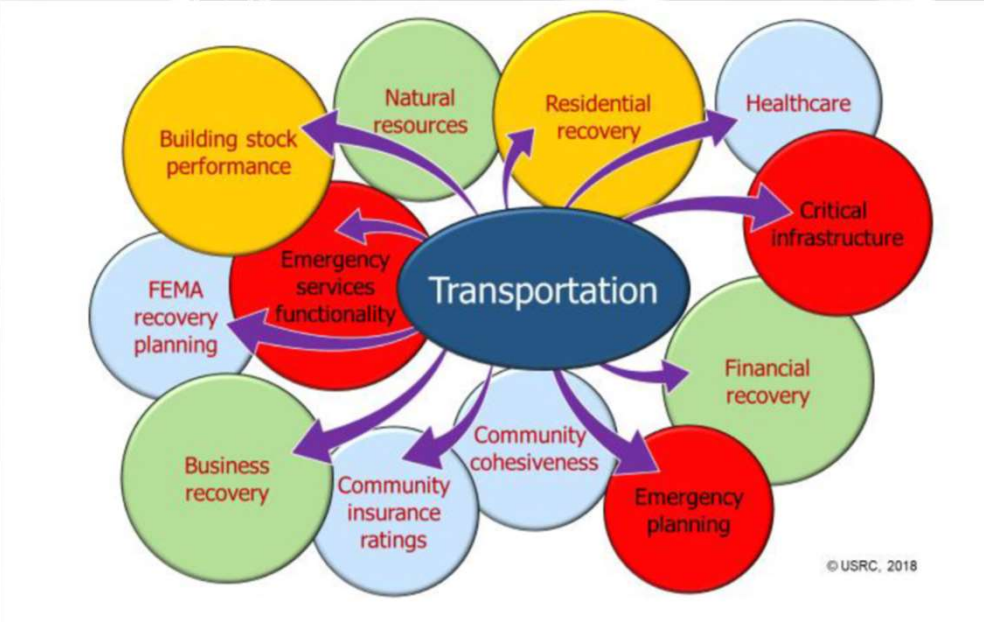
Resiliency



https://informedinfrastructure.com/16469/dot-helps-states-local-communities-improve-transportation-resilience/

http://www.planhillsborough.org/resilient-tampa-bay-transportation/

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Gregg A. Freeby, PE
American Segmental Bridge Institute (ASBI)
Austin, TX

POST-TENSIONING CONTRIBUTIONS TO ACCELERATED BRIDGE CONSTRUCTION

Tony Johnson, P.E.

Executive Director

Post-Tensioning Institute

(Presented by Gregg Freeby)

pti POST-TENSIONING INSTITUTE ®

BRIDGES NEED POST-TENSIONING

pti POST-TENSIONING INSTITUTE ®

PRECAST SPLICED GIRDERS – EFFICIENCY GAINED BY CONTINUITY ENABLED BY POST-TENSIONING

pti POST-TENSIONING INSTITUTE ®

SUCCESSFUL PROJECT SPECIFICATIONS & TRAINING

- Materials (Specifications)
  - Selection of materials
  - Qualification testing
  - Conformance testing
  - QA, QC
  - Inspection
- Execution (Specifications and Training)
  - Materials handling
  - Installation
  - Knowledgeable workforce
  - Inspection
- Both Required for a Successful Project
  - Follow PTI specifications
  - Insist on Field Personnel Training

pti POST-TENSIONING INSTITUTE ®

M50.3 AND M55.1 SPECIFICATIONS FOR POST-TENSIONING

- PTI/ASBI M50.3-19, Specification for Multistrand and Grouted Post-Tensioning
- PTI M55.1-19, Specification for Grouting of Post-Tensioned Structures
- State-of-the-Art Post-Tensioning Specifications

- Industry stakeholders
- ANSI Consensus process including public review
- Set of rules for the contractor
- Materials
- Testing
- Installation
- Stressing
- Grouting
- Post-grouting inspection

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M50.3 AND M55.1 SPECIFICATIONS FOR POST-TENSIONING

- Specification (mandatory)
  - Minimum requirements
  - Based on proven knowledge
- Commentary (guidance)
  - Additional explanations and guidance
- Applicability
  - Any project with post-tensioning
- Comprehensive
  - Acceptance for Post-Tensioning Systems
  - Details and installation methods for multistrand and grouted PT

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STAKEHOLDER CONSENSUS AND BALANCE OF INTEREST:
OWNERS (FHWA, STATE DOTS), DESIGNERS, RESEARCHERS, CONTRACTORS, SUPPLIERS

TENDON PROTECTION LEVELS (PL) *

Four levels of increasing protection:

- **Protection Level 1A (PL-1A):** Basic – providing durable corrosion protection
- **Protection Level 1B (PL-1B):** PL-1A plus engineered grout & permanent grout caps
- **Protection Level 2 (PL-2):** PL-1B plus airtight envelope
- **Protection Level 3 (PL-3):** PL-2 plus monitorable / inspectable at any time

* Unified approach from the PTI/ASBI M50.3-19 Specification for Multistrand & Grouted Post-Tensioning

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WHY TO USE M50.3 AND M55.1 SPECIFICATIONS FOR POST-TENSIONING?

- Uniform Standards

- Use in its entirety
- No need for modifications/exceptions
- Reduces/eliminates unnecessary differences in requirements, and potential for errors/misunderstanding
- Avoids provisions out of context or "holes" when aspects not covered
- Consistency and standardization; allows focus on proper execution
- Example: TXDOT full adoption of M50.3 and M55.1, with minor exceptions

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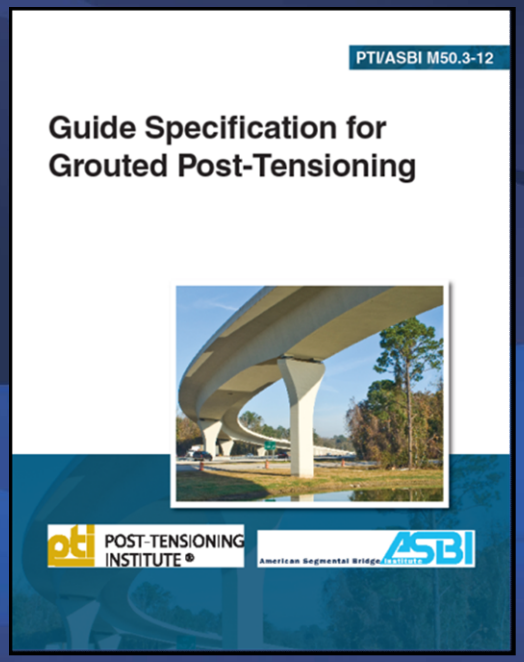
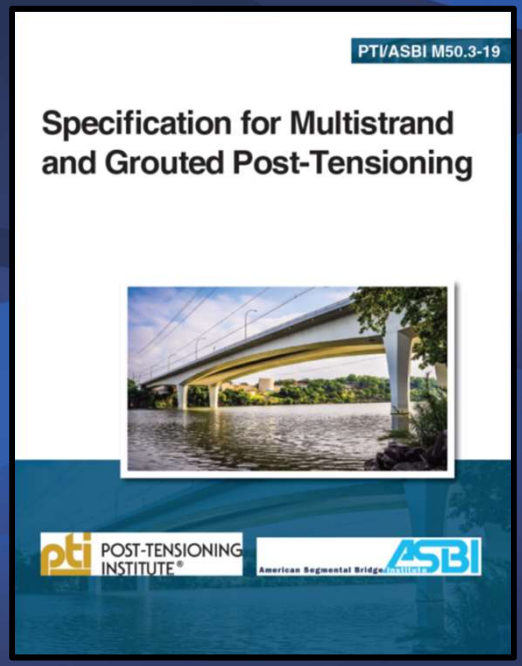
PTI/ASBI M50.3-19, SPECIFICATION FOR MULTISTRAND AND GROUTED POST-TENSIONING



First Edition published in 2012



Second Edition – **September 2019**

POST-TENSIONING INSTITUTE ®

PTI/ASBI M50.3-19, SPECIFICATION FOR MULTISTRAND AND GROUTED POST-TENSIONING GOALS & BENEFITS FOR STAKEHOLDERS

- Minimum Standard
- Performance Levels – Durability Goals
- Design and Testing Requirements for PTS
- Technically Sound Methods
- Grouting materials, testing, and procedures referred to PTI M55.1 Specification
- Reduction or elimination of unnecessary differences in requirements – Reduces potential confusion
- Proven best practice procedures
- Specification allows for different protection levels (PLs)
- Significant simplification of PTS prequalification

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PERSONNEL QUALIFICATIONS – CERTIFICATION

- Direct Supervisor
- Foreman of Installation and Stressing Crew
- Foreman of Grouting Crew
- Crew (at Least 25%)

- PTI Level 2 Multistrand & Grouted PT Specialist
- PTI Level 2 Multistrand & Grouted PT Specialist
- PTI Level 2 Multistrand & Grouted PT Specialist
- ASBI Grouting Technician
- PTI Level 1 Multistrand & Grouted PT Installation

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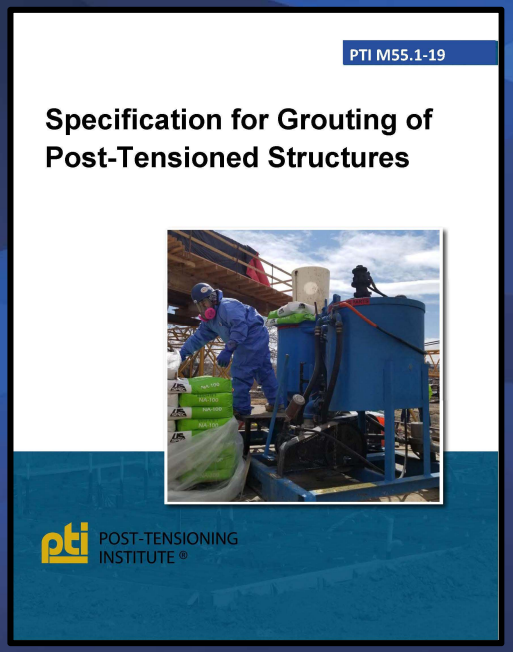
M50.3 SPECIFICATION
FUTURE OUTLOOK – NEW BUSINESS ITEMS

- Tendon Protection Level, PL-3
  - Options when appropriate

- **Replaceable Tendons**
  - FHWA Draft
  - Diabolos at deviators
  - Duct inserts at anchorages for replaceability
  - Design of space at anchorages for access
  - Drafting and balloting in M-50
  - For external tendons

- **Electrically Isolated Tendons, EIT**
  - FHWA Draft
  - International PT Technology Exchange
  - Study Group to Italy and Switzerland in May 2019
  - Final meeting in May 2020 – Final Report
  - Final drafting and balloting in M-50
  - Augmented quality of installation
  - Isolation effectiveness tested after completion
  - Monitoring in intervals available

PTI M55.1-19, SPECIFICATION FOR GROUTING OF POST-TENSIONED STRUCTURES



- First Edition published in 2001
- Second Edition 2003
- Third Edition 2012; w. Addendum 2013

Fourth Edition – **September 2019**

POST-TENSIONING INSTITUTE ®

PTI M55.1-19, SPECIFICATION FOR GROUTING OF POST-TENSIONED STRUCTURES

Comprehensive Grouting Specification

- Grout Plan
- Grout materials
- Engineered grout
- Testing for QC and QA
- Lab testing
- Field trial testing
- Mock up testing
- Production testing
- Grouting procedures
- Contingencies

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PTI M55.1-19, SPECIFICATION FOR GROUTING OF POST-TENSIONED STRUCTURES

- Standard for the Materials Used for Grouting of Post-Tensioning Tendons
  - Standard for All Classes of Post-Tensioning Grout Materials related to the Protection Levels of the PTS
  - Design and Qualification Testing Requirements for Post-Tensioning Grout Materials
- Standards for Grouting Procedures of Post-Tensioning Systems
  - Mixing and Pumping Procedures to Ensure Quality Workmanship
  - Production Testing of Grout to Ensure the Durability Goals Will be Achieved
  - Post Grouting Inspection Methods

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M55.1 SPECIFICATION, FUTURE OUTLOOK – NEW BUSINESS ITEMS

- Inline Density Flowmeter

- Flexible Filler
  - Inclusion of flexible filler specification in M-50 and/or M-55 specifications

- **PTI Research Project by Dr. Schokker**
  - Completed in early 2019
  - Tested on a segmental bridge in August 2019
  - Flowmeter continuously measures and records:
    - Density
    - Temperature
  - Option 1: Flowmeter installer at the inlet
    - Simple; stays in place
    - No impact on production
    - Allows constant monitoring
  - Option 2: Flowmeter installed at the outlet
    - More complicated – moved from outlet to another
    - Cleaning between tendons – time lag
  - Good correlation between Flowmeter and Mud Ballance
  - Output file exported to Excel and formatted as desired
  - Routine and continuous monitoring of grout density and temperature at the inlet of all tendons possible
  - Documentation available for all tendons

PTI LEVEL 1&2 MULTISTRAND & GROUTED PT SPECIALIST CERTIFICATION

Scope	PT basics, materials, installation, stressing, grouting
Training Duration	3 Days classroom including ½ day field demonstration (with grout testing)
Exam	60-question written exam (closed book)
Level 1 Requirements	Complete training; pass exam 70%
Level 2 Requirements	Complete training; pass exam 80%; total 1500 hours field work experience (Minimum 250 hours in each, installation, in stressing, and in grouting)
Renewals	Every 4 years; online exam; additional online training; continuing experience for Level 2
More Information	www.post-tensioning.org

pti POST-TENSIONING INSTITUTE ®

PTI LEVEL 1&2 MULTISTRAND & GROUTED PT SPECIALIST CERTIFICATION

- Comprehensive 3-day class with field demonstration
- Thousands of people certified

- Post-Tensioning (PT) 101
- Tendon Protection Levels (PL)
- PT Systems and Components
- Materials and Testing
- Installation
- Stressing and Safety
- Grout Materials, Prequalification Testing, Production Testing, and Grouting Procedures
- Contract Documents
- Troubleshooting
- Field Demonstration: Grout Testing, Components, Equipment

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PTI LEVEL 1&2 MULTISTRAND & GROUTED PT INSPECTOR CERTIFICATION

- Scope
- Training Duration
- Exam
- Level 1 Requirements
- Level 2 Requirements
- Renewals
- More Information

- Multistrand and grouted PT Inspector viewpoint
- 1 Day classroom: Prerequisite is attendance of the 3-day Specialist training (Level 1 or 2 certification)
- 30-question written exam (closed book)
- Complete training; pass exam 70%
- Complete training; pass exam 80%; total 500 hours field work experience (Minimum 100 hours in each of installation, stressing, and grouting inspection)
- Every 4 years; online exam; additional online training; and experience for Level 2
- www.post-tensioning.org

pti POST-TENSIONING INSTITUTE ®

PTI LEVEL 1&2 MULTISTRAND & GROUTED PT INSPECTOR CERTIFICATION

- New Certification Program
- Independent Inspection to ensure compliance with specifications

- Knowledge of post-tensioning – prior certification required
- All aspects of materials and testing, installation, stressing, grouting, post-grouting inspection, finishing, record keeping
- Critical items
- Check points & stop points
- Checklists of inspection items

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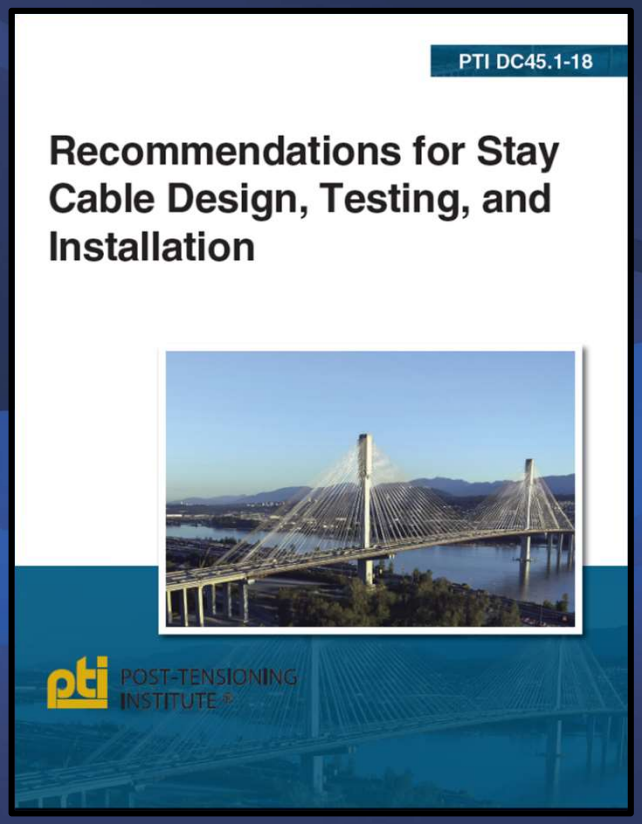
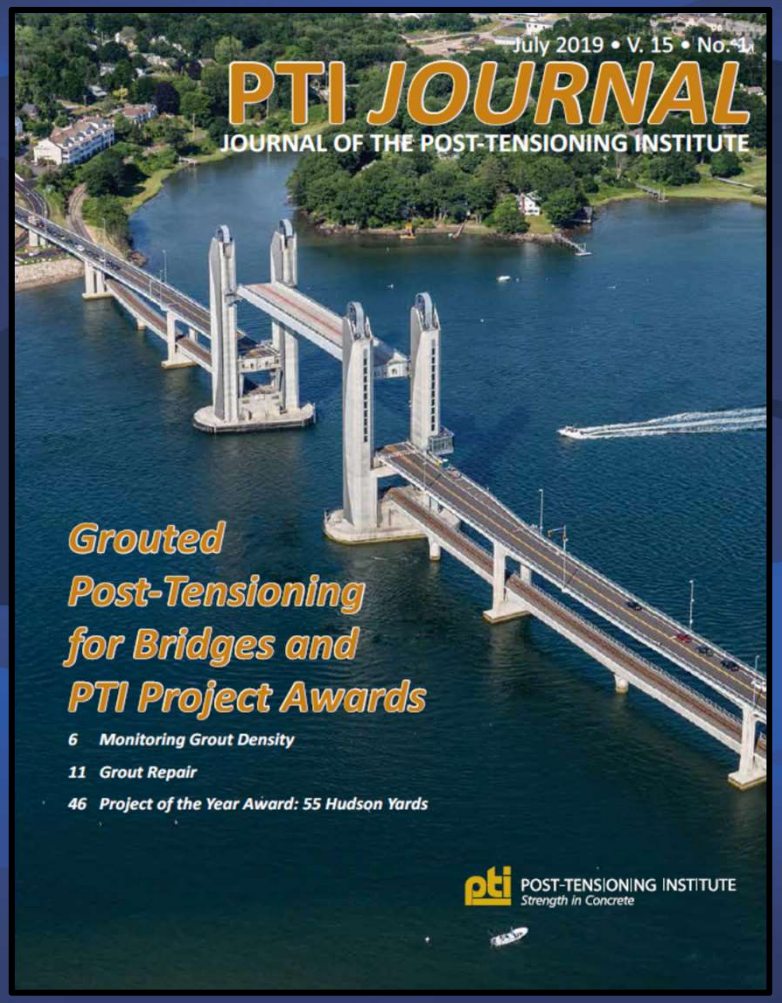
PTI DC45.1-18, RECOMMENDATIONS FOR STAY CABLE DESIGN, TESTING, AND INSTALLATION



Seventh Edition

November 2018

POST-TENSIONING INSTITUTE ®



PTI *JOURNAL*

Published twice a year

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PTI *JOURNAL*

PTI Research

- Inline monitoring of grout density during pumping, Jacob Bray and Andrea Schokker

TECHNICAL PAPERS

INLINE MONITORING OF GROUT DENSITY DURING PUMPING

BY JACOB BRAY AND ANDREA SCHOKKER

Cementitious grout has proven to be an effective corrosion protection method in post-tensioning systems. While successful grouting has been used in numerous post-tensioned (PT) bridges, quality control of the material and placement in the field remains a challenge. During the grouting process on site, ensuring that the grout being placed in the tendon is representative of the intended grout design is critical for the performance of the system. Inconsistencies in the placed grout can be attributed to varying mixing procedures used in the field (such as the addition of water above the design value). Advancements in the quality of in-place grouts can be made by refining specifications and developing a procedure to continuously measure the density of the grout as it is pumped into the tendon. This paper focuses on the results of testing of an in-line density meter for nearly continuous monitoring and recording of grout density and temperature.

Keywords:
density meter; flow meter; grout density; grouting; specifications.

INTRODUCTION

Cementitious grouts for post-tensioning have a good track record when a quality grout is used under well-controlled construction conditions. However, during grouting in the field, ensuring that the prequalified product is the actual end product being injected into the tendons can be difficult. The reason is twofold: the product material may differ from that tested in a laboratory setting and the actual procedures (including addition of water and mixing) on site may vary from best practice. The single biggest downfall for a good prequalified material is the over-addition of water.

Over the past nearly 20 years, considerable effort has been spent in developing specifications for grouting materials and testing as well as training for grouting crews. However, tendons with grout voids that appear to be directly related to a material, mixing, or pumping failure continue to exist. An area that can produce a major advance in quality of the in-place grout material is to develop a procedure to measure the density of the grout continuously as it is pumped into the tendon. Information for contractors and education of construction and inspection practices has increased dramatically over the past two decades; however, the test requirements have seen less evolution. Flow cones, mud balances, and other test methods are nearly the same as they were 20 years ago. With the technology available today, easier and more effective quality control measures are possible and needed in the field to help the inspectors and grout operators produce more consistent grout that is representative of the material developed to pass the specification.

RESEARCH SIGNIFICANCE

This research provides the foundation for use of an inline density meter that can be specified for quality control during grouting in the field. The proposed device can be used in place of mud balance testing at the inlet and could also be used for the outlet.

TESTING APPARATUS: INLINE DENSITY METER

The inline density meter tested in this program is a Coriolis flowmeter and is one of several brands available commercially. The meter used was a Krohne OPTIMASS 1400C S25 flowmeter as shown in Fig. 1. It is a twin straight-tube Coriolis mass flowmeter consisting of two measuring tubes, a drive coil, and two sensors positioned on either side of the drive coil. When the meter is energized, the drive coil vibrates the measuring tubes, causing them to oscillate producing a sine wave. The sine wave is monitored by the two sensors. As the grout passes through the tubes, the Coriolis effect causes a phase shift in the sine wave that is detected by the sensors. The phase shift is directly proportional to the mass flow. Density measurement is made by evaluation of the frequency of vibration and temperature measurement is made using a Pt500 sensor. Live inline density and temperature measurements provide instantaneous feedback via readout screen. The meter is also equipped with a data recorder that saves the measurements onto a micro SD card that allows a record of the data that can

PTI JOURNAL, V. 15, No. 1, July 2019. Received and reviewed under Institute journal publication policies.

Fig. 1—Coriolis inline density meter setup.

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CONCLUSIONS

- M50 & M55 Specifications
  - Use Standard Specifications to ensure proper materials, testing, and installation
  - M50 & M55 work together for the complete post-tensioning system
- Training of Field Personnel
  - PTI Level 1&2 Multistrand and Grouted PT Specialist Certification
  - ASBI Grouting Technician Certification
  - PTI Level 1&2 Multistrand and Grouted PT Inspector Certification
- Use PTI Resources
  - Other PTI documents and programs

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CONCLUSIONS – NEW ITEMS TO ADVANCE PT CONSTRUCTION ADDED IN 2019

- M50.3 Specifications (New Edition)
  - Added Commentary to most provisions
  - Bulletin 75 also included
  - Updates of some other provisions
- M55.1 Specifications (New Edition)
  - Grout wet density at last tendon outlet
  - Robustness test
  - Water
  - Shelf life
  - Corrosive agents
- Training of Field Personnel
  - New training for Bridge Inspectors

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CONCLUSIONS – NEW ITEMS TO ADVANCE PT CONSTRUCTION TO BE ADDED IN NEAR FUTURE

- **PTI CRT-70 PT System Qualification Testing and Certification**
  - PTI Quality Management System (QMS)
  - CRT-70 Administrative Manual
  - CRT-70 Technical Manual

- Prequalified PT Systems on PTI website
- User access permissions

- Based on PTI Plant Certification Program
- ANSI accredited provider
- Confidentiality; appeal process, etc.

- Procedures pertaining to the PTS program
- Independent inspection agency – audits

- Technical requirements and checklists

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Resources Available from the National Concrete Bridge Council

2021 Michigan Bridge Week

Virtual Presentation – March 17, 2021 8:40 AM – 10:15 AM

American Segmental Bridge Institute

Your Authority in Concrete

Segmental Bridge Construction

Gregg Freeby
Executive Director
American Segmental Bridge Institute

Outline

- **Who or what is ASBI?**
- **What resources does ASBI provide?**

What is ASBI?

Incorporated in 1988 as a nonprofit organization to provide a forum where owners, designers, constructors, and suppliers can meet to further advance concrete segmental bridges.

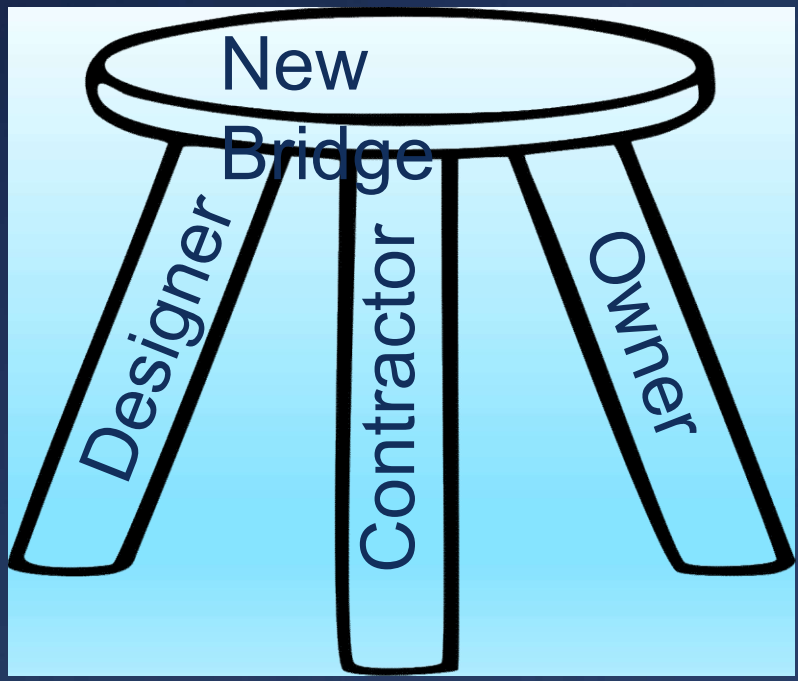
ASBI's Founding Members — A Moment in History Standing (left to right): W. Burr Bennett Jr., consultant; Robert P. McCrossen, material supplier; Clifford L. Freyermuth; Eugene C. Figg Jr., consultant; Raymond Schmahl, contractor; Juergen L. Plaehn, material supplier; Seated (left to right) David T. Swanson, material supplier; W. Jack Wilkes, consultant; and Gary L. Peters, contractor.

ASBI Founders

American Segmental Bridge Institute

Why ASBI?

Segmental is a construction method with design implications.



American Segmental Bridge Institute

Mission Statement

ASBI's mission is to advance, promote, and innovate segmental bridging technology; share the knowledge; educate stakeholders; build professional relationships; and increase the value of our infrastructure by providing sustainable solutions.

American Segmental Bridge Institute

Promote & Educate

- Publications
- Seminars & Formal Training
- Certifications

American Segmental Bridge Institute

What Is ASBI?

American Segmental Bridge Institute

Construction Practices Handbook

*** NEW ***

Construction Practices Handbook for Concrete Segmental and Cable-Supported Bridges 3rd Edition, July 2019

Price - FREE

This "How-To Handbook" was developed to provide guidance for construction of concrete segmental bridges. Although the segmental construction concept is generally very simple, the construction technology involved is, in numerous ways, more demanding than that required for other types of technology used in the industry. The use of concrete segmental bridge construction continues to grow throughout the United States and Canada. Increased use of this technology has led to a need to provide industry standard information for use by contractors, inspectors, quality control staff, and owners. In the interest of educating the industry, sharing best practices, and standardizing methods, this handbook is intended to provide a basic understanding of segmental construction technology. The overall goal is to facilitate the construction process, avoid common difficulties previously encountered, and reduce impacts to projects. This handbook is intended to be an industry guide aimed at focusing on specific aspects of the technology based on past experience.

Publication Download (PDF File)

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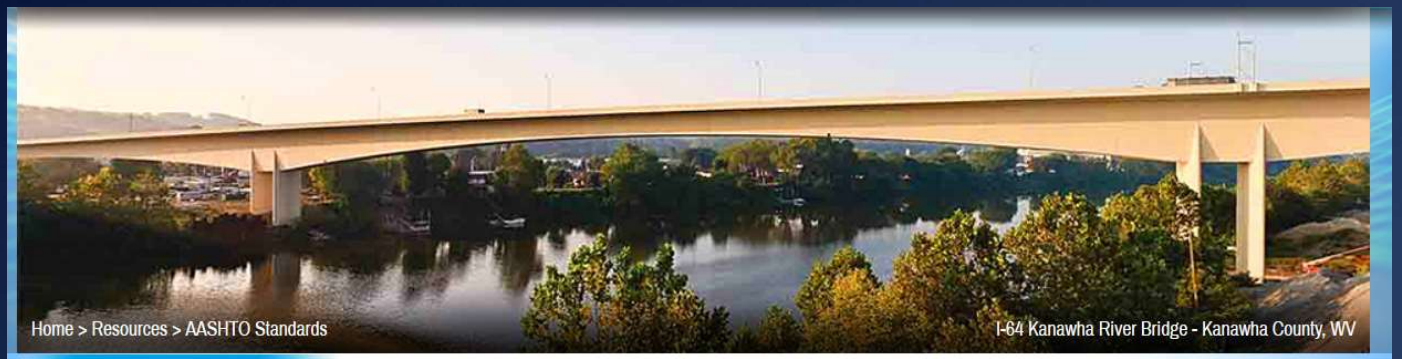
Segmental Box Girder Standards



- AASHTO Standards
- Shear Strength Eurocode 2
- Aspire Bridge Magazine
- Videos
- Federal Highway Administration (FHWA) Manuals
- FREE Resources

AASHTO Segmental Box Girder Standards

AASHTO-PCI-ASBI Segmental Box Girder Standards for Span-by-Span and Balanced Cantilever Construction (May 2000), U.S. Customary Units including the following:

Span-by-Span Standards 100' to 150'

Balanced Cantilever Standards 100' to 200'

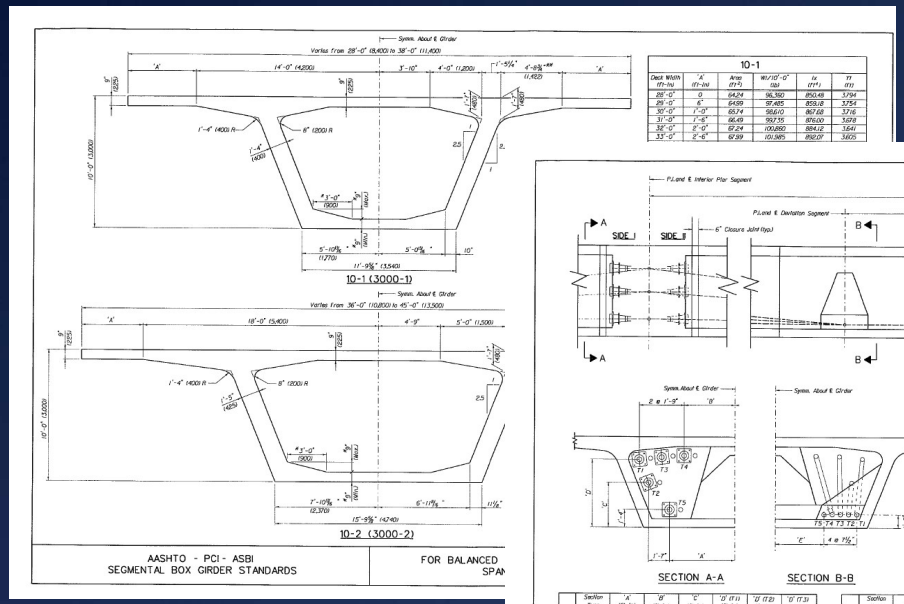
Deck Widths 28'-0" to 45'-0"

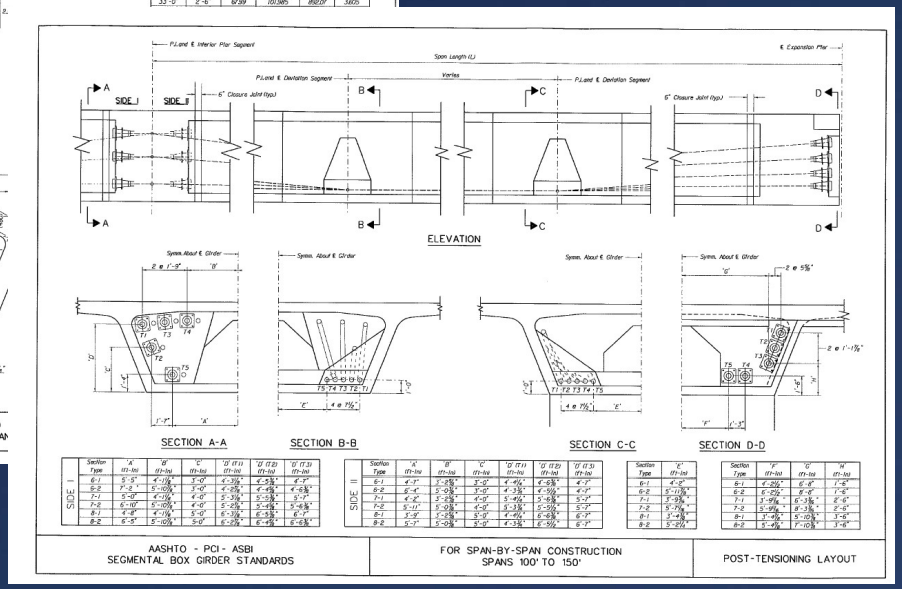
Precast Box Pier Details

Standard Drawings (U.S. Customary)

American Segmental Bridge Institute

Segmental Box Girder Standards





American Segmental Bridge Institute

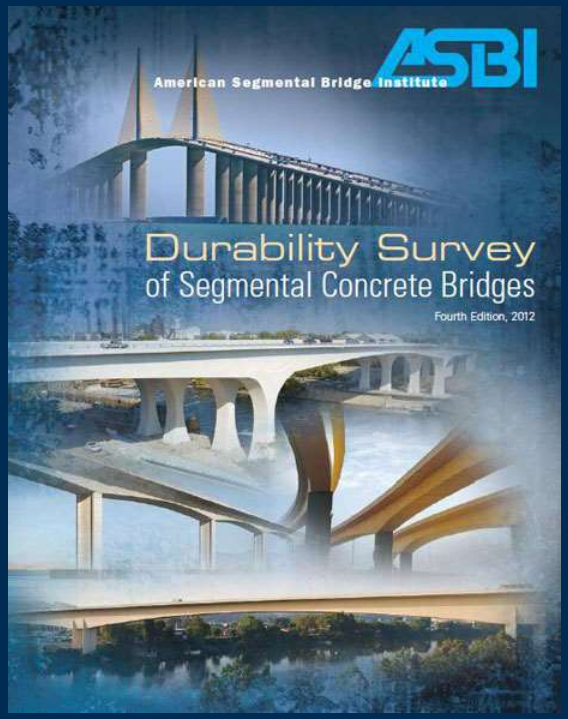
Segmental Box Girder Standards

- **Developed in cooperation with AASHTO, PCI & ASBI**
- **Provides standard sections for Span-by-Span and Balanced Cantilever Construction**
  - Span-by-Span Standards 100’ to 150
  - Balanced Cantilever Standards 100’ to 200’
  - Deck Widths 28’-0” to 45’-0”
  - Precast Box Pier Details

Note: Details in Metric units are also available

American Segmental Bridge Institute ASBI

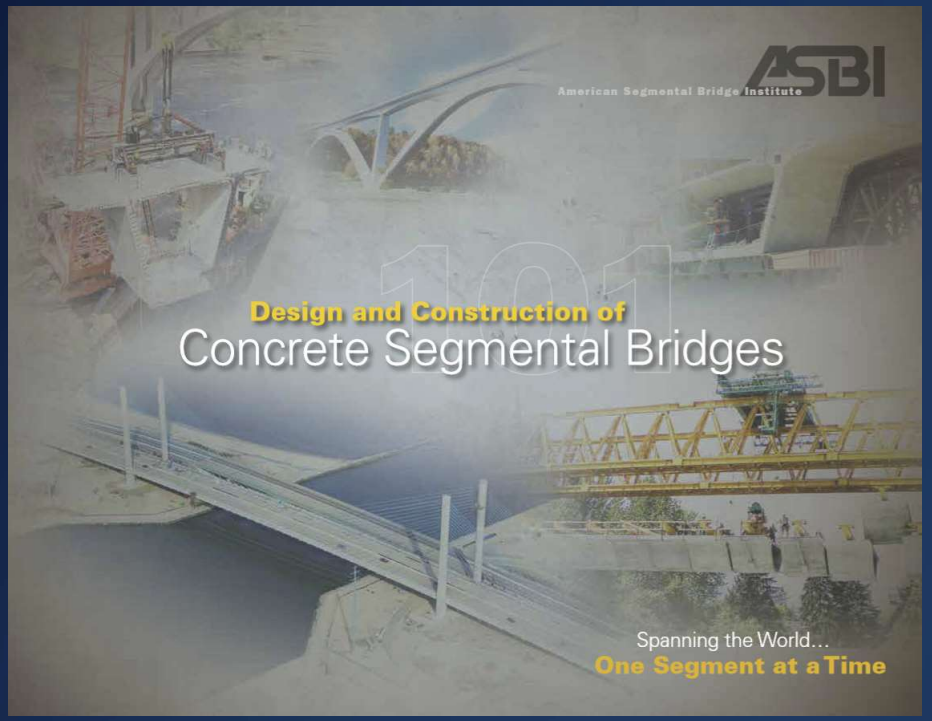
Durability Survey of Segmental Concrete Bridges



- The inspection data indicates that these superstructures are performing very well over time, with average condition ratings of 6.9, indicating “good condition” for all segmental bridges reported in the survey.
- Data further indicates that a service life of 100 years for segmental bridges can be expected with proper construction and maintenance

2012 Durability Survey is based on 2011 NBI Data

Segmental 101 Brochure



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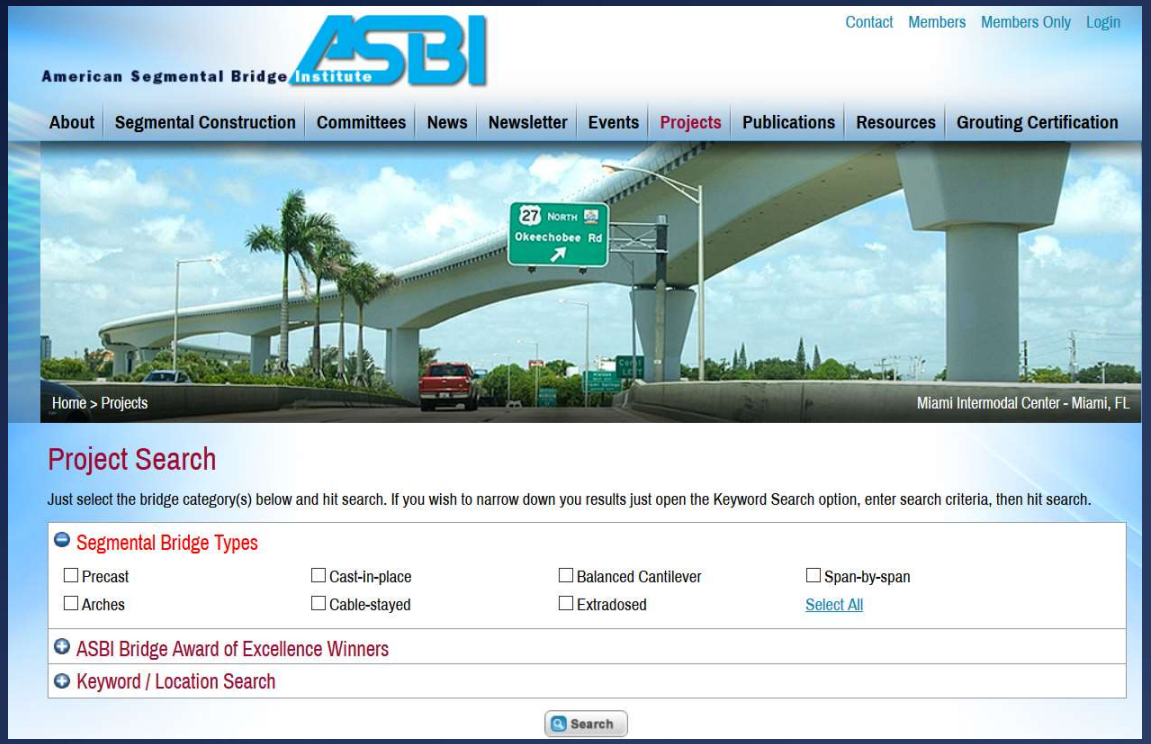
Segments Newsletter

American Segmental Bridge Institute

Project Database



American Segmental Bridge Institute

Annual Convention

- 300-400 attendees
- Different location each year
- Technical Program
- Networking

November 8-10, 2021
Westin La Paloma Resort & Spa (Tucson, AZ)

American Segmental Bridge Institute

Construction Practices Seminar

Who should attend?

- Owners (Free Registration)
- Contractors and Suppliers
- Designers

Planning to host another Seminar in 2020, probably on the West Coast.

American Segmental Bridge Institute ASBI

ASBI Grouting Certification Program Purpose

Provide Supervisors and Inspectors of Grouting Operations with the Training Necessary to Understand and Successfully Implement Grouting Specifications for Post-Tensioned Structures

American Segmental Bridge Institute

Why Grouting Certification Training?

- Communicate the Importance of Grouting to Long-Term Durability (100 Year + Service Life)
- Ensure That Job Site Grouting Supervisors and Inspectors Fully Understand Grouting Technology
- Provide Assurance to Owners That Grouting is Performed Under the Supervision of Qualified Personnel in Accordance with the Specifications

American Segmental Bridge Institute

ASBI Certified Grouting Technician

- Successfully Complete Training
- Provide 3 Years Experience in Construction of Grouted Post-Tensioned Structures
- Certificate Valid for 5 Years

Note: Per PT M55.1-19, grouting crew foreman must be PTI Level 2 *Multistrand and Grouted PT Specialist* AND hold an ASBI *Grouting Technician Certificate*

American Segmental Bridge Institute

ASBI Grouting Training Certificate

- Successfully Complete Training
- Less Than 3 Years Experience in Construction of Grouted Post-Tensioned Structures
- Certificate Valid for 5 Years
  - Obtain 3 Years Experience During This Time
  - Certified Grouting Technician

American Segmental Bridge Institute

Re-Certification

- Required Every 5 Years After Certification
- Online Examination
- Additional 1½ Years Experience Required for Certified Grouting Technician

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Records

- Participants Records Maintained by ASBI
- Lists of Certificate Holders Available

  Online: www.asbi-assoc.org

American Segmental Bridge Institute

Flexible Filler Training

ASBI host's this training annually for the Florida DOT

American Segmental Bridge Institute

Summary of Available Resources

- **Construction Practices Handbook**
- **Segmental Box Girder Standards**
- **Durability Survey**
- **Segmental 101 Brochure**

American Segmental Bridge Institute

Summary of Available Training

- **Annual Seminar**
- **Construction Practices Seminar**
- **Grouting Training & Certification**
- **Flexible Filler Training**

American Segmental Bridge Institute

Resources Available from the National Concrete Bridge Council

2021 Michigan Bridge Week

Virtual Presentation – March 17, 2021 8:40 AM – 10:15 AM

HOW PRECAST **BUILDS**

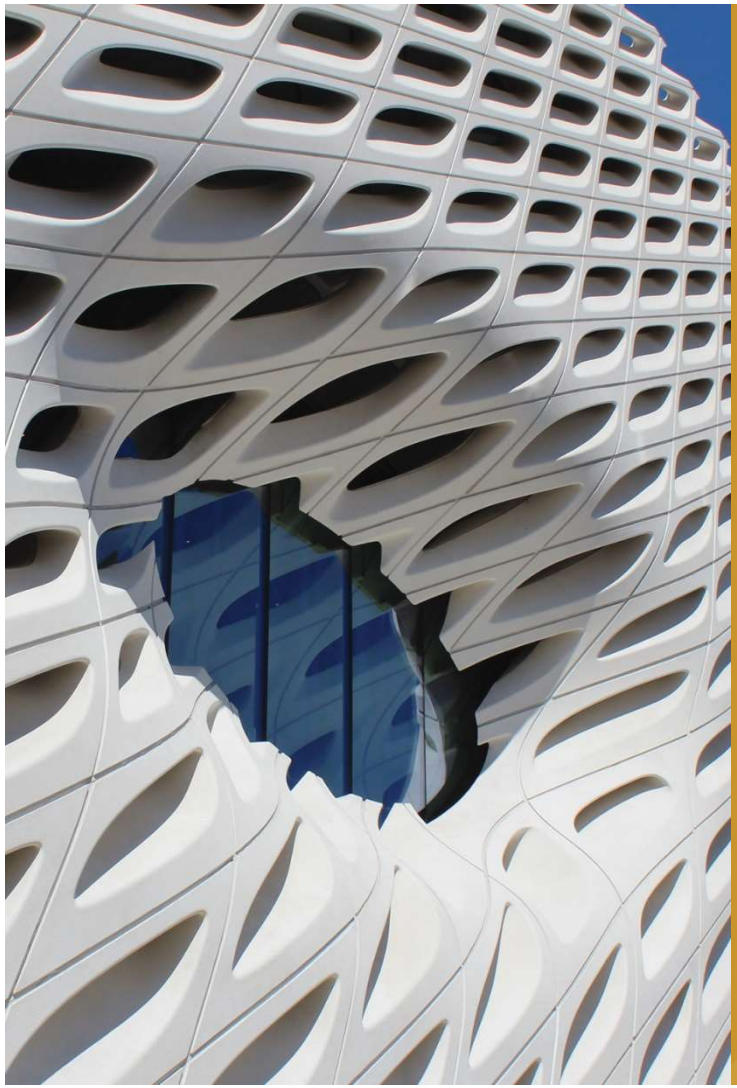
Precast/Prestressed Concrete Institute

William N. Nickas, P.E.
Managing Director, Transportation Services
Precast/Prestressed Concrete Institute
Chicago, IL.
(Presented by Gregg Freeby)

PCI Precast/Prestressed Concrete Institute

LEARNING **OBJECTIVES**

1. Concept of the Body of Knowledge and Training for Plants, QC staff and Auditors
2. Cover a few Transportation Publications. These include Manuals, Recommended Practices and State-of-the-Art reports
3. eLearning for engineers (Free PDH/CEUs)
4. Opportunities to improve and lower the costs of ABC components
5. The future changes including UHPC efforts and why
6. NCBC



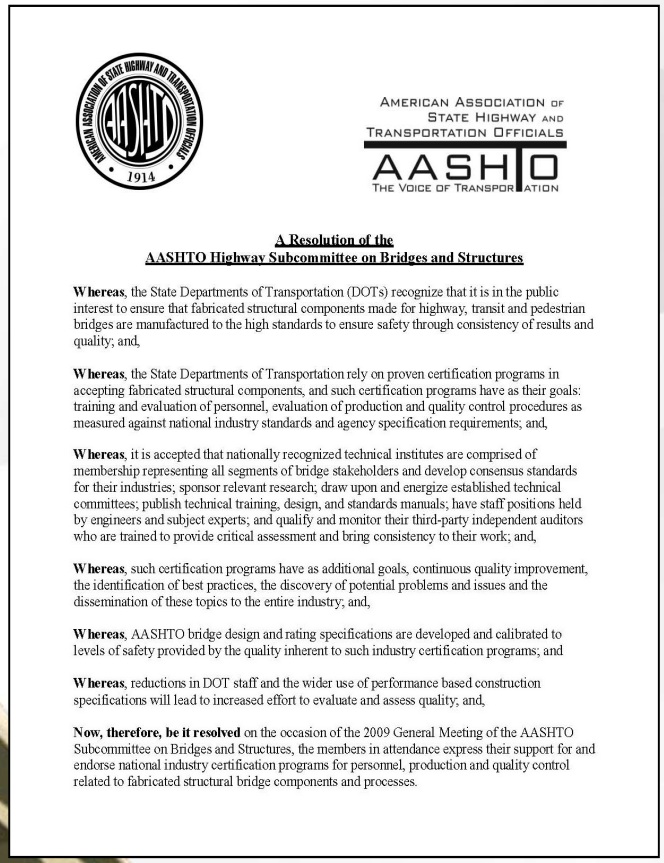
HOW PRECAST **BUILDS**

Concept of the Body of Knowledge and Institute based certification programs for Plants and Personnel

Why code organizations turn to institutes when developing their own standards

- American Iron and Steel Institute (AISI) plate standards;
- AISC for best practices and plant certification;
- American Segmental Bridge Institute (ASBI) for best practices and grouting-personnel certification;
- American Concrete Institute (ACI) for best practices and personnel certification;
- ASTM International for materials and test standards;
- American Welding Society (AWS) structural welding code, after-welding distortion tolerances, best practices, and personnel certification;
- Concrete Reinforcing Steel Institute (CRSI) reinforcement dimensions, bending and placement standards, and epoxy coating plant certification;
- PCI for best practices, plant certification, and personnel certification; and
- Post-Tensioning Institute (PTI) for best practices, hardware standards, and personnel certification.

AASHTO SCOBS and SOM (2009)



American Association of State Highway and Transportation Officials

AASHTO The Voice of Transportation

A Resolution of the
AASHTO Highway Subcommittee on Bridges and Structures

Whereas, the State Departments of Transportation (DOTs) recognize that it is in the public interest to ensure that fabricated structural components made for highway, transit and pedestrian bridges are manufactured to the high standards to ensure safety through consistency of results and quality; and,

Whereas, the State Departments of Transportation rely on proven certification programs in accepting fabricated structural components, and such certification programs have as their goals: training and evaluation of personnel, evaluation of production and quality control procedures as measured against national industry standards and agency specification requirements; and,

Whereas, it is accepted that nationally recognized technical institutes are comprised of membership representing all segments of bridge stakeholders and develop consensus standards for their industries; sponsor relevant research; draw upon and energize established technical committees; publish technical training, design, and standards manuals; have staff positions held by engineers and subject experts; and qualify and monitor their third-party independent auditors who are trained to provide critical assessment and bring consistency to their work; and,

Whereas, such certification programs have as additional goals, continuous quality improvement, the identification of best practices, the discovery of potential problems and issues and the dissemination of these topics to the entire industry; and,

Whereas, AASHTO bridge design and rating specifications are developed and calibrated to levels of safety provided by the quality inherent to such industry certification programs; and

Whereas, reductions in DOT staff and the wider use of performance based construction specifications will lead to increased effort to evaluate and assess quality; and,

Now, therefore, be it resolved on the occasion of the 2009 General Meeting of the AASHTO Subcommittee on Bridges and Structures, the members in attendance express their support for and endorse national industry certification programs for personnel, production and quality control related to fabricated structural bridge components and processes.

- **Recognizes contributions of National Technical Institutes**
- **Bridge Code calibrated based on quality standards set forth from the practices formulated by Nation Institutes**

National Steel Bridge Alliance NSBA Founded 1995

PCI

AISC / PCI (2009)

AISC/PCI White Paper on
Quality Systems in the Construction Industry

American Institute of Steel Construction
One E. Wacker Dr., Suite 700
Chicago, IL 60601
www.aisc.org

Precast/Prestressed Concrete Institute
209 W. Jackson Blvd., Suite 500
Chicago, IL 60606
www.pci.org

Introduction

This white paper identifies 12 characteristics essential to any organization offering construction industry certification. Typically, these characteristics are found within the national not-for-profit *technical institutes* established to provide a consensus-driven forum for the development and continuous refinement of engineering, design, and quality standards and related certification programs. Owners and specifiers of both public and private facilities have depended on such organizations for conformity assessment and quality standards for more than 40 years.

Technical Institutes

Technical institutes are usually national or international in scope. Each is recognized as the preeminent forum for exchanging information and as the principal body of knowledge for the industry it serves. National technical institutes facilitate the exchange of knowledge between many different industry stakeholders, including subject matter experts, academics, designers, contractors, owners, code officials, fabricators, erectors, and manufacturers. With well organized membership bases and a focus on collaboration and dissemination of information, technical institutes provide a framework that independent industry organizations cannot. While any number of associations may serve an industry for a variety of professional and economic reasons, there is only one technical institute. When one industry overlaps with, or is a subset of, another, the technical institutes involved typically have well-established collaborative relationships with one another to effectively combine their bodies of knowledge. Technical institutes are not developed overnight; establishing expertise, standard-setting authority, and a reputation for reliability takes time, often decades.

Certification Programs

Because their properties may be difficult to verify at the construction site, prefabricated engineered components must be manufactured to meet contract requirements and to ensure quality and reliability. Direct independent observation and assessment of a fabricator's quality management system saves time and money, and provides assurance that a particular product has met a minimum level of acceptable quality standards. Specifiers need to rely on the nationally recognized *certification program* of an industry's technical institute to provide assurance that a fabricator has the personnel, organization, experience, procedures, knowledge, equipment, capability, and commitment to produce quality work.

In order to successfully and reliably perform this important function, a certification program cannot stand alone, it must be part of a comprehensive quality system *specific to the engineered components addressed*. The essential functional elements of a comprehensive quality system are listed in the attached discussion.

Certification Organization

Some public sector agencies establish certification programs in-house, often drawing upon the body of knowledge promulgated by the appropriate technical institutes (either directly or via public sector standards bodies) as the basis of their quality systems. Recognizing the resources and expertise necessary to establish the entire quality system for a given class of engineered components, owners may alternatively choose to specify institute-developed certification programs to provide prequalification of component fabricators.

Many commercial companies and industry associations also offer certification services. However, not all such offerings are supported by the necessary functional elements of comprehensive quality systems typically embodied in an industry's technical institute.

A certification program developed and run by an independent technical institute ensures transparency, allows for continued process improvement, and removes any fear of bias towards one or more companies.

In the construction industry, *only the technical institute serving the corresponding industry segment provides all of the necessary functional elements of a comprehensive quality system and therefore currently serves as a singular, standardized, and accredited certification organization.*

- **White Paper expands on AASHTO Resolution**
- **Set forth 12 essential elements of a comprehensive Quality Program**

PCI Personnel Training & Certification

Precast/Prestressed Concrete Plant & Quality Personnel Certifications

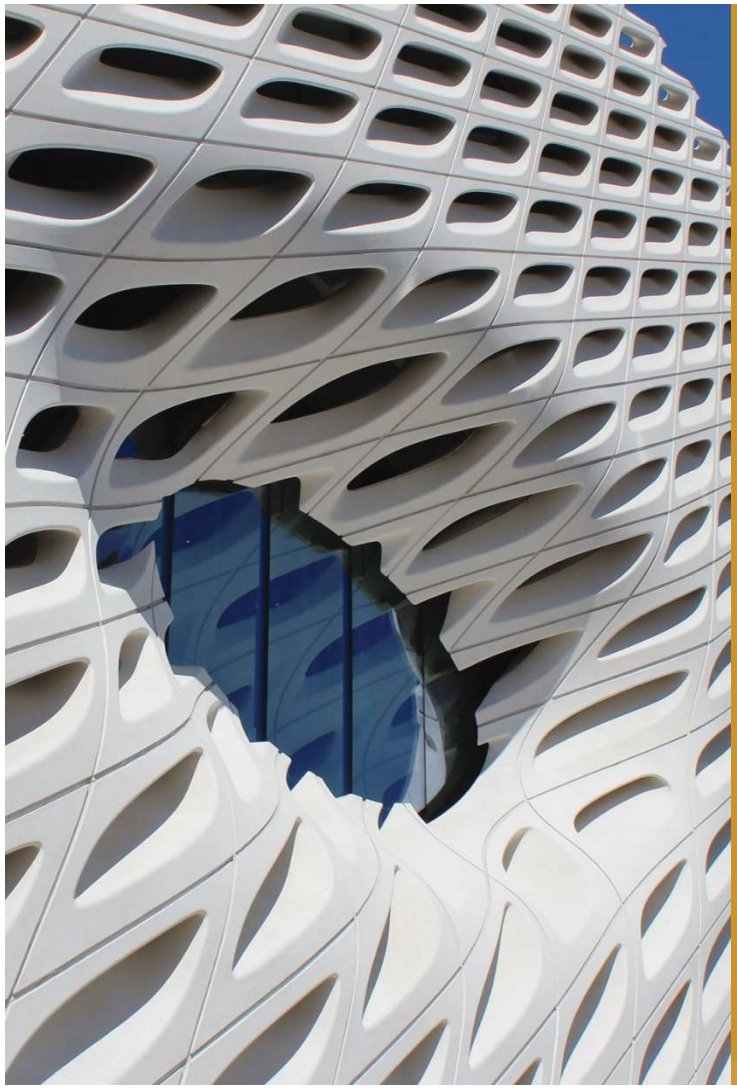
- Level III
- Level II
- Level I

Field Quality Personnel Certification

- Certified Field Auditor (CFA)

- Certified Company Auditor (CCA)

PCI Precast/Prestressed Concrete Institute



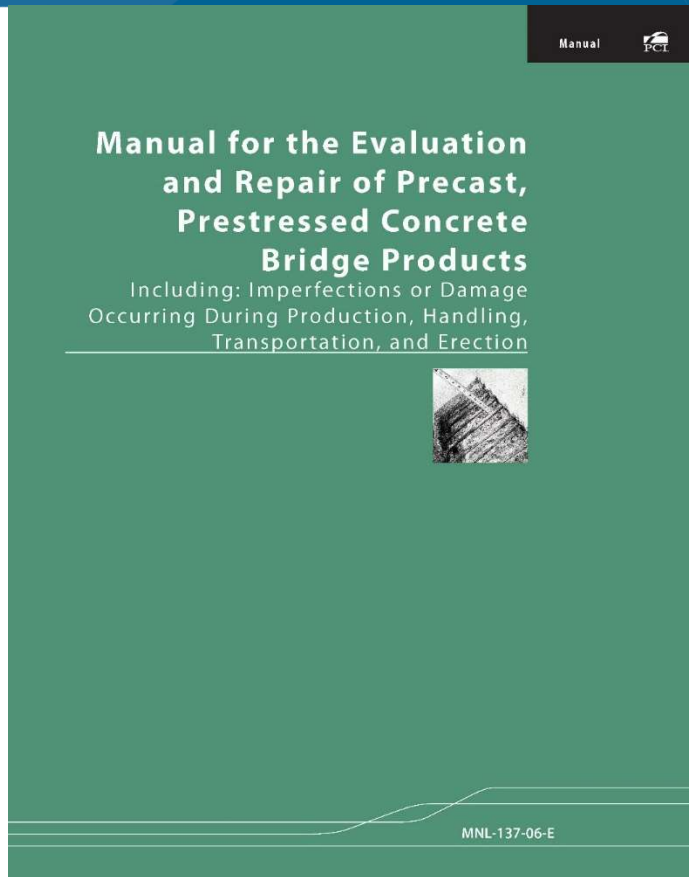
HOW PRECAST **BUILDS**

Transportation Publications.

These include Manuals, Recommended Practices and State-of-the-Art reports

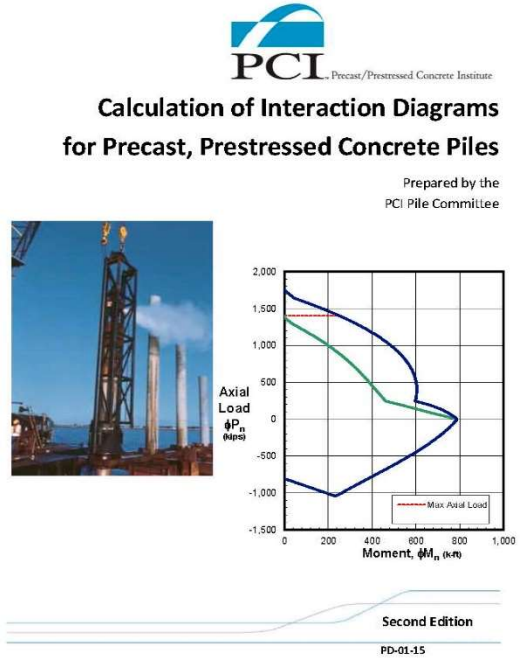
Manual for Evaluation and Repair

- Organized to address:
  Root Cause and
  Solutions
- May be adopted by some
  plants as part of QSM
- Offers Trouble shooting,
  Repair and
  Injection processes



Precast, Prestressed Concrete Piles

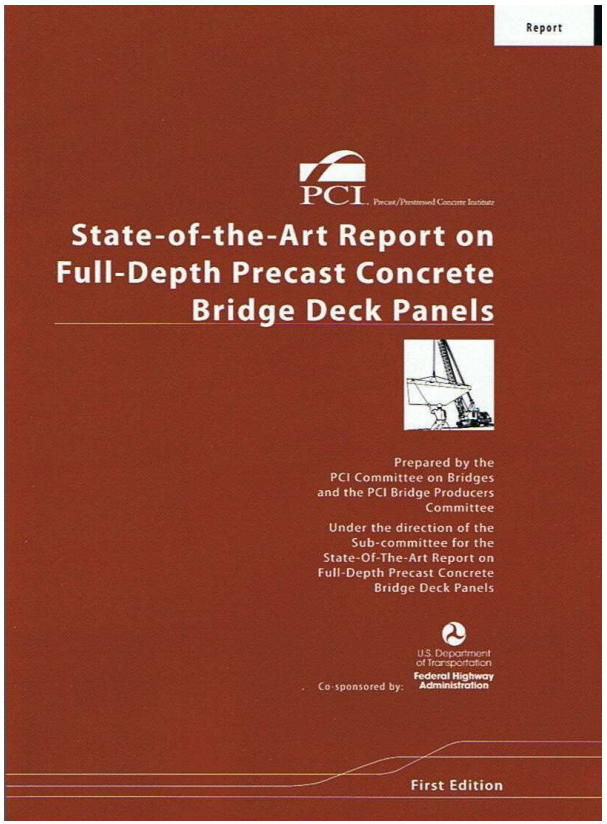
- Excel Workbook addresses:
  - Pile lofting
  - multi point picking and handling
  - Design Interaction Diagrams
  - Sample Parallel Calculations
  - and User Guidance



Full-Depth Precast Concrete Deck Panels

- Table of Contents
  - Introduction,
  - Concept & Advantages
  - Component of the FDDP*
  - Details of the FDDP*
  - Miscellaneous issues
  - Examples Projects
  - Design Example
  - Available resources

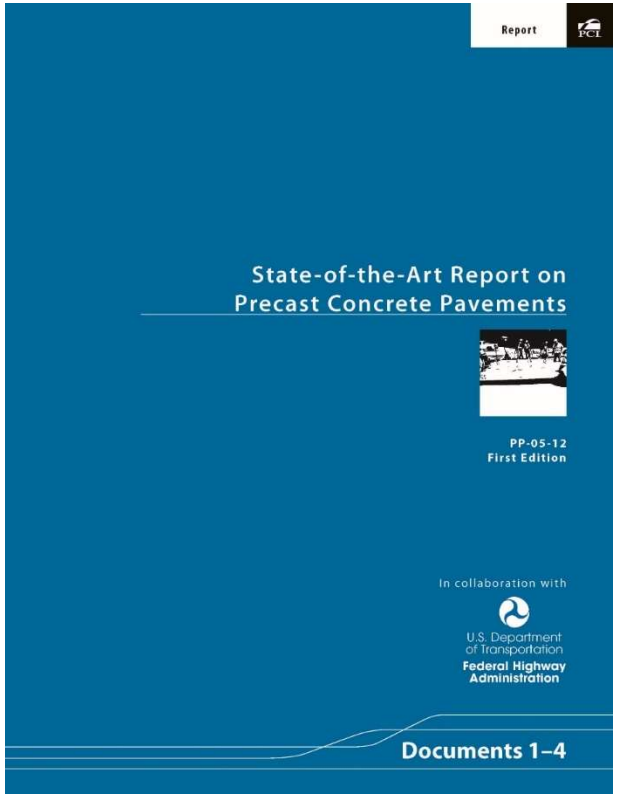
(* FDDP = Full-Depth Precast Concrete Deck Panels)



Precast Pavement

- Addresses Accelerated Construction goals
- PCI Guidance Documents
- 4 parts
  - Applications
  - Design & Maintenance
  - Manufacturing
  - Construction

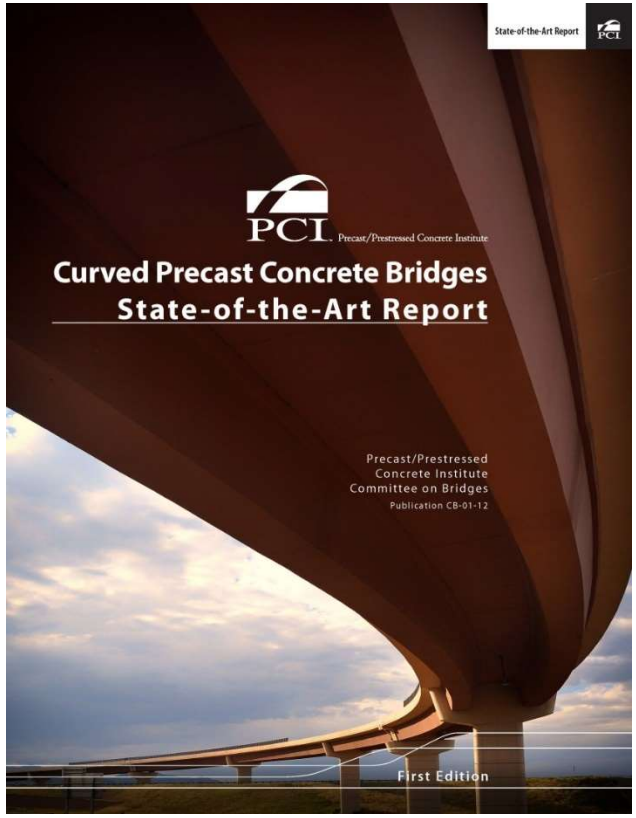
Precast Pavement Repository:
www.precastconcretepavement.com



Curved Precast Concrete Bridges

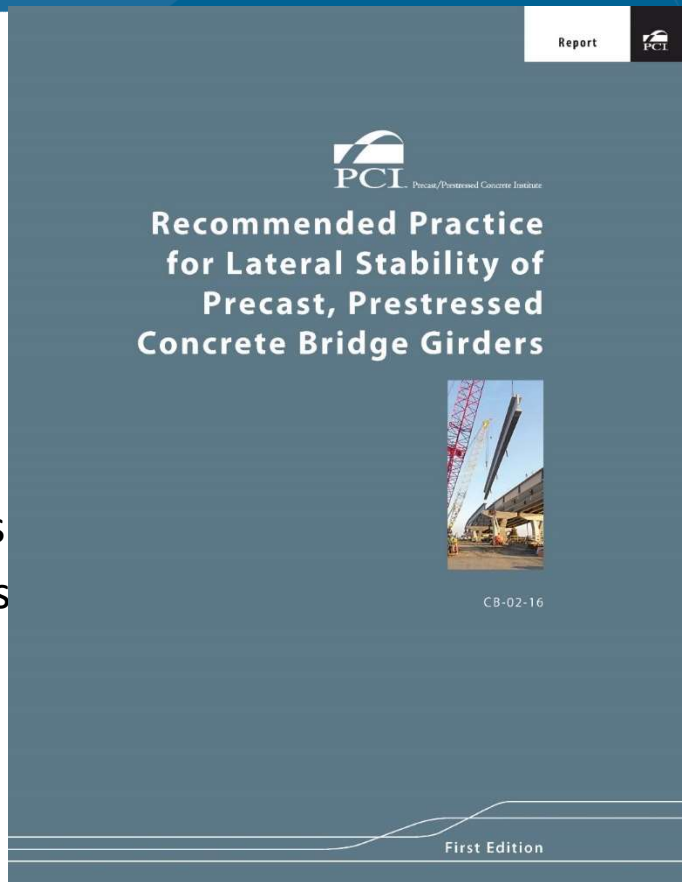
- Address how to build curved
  Structures with corded
  & curved precast
  Prestressed concrete girders

- Illustrate how Colorado
  standardized and developed
  an economical system



Recommended Practice for Stability

- Understand the various
  stages in the life of a girder
- Understand root causes of
  lateral instability
  and the need for analysis.
- Understanding of the concept of
  roll axis and
  variety of support conditions
- Identify the equilibrium conditions
  for supported girder.
- Case studies of knowledge gained
  calculation and modification
  to improve stability.

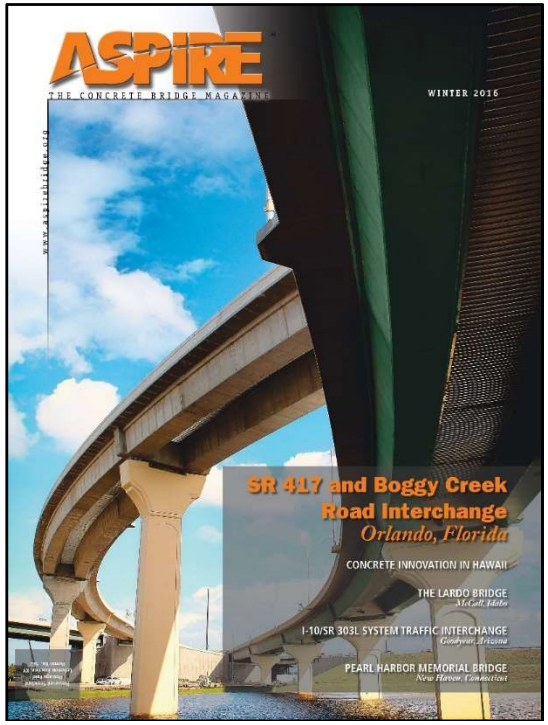


Advanced Precast Element Design and Construction State of Practice

Prefabricated Bridge Elements and Systems for Horizontally Curved Alignments Manual

Objective

- Provide guidelines for preliminary and final design of curved, spliced U-Beam systems
- Design and detailing using examples and reference to constructed projects
- Communicate the current state-of-the-art as represented by recent completed projects
- Not all encompassing, nor limiting the ingenuity of design professionals



Advanced Precast Element Design and Construction State of Practice

Bridge Geometry Manual

Guidance Manual Chapters

1.Introduction

2.Horizontal Roadway Geomtry

3.Vertical Geometry

4.Roadway Super Elevation

5. Working with Horizontal Roadway
6. Geometry of Straight Bridges
7. Geometry of Curved Bridges
8. Segmental Bridges

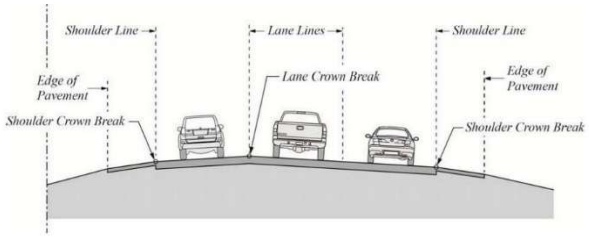


Figure 1.9 – Locations within a Highway Cross Section

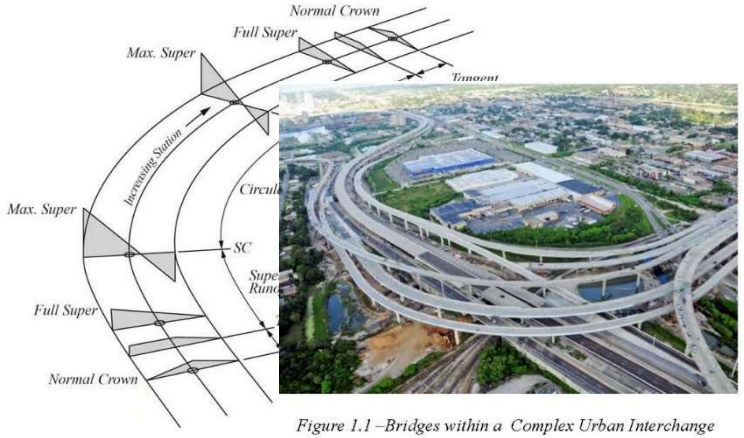


Figure 4.12 – Superelevation Transitions

Figure 1.1 –Bridges within a Complex Urban Interchange

PCI Transportation Trifecta

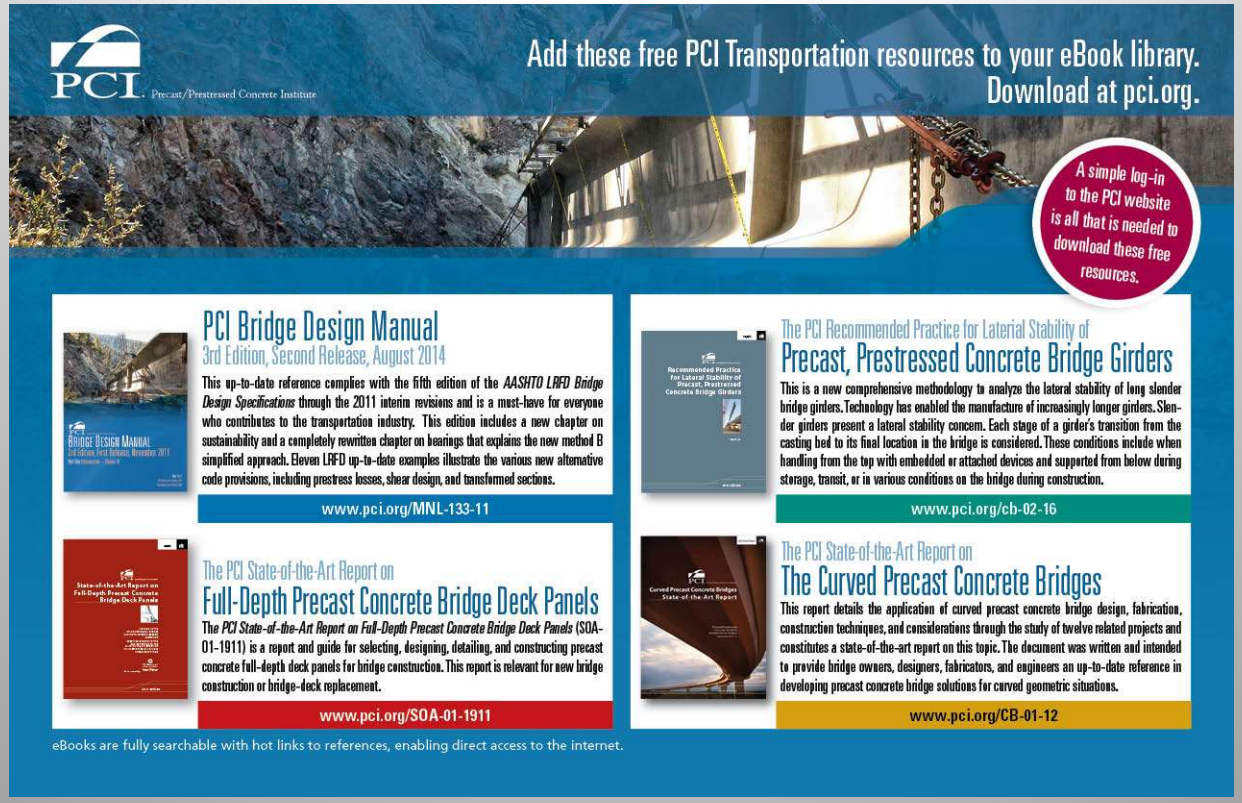
Bridge Related Research Papers included and vetted in the ***Journal***

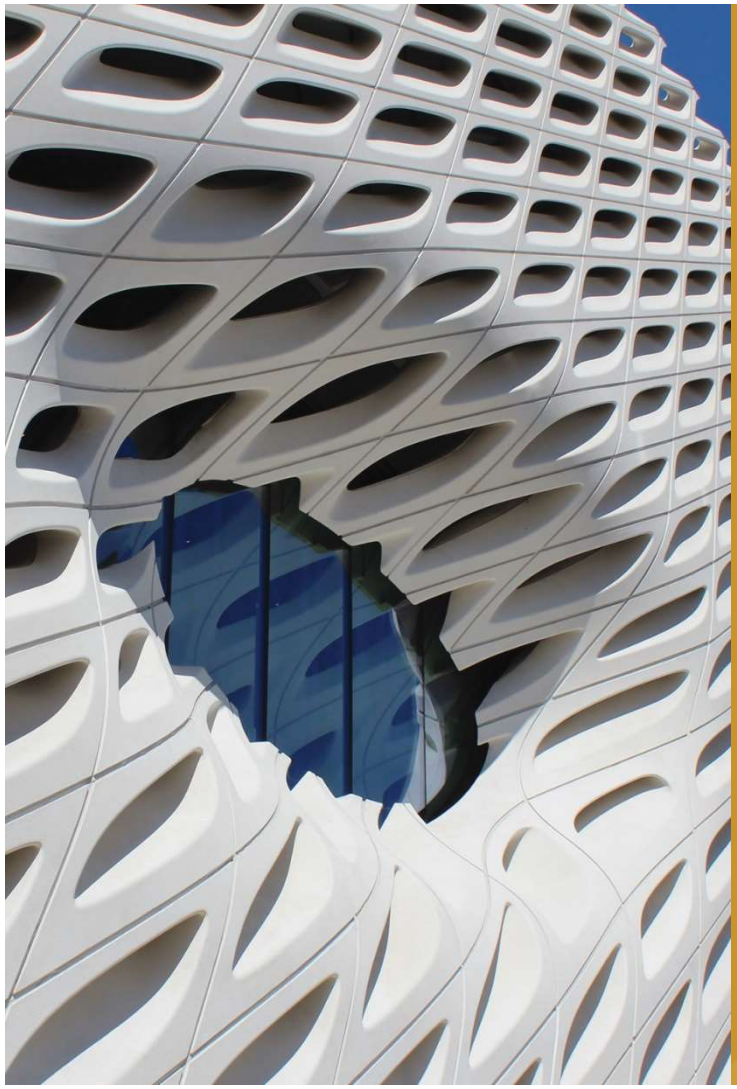
Aspire showcases
Projects and Concepts

PCI Bridge Design Manual gives industry tested engineering solutions in its third edition

PCI
Precast/Prestressed Concrete Institute

Also Note We are trying tell folks





HOW PRECAST **BUILDS**

eLearning for Concrete Bridge Designers, Inspectors and Builders

Link http://elearning.pci.org/

Search for released. Best to use “Transportation Systems”

FHWA/AASHTO/PCI Complex Concrete

eLearning #	Module Title
PCI Bridge Design Manual	
T110	Preliminary Design
T115	Materials and Manufacturing
T120	Loads and Load Distribution
T125	Flexural Analysis & Design: Service Limit State
T130	Flexural Analysis & Design: Strength Limit State
T135	Refined Losses for Members w/o or Prior to Decking
T145	Shear (MCFT)
T160	End Zone Design
T310	Extending Spans
T710	Load Rating (Overview & Methods)
T450	Bearing Pads - Theory and Method A
T455	Bearing Pads - Method B

FHWA/AASHTO/PCI Complex Concrete

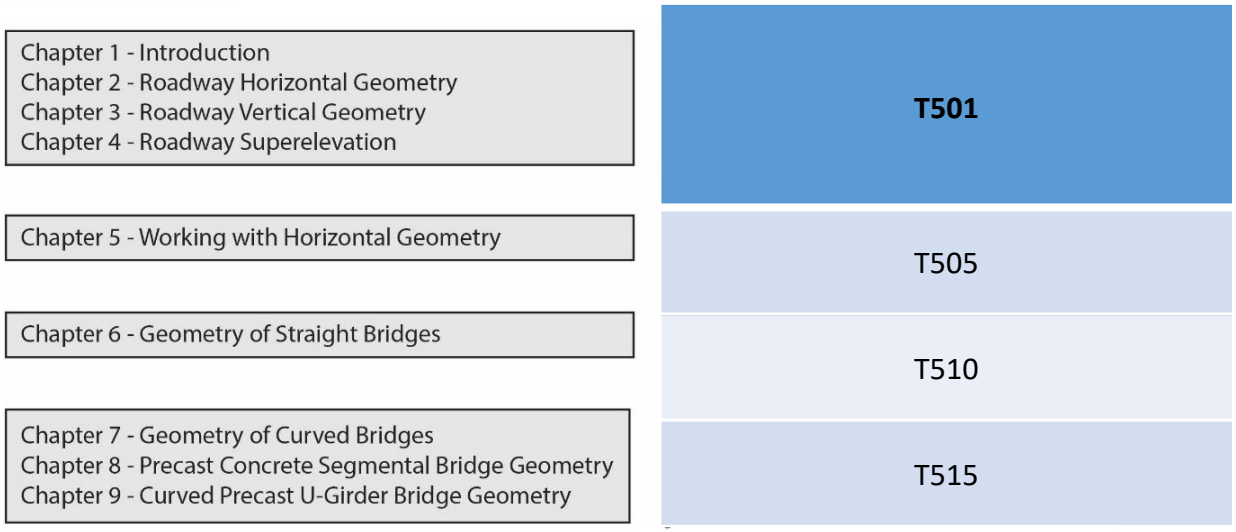
eLearning #	Module Title
Full Depth Precast Bridge Decks State-of-Art	
T210	Introduction on Full-Depth Panel Precast Concrete Deck System and its Advantages
T215	Design and Detailing of Full-Depth Precast Concrete Deck Panels
T220	Production and Construction Details of Full-Depth Precast Concrete Deck Panels
T225	Case Studies and Emerging Developments of Full-Depth Precast Concrete Deck Panels
Stability User Manual and Excel Calculator	
T520	Introductory Material and Hanging Girders
T523	Stability of Transported Girders
T525	Seated Girders and Stability Issues from Bed to Bridge
T527	Calculations and Sensitivity Analysis

FHWA/AASHTO/PCI Complex Concrete

eLearning #	Module Title
Bridge Geometry Guidance Document and Training	
T501	Roadway Geometry Basics
T505	Working with Horizontal Alignments
T510	Geometry of Straight Bridges
T515	Curved Bridge Geometry
Curved U Girder Guidance Document and Training	
T350	Introduction, Implementation and Delivery
T353	Modeling, Analysis and Design Considerations
T356	Design Details
T358	Design Example

FHWA/AASHTO/PCI Complex Concrete Bridge Geometry manual map to ILT

Four Instructor Led Training Courses (ILT Courses) are being developed to facilitate the use of the Bridge Geometry Manual. The relationship between the chapters of the manual and the four ILT Courses are shown in the figure below.



Distance Learning and a changing profession

<u>These slides are just a sampling of how you can be part of the BOK</u>

- On line classes are Self Paced
- Need to stay current with Structure Codes today that are more detailed
- New Generation very rooted in rigorous mathematics based theories
- New Materials coming on line

EDITORIAL

Photo: PCI.

Those That Show Up Help Make the Rules

William Nickas, *Editor-in-Chief*

Midway through my career, I had the privilege to be appointed to serve as a state bridge engineer our families and communities. Expanding and building relationships is very important, but growing our minds

EDITORIAL

Photo: PCI.

Make a New Year's Resolution: "Stay in Touch with Suppliers"

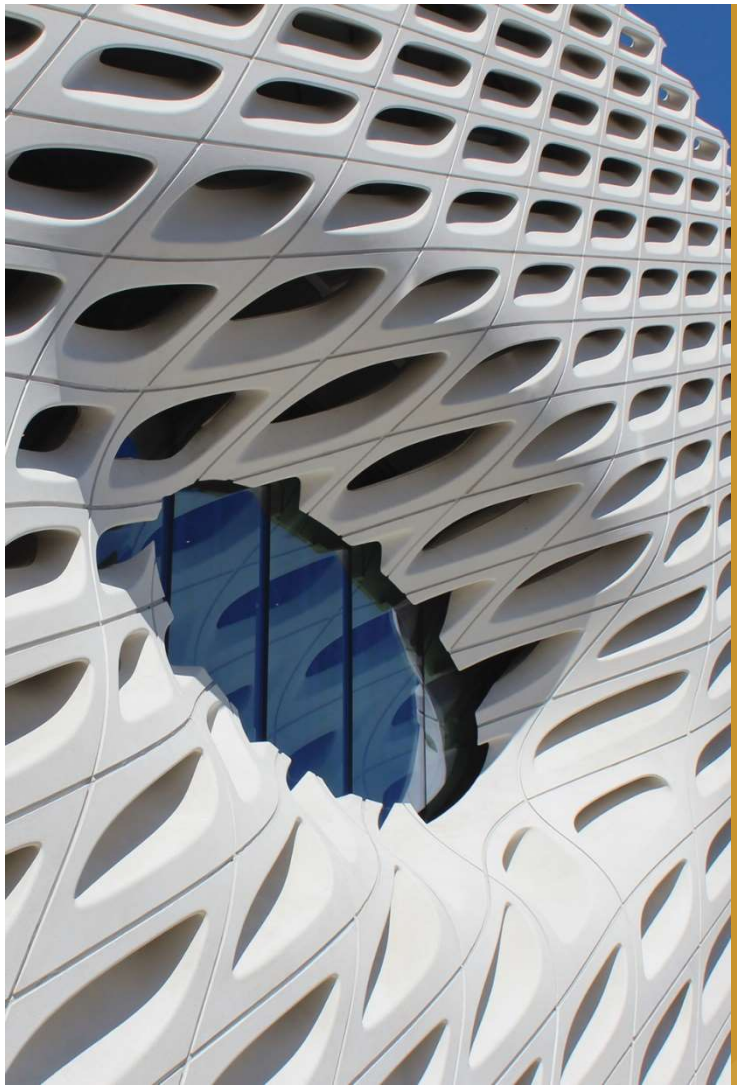
William Nickas, *Editor-in-Chief*

Every New Year brings resolutions and promises of change. Sixteen years ago, software venders started producing special Type III cements with either fly ash or slag (supplementary cementitious materials or

ASBI
American Segmental Bridge Institute

EIG CRSI

PCI
Precast/Prestressed Concrete Institute



HOW PRECAST **BUILDS**

The future changes including UHPC efforts and why

PCI TechnoQuest 2016


SAFETY FIRST


SAFETY FIRST

Changes in LRFD Concrete Bridge Design
Training delivered in 2020 from TRB

- **Purpose**: Accelerate implementation of the new LRFD section for concrete anchor design and minimize State Highway Agency (SHA) overlapping efforts in implementation through the use of a "deployment kit" for nationwide implementation.

- **NCHRP 639**: Adhesive Anchors in Concrete Under Sustained Load (exploratory report 67 pages plus references)
- **NCHRP 757:** Long Term Performance of Epoxy Adhesive Anchor Systems

Implementation of Concrete Anchors
PCI contracting with TRB

PCI-AASHTO Bridge Engineers

Draft of One-day Seminar on Anchoring to Concrete/Masonry

General Outline

1. Scope and objectives of seminar
2. General background on anchor behavior
3. Available codes
4. Available design software
5. Anchorage selection process
6. Product qualifications, specifying anchors for a project, and anchor procurement
7. Adhesive anchor installer and installer inspector certification
8. Construction compliance testing

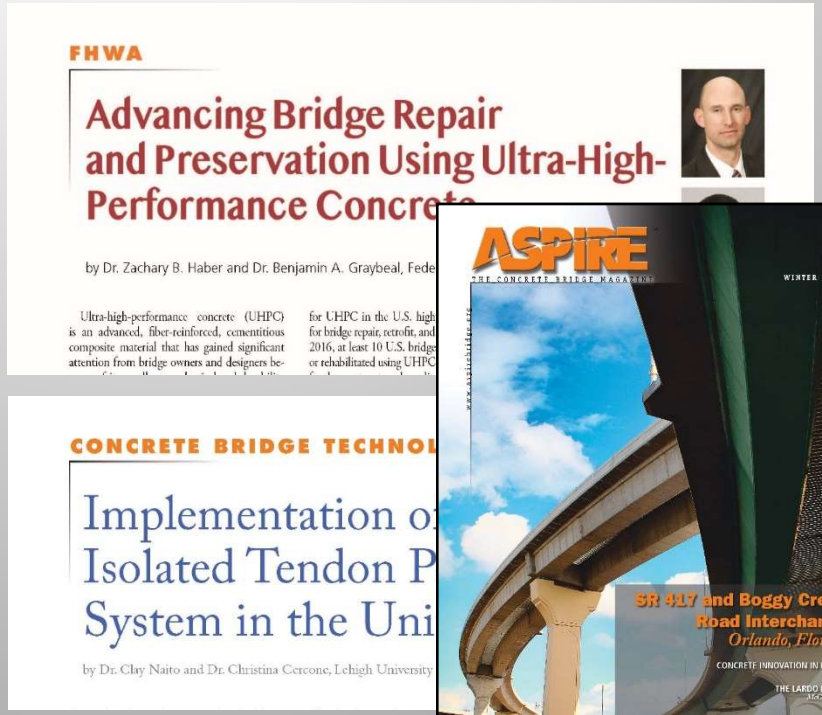
Knapsack Material

Items that will be given to each participant after the class

Leave workshop with a model Agency Implementation Plan and toolkit

Two Pilots and then ready for broad dissemination 12 months from contract execution.

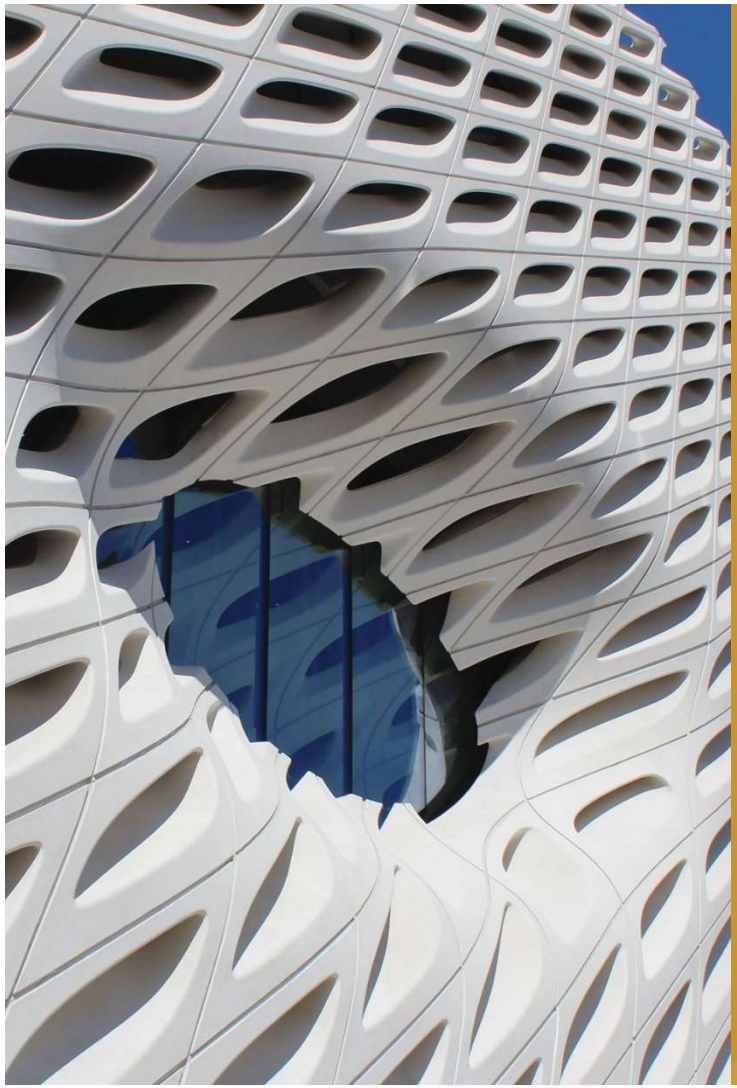
Aspire Magazine



PCI Precast/Prestressed Concrete Institute

2021 NCBC

- American Segmental Bridge Institute
- Concrete Reinforcing Steel Institute
- Expanded Shale, Clay, and Slate Institute
- National Ready Mixed Concrete Association
- Portland Cement Association
- Precast/Prestressed Concrete Institute
- Post-Tensioning Institute
- Silica Fume Association
- Wire Reinforcement Institute



HOW PRECAST **BUILDS**

Stay in touch with NCBC for changes in Concrete Bridge solutions

LEARNING **OBJECTIVES**

1. Concept of the Body of Knowledge and Training for Plants, QC staff and Auditors
2. Cover a few Transportation Publications. These include Manuals, Recommended Practices and State-of-the-Art reports
3. eLearning for engineers (Free PDH/CEUs)
4. Opportunities to improve and lower the costs of ABC components
5. The future changes including UHPC efforts and why
6. NCBC
7. THE END……..

Resources Available from the National Concrete Bridge Council

2021 Michigan Bridge Week

Virtual Presentation – March 17, 2021 8:40 AM – 10:15 AM

Reid W. Castrodale, PhD, PE
Expanded Shale, Clay and Slate Institute (ESCSI) / Castrodale Engrg Consultants, PC
Chicago, IL / Concord, NC

Gregg A. Freeby, PE
American Segmental Bridge Institute (ASBI)
Austin, TX

Resources for Concrete Bridge Design and Construction

Listing Documents from AASHTO, FHWA,
Members of the National Concrete Bridge Council, and
Other Relevant Sources

December 2019
Version 2.3

Preface

This publication is a listing of resources that are available to the concrete bridge practitioner from the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), and the members of the National Concrete Bridge Council (NCBC) which are listed below.

This document is intended to be a catalog or "bookshelf" that lists important resources for the design and construction of concrete bridges. The list is not exhaustive. Other documents that may be useful for the practitioner, such as research reports, journal articles, or other publications, may also be included.

Members of the National Concrete Bridge Council:

ASBI	American Segmental Bridge Institute
CRSI	Concrete Reinforcing Steel Institute
EIG	Epoxy Interest Group of CRSI
ESCSI	Expanded Shale, Clay and Slate Institute
NRMCA	National Ready Mixed Concrete Association
PCA	Portland Cement Association
PCI	Precast/Prestressed Concrete Institute
PTI	Post-Tensioning Institute
SFA	Silica Fume Association [*currently not participating in this document*]
WRI	Wire Reinforcement Institute [*currently not participating in this document*]

Guide to Resources for Concrete Bridge Design and Construction

Table of Contents

Introduction

For each agency or organization, information is listed in each of the following areas:

ORGANIZATION DESCRIPTION

A brief description of the organization's mission.

MANUALS OF PRACTICE & SPECIFICATIONS

Industry-developed manuals of practice and guide or standard specifications

REFERENCES

Reference documents produced by the organization or relevant to the organization's products and processes

TRAINING

Available training related to the organization's products and processes

CERTIFICATIONS

Certifications available for the organization's products and processes as well as industry certifications for plants and personnel involved with production of products

American Association of State Highway and Transportation Officials (AASHTO)

ORGANIZATION DESCRIPTION

The **American Association of State Highway and Transportation Officials (AASHTO)** is a nonprofit, nonpartisan association representing highway and transportation departments in the 50 states, the District of Columbia, and Puerto Rico. It represents all transportation modes. Its primary goal is to foster the development, operation, and maintenance of an integrated national transportation system by educating the public and key decision makers about the critical role that transportation plays in securing a good quality of life and sound economy for our nation. AASHTO serves as a liaison between state departments of transportation and the Federal government. Standards are issued for design, construction of highways and bridges, materials, and many other technical areas.

AASHTO's policy development, standards setting, and technical activities are the product of volunteer state department of transportation personnel who work through the AASHTO committee structure. The committees collaborate throughout the year and typically meet annually. These committees, which represent the highest standard of transportation expertise in the country, address virtually every element of planning, designing, constructing, and maintaining transportation services.

Organization description adapted from www.transportation.org/home/organization/ accessed on 11/16/19.

Website: www.transportation.org

MANUALS OF PRACTICE & SPECIFICATIONS

The following publications are available for purchase on the Bridges & Structures Publications website: https://store.transportation.org/publications?/C_BR

AASHTO LRFD Bridge Design Specifications, 8th Ed. (2017)

The *AASHTO LRFD Bridge Design Specifications* are intended for use in the design, evaluation, and rehabilitation of bridges. The specifications employ the Load and Resistance Factor Design (LRFD) methodology, using factors developed form current statistical knowledge of loads and structure performance. This 8th edition includes revisions to almost all of the specifications. It supersedes the 201 7th edition and its 2015 and 2016 revisions.

AASHTO LRFD Bridge Construction Specifications, 4th Ed. (2017)

These specifications are intended for use in the construction of bridges. They employ the Load and Resistance Factor Design (LRFD) methodology, and are designed to be used in conjunction with the *AASHTO LRFD Bridge Design Specifications*. The specifications have been updated from the 2010 3rd edition to include a complete revision of Section 3, Temporary Works, as well as changes to Section 10, Prestressing; Section 11, Steel Structures; Section 19, Bridge Deck Joint Seals; and Section 27, Concrete Culverts.

Construction Handbook for Bridge Temporary Works, 2nd Ed. (2017)

This handbook, developed for contractors, construction engineers, and falsework design engineers involved in bridge construction focuses primarily on standards of material quality and means and methods of construction. It also contains chapters on falsework, formwork, and temporary retaining structures. It supplements information in the *Guide Design Specifications for Bridge Temporary Works*.

Guide Specifications for Wind Loads on Bridges During Construction, 1st Ed. (2017)

These guide specifications establish minimum requirements for wind loads on bridges during construction before a deck is placed. The wind loads determined using these specifications are to be used for checking bridge girders, temporary and permanent bracing, and the permanent substructure during the erection of the girders and up to the time of placement of the deck. All other aspects of the design are to be performed in accordance to the *AASHTO LRFD Bridge Design Specifications* or as specified as appropriate by the bridge owner.

Manual for Bridge Evaluation, 3rd Ed., with 2019 Interim Revisions (2018)

This manual has been developed to assist bridge owners by establishing inspection procedures and evaluation practices that meet the National Bridge Inspection Standards (NBIS). The manual has been divided into eight Sections with each Section representing a distinct phase of an overall bridge inspection and evaluation program. This manual replaces both the 2011 AASHTO *Manual for Bridge Evaluation*, 2nd Edition and the 2011, 2013, 2014, 2015, and 2016 interims. Sections 3: Bridge Management Systems; 4: Inspection; 6: Load Rating; and 7: Fatigue Evaluation of Steel Bridges have been updated.

Manual for Bridge Element Inspection, 2nd Ed. (2019)

The Manual for Bridge Element Inspection (MBEI) is a reference for standardized element definitions, element quantity calculations, condition state definitions, element feasible actions, and inspection conventions. Its goal is to capture the condition of bridges in a simple, effective way that can be standardized nationwide, while providing enough flexibility to be adapted by both large and small agencies. It is designed for use by state departments of transportation and other agencies that perform element-level bridge inspections.

This new, second edition, which supersedes the first edition published in 2013, was developed as a result of NCHRP Project 12-104 “Guidelines to Improve the Quality of Element-Level Bridge Inspection.” It incorporates suggested changes by numerous inspecting agencies, consultant inspection firms, and training instructors, and attempts to cover the majority of bridge elements found on highway bridges in the United States.

LRFD Guide Specifications for Accelerated Bridge Construction, 1st Ed. (2018)

Many state DOT’s and the Federal Highway Administration are actively promoting accelerated bridge construction (ABC) to reduce traffic impacts, onsite construction time, environmental impacts, and life cycle costs; and to improve work zone safety, site constructability, material quality, and product durability, while replace the nation’s transportation infrastructure. With ABC, prefabricated elements reduce or eliminate the onsite construction time that is needed to build a similar structural component using conventional construction methods. These guide specifications compile the growing body of recommended design and construction specifications for prefabricated bridge elements and systems for ABC with a focus on constructability and durability.

Guide Specifications for Bridges Carrying Light Rail Transit Loads, 1st Ed. (2018)

These guide specifications are an introductory supplement to the *AASHTO LRFD Bridge Design Specifications* that addresses the design of bridges subjected to light rail transit (LRT) loadings, or both LRT and conventional highway traffic loadings. This document is largely dedicated to LRT load cases and load effects, and analysis of bridges subjected to LRT loadings. Topics outside of design of these bridges are not addressed in these guide specifications. The commentary is intended to provide a general overview of the studies and research data reviewed in formulating the provisions of the LRT Guide Specifications. However, technical discussions are provided as required.

AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Ed., with 2012, 2014 and 2015 Interim Revisions (2011)

These guide specifications cover seismic design for typical bridge types and apply to non-critical and non-essential bridges. They are approved as an alternate to the seismic provisions included in the *AASHTO LRFD Bridge Design Specifications*, differing in the use of displacement-based design procedures, instead of the traditional force-based R-Factor method. The specifications include detailed guidance on earthquake-resistant elements and systems, global design strategies, demand modelling, capacity calculation, and liquefaction effects. Capacity design procedures underpin the specifications' methodology and include prescriptive detailing for plastic hinging regions and design requirements for capacity protection of those elements that should not experience damage.

Guide Specifications for Seismic Isolation Design, 4th Ed. (2014)

These guide specifications address major changes in the state of the art of seismic isolation design for highway bridges and reflect changes in the way seismic hazard is defined in the *AASHTO LRFD Bridge Design Specifications* and the *Guide Specifications for LRFD Seismic Design*. The specifications include industry trends in the design and construction of isolators, and provisions in the design specifications that impact the design and testing of isolation bearings. The newly added Appendix B contains 14 design examples.

Guide Specifications for the Design of Concrete Bridge Beams Prestressed with Carbon-Fiber-Reinforced Polymer (CFRP) Systems, 1st Ed. (2018)

These guide specifications apply to the design of prestressed concrete beams constructed of normal weight concrete and prestressed by carbon fiber-reinforced polymer (CFRP) prestressing systems.

AASHTO LRFD Bridge Design Guide Specifications for GFRP-Reinforced Concrete, 2nd Ed. (2018)

These guide specifications offer a description of the unique material properties of glass fiber-reinforced polymer (GFRP) composite materials, as well as provisions for the design and construction of concrete bridge decks and railings reinforced with GFRP reinforcing bars. The revised edition includes information on the advancements in material specifications, and new knowledge and field experiences beyond bridge decks and traffic railings.

Some of the major updates in this new edition include a title change from the 2009 first edition, AASHTO *LRFD Bridge Design Guide Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railings*, to acknowledge the inclusion of information beyond bridge decks and traffic railings; greater consistency with the *AASHTO LRFD Bridge Design Specifications*, 8th Edition; consideration of flexural members, such as girders and bent caps, not included in the first edition; consideration of

substructure and foundation elements along with compression members; differentiation between the fatigue and creep limit states; and revised shear design methodology.

Guide Specifications for Design of Bonded FRP Systems for Repair and Strengthening of Concrete Bridge Elements, 1st Ed. (2012)

These guide specifications are intended for the repair and strengthening of reinforced and prestressed highway bridge structures using externally bonded fiber-reinforced polymer (FRP) composite systems.

LRFD Guide Specifications for the Design of Pedestrian Bridges, 2nd Ed., with 2015 Interim Revisions (2009)

These guide specifications address the design and construction of typical pedestrian bridges that are designed to carry, primarily, pedestrians, bicyclists, equestrian riders, and light maintenance vehicles.

Standard Specifications for Highway Bridges, 17th Ed. (2002)

These specifications are the archived version of the bridge design specifications in use prior to the introduction of the *AASHTO LRFD Bridge Design Specifications*. These standards are available for the maintenance and rehabilitation of older, existing structures.

Guide Specifications for Design and Construction of Segmental Concrete Bridges, 2nd Ed., with 2003 Interim Revisions (1999)

Developed by a committee organized by the American Segmental Bridge Institute, these guide specifications apply to the design and construction of segmental concrete bridges and are designed to be used in conjunction with the *Standard Specifications for Highway Bridges*.

Bridge Security Guidelines, 1st Ed. (2011)

These guidelines offer guidance on bridge design for extreme events induced by man. It includes information on the response of concrete bridge columns subjected to blast loads, and blast-resistant design detailing guidelines and analytical models of blast load distribution. These guidelines should be considered in situations where resisting blast loads is deemed warranted by the owner or designer.

Guide Specifications for Bridges Vulnerable to Coastal Storms, 1st Ed. (2008)

This document contains comprehensive specifications for the design of brides vulnerable to coastal storms. The methods for calculating wave forces on superstructures are based, primarily, on numerical simulation of the state of pressure, velocity, and acceleration within the water as a wave passes under or over bridge cross sections. Coefficients needed for the numerical simulation process, known as the Physics Based Method (PBM), were developed through physical wave tank tests. Bridge failures due to storm surge and wave loading in Gulf Coast states in recent years provided limited field data that was used to further verify these methods. Also included are current-induced forces guidelines that were the results of recent research conducted at the Turner-Fairbank Highway Research Center.

REFERENCES

AASHTO Materials Specifications and Test Methods

AASHTO provides many material standards that are used in the construction of concrete bridges.

Publications are available for purchase on the AASHTO Materials, Testing & Pavement Publications webpage: https://store.transportation.org/publications?/C_MA

Equivalencies Between AASHTO and ASTM Specifications and Test Methods

The AASHTO Committee on Materials and Pavements provides a useful list of equivalencies between specifications and test methods published by AASHTO and ASTM International.

https://materials.transportation.org/wp-content/uploads/sites/24/2019/09/AASHTO_w-ASTM_Equivs_2019-08-26.pdf

TRAINING

The AASHTO Store lists many training opportunities, including many free offerings under the Transportation Curriculum coordination Council (TC3) program. TC3 is a technical service program within AASHTO that focuses on developing training products for technical staff in the areas of construction, maintenance, and materials. TC3 has a library of more than 190 online training modules covering a variety of topics in the three primary disciplines. As a national resource, TC3 helps states, local government, and industry save money at a critical time of infrastructure investment through course development, web-based trainings, information, and resource sharing that is available at substantially reduced cost. All 50 state DOTs have used the TC3 web-based training resources, which are also being used by local governments, universities, consultants, contractors, industry, contractor organizations, and international groups.

TC3 website: https://tc3.transportation.org/

CERTIFICATIONS

AASHTO certification opportunities are listed on the National Transportation Product Evaluation Program (NTPEP) website: www.ntpep.org

Federal Highway Administration (FHWA)

ORGANIZATION DESCRIPTION

The **Federal Highway Administration (FHWA)** is an agency within the U.S. Department of Transportation that supports State and local governments in the design, construction, and maintenance of the Nation's highway system (Federal Aid Highway Program) and various federally and tribal owned lands (Federal Lands Highway Program). Through financial and technical assistance to State and local governments, the Federal Highway Administration is responsible for ensuring that America's roads and highways continue to be among the safest and most technologically sound in the world.

The Federal Highway Administration was created on October 15, 1966, after having had several predecessor organizations. In 1893, the Office of Road Inquiry was founded. In 1905 that organization's name was changed to the Office of Public Roads which became a division of the United States Department of Agriculture. The name was changed again to the Bureau of Public Roads in 1915 and to the Public Roads Administration in 1939. It was then shifted to the Federal Works Agency which was abolished in 1949 when its name reverted to Bureau of Public Roads under the Department of Commerce. In 1966 the FHWA was created; and in 1967 the functions of the Bureau of Public Roads were transferred to FHWA.

Website: www.fhwa.dot.gov
FHWA Concrete Bridge webpage: www.fhwa.dot.gov/bridge/concrete/

MANUALS OF PRACTICE & SPECIFICATIONS

Construction

Post-Tensioning Installation and Grouting Manual, FHWA-NHI-13-026 (2013)

This Manual includes state-of-the-art information relative to materials, post-tensioning systems, construction practices and grouting of post-tensioning tendons for bridges. The Manual is targeted at Federal, State and local transportation departments and private company personnel that may be involved in the design, inspection, construction, or maintenance of bridges that contain post-tensioning tendons. This Manual will serve as a reference and guide to designers, inspectors and construction personnel for post-tensioning materials, installation and a grouting of bridge tendons. The document is part of the Federal Highway Administration's national technology deployment program and may serve as a training manual.

www.fhwa.dot.gov/bridge/construction/pubs/hif13026.pdf
Companion training (at no cost) is available as NHI course number 130103. Refer to training section below for more information.

Engineering for Structural Stability in Bridge Construction – Reference Manual, FHWA-NHI-15-044 (2015)

This manual provides guidance to bridge erection engineers, resident/construction engineers, and design engineers to assist in the design and evaluation of bridge superstructures during construction. It is intended primarily to cover common steel and concrete multi-girder I-girder and tub, or box-

girder, bridges. Proper assessment of bridge superstructure performance during construction is critical to ensure that member instability or deformations do not lead to unsafe conditions or to poor geometry control that may be reflected in the finished structure.

www.fhwa.dot.gov/bridge/pubs/nhi15044.pdf
Companion training (for cost) is available as NHI course number 130102. Refer to training section below for more information.

Analysis and Design

Load and Resistance Factor Design (LRFD) for Highway Bridge Superstructures - Reference Manual, FHWA-NHI-15-047 (2015)

This document presents the theory, methodology, and application for the design and analysis of both steel and concrete highway bridge superstructures. The manual is based on the AASHTO LRFD Bridge Design Specifications, Seventh Ed., 2014, with Interim Revisions through 2015. Design examples and commentary throughout the manual are intended to serve as a guide to aid bridge engineers with the implementation of the AASHTO LRFD Bridge Design Specifications.

www.fhwa.dot.gov/bridge/pubs/nhi15047.pdf
Companion training (for cost) is available as NHI course number 13081. Refer to training section below for more information.

Post-Tensioned Box Girder Design Manual, FHWA-HIF-15-016 (2016)

This Manual contains information related to the analysis and design of cast-in-place concrete box girder bridges prestressed with post-tensioning tendons. The Manual is targeted at Federal, State and local transportation departments and private company personnel that may be involved in the analysis and design of this type of bridge. The Manual reviews features of the construction of cast-in-place concrete box girder bridges, material characteristics that impact design, fundamentals of prestressed concrete, and losses in prestressing force related to posttensioned construction. Also presented in this Manual are approaches to the longitudinal and transverse analysis of the box girder superstructure. Both single-cell and multi-cell box girders are discussed. Design examples are presented in Appendices to this Manual. The document is part of the Federal Highway Administration's national technology deployment program and may serve as a training manual.

www.fhwa.dot.gov/bridge/concrete/hif15016.pdf

Strut-and-Tie Modeling (STM) for Concrete Structures, FHWA-NHI-17-017 (2017)

This Manual provides four design examples illustrating the application of the strut-and-tie method for a variety of structural configurations, including a simply-supported deep beam, a cantilever bent cap, an inverted-tee moment frame straddle bent cap, and a drilled shaft footing. Each design example is based on the 8th Edition of the AASHTO LRFD Bridge Design Specifications. This Manual is intended for state DOT bridge and structures engineers and practicing bridge engineers who are responsible for concrete bridge design and evaluation. This Manual will serve as a reference and a guide for engineers of all levels, including designers, consultants, reviewers, maintenance engineers, management engineers, and load rating engineers. This document is part of a training program that also includes a one-and-a-half-day instructor-led training (ILT) course.

www.fhwa.dot.gov/bridge/concrete/nhi17071.pdf
Companion training (for cost) is available as NHI course number 130126. Refer to training section below for more information.

Manual for Refined Analysis in Bridge Design and Evaluation, FHWA-HIF-18-046 (2019)

This manual provides technical guidance on using refined methods of analysis for design and evaluation of highway bridges, to supplement the provisions and commentary of the AASHTO specifications. The application of refined methods is needed when a bridge design falls outside of the limits for the approximate methods in the AASHTO specifications or when refined methods can provide a more rigorous treatment to appropriately account for unique details and/or behaviors. Refined methods can also be used to achieve a more effective design or a more accurate load rating. To generate confidence, this manual includes seven case study analysis examples and provides trusted results that can be used by software providers and engineers to verify their modeling techniques.

www.fhwa.dot.gov/bridge/pubs/hif18046.pdf

REFERENCES

Public Roads

Public Roads is the quarterly magazine of the Federal Highway Administration (FHWA). Reading *Public Roads* is the easiest way to keep up-to-date on developments in federal highway policies, programs, and research and technology. More specifically, the magazine "covers" advances and innovations in highway/traffic research and technology, critical national transportation issues, important activities and achievements of FHWA and others in the highway community, specific FHWA program areas, and subjects of interest to highway industry professionals. Each issue contains standard departments that include information on topics of general interest, notices of recent publications in research and development and in technology applications, Internet-related information applicable to transportation professionals, programs and courses offered by the National Highway Institute, and a calendar of major conferences and special events. *Public Roads* also emphasizes the continuing commitment of FHWA to be a world leader in promoting highway research and technology transfer.

www.fhwa.dot.gov/publications/publicroads/

TRAINING

The National Highway Institute (NHI) is the training and education arm of the Federal Highway Administration (FHWA), NHI has a long and rich history of innovation and expertise in delivering transportation training. Improving the conditions and safety of our nation's roads, highways, and bridges means continuously building on the skills of highway professionals and enhancing job performance in the transportation industry across the country.

All the courses listed below can be accessed by entering the course number in the provided link's search feature.

www.nhi.fhwa.dot.gov/home.aspx

Post-Tensioning Installation and Grouting – Course 130103, FHWA-NHI-130103 (2013)

Post-Tensioning Tendon Installation and Grouting Web-based Training (WBT) delivers content on post-tensioning principles, system components, and installation procedures - including quality control procedures - which will assist supervisors, inspectors, and construction inspectors in the performance of their job. This 6-hour WBT course provides guidance to individuals involved in the design,

installation, grouting, and inspection of post-tensioning tendons for prestressed concrete bridges and is intended to be an online complement to the Post-Tensioning Tendon Installation and Grouting Manual. Participants who complete this WBT will have a general understanding of post-tensioning components, construction, as well as testing and acceptance procedures. This WBT will better prepare individuals for more intensive certification courses in post-tensioning installation and grouting (PTI Level 1 & 2 PT Field Specialist and ASBI Grouting Certification Training). Course is available at no cost.

Engineering for Structural Stability in Bridge Construction – Course 130102, FHWA-NHI-130102 (2015)

The objective of this 2.5-day instructor led course is to train participants on the behavior of steel and concrete girder bridges during construction and teach them to identify vulnerabilities and engineering methods to investigate the structure's strength and stability at each critical stage. This is done within the practical context of engineering, development, verification, and/or review of erection plans. Course is available for cost.

Load and Resistance Factor Design (LRFD) for Highway Bridge Superstructures – Course 130081, FHWA-NHI-130081 (2015)

This updated 4-day instructor led course describes Load and Resistance Factor Design (LRFD) for steel and concrete highway bridge superstructures. It provides a combination of instructor-led discussions and workshop exercises. The course also includes LRFD theory applied to design examples and illustrates step-by-step LRFD design procedures. The curriculum follows the AASHTO LRFD Bridge Design Specifications, 7th Edition, 2014 (AASHTO LRFD), including the approved 2015 Interims. The training includes the extensive use of student exercises and example problems to demonstrate overall design, detailing, and construction principles addressed in the reference materials. It affords hands-on experience in LRFD design and detailing of highway bridge superstructures. The curriculum materials are comprised of a comprehensive reference manual (FHWA Publication No. FHWA-NHI-15-047), lecture and workshop exercises intended to promote or enhance a working knowledge of AASHTO LRFD, and a participant workbook for lecture notes and exercises. Course is available for cost.

Strut-and-Tie Modeling (STM) for Concrete Structures – Course 130126, FHWA-NHI-130126 (2017)

This 1.5-day instructor led training on STM provides engineers with a simplistic analysis and design tool for deep concrete bridge elements and disturbed regions that would otherwise require a rigorous refined analysis. STM has long been established as a reasonable analysis tool for disturbed regions and deep beams. However, this modeling tool has had difficulty being integrated into our bridge design state-of-practice, which has resulted in inappropriate use of the simplistic elastic beam theory design for deep beams and disturbed regions. In some cases, it has resulted in poor in-service performance. This training course serves as a significant step in providing the knowledge transfer necessary for STM to be used more frequently and more effectively. Course is available for cost.

CERTIFICATIONS

No certifications are offered.

National Concrete Bridge Council (NCBC)

ORGANIZATION DESCRIPTION

The **National Concrete Bridge Council (NCBC)** is a council of allied industry organizations dedicated to:

- Promote quality in concrete bridge construction.
- Gather and disseminate information on design, construction, and condition of concrete bridges.
- Establish communication with federal and state departments of transportation, city and county public works departments, and consulting engineers.
- Provide information on behalf of the concrete industries to codes and standards groups.

The member organizations of the NCBC are listed on the first page of this document.

Website: http://nationalconcretebridge.org/

REFERENCES

Resources are presented in the following sections that are available from each of the members of the National Concrete Bridge Council (NCBC).

ASPIRE, the concrete bridge magazine

ASPIRE is a quarterly magazine published by the Precast/Prestressed Concrete Institute (PCI) in cooperation with several members of the National Concrete Bridge Council. Each issue provides information on the latest projects, technologies, and key issues related to all aspects of design, construction, and preservation of concrete bridges of any type or size. Content is tailored to federal, state, and local agencies, consultants, contractors, planners, suppliers, and universities. Subscriptions are available at no charge.

Website: www.aspirebridge.org

Concrete Bridge Views

Concrete Bridge Views is a newsletter that was published jointly by the Federal Highway Administration (FHWA) and the National Concrete Bridge Council. The newsletter was first published in 1999 as *HPC Bridge Views.* The newsletter initially provided information on high-performance concrete (HPC) as the industry was beginning to embrace that concept. After HPC became well accepted, the newsletter began to address more general topics related to the use of concrete in bridges. A total of 80 issues of both newsletters were published; all are still available on the website and provide important information on many topics.

Website: www.concretebridgeviews.com/

American Segmental Bridge Institute (ASBI)

ORGANIZATION DESCRIPTION

The **American Segmental Bridge Institute (ASBI)** is a nonprofit organization that provides a forum where owners, designers, constructors, and suppliers can meet to further refine current design, construction and construction management procedures, and evolve new techniques that will advance the quality and use of concrete segmental bridges.

ASBI is a focal point of the development of technical information for design and construction of segmental concrete bridges in the U.S. as well as internationally by providing educational programs and publications.

Website: www.asbi-assoc.org
All ASBI publications are available for free download at the links provided.

MANUALS OF PRACTICE & SPECIFICATIONS

ASBI Construction Practices Handbook for Concrete Segmental and Cable-Supported Bridges, 3rd Ed. (2019)

The purpose of the handbook is to provide guidance for construction of concrete segmental bridges. Increased use of this technology has led to a need to provide industry standard information for use by contractors, inspectors, quality control staff, and owners. This handbook is intended to provide a basic understanding of segmental construction technology. Construction methods discussed include:

- Precast Segmental Span-by-Span
- Precast Segmental Balanced Cantilever Bridges
- Cast-in-Place Segmental Balanced Cantilever Bridges
- Precast Segmental Progressive Placement
- Cast-in-Place Segmental Incremental Launching
- Precast and Cast-in-Place Segmental Cable-Stayed Bridges

www.asbi-assoc.org/index.cfm/publications/handbook-download

AASHTO-PCI-ASBI Segmental Box Girder Standards for Span-by-Span and Balanced Cantilever Construction (2000)

These drawings provide standardized details for segmental box girders for Span-by-Span and Balanced Cantilever Construction (U.S. customary units) including the following:

- Span-by-Span Standards 100’ to 150’
- Balanced Cantilever Standards 100’ to 200’
- Deck Widths 28’-0” to 45’-0”
- Precast Box Pier Details

CADD format drawings and a metric version are available upon request.

www.asbi-assoc.org/index.cfm/resources/aashto

REFERENCES

Design and Construction of Concrete Segmental Bridges

This publication is a brief brochure style document that provides an overview of segmental bridge design and construction.

www.asbi-assoc.org/cfcs/cmsIT/baseComponents/fileManagerProxy.cfc?method=GetFile&fileID=688B8860-F51E-0459-FC816AEE9F38F555

Durability Survey of Segmental Concrete Bridges, 4th Ed. (2012)

This report uses data from the 2011 National Bridge Inspection (NBI) database and available bridge inspection reports to evaluate the durability and long-term performance of segmental concrete bridges.

www.asbi-assoc.org/cfcs/cmsIT/baseComponents/fileManagerProxy.cfc?method=GetFile&fileID=71FF0991-90D0-C829-C2C6BEFEB2CB7445

ASBI Segmental Bridge Project Database

This web-based application allows the user to input simple search parameters to find a sampling of example segmental bridge projects. While this is not intended as a complete listing of segmental bridges it does provide the reader with more in-depth information on several select projects.

This web-based resource can be found here: www.asbi-assoc.org/projectGallery

TRAINING

All upcoming training or seminar opportunities can be found on the Events page of the ASBI website: www.asbi-assoc.org/index.cfm/events/upcoming-events

ASBI Grouting Certification Training

The purpose of the *ASBI Grouting Certification Training* is to provide supervisors and inspectors of grouting operations with the training necessary to understand and successfully implement grouting specifications for post-tensioned structures. This is a full day classroom style training class with PowerPoint presentations, videos and lectures by experts in the field of cementitious grouting of post-tensioned structures.

Flexible Filler Training

This one-day long training is required for the foremen, technicians, as well as quality control inspectors involved with post-tensioning tendon flexible filler injection for Florida Department of Transportation projects.

Construction Practices Seminar

The Seminar is designed as a day-and-a-half classroom style educational training program based on the *"ASBI Construction Practices Handbook for Concrete Segmental and Cable-Supported Bridges"* for

the purpose of providing comprehensive coverage of the state-of-the-art construction practices related to segmental concrete bridges.

CERTIFICATIONS

ASBI Grouting Training Certification

Individuals who successfully complete the ASBI Grouting Certification Training and do not have three years of verifiable documented experience in construction of grouted post-tensioned structures, will receive an "ASBI Grouting Training Certificate." In the five-year period following completion of the training, individuals with this certificate may obtain an "ASBI Certified Grouting Technician Certificate" upon submission of verifiable documentation of three years' experience in construction of grouted post-tensioned structures.

ASBI Grouting Technician Certification

Individuals who successfully complete the ASBI Grouting Certification Training and provide verifiable documentation of three years of experience in construction of grouted post-tensioned structures, will receive a certificate as an "ASBI Certified Grouting Technician." The certificate will be valid for a period of five years and will be renewable at the end of that time through participation in an online recertification examination. To receive this certificate, submission of verifiable documentation of experience is required at the time of registration for the training.

Concrete Reinforcing Steel Institute (CRSI)

ORGANIZATION DESCRIPTION

The **Concrete Reinforcing Steel Institute (CRSI)**, founded in 1924, is a technical institute and Standards Developing Organization (SDO) that stands as the authoritative resource for information related to steel reinforced concrete construction. CRSI offers many industry-trusted technical publications, standards documents, design aids, reference materials, and educational opportunities.

Approximately 8 million tons of reinforcing steel (rebar) is manufactured per year using scrap steel in efficient manufacturing operations. It is estimated that the industry impacts over 75,000 people in steel transportation and placement.

CRSI members include manufacturers, fabricators, material suppliers, and placers of steel reinforcing bars and related products as well as professionals who are involved in the research, design, and construction of steel reinforced concrete. CRSI members employ approximately 15,000 people in steel production and rebar fabrication at over 450 locations in 47 states throughout North America.

The non-profit CRSI Research & Education Foundation fosters the educational and research mission of the Institute through educational programs and scholarships for students majoring in civil engineering, architecture, and other related disciplines at universities and technical schools. The Foundation also supports research fellowships and projects, which will ultimately advance the reinforced concrete industry. CRSI is headquartered in Schaumburg, Illinois, with regional offices located across the United States.

Website: www.crsi.org

MANUALS OF PRACTICE & SPECIFICATIONS

Manual of Standard Practice, 29th Ed. (2018)

The 29th Edition of this publication contains information on recommended industry practices for estimating, detailing, fabricating, and placing reinforcing steel for reinforced concrete construction. Includes suggested specifications for reinforcing steel.

New material includes:

- Expanded coverage of all 4 types of reinforcing bars
- Coverage of new bar size #20 where possible
- Updated and expanded markings for all Grades of reinforcing bars produced in the U.S.
- Reformat of Chapter 3, Bar Supports, to serve as a Commentary to ANSI/CRSI RB4.1, Standard for Supports for Reinforcement used in Concrete
- Expanded “first bar placement” illustrations for various types of reinforced concrete members
- Doubled number of Typical Bend Shapes and added coverage of Typical Measuring Points for reinforcing bar fabrication
- Added coverage of voided concrete slab construction
- New chapters on highways and bridges and sustainability in reinforced concrete

https://netforum.avectra.com/eweb/shopping/shopping.aspx?site=mycrsi&prd_key=b8096903-0997-4c2a-8495-855c9479c8e3 *Purchase required*

Reinforcing Bars: Anchorages and Splices, 6th Ed. (2017)

The definitive source for information on development and splicing of reinforcing bars. Features technical data on mechanical splices including load tests for Type 1 and Type 2 splices, Grades 40 to 80. Includes extensive tables of development and lap splice lengths for Grade 60 uncoated and epoxy-coated reinforcing bars with 3,000 to 10,000 psi concrete compressive strengths. Also included are the following: development and lap splice length tables for welded wire reinforcement, expanded information on headed bars, and supporting formulas for all development and lap splice tables. Sixth edition conforms to ACI 318-14 and *AASHTO LRFD Bridge Design Specifications* (2016).

https://netforum.avectra.com/eweb/shopping/shopping.aspx?site=mycrsi&shopsearch=anchorage&prd_key=1a1245ba-e844-4552-9b94-3f0b5dabf2b9 *Purchase required*

Placing Reinforcing Bars, 10th Edition (2019)

This unique and popular publication presents the best accepted current practices in placing reinforcing bars in structures and pavement. It is written for apprentices, journeymen ironworkers, and inspectors. A definitive resource for preparing provisions in project specifications. Eighteen heavily illustrated chapters cover topics including types of materials, handling of bars at the jobsite, general principles for bar placing, splicing, and tying, bar placement in footings, walls, columns, floors, roofs, pavement and transportation structures. Also includes a chapter on epoxy and other coated reinforcement.

https://netforum.avectra.com/eweb/shopping/shopping.aspx?site=mycrsi&prd_key=46f00dc7-9bf7-4764-9a8a-03123ed82e9c *Purchase required*

REFERENCES

Design Guide for AASHTO Pile Caps (2018)

This design guide has been developed to provide the practicing engineer with a detailed overview of AASHTO pile cap design, detailing, and analysis methodologies that represent the current state of practice in the industry. The guide contains comprehensive technical content and practical design examples utilizing approximately 30 different, yet commonly used, pile cap configurations. Tabulated designs are also provided for all aforementioned pile cap configurations and a wide range of vertical loading, lateral loading, and overturning effects. In order to better understand the behavior of deep pile caps, a finite element study was performed and recommendations obtained from that study are presented here.

https://netforum.avectra.com/eweb/shopping/shopping.aspx?site=mycrsi&prd_key=eedf884b-ae0e-461d-a5b4-54d7b84d2e58 *Purchase required*

Design Guide for Drilled Piers (2016)

This publication has been developed to provide the practicing engineer with a detailed overview of drilled pier design, detailing, and analysis methodologies that represent the current state of practice in the industry and meet the latest codes and standards including the 2015 International Building Code (IBC), ACI 318-14 (ACI) and the 2014 *AASHTO LRFD Bridge Design Specifications* (AASHTO). Several complete building and bridge application design examples for drilled piers to resist the combined effects of vertical loading, lateral loading, and overturning are included in this Guide. Tabulated designs are provided for commonly assumed soil profiles and a wide range of vertical

loading, lateral loading, and overturning conditions. Additional design aids are provided throughout the text and access to design software is made available to expedite the design process and to validate hand calculations.

https://netforum.avectra.com/eweb/shopping/shopping.aspx?site=mycrsi&webcode=shopping&shopsearch=design+guide&shopsearchcat=merchandise&productcat=design&prd_key=76dceb9c-63a9-4b7d-9dcb-d78664689d0e *Purchase required*

Design Guide for Cantilevered Retaining Walls (2014)

This design guide presents a thorough coverage of designing cantilevered retaining walls for the design engineer, including tabulated designs for various soil characteristics with level and sloping backfill, for walls 3 to 22 feet high. Also included are two manual examples to show how the tabulated values were determined.

https://netforum.avectra.com/eweb/shopping/shopping.aspx?site=mycrsi&webcode=shopping&shopsearch=design+guide&shopsearchcat=merchandise&productcat=design&prd_key=00bfecbf-c6ba-4e90-92e4-f5a260c10082 *Purchase required*

Specialty & Corrosion-Resistant Steel Reinforcement: Product Guide, 1st Ed. (2013)

This Guide provides information for the specification, fabrication, estimating, detailing and placement of reinforcing steel bars specified for improved corrosion resistance, or other special uses or conditions. This document is a guide, not a standard, and appropriate project-specific contractual documents should be reviewed.

This Guide does not provide guidance concerning the selection of materials for a specific purpose. The licensed design professional (LDP) or specifier should consult relevant design requirements to determine whether corrosion-resistant reinforcing bars or specialty reinforcing bars might be beneficial for a particular use or project.

https://netforum.avectra.com/eweb/shopping/shopping.aspx?site=mycrsi&shopsearch=epoxy&prd_key=dac78b96-e714-4d59-baee-52b48b2faec2 *Purchase required*

Rebar Reference Mobile App, Version 2 (2019)

This quick reference app is handy for both desk and field reference and includes information on ASTM standard reinforcing bars (rebar), standard hook details, standard stirrup/tie hook details, and ASTM reinforcing bar marking requirements. Links to the Concrete Reinforcing Steel Institute's online resources are included.

The app provides standard rebar specifications including sizes, diameters, areas and weights along with 90-, 135- and 180-degree hook details. Minimum yield and minimum tensile requirements per ASTM are also included. Industry standard bar markings for inch-pound rebar is illustrated for grades 40, 50, 60, 75, 80, 100 (A615), 100 (A1035), and 120.

This app is free. A nominal fee is required to activate the rebar identifier and field inspection modules of the app.

http://resources.crsi.org/resources/rebar-reference-mobile-app/?resourceTypes=&resources=&latest=true&tag=&pageNo=1&keywords=&resourceview=grid&shown=12

TRAINING

Steel Reinforced Concrete: Essentials

This course introduces steel reinforced concrete: production, fabrication and placement including valuable guidance with regard to early design considerations, material properties and options, pre-construction planning, and general field considerations. A fee is not required to register for this course (1 hour).

RebarU:

This resource contains a variety of e-learning courses and webinar presentations on design and construction topics. Webinar courses are eligible for continuing education units (CEU) and professional development hours (PDH). Fees are required to register for courses and webinars, except for CRSI members.

https://learning.crsi.org/course/index.php?categoryid=1

CERTIFICATIONS

All of the following standards can be found at: www.crsi.org/index.cfm/standards/standards_docs.

CRSI RB4.1 - Supports for Reinforcement Used in Concrete (2016)

This specification covers the design, use, and material requirements of reinforcement supports used in concrete to support various types of reinforcement, including but not limited to plain and deformed reinforcing bars, prestressing steel, post-tensioning tendons, steel wire, and plain and deformed steel welded wire reinforcement.

CRSI CG1.1 - Epoxy Coating Plant: Straight Bar Lines (2016)

This standard specifies procedures used to monitor production and assess quality during the application of epoxy coating to straight steel reinforcing bars. This standard also describes minimum requirements for documentation, observation and testing as part of a quality control program.

CRSI CG1.2 - Epoxy-Coated Facilities: Custom Lines (2016)

This standard specifies procedures used to monitor application process and ensure quality during the application of epoxy coating to steel for use in concrete using custom coating operations. This standard also describes minimum requirements for documentation, observation and testing as part of a quality control program.

CRSI CG2.1 - Epoxy-Coated Steel Reinforcing Bar Fabrication Facilities (2016)

This standard describes standard practice for fabrication quality processes for epoxy-coated steel reinforcing bars.

CRSI IPG4.1 - Stainless Steel Reinforcing Bar Fabrication Facilities (2016)

This standard describes standard practice for fabrication quality processes for stainless steel reinforcing bars.

Epoxy Interest Group (EIG) of CRSI

ORGANIZATION DESCRIPTION

The **Epoxy Interest Group (EIG)** of CRSI (Concrete Reinforcing Steel Institute), is a not-for-profit trade association providing an authoritative resource for information related to use of epoxy-coated steel (epoxy rebar) in reinforced concrete. Epoxy-coated reinforcing steel is also known as ECR (epoxy-coated rebar) and FBECR (fusion bonded epoxy coated rebar).

EIG's primary mission is to enhance value for its member companies (epoxy coaters, epoxy fabricators, and epoxy powder manufacturers) by creating infrastructure protection and preservation programs. EIG accomplishes this goal by promoting the use of and advancing the quality of epoxy coated rebar. EIG offers education, technical support, training, and an open forum for our members to interact with the community of material specifiers in the construction industry. EIG serves the construction market in the United States, Canada, and Mexico.

Website: http://epoxyinterestgroup.org/

MANUALS OF PRACTICE & SPECIFICATIONS

Manuals of practice and specifications for epoxy coated reinforcement are administered by the Concrete Reinforcing Steel Institute (CRSI) – see descriptions in the CRSI resource list.

REFERENCES

Recommended Field Handling of Epoxy-Coated Reinforcing Bars

This is a card that has information on Recommended Field Handling of Epoxy-Coated Reinforcing Bars and Job-Site Repair of Damaged Epoxy Coating.

www.epoxyinterestgroup.org/resources/recommended-field-handling-of-epoxy-coated-reinforcing-bars/?resourceTypes=0543BDE4-C73B-F057-0A739AAA6330F116&resources=&latest=&tag=&pageNo=1&keywords=&resourceview=grid&shown=9

Highlights and Guidelines of Specifications for Coating, Fabrication, and Field Handling

As epoxy-coated reinforcing bars may be specified using several different ASTM and AASHTO specifications, this document compares A775, A934 and D3963 in a tabular format.

www.epoxyinterestgroup.org/resources/highlights-and-guidelines-of-specifications-for-coating-fabrication-and-field-handling/?resourceTypes=0543BDE4-C73B-F057-0A739AAA6330F116&resources=&latest=&tag=&pageNo=1&keywords=&resourceview=grid&shown=9

Field Handling and Repair

This document is a two-page summary for field handling and field repair best practices.

www.epoxyinterestgroup.org/resources/field-handling-and-field-repair/?resourceTypes=04EE8B36-E192-8ACD-025019BA0B306B76&resources=&latest=&tag=&pageNo=1&keywords=&resourceview=grid&shown=1000

Cost-Effective Corrosion Protection Systems for Reinforced Concrete

This document compares uncoated, epoxy-coated and stainless reinforcing steel, based on a University of Kansas study.

www.epoxyinterestgroup.org/resources/cost-effective-corrosion-protection-systems-for-reinforced-concrete/?resourceTypes=04EE8B36-E192-8ACD-025019BA0B306B76,0543BDE4-C73B-F057-0A739AAA6330F116&resources=&latest=&tag=&pageNo=2&keywords=&resourceview=grid&shown=9

TRAINING

Video on the Manufacturing of Epoxy-Coated Rebar

www.epoxyinterestgroup.org/resources/manufacturing-of-epoxy-coated-rebar/?resourceTypes=0FB3DC31-CF51-3695-BE6A48B8677E9C1C&resources=&latest=&tag=&pageNo=1&keywords=&resourceview=grid&shown=9

Video on Field Handling Techniques for Epoxy-Coated Rebar

www.epoxyinterestgroup.org/resources/field-handling-techniques-for-epoxy-coated-rebar/?resourceTypes=0FB3DC31-CF51-3695-BE6A48B8677E9C1C&resources=&latest=&tag=&pageNo=1&keywords=&resourceview=grid&shown=9

CERTIFICATIONS

Certifications for epoxy coated reinforcement are administered by the Concrete Reinforcing Steel Institute (CRSI) – see descriptions in the CRSI resource list.

Expanded Shale, Clay and Slate Institute (ESCSI)

ORGANIZATION DESCRIPTION

The **Expanded Shale, Clay and Slate Institute (ESCSI)** was founded in 1952 and is the international trade association for manufacturers of ESCS lightweight aggregate. Based on research and development, educational material is disseminated to all phases of the building industry. The institute works closely with other technical organizations, ACI, ASTM, etc. to maintain product quality, life-safety and professional integrity throughout the construction industry and related building code bodies.

Website: www.escsi.org
Bridge related resources webpage: www.escsi.org/structural-lightweight-concrete/

MANUALS OF PRACTICE & SPECIFICATIONS

ESCSI Reference Manual for the Properties and Applications of Expanded Shale, Clay and Slate Lightweight Aggregate

This comprehensive Reference Manual provides information on the production, properties, and use of expanded shale, clay or slate (ESCS) lightweight aggregate for a wide range of applications.

www.escsi.org/reference-manual/

Guide Specification for Structural Lightweight Concrete (2001)

This guide specification for structural lightweight concrete supplements the standard concrete specifications typically used by architects and engineers.

www.escsi.org/structural-lightweight-concrete/technical-docs/

ESCSI Guide Specifications for Internally Cured Concrete (2012)

This guide specification can be used for modifying a conventional normal weight concrete mixture to provide internal curing of the concrete by replacing a portion of the normal weight fine aggregate with prewetted fine or intermediate expanded shale, clay or slate (ESCS) lightweight aggregate.

www.escsi.org/internal-curing/technical-docs/

REFERENCES

References without a web link can be obtained from:
www.escsi.org/structural-lightweight-concrete/technical-docs/

Cracking Tendency of Lightweight Concrete (2010)

This research report presents the results of the cracking tendency of lightweight concrete performed by the Highway Research Center at Auburn University's College of Engineering.

www.escsi.org/wp-content/uploads/2017/10/ESCSI-Final-Report-Auburn-University.pdf

Effect of Lightweight Aggregate on Early-Age Cracking of Mass Concrete (2017)

This research report looks at the effect of lightweight aggregate on the early-age cracking tendency of mass concrete. This research shows that although increasing the amount of lightweight aggregate will increase the maximum concrete temperature in mass concrete applications, the increasing use of lightweight aggregate will reduce the modulus of elasticity, reduce the coefficient of thermal expansion, and eliminate autogenous shrinkage effects, which all contribute to improve the resistance to early-age cracking.

www.escsi.org/wp-content/uploads/2018/01/ESCSI-Final-AU-Report-Mass-Concrete-2017.pdf

Specified Density Concrete, (2005)

This paper discusses applications of Specified Density Concrete (SDC) and internally cured concrete in the 115-135 lb/ft^3 density range using lightweight aggregates to improve structural efficiency (the strength to density ratio), reduce transportation cost, and to enhance the hydration of cementitious concrete mixtures.

Building Bridges and Marine Structures with Structural Lightweight Aggregate Concrete, (2001)

General information on 25 bridges and marine structures with lightweight concrete.

Back-up Statistics to Building Bridges and Marine Structures (2001)

Detailed information on 25 bridges and marine structures with lightweight concrete.

Criteria for Designing Lightweight Concrete Bridges (FHWA) (1985)

Federal Highway Administration (FHWA) report on applications of lightweight concrete in structures, especially bridge structures. Provides bridge engineers with useful information on past experience when considering the possible use of lightweight concrete in their structures

Long-Term Service Performance of Lightweight Concrete Bridge Structures (Reprint 1995)

Report on the long-term field performance of structural lightweight concrete bridge members constructed in Florida on U.S. Route 19 at Fanning Springs. The bridge incorporates a four-span precast prestressed lightweight concrete framing system with lightweight concrete cast-in-place deck slabs.

Bridge Rehabilitation with Structural Lightweight Concrete (1996)

Article excerpted and reprinted from ***MATERIALS For The New Millennium*** Proceedings of the 4th Materials Engineering Conference; Sponsored by the Materials Engineering Division, ASCE, detailing rehabilitation of the Whitehurst Freeway in Washington D.C. using structural lightweight concrete to replace the original heavier concrete deck system.

Lightweight HPC on Route 106 Bridge in Virginia (2004)

Article on high performance lightweight concrete used on a bridge in Virginia and monitored under the FHWA Innovative Bridge Research and Construction Program.

Lightweight Concrete for a Segmental Bridge (1994)

An article on the 1.2 mile long Benicia-Martinez Bridge across the San Pablo Bay in California discusses advantages of lightweight aggregate concrete and its use to minimize forces induced on the superstructure during potential seismic events.

Benefits of Lightweight HPC (2001)

An article highlighting the primary design-related and construction related benefits of structural lightweight concrete as well as economic and durability considerations.

Lightweight Concrete for California's Highway Bridges (1997)

This article looks at the use of structural lightweight concrete on several bridges in California. It was reprinted from the Portland Concrete Association ***Engineered Concrete Structures***, Vol. 10 No. 3, December 1997.

Pumping Structural Lightweight Concrete (1996)

These guidelines for pumping lightweight concrete include moisture-conditioning the aggregate, mix design considerations, pumping equipment, field mix adjustments, testing, etc.

FHWA Research Program on Lightweight High-Performance Concrete (2009)

Presented at The International Bridge Conference (IBC) held in Pittsburgh, PA in June 2009,

Internal Curing: Helping Concrete Realize its Maximum Potential (2012)

This brochure covers how internal curing offers benefits of improved hydration, reduced chloride ingress and reduced early age cracking, which helps concrete achieve its maximum potential as a sustainable building material by extending its service life.

www.escsi.org/wp-content/uploads/2017/10/ESCSI-IC-Brochure-4362.1.pdf

Test Method for Determining the Moisture Content of Fine Lightweight Aggregate in Stockpiles (2014)

This test method describes the procedures for determining the total absorbed and surface (free) moisture of fine lightweight aggregate to be used for internal curing of concrete.

www.escsi.org/wp-content/uploads/2017/10/Test-Method-for-Moisture-Content-of-FLWA-4362.3-1.pdf

The Team Approach to Internally Cured Concrete (2014)

This publication offers guidelines for a successful internal curing project and covers aggregate selection, concrete mixture considerations, aggregate saturation and stockpile management, batch plant adjustments to IC aggregates, concrete testing and information for the Design Engineer, General Contractor, Concrete Producer and Testing Labs.

www.escsi.org/wp-content/uploads/2017/10/The-Team-Approach-to-ICC-Publication-FINAL-8-22-14.pdf

Determination of Transport Properties of Lightweight Aggregate Concrete for Service Life Modeling (2018)

A study recently conducted to determine the effects of expanded shale, clay and slate (ESCS) lightweight coarse and fine aggregates on the transport properties and other durability related properties of concrete show that the service life will be increased when using lightweight aggregate as compared to normalweight concrete. This article summarizes this study and its conclusions.

www.escsi.org/wp-content/uploads/2019/10/LWA-Transport-Property-Article-10-19.pdf

TRAINING

The following web-based training videos can be accessed at www.escsi.org/professional-courses/

Expanded Shale, Clay, and Slate Lightweight Aggregate: A Brief Introduction

This video provides an introduction and overview of expanded shale, clay and slate lightweight aggregate including how they are manufactured and some of their most common applications.

Expanded Shale, Clay, and Slate Geotechnical Applications: A Brief Introduction

This video provides an introductory review of geotechnical applications of expanded shale, clay and slate lightweight aggregate.

Internal Curing using Fine Expanded Shale, Clay, and Slate: An Introduction

This video provides an in-depth discussion of internal curing of concrete using prewetted lightweight fine aggregate. Topics include definitions, specifications and applications of internally cured concrete mixtures. This one-hour training video may qualify for one Professional Development Hour in some states.

The following web-based training videos can be accessed at www.escsi.org/videos/

Modules 1-5 are a series of courses on internal curing developed and presented in 2013 by Dr. Jason Weiss of Oregon State University under the sponsorship of ESCSI.

Module 1: Improving the Performance of Concrete with Internal Curing (2013)

Module 2: Internal Curing Concept, Proportioning and Aggregate (2013)

Module 3: Internal Curing Shrinkage and Shrinkage Cracking (2013)

Module 4: Internal Curing Mechanical and Transport Properties (2013)

Module 5: Improving Sustainability with Internal Curing (2013)

ASTM C173 Volumetric Air Meter Test Video

This video demonstrates ASTM C173, the Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method; it is commonly referred to as the Roll-a-Meter test. The Volumetric Air Test method covers the determination of the air content of freshly mixed concrete. It measures the air contained in the mortar fraction of the concrete; it is not affected by air that may be present inside the porous lightweight aggregate particles.

Centrifuge Test for Internal Curing Lightweight Aggregate

This video demonstrates the centrifuge test for internal curing moisture testing with lightweight aggregate.

Internally Cured Concrete Part One: Lightweight Aggregate Preparation, Moisture Testing and Mix Design

This video is part one of a two-part series on how to easily produce internally cured concrete.

Internally Cured Concrete Part Two: Plant Charging and Batching Considerations

This video is part two of a two-part series on how to easily produce internally cured concrete.

Determining the Moisture Content of Lightweight Aggregate Using the Towel Dry Method

This video demonstrates the towel dry test method for lightweight aggregate moisture testing.

CERTIFICATIONS

No certification programs are available at this time.

National Ready Mixed Concrete Association (NRMCA)

ORGANIZATION DESCRIPTION

The **National Ready Mixed Concrete Association (NRMCA)**, founded in 1930, is the leading ready mixed concrete industry advocate. Our mission is to provide exceptional value for our members by responsibly representing and serving the entire ready mixed concrete industry through leadership, promotion, education and partnering to ensure ready mixed concrete is the building material of choice.

We work in conjunction through a partnership agreement with state associations on issues such as promotion and regulatory concerns and extend what they can do to a national level. Our commitment to our members is to communicate on the latest information, products, services and programs to help our members expand their markets, improve their operations and be their voice in Washington.

NRMCA has several committees in which members and professional staff work together to support the mission. They include Concrete Promotion, Mixer and Truck Bureaus, Government Affairs, Political Action, Research, Engineering & Standards, Safety, Environmental & Operations and Workforce Development.

Website: www.nrmca.org

MANUALS OF PRACTICE & SPECIFICATIONS

User's Guide to ASTM Specification C94

Twenty comprehensive chapters explain every section of ASTM C94/C94M, including background, scope, referenced documents, ordering information, materials and much more.

https://my.nrmca.org/Main/ItemDetail?iProductCode=2PMNL49&CATEGORY=ENG

Plant Inspector Guide & Qualification

The NRMCA administers a plant certification program that ensures that the production facilities used to manufacture concrete are in compliance with industry standards and are capable of furnishing quality concrete. The inspection is conducted by a licensed professional engineer who goes through a thorough checklist. Requirements and policy for the program are established by the NRMCA Research Engineering and Standards (RES) Committee. The Plant Inspector's Guide instructs the inspector on the intent of requirements of the certification program. The Guide will be used as a basis to qualify inspectors to conduct plant inspections. The development of the guide is to facilitate a uniform understanding of the plant inspection requirements for both the inspector and the ready mixed concrete producer. It is also a useful document for companies who have or wish to get their plants certified as it covers the details on the intent of each inspection item in the Check List.

https://my.nrmca.org/Main/ItemDetail?iProductCode=2PIGE&CATEGORY=ENG

Improving Concrete Quality

Improved concrete quality has far reaching benefits - in improved performance, reduced time and costs, a lower environmental footprint of concrete and an overall improvement in the quality of concrete construction. This book discusses concrete quality measurement as well as the tangible and

intangible benefits due to improved quality. The book suggests steps to measure and reduce variability due to concrete ingredient materials, manufacturing and testing and thereby improve concrete quality. The book gets into basic statistics and how to use test data to improve quality. The book addresses a number of topics that are of great interest including how to identify non-standard testing and initial curing; how do identify abnormal material variation; how to control mixing water variation; improving batching accuracy; how to ensure ingredient material quality; elements of a quality management system; how to do a quality audit; and tests a concrete producer should do.

This book will be of significant value to concrete producers who will come away with readily implementable steps to reduce variability and attain a more consistent product thereby seeing performance benefits and cost savings. This book provides suggestions on how architects and engineers can ensure good quality concrete through their specifications. This book will help testing labs measure and improve testing quality. This book will assist cementitious and admixture suppliers better understand how their material variability affects concrete performance and thus can help reduce it.

https://my.nrmca.org/Main/ItemDetail?iProductCode=2PE005&CATEGORY=ENG

Guide to Improving Specifications for Ready Mixed Concrete

This document proposes specification clauses and includes accompanying commentary as guidance, which emphasizes the fundamental concepts of specifications for ready mixed concrete as addressed in industry standards published by ACI or ASTM International. Provisions are incorporated, relating to requirements concerning concrete ingredients and materials, mixture design, production, and delivery.

Only those sections pertinent to concrete ingredients and mixtures are covered in this document. It does not include sections pertinent to reinforcement, formwork, or any other construction means/methods.

www.nrmca.org/research_engineering/Documents/GuideToSpecs2015.pdf

Thermal Measurements of Hydrating Concrete Mixtures

With recent advances in technological understanding and availability of low cost thermal sensors simple temperature measurements of hydrating concrete, mortar, or paste mixtures (referred to as semi-adiabatic calorimetry or SAC) is becoming a powerful quality control tool. Hydrating concrete materials generate heat, and the profile of the resulting thermal history can provide a useful indication of setting time, early hydration efficiency, and various other aspects of performance. Specific SAC applications include evaluating the setting time influences of changes in admixtures, dosage rates, cementitious component proportions, and mixture temperatures; tracking materials variability in routine SAC testing for QC; comparing candidate materials or sources in typical mixture proportions; verifying seasonal adjustments to mixtures; and troubleshooting abnormal hydration behavior or "incompatibility" tendencies that cause certain concrete field problems. This publication introduces readers to SAC equipment, applications, and basics of how to plan and conduct an effective SAC testing program. Interpretation of SAC thermal profiles are also discussed.

https://my.nrmca.org/Main/ItemDetail?iProductCode=2PE003&CATEGORY=ENG

REFERENCES

The *Concrete in Practice (CIP), Technology in Practice (TIP)* and *Specification in Practice (SIP)* are series of short information pieces on important topics written in an easy understandable "What, Why and How?" format. They are intended to be used for education and knowledge sharing. They are free on the NRMCA.org website and can be purchased in print form. The CIPs are also available in Spanish. Titles are directly linked to the documents.

Concrete in Practice Series (CIPS)

Dusting Concrete Surfaces www.nrmca.org/aboutconcrete/cips/01pr.pdf
Scaling Concrete Surfaces www.nrmca.org/aboutconcrete/cips/02pr.pdf
Crazing Concrete Surfaces www.nrmca.org/aboutconcrete/cips/03pr.pdf
Cracking Concrete Surfaces www.nrmca.org/aboutconcrete/cips/04pr.pdf
Plastic Shrinkage Cracking www.nrmca.org/aboutconcrete/cips/05pr.pdf
Joints in Concrete Slabs on Grade www.nrmca.org/aboutconcrete/cips/06pr.pdf
Cracks in Residential Basement Walls www.nrmca.org/aboutconcrete/cips/07pr.pdf
Discrepancies in Yield www.nrmca.org/aboutconcrete/cips/08pr.pdf
Low Concrete Cylinder Strength www.nrmca.org/aboutconcrete/cips/09pr.pdf
Strength of In-Place Concrete www.nrmca.org/aboutconcrete/cips/10pr.pdf
Curing In-Place Concrete www.nrmca.org/aboutconcrete/cips/11pr.pdf
Hot Weather Concreting www.nrmca.org/aboutconcrete/cips/12pr.pdf
Blisters on Concrete Slabs www.nrmca.org/aboutconcrete/cips/13pr.pdf
Finishing Concrete Flatwork www.nrmca.org/aboutconcrete/cips/14pr.pdf
Chemical Admixtures for Concrete https://www.nrmca.org/aboutconcrete/cips/15pr.pdf
Flexural Strength of Concrete www.nrmca.org/aboutconcrete/cips/16pr.pdf
Flowable Fill www.nrmca.org/aboutconcrete/cips/17pr.pdf
Radon Resistant Buildings www.nrmca.org/aboutconcrete/cips/18p.pdf
Curling of Concrete Slabs www.nrmca.org/aboutconcrete/cips/19pr.pdf
Delamination of Troweled Concrete Surfaces www.nrmca.org/aboutconcrete/cips/20pr.pdf
Loss of Air Content in Pumped Concrete www.nrmca.org/aboutconcrete/cips/21pr.pdf
Grout www.nrmca.org/aboutconcrete/cips/22pr.pdf
Discoloration www.nrmca.org/aboutconcrete/cips/23pr.pdf
Synthetic Fibers for Concrete www.nrmca.org/aboutconcrete/cips/24pr.pdf
Corrosion of Steel in Concrete www.nrmca.org/aboutconcrete/cips/25pr.pdf
Jobsite Addition of Water www.nrmca.org/aboutconcrete/cips/26pr.pdf
Cold Weather Concreting www.nrmca.org/aboutconcrete/cips/27pr.pdf
Concrete Slab Moisture www.nrmca.org/aboutconcrete/cips/28pr.pdf
Vapor Retarders Under Slabs on Grade www.nrmca.org/aboutconcrete/cips/29pr.pdf
Supplementary Cementitious Materials www.nrmca.org/aboutconcrete/cips/30pr.pdf
Ordering Ready Mixed Concrete www.nrmca.org/aboutconcrete/cips/31pr.pdf
Concrete Pre-Construction Conference www.nrmca.org/aboutconcrete/cips/32pr.pdf

Concrete in Practice Series (CIPS) (continued)

High Strength Concrete www.nrmca.org/aboutconcrete/cips/33pr.pdf

Making Concrete Cylinders in the Field www.nrmca.org/aboutconcrete/cips/34pr.pdf

Testing Compressive Strength of Concrete www.nrmca.org/aboutconcrete/cips/35pr.pdf

Structural Lightweight Concrete www.nrmca.org/aboutconcrete/cips/36pr.pdf

Self-Consolidating Concrete (SCC) www.nrmca.org/aboutconcrete/cips/37pr.pdf

Maturity Methods to Estimate Concrete Strength www.nrmca.org/aboutconcrete/cips/39pr.pdf

Aggregate Popouts www.nrmca.org/aboutconcrete/cips/40pr.pdf

Acceptance Testing of Concrete www.nrmca.org/aboutconcrete/cips/41pr.pdf

Thermal Cracking of Concrete www.nrmca.org/aboutconcrete/cips/42p.pdf

Alkali Aggregate Reactions (AAR) www.nrmca.org/aboutconcrete/cips/43pr.pdf

Durability Requirements for Concrete www.nrmca.org/aboutconcrete/cips/44pr.pdf

Technology in Practice Series (TIPS)

Quantifying Concrete Quality www.nrmca.org/aboutconcrete/downloads/Tip1w.pdf

Aggregate Sampling for Laboratory Tests www.nrmca.org/aboutconcrete/downloads/Tip3w.pdf

Aggregate Sample Reduction for Laboratory Tests
www.nrmca.org/aboutconcrete/downloads/Tip4w.pdf

Capping Cylindrical Concrete Specimens with Sulfur Mortars and Unbonded Caps
www.nrmca.org/aboutconcrete/downloads/Tip5w.pdf

Aggregate Moisture and Making Adjustments to Concrete Mixtures
www.nrmca.org/aboutconcrete/downloads/Tip6w.pdf

Creating and Using Three Point Curves for Laboratory Trial Batches
www.nrmca.org/aboutconcrete/downloads/Tip7w.pdf

Concrete Yield www.nrmca.org/aboutconcrete/downloads/Tip8w.pdf

Density of Structural Lightweight Concrete www.nrmca.org/aboutconcrete/downloads/Tip9w.pdf

Mixing Water Quality for Concrete www.nrmca.org/aboutconcrete/downloads/Tip10w.pdf

Testing Concrete Cores www.nrmca.org/aboutconcrete/downloads/TIP11w.pdf

Slump Loss of Concrete www.nrmca.org/aboutconcrete/downloads/TIP12w.pdf

Chloride Limits in Concrete www.nrmca.org/aboutconcrete/downloads/Tip13w.pdf

Time of Setting of Concrete Mixtures www.nrmca.org/aboutconcrete/downloads/Tip14w.pdf

Estimating Concrete Strength Using Maturity
www.nrmca.org/aboutconcrete/downloads/Tip15w.pdf

Evaluating Strength Test Results www.nrmca.org/aboutconcrete/downloads/TIP16w.pdf

Drying Shrinkage of Concrete www.nrmca.org/aboutconcrete/downloads/TIP17w.pdf

Managing Concrete Temperature for Specified Requirements
www.nrmca.org/aboutconcrete/downloads/TIP18w.pdf

Reuse of Returned Concrete www.nrmca.org/aboutconcrete/downloads/TIP19w.pdf

Understanding Variability of Test Methods—Precision Statements
www.nrmca.org/aboutconcrete/downloads/TIP20w.pdf

Specification in Practice (SIP)

Limits on Quantity of Supplementary Cementitious Materials
www.nrmca.org/aboutconcrete/downloads/SIP1.pdf

Limits on Water-Cementitious Materials Ratio (w/cm)
www.nrmca.org/aboutconcrete/downloads/SIP2.pdf

Minimum Cementitious Materials Content www.nrmca.org/aboutconcrete/downloads/SIP3.pdf

Restrictions on Type and Characteristics of Fly Ash
www.nrmca.org/aboutconcrete/downloads/SIP4.pdf

Restrictions on Aggregate Grading www.nrmca.org/aboutconcrete/downloads/SIP5.pdf

TRAINING

Online Safety Series

This course for the ready mixed concrete industry teaches its participants about OSHA SAFETY compliance. It begins with why safety is so important and details the reasons why an effective safety program actually saves money through loss prevention and control. Participants learn about electrical safety, machine guarding, fall protection, hazard communication, confined spaces, personal protective equipment, fire fighting and evacuation, chute handling, fleet safety, pre-trip inspection, and more.

www.nrmca.org/store/SafetySeries.asp

Requirements and Standards for Concrete Strength

This seminar covers the fundamental statistics and associated provisions for submittals, acceptance, and referee testing of concrete strength. It covers factors that influence measured concrete strength and the standards that govern strength testing.

my.nrmca.org/scriptcontent/BeWeb/Orders/ProductDetail.cfm?pc=PPV_RSCS

CERTIFICATIONS

NRMCA Plant Certifications

Plant and Truck Certification www.nrmca.org/Research_Engineering/Plant_Certification/Main.htm

Quality Certification Program
www.nrmca.org/research_engineering/quality_certification/default.htm

Green-Star Certification Program
www.nrmca.org/operations/ENVIRONMENT/certifications_greenstar.htm

Sustainable Concrete Plant Certification
www.nrmca.org/sustainability/Certification/PlantCertification.asp

NRMCA Personnel Certifications

Concrete Exterior Flatwork Finisher Program
www.nrmca.org/Education/Certifications/Concrete_Exterior_Flatwork.htm

Certified Sustainability Professional www.nrmca.org/education/Certifications/Sustainability.htm

Concrete Delivery Professional Certification
www.nrmca.org/Education/Online_Learning/OnDemand/CDP_overview.htm

Concrete Field Testing Technician Grade II
www.nrmca.org/Education/Certifications/Concrete_Field_Tech.htm

Concrete Sustainability Professional Certification
www.nrmca.org/Education/Certifications/Sustainability.htm

Concrete Technologist Level 2
www.nrmca.org/Education/Certifications/TechnicalShortCourse.htm#Level2

Concrete Technologist Level 3
www.nrmca.org/Education/Certifications/TechnicalShortCourse.htm#Level3

Concrete Technologist Level 4 www.nrmca.org/Education/Certifications/DurabilityCourse.htm

Effective RMC Supervisor Certification
www.nrmca.org/Education/Certifications/RMC_Supervisor.htm

Environmental Professional Certification for the Ready Mixed Concrete Industry
www.nrmca.org/Education/Certifications/Environmental_Cert.htm

Fleet Manager Certification www.nrmca.org/Education/Certifications/FleetManager.htm

NRMCA Safety Certification

OSHA 10-Hour Safety Certification for General Industry
www.nrmca.org/Education/Certifications/SafetyCourse_OSHA.htm

NRMCA Plant Manager Certification

www.nrmca.org/operations/OPERATIONS/Courses_plant-manager.htm

NRMCA Product Certifications

NRMCA Certified Environmental Product Declaration Program
www.nrmca.org/sustainability/EPDProgram/Index.asp

Portland Cement Association (PCA)

ORGANIZATION DESCRIPTION

The **Portland Cement Association (PCA)**, founded in 1916, is the premier policy, research, education, and market intelligence organization serving America's cement manufacturers. PCA members represent 91 percent of U.S. cement production capacity with facilities in all 50 states. PCA promotes safety, sustainability, and innovation in all aspects of construction, fosters continuous improvement in cement manufacturing and distribution, and generally promotes economic growth and sound infrastructure investment.

Website: www.cement.org

MANUALS OF PRACTICE & SPECIFICATIONS

Design & Control of Concrete Mixtures – the guide to applications methods and materials, 16th Edition – EB001 (2016)

For over 100 years, PCA has provided technical guidance to the concrete practitioner on how to design and control concrete mixtures. Many advances have been made in concrete technology over the decades ranging from new materials and testing methods, to improved concrete properties and construction practices. Concrete construction today follows a mantra of quicker, stronger, more durable, more resilient, and more sustainable. This edition reflects the latest comprehensive information on standards, specifications, and test methods of ASTM International (ASTM), the American Association of State Highway and Transportation Officials (AASHTO), and the American Concrete Institute (ACI) in order to meet the growing needs of owners, architects, engineers, builders, concrete producers, concrete technologists, instructors, and students.

www.cement.org/learn/concrete-technology/concrete-design-production/design-and-control-mixtures-landing-page *Purchase required*

LRFD Design of Cast-in-Place Concrete Bridges (2006)

Understand the design of cast-in-place bridge superstructures according to the AASHTO LRFD Bridge Design Specifications. This book presents step-by-step analysis and design procedures with minimal use of computer software. Five detailed design examples include: (1) Simple span flat slab bridge, (2) Simple span T-beam bridge, (3) Three span flat slab bridge, (4) Three span T-beam bridge, and (5) Deck overhang.

http://members.cement.org/EBiz55/ProductCatalog/Product.aspx?ID=305 *Purchase required*

Guide Specification for High Performance Concrete for Bridges (2005)

This guide specification is intended to serve as a guide for developing specifications for all high performance concretes supplied for highway bridges, whether produced by a ready mix supplier, a general contractor, or in a permanent plant of a precast concrete manufacturer. For the purposes of this specification, high performance concrete (HPC) is considered as concrete engineered to meet specific needs of a project; including mechanical, durability, or constructability properties. The document provides mandatory language that the specifier can cut and paste into project

specifications. It also includes guidance on what characteristics should be specified in a given case, and what performance limit is needed to ensure satisfactory performance for a given element or environment.

https://www.cement.org/docs/default-source/fc_concrete_technology/durability/eb233-guide-specification-for-high-performance-concrete-for-bridges.pdf

Mass Concrete for Buildings and Bridges (2007)

Mass concrete has been historically associated with large structures such as dams and other large volume placements. However, due to the increasingly common use of fast-track construction practices and high-performance concretes with high cementitious material contents, mass concrete issues are being encountered in typical bridge and building placements. This document provides practical guidance on understanding mass concrete, how to manage concrete temperatures, and prevent or minimize temperature-related cracking. Understanding the implications of using mass concrete (high internal temperatures and temperature-related cracking) is the key to producing a structure that provides many years of service.

http://members.cement.org/EBiz55/ProductCatalog/Product.aspx?ID=318 *Purchase required*

REFERENCES

This section will contain a list of important concrete bridge related items.

TRAINING

This section will contain a list of important concrete bridge related items.

CERTIFICATIONS

This section will contain a list of important concrete bridge related items.

Precast/Prestressed Concrete Institute (PCI)

ORGANIZATION DESCRIPTION

The **Precast/Prestressed Concrete Institute (PCI)**, founded in 1954, is the technical institute and trade association for the precast/prestressed concrete structures industry. As a technical institute, PCI develops, maintains, and disseminates the Body of Knowledge for the design, fabrication, and erection of precast concrete structures and systems by:

- conducting research and development projects in concert with universities and research laboratories nationwide;
- publishing a broad array of technical resources, including design manuals, state-of-the-art reports, periodicals, and more;
- certifying companies and individuals involved in the manufacture and erection of precast/prestressed concrete products;
- educating precast personnel and industry stakeholders on the proper specification, design, fabrication, erection, and use of precast/prestressed concrete;
- representing the industry in code advocacy activities.

PCI also serves as the industry trade association, advancing members' interests by:

- promoting the use of structural and architectural precast concrete for a variety of applications in partnership with 11 regional affiliates across the United States;
- publishing safety manuals and materials;
- providing education and training materials;
- representing the industry through regulatory and legislative advocacy;
- offering meetings and networking opportunities, awards programs, and much more.

PCI members include precast concrete manufacturers, companies that provide products and services to the industry, precast concrete erectors, and individual members, such as architects, consultants, contractors, developers, educators, engineers, and students.

Website: www.pci.org
All PCI publications are available for free download at the links provided unless indicated otherwise.

MANUALS OF PRACTICE & SPECIFICATIONS

PCI Bridge Design Manual, 3rd Edition, Second Release – MNL-133-11 (2014)

This up-to-date reference complies with the fifth edition of the AASHTO LRFD Bridge Design Specifications through the 2011 interim revisions and is a must-have for everyone who contributes to the transportation industry. This edition includes a new chapter on sustainability and a completely rewritten chapter on bearings that explains the new method B simplified approach. Eleven up-to-date LRFD design examples illustrate new alternative code provisions, including prestress losses, shear design, and transformed sections.

www.pci.org/MNL-133-11

Manual for the Evaluation & Repair of Precast, Prestressed Concrete Bridge Products, 1st Edition – MNL-137-06 (2006)

This manual on repair of damage to or non-conformances in bridge products contains diagrams of the various types of cracks, chips, voids, missing bars, etc. that occur from time to time in manufacture. It has become widely used by state highway agencies and precasters alike. Each type of occurrence is evaluated for cause, prevention, engineering effect, and repair consideration. Chapters include information on "standard" repair procedures that define methods to repair damage and defects and methods of patching and epoxy injection.

www.pci.org/ItemDetail?iProductCode=EPUB-MNL-137-06&Category=EPUB&WebsiteKey=5a7b2064-98c2-4c8e-9b4b-18c80973da1e *Purchase required*

Recommended Practice of Lateral Stability of Precast, Prestressed Concrete Bridge Girders – CB-02-16 (2016)

This document presents a new comprehensive methodology to analyze the lateral stability of long slender bridge girders. Technology has enabled the manufacture of increasingly long girders. Slender girders present a lateral stability concern. Each stage of a girder's transition from the casting bed to its final location in the bridge is considered. These conditions include when handling from the top with embedded or attached devices and supported from below during storage, transit, or in various conditions on the bridge during construction. These recommendations are the result on ground-breaking research conducted by Robert Mast in the 1990s. In 2007, the PCI Committee on Bridges clearly saw the need to address girder stability. They selected a specialized team to develop these recommendations. The producer members of the team have contributed substantial practical field experience. Together with a large number of designer practitioners, the team has developed an industry consensus recommended practice that provides methods to calculate the factors of safety during each of several stages of a girder's life. This is a must-have publication for all stakeholders in bridge design, fabrication, and construction.

www.pci.org/cb-02-16

Manual for Quality Control for Plants and Production of Structural Precast Concrete Products, 4th Edition – MNL-116-99 (1999)

These standards and the accompanying commentary are printed side-by-side to provide convenient explanation, discussion, and amplification of the standards. Published in loose-leaf binder with tabs.

Bridge components consist of precast concrete or precast, prestressed concrete products and are usually produced with gray cement and local aggregates. Those in Group BA have form, machine, or special finishes. Note: Some precast bridge products are not automatically covered in routine plant audits. These include highway median barriers, box culverts, and three-sided arches. These products are audited at the request of the precaster or if PCI Certification is required by the project specifications.

B1 – Precast Bridge Products (No Prestressed Reinforcement) – Mild-streel-reinforced precast concrete elements, including some types of bridge beams or slabs, as well as products such as piling, sheet piling, pile caps, retaining wall elements, and sound barriers.

B2 – Prestressed Miscellaneous Bridge Products (Non-superstructure) – Any precast, prestressed elements except for superstructure beams. This includes piling, sheet piling, retaining-wall elements, stay-in-place bridge deck panels, full-depth deck panels, and all products covered in B1.

B3 – Prestressed Straight-Strand Bridge Beams (Superstructure) – All precast, prestressed superstructure elements using straight, pretensioning, or post-tensioning strands such as box beams, I-girders, bulb-tee beams, stemmed members, solid slabs, segmental box beams, and all products covered in B1 and B2.

B4 – Prestressed Deflected-Strand Bridge Beams (Superstructure) – Precast concrete bridge members that are reinforced with deflected pretensioning or post-tensioning strand. Included are box beams, I-girders, bulb-tee beams, stemmed members, sold slabs, and all products in B1, B2, and B3.

BA – Bridge Products with an Architectural Finish – These products are the same as those in Group B, but they are produced with an architectural finish. They will have a form, machine, or special finish. Certification for Group BA production supersedes Group B in the same category.

www.pci.org/ItemDetail?iProductCode=MNL-116-99&Category=QA&WebsiteKey=5a7b2064-98c2-4c8e-9b4b-18c80973da1e *Purchase required.*

REFERENCES

Curved Precast Concrete Bridges – State-of-the-Art Report – CB-01-12 (2012)

This report details the application of curved precast concrete bridge design, fabrication, construction techniques, and considerations through the study of twelve related projects and constitutes a state-of-the-art report on this topic. The document was written and intended to provide bridge owners, designers, fabricators, and engineers an up-to-date reference in developing precast concrete bridge solutions for curved geometric situations.

www.pci.org/CB-01-12

State-of-the-Art Report on Full-Depth Precast Concrete Bridge Deck Panels (2011)

This document is a report and guide for selecting, designing, and constructing precast concrete full-depth deck panels for bridge construction. This report is relevant for new bridge construction or bridge-deck replacement.

www.pci.org/SOA-01-1911

The PCI State-of-the-Art Report on Seismic Design of Precast Concrete Bridges – SD-01-13 (2013)

Seismic design of precast concrete bridges begins with a global analysis of the response of the structure to earthquake loadings and a detailed evaluation of connections between precast elements of the superstructure and substructure. Because modeling techniques have not yet been implemented for jointed details, the focus of this report is on procedures for the evaluation of system response and the detailing of connections for emulative behavior.

www.pci.org/SD-01-13

The State-of-the-Art of Precast/Prestressed Integral Bridges – IB-01-02 (2001)

This publication is filled with details and design information on bridges made integral with their piers and abutments. The appendix contains five case studies representing major and minor projects.

www.pci.org/ItemDetail?iProductCode=IB-01&Category=FREE&WebsiteKey=5a7b2064-98c2-4c8e-9b4b-18c80973da1e

State-of-the-Art of Spliced I-Girder Bridges - SG-92-01 (1992)

This publication contains descriptions of structural systems, types of girder splices, construction methods and techniques, analysis and design, and design examples with cost analysis. Includes a report on a survey that documents over 40 bridges built with spliced members. The survey includes design, production and construction details, plus names and addresses of contacts for each project.

www.pci.org/ItemDetail?iProductCode=SG-92-1&Category=FREE&WebsiteKey=5a7b2064-98c2-4c8e-9b4b-18c80973da1e

The State of the Practice of Precast Prestressed Adjacent Box Beam Bridges, 1st Ed. – SOP-02-2011 (2011)

This report presents the state of the practice on adjacent precast pretensioned box beam bridges. A discussion on current practice, historical issues, lessons learned, and improved performance of box girder bridges is provided. Much of the information presented is based on responses to a survey of states and Canadian provinces and a review of current practices and publications.

www.pci.org/ItemDetail?iProductCode=SOP-02-2011&Category=FREE&WebsiteKey=5a7b2064-98c2-4c8e-9b4b-18c80973da1e

Precast Prestressed Concrete Piles - Chapter 20, Bridge Design Manual, 1st Edition – BM-20 (2004)

This publication was first printed in the *PCI Bridge Design Manual*, MNL-133, as Chapter 20, Precast Prestressed Concrete Piles. It is reprinted in this form as a convenience for designers and others with an interest in precast, prestressed concrete piles.

https://www.pci.org/ItemDetail?iProductCode=BM-20H&Category=TRANSPORT&WebsiteKey=5a7b2064-98c2-4c8e-9b4b-18c80973da1e

Calculation of Interaction Diagrams for Precast, Prestressed Concrete Piles, 2nd Edition – PD-01-15

This publication provides context and instructions for the use of the 2015 revised version of the Microsoft Excel workbook to compute pile stresses, plot interaction diagrams, and compute lifting points of precast concrete piles. Examples are also solved using Mathcad to validate the workbook solution; a table of results compares the two methods. The manual provides link to a password protected portal for download of spreadsheet.

www.pci.org/pd-01-15

PCI Design Handbook, 8th Edition – MNL-120-17 (2017)

The standard for the design manufacture and use of structural precast, prestressed concrete and architectural precast concrete. The eighth edition design guide for precast and prestressed concrete provides easy to follow design procedures; numerical examples; and both new and updated design aids. It provides the designer with comprehensive and efficient procedures for the safe design of both

architectural and structural precast and prestressed concrete products. [Not bridge related, but still useful for some background information and details]

www.pci.org/ItemDetail?iProductCode=EPUB-MNL-120-17&Category=EPUB&WebsiteKey=5a7b2064-98c2-4c8e-9b4b-18c80973da1e *Purchase required*

The PCI State-of-the-Art Report on Precast Concrete Pavements – PP-05-12

This report is the combination of four documents on the sue of precast concrete payment systems (PCPS) and constitutes a state-of-the-art report. The documents were developed through a cooperative agreement between PCI and the Federal Highway Administration and cover the following: Applications for Precast Concrete Pavements, Design and Maintenance, Manufacture of Precast Concrete Pavement Panels, and Construction of Precast Concrete Pavements.

www.pci.org/PP-05-12

Quality Control Technician/Inspector Level I & II Training Manual – TM-101-87 (bookstore TM-101-16)

Intended as a self-study guide to prepare QC personnel for the PCI Technician/Inspector examinations, this manual can also be used to introduce new QC employees and others to prestressed concrete and common plant procedures. Contains many illustrations and diagrams to amplify the next. Sample questions are featured at the end of each chapter. Softcover. 230 pp.

www.pci.org/ItemDetail?iProductCode=TM-101-16&Category=QA&WebsiteKey=5a7b2064-98c2-4c8e-9b4b-18c80973da1e *Purchase required*.

Quality Control Technician/Inspector Level III Training Manual – TM-103-96

A logical continuation of many of the topics presented in the Levels I and II Training Manual (TM-101). The text is easy to understand and includes study questions after each chapter. A textbook for the Technician/Inspector Level III school and examination, this book is also valuable for training new personnel and as a trouble-shooting guide. The manual is post-bound to permit insertion into a loose-leaf book, which facilitates the addition of notes, practice problems, etc. Softcover. 210 pp.

www.pci.org/ItemDetail?iProductCode=TM-103-96&Category=QA&WebsiteKey=5a7b2064-98c2-4c8e-9b4b-18c80973da1e *Purchase required*.

Safety and Loss Prevention Manual (SLP-100-01)

Guidelines for establishing and administering a plant safety program. Rules and recommendations governing safety and loss prevention are presented in the same format as the Federal OSHA standards. Section IV of the manual contains safety information specific to the manufacture of precast and prestressed concrete products. Loose-leaf. 310 pp.

www.pci.org/ItemDetail?iProductCode=SLP-100&Category=QA&WebsiteKey=5a7b2064-98c2-4c8e-9b4b-18c80973da1e *Purchase required*.

TRAINING

PCI eLearning Web-Based Training (WBT) Courses

The PCI eLearning Center is offering a new set of courses that will help experienced bridge designers become more proficient with advanced design methods for precast, prestressed concrete flexural members. There is no cost to enroll in and complete any of these new bridge courses.

The courses are based on the content of AASHTO LRFD and PCI publications. These include several State-of-the-Art and Recommended Practice publications, as well as the *PCI Bridge Design Manual*. These are available for free to course participants after registering with a valid email. While the courses are designed for an engineer with five or more years of experience, a less experienced engineer will find the content very helpful for understanding concepts and methodologies.

Where applicable, the material is presented as part of a "real world" example of a complete superstructure design so that students can see how actual calculations are completed according to the AASHTO LRFD specifications.

Website: http://elearning.pci.org/

Precast, Prestressed Concrete Bridge Girder Series *(12 courses)*

T110 Preliminary Design

T115 Materials and Manufacturing

T120 Loads and Load Distribution

T125 Flexural Analysis & Design: Service Limit State

T130 Flexural Analysis & Design: Strength Limit State

T135 Refined Losses for Members w/o or Prior to Decking

T145 Shear (MCFT)

T160 End Zone Design

T310 Extending Spans

T710 Load Rating (Overview & Methods)

T450 Bearing Pads - Theory and Method A

T455 Bearing Pads - Method B

Full-Depth Precast Concrete Deck Panels Series *(4 courses)*

T210 Introduction on Full-Depth Panel Precast Concrete Deck System and its Advantages

T215 Design and Detailing of Full-Depth Precast Concrete Deck Panels

T220 Production and Construction Details of Full-Depth Precast Concrete Deck Panels

T225 Case Studies and Emerging Developments of Full-Depth Precast Concrete Deck Panels

Lateral Stability of Precast, Prestressed Concrete Bridge Girders Series *(4 courses)*

T520 Introductory Material and Hanging Girders

T523 Stability of Transported Girders

T525 Seated Girders and Stability Issues from Bed to Bridge

T527 Calculations and Sensitivity Analysis

PCI Instructor-Led Training (ILT) Courses

The following courses were developed as instructor-led training courses. These presentations were recorded are available for download upon request. These will be added to the eLearning Center in the first quarter of 2020. There is no cost to enroll in and complete any of these new bridge courses.

Bridge Geometry Guidance Document and Training *(4 courses)*

A draft manual, presentation and recordings are available for each course.

T501 Roadway Geometry Basics

T505 Working with Horizontal Alignments

T510 Geometry of Straight Bridges

T515 Curved Bridge Geometry

Curved U Girder Guidance Document and Training *(4 courses)*

A draft manual, presentation and recordings are available for each course.

T350 Introduction, Implementation and Delivery

T353 Modeling, Analysis and Design Considerations

T356 Design Details

T358 Design Example

CERTIFICATIONS

PCI Plant Quality Personnel Certification

Conducting an effective quality-control program requires knowledgeable and motivated testing and inspection personnel. These employees must understand the key ingredients that produce overall quality, the specifics of how each product is manufactured, and how to conduct precise tests and inspections. PCI has been training quality-control personnel since 1974 and published its first technician training manual in 1985. Three distinct levels of Plant Quality Personnel Certification can each be achieved by passing a written PCI examination.

PCI Level I – This basic level requires six months of precast concrete industry experience (or other educational, technical, or professional criteria. Level I certification focuses on the fundamental requirements of the many quality-control issues typically encountered in a precast plant. Requirements also include current certification by the American Concrete Institute in the Concrete Field Testing Technician Program, Grade 1.

PCI Level II – Level II certification provides greater detail in maintaining and improving quality levels, such as tensioning and strand-elongation corrections, effects of accelerated curing, material-control

tests, welding basics, and a variety of plant topics. Requirements include PCI Level I and one year of precast concrete industry experience (or other educational, technical, or professional criteria).

PCI Level III – The highest level of certification provides significant instruction in concrete materials and technology. Certification requires two years of precast concrete industry experience, attendance at a four-day PCI school, and PCI Level II certification.

PCI Field Quality Personnel Certification

Certified Field Auditor (CFA) – This program, instituted in 1999, provides certification for personnel trained to conduct field audits of industry erection procedures and evaluate compliance with PCI standards. CFA certification requires a minimum of two years of precast concrete erection experience and a commitment to upholding professional standards appropriate to the program. Certification helps ensure that the high quality achieved in the plant is maintained throughout installation.

Certified Company Auditor (CCA) – PCI Certified company auditors perform the company audits that lead to PCI-Certified Erector status. CCA certification requires two years of academic experience in the supervision of the erection of precast concrete and current CFA certification.

PCI Plant Certification

See discussion under **MNL-116-99 (1999)** listed under section on **MANUALS OF PRACTICE & SPECIFICATIONS.**

Post-Tensioning Institute (PTI)

ORGANIZATION DESCRIPTION

The **Post-Tensioning Institute (PTI),** established in 1976, is a nonprofit organization for the advancement of post-tensioned prestressed concrete design and construction. PTI represents a community of businesses and professionals dedicated to expanding quality post-tensioning applications.

PTI promotes and advances the post-tensioning industry through education and technical leadership.

PTI activities include:

- Production of publications for all post-tensioning applications including bridges, specifications, training manuals, etc. PTI technical committees operate under the ANSI consensus process, encouraging all stakeholders to participate in this open process.
- Training and certification of personnel involved in the field. PTI certification committees operate under the ANSI consensus process and monitor and update the numerous training programs.
- PTI *Journal* publication twice a year with contributions on bridge related subjects and other post-tensioning applications.
- Plant Certification Program for ANSI accredited certification of plants producing single strand unbonded tendons.
- Educational programs including design and construction seminars for different post-tensioning applications.
- Research projects as needed to advance post-tensioning applications.

PTI Website: www.post-tensioning.org

MANUALS OF PRACTICE & SPECIFICATIONS

Publications listed below are available for purchase at the PTI Publications webpage: www.post-tensioning.org/publications/store.aspx

Post-Tensioning Manual, 6th Edition – PTI TAB.1-06 (2006)

The sixth edition has been extensively rewritten and expanded from the fifth edition, which was published in 1990. The manual contains 12 new chapters that give design guidance on modern applications of post-tensioning. New topics include seismic design, post-tensioned concrete floors, parking structures, slabs-on-ground, bridges, stay cables, storage structures, barrier cables, dynamic and fatigue, durability, inspection and maintenance, and field and plant certification. This book is an invaluable resource for practicing engineers, architects, students, educators, contractors, inspectors, and building officials, providing basic information and essential principles of post-tensioning.

A new edition of this Manual is expected in 2020.

Specification for Multistrand and Grouted Post-Tensioning – PTI/ASBI M50.3-19 (2019)

This is a second edition of a comprehensive Specification providing minimum requirements for the post-tensioning system component testing and acceptance, design, and installation of multistrand and grouted post-tensioning systems. Based on proven knowledge and developed with the ANSI

consensus process, it addresses the selection of tendon protection levels, system components, materials, installation, and stressing of post-tensioning tendons. It provides requirements and guidance for furnishing complete post-tensioning systems and all required accessories, including but not limited to anchorages, local zone reinforcement, ducts, pipes, strands, and bars from a single supplier, as required. Provisions further address submittal samples, drawings, calculations, procedures, reports, manuals, and certifications. Both temporary and permanent post-tensioning is covered in this Specification.

This Specification should be used in its entirety to avoid unnecessary differences in requirements and provisions out of context. It is primarily intended for use in bridges but is also applicable to a wide variety of structure types, including buildings. The companion document PTI M55.1, Specification for Grouting of Post-Tensioned Structures, should be used in conjunction with this document.

One of the major features of this edition is the addition of a Commentary that provides guidance for most mandatory provisions of the Specification. Grouting related items that are installed with the ducts are now included. The PT duct provisions are expanded to allow for use of either fib Bulletin 7 or 75, depending on project needs. Pour-back details are provided in the Appendix. Many other provisions received smaller revisions.

Specification for Grouting of PT Structures – PTI M55.1-19 (2019)

This is a fourth edition of a comprehensive Specification providing minimum requirements for the selection, design, testing, and installation of cementitious grouts. Based on proven knowledge and developed with the ANSI consensus process, it addresses grout materials, QA/QC testing, and detailed grouting procedures. It provides requirements and guidance for the different Classes of post-tensioning grout materials related to the tendon protection levels and the qualification testing for PT grout materials. It also covers mixing and pumping procedures, production testing, and post grouting inspection.

This Specification should be used in its entirety to avoid unnecessary differences in requirements and provisions out of context. It is primarily intended for use in bridges but is also applicable to a wide variety of structure types, including buildings. The companion document PTI/ASBI M50.3, *Specification for Multistrand and Grouted Post-Tensioning*, should be used in conjunction with this document.

This edition of the Specification includes many far-reaching modifications that directly address grouting issues encountered in the past; some of them are:

- Wet density testing at last outlet of each tendon to ensure grout quality and documentation
- Robustness test; grout testing with 110% of maximum recommended water
- Field testing for acid-soluble chloride ion (Cl-) based on either cement weight or weight of mixed grout
- Grout material bag weight and sulfate ion level certification
- New addition of shelf life requirements
- Explicit prohibition of tendon flushing

Recommendations for Stay Cable Design, Testing, and Installation – PTI DC45.1-18 (2018)

These Recommendations pertain to the design, testing, and installation of stay cables for cable stayed bridges using prestressing wires, strand, or bar as the main tension element. Recommendations are presented only for stay cables used in redundant cable-stayed bridges.

These Recommendations are intended to be used in conjunction with the appropriate provisions of the *AASHTO LRFD Bridge Design Specifications* from the American Association of State Highway and Transportation Officials (AASHTO).

This seventh edition supersedes all previous editions. Standards and specifications shall refer to the latest edition unless a specific date is given.

Updated items include saddle testing provisions, fire resistance qualification testing and vibration control system requirements.

REFERENCES

Anchorage Zone Design – PTI M50.2-00 (2000)

This manual provides guidance on the comprehensive treatment of tendon anchorage zone requirements and analysis methods. There is a special emphasis on practical applications of a strut-and-tie design approach, which is recommended by AASHTO and ACI. Step-by-step design analyses for a number of typical anchorage zone conditions are included in this manual.

Acceptance Standards for PT Systems – PTI M50.1-98 (1998)

This publication provides specific technical requirements for the approval and acceptance of post-tensioning systems. Standards and performance requirements for prestressing materials, bearing plates, wedge plates, connections, and sheathing are discussed in detail. Qualification tests and acceptance criteria are presented for each of the individual components as well as for the complete system. A system approval summary outlines the test requirements and number of successful tests necessary for approval of a post-tensioning system.

PTI Journal

A journal published twice a year with peer-reviewed papers, other technical papers, job reports, case studies, project award papers, convention technical session papers, viewpoints, FAQs, and industry news.

Contributions include bridge related research and case studies, and papers on other post-tensioning applications such as buildings, containment structures, rock & soil anchors, ground-supported structures, etc.

Additional information is on the PTI Journal webpage at: www.post-tensioning.org/publications/ptijournal.aspx

TRAINING

PTI training opportunities are offered by either a Scheduled Training Workshop or by a Special Request Training Workshop. Every year, PTI publishes a schedule of workshops of different types and at different locations to choose from. PTI also offers workshops per special request, with training at the client's location and desired dates. The added benefit for a special request workshop for a specific bridge construction project is the opportunity of all involved to go through the same training, making communication easier.

General information on PTI Certification Programs is on the PTI Field Personnel Certification Program Overview website at: www.post-tensioning.org/certification/fieldpersonnelcertification/personnelcertificationoverview.aspx

Scheduled Workshops and online registration are on the PTI website at: www.post-tensioning.org/certification/fieldpersonnelcertification/scheduledworkshopsregistration.aspx

Special Request Workshop information and application are on the PTI website at: www.post-tensioning.org/certification/fieldpersonnelcertification/specialrequestworkshops.aspx

PTI Level 1&2 Multistrand & Grouted PT Specialist Training Workshop

This comprehensive 3-day workshop covers the basics about how post-tensioning works, the types of post-tensioning, and the components of the different systems. It covers the materials used, testing, installation and stressing procedures of multistrand and bar PT systems, including safety. Special focus is also on the grout materials, testing, and grouting techniques. The equipment used for the various steps is also addressed. This workshop includes a half day of field demonstration that includes:

- Grout sample mixing and testing using two different grout classes to illustrate the different behavior.
- Review of displayed post-tensioning equipment used for installation, stressing, and grouting.
- Review of displayed sample components of multistrand and bar PT systems.

Additional information is on the PTI website at: www.post-tensioning.org/certification/fieldpersonnelcertification/multistrandgroutedworkshops/level12multistrandgroutedptspecialist.aspx

PTI Level 1&2 Multistrand & Grouted PT Inspector Training Workshop

This workshop is a 1-day workshop designed specifically for multistrand and grouted PT Inspectors. This workshop builds on the knowledge of attendees gained from the 3-day Specialist workshop that is a prerequisite for attendance. This class enhances the knowledge and capabilities of individuals involved in the bridge inspection by addressing all aspects of materials and testing, installation, stressing, grouting, post-grouting inspection, finishing, and record keeping from the point of view of the inspector. Critical items check points & stop points, and checklists of inspection items are discussed.

Workshop attendance prerequisites:

- Current certification Level 1 Multistrand & Grouted PT Installation, OR
- Current certification Level 2 Multistrand & Grouted PT Specialist, OR
- Level 1 & 2 Multistrand & Grouted PT Specialist workshop attendance immediately before this workshop

Additional information is on the PTI website at: www.post-tensioning.org/certification/fieldpersonnelcertification/multistrandgroutedworkshops/multistrandgroutedptinspector.aspx.aspx

CERTIFICATION

PTI certification has two levels; Level 1 and 2 include the same classroom and field demonstration training, but the Level 2 requires extensive field work experience. Individuals with the Level 2 training

have a rounded and detailed knowledge of all aspects of multistrand and grouted post-tensioning, backed up by the first-hand knowledge gained from the work performed on actual projects.

Field personnel certification program webpage: www.post-tensioning.org/certification/fieldpersonnelcertification/personnelcertificationoverview.aspx

PTI Level 1 Multistrand & Grouted PT Installation Certification

Individuals with the Level 1 certification possess wide knowledge of all aspects of the multistrand and grouted post-tensioning including detailed comprehension of the installation, stressing, and grouting procedures. They have passed a written 60-question closed-book exam. The certification is valid for four years and can be renewed by taking an online renewal exam and viewing a webinar with the latest specification changes.

The certification requirements are:

- Full workshop attendance
- Exam score: min 70%
- Field work experience: None

PTI Level 2 Multistrand & Grouted PT Specialist Certification

Individuals with the Level 2 certification have not only the comprehensive knowledge of all aspects of the multistrand and grouted post-tensioning, but they have also demonstrated an extensive field work experience. A Field Work Experience Affidavit must be submitted with signatures of two independent people in responsible charge who attest to the candidate's experience. The certification is valid for four years and can be renewed by taking an online renewal exam, viewing a webinar with the latest specification changes, and submitting continuing field work experience.

The certification requirements are:

- Full workshop attendance
- Exam score: min 80%
- Field work experience: Total of 1,500 hours, of which minimum 250 hours in installation, minimum 250 hours in stressing, and minimum 250 hours in grouting

PTI Level 1 Multistrand & Grouted PT Inspector Certification

Individuals with the Level 1 certification have successfully passed both, the comprehensive 3-day installation, stressing, and grouting training and the specialized 1-day inspector training. They have detailed knowledge of all aspects of post-tensioning installation, stressing, grouting, and inspection of the PT systems and understand the important aspects of each step.

The certification requirements are:

- Current certification Level 1 Multistrand & Grouted PT Installation, OR
- Current certification Level 2 Multistrand & Grouted PT Specialist
- Full workshop attendance
- Exam score: min 70%
- Field work experience: None

PTI Level 2 Multistrand & Grouted PT Inspector Certification

Individuals with the Level 2 certification have successfully passed both, the comprehensive 3-day installation, stressing, and grouting training and the specialized 1-day inspector training. They have detailed knowledge of all aspects of post-tensioning installation, stressing, grouting, and inspection of the PT systems and understand the important aspects of each step, including the understanding of critical items that may necessitate stopping of the work. Their knowledge is backed up by the extensive field work experience in inspecting actual projects, including inspections of all three critical operations: Installation, stressing, and grouting.

The certification requirements are:

- Current certification Level 1 Multistrand & Grouted PT Installation, OR
- Current certification Level 2 Multistrand & Grouted PT Specialist
- Full workshop attendance
- Exam score: min 80%
- Field work experience: Total of 500 hours, of which minimum 100 hours in installation inspection, minimum 100 hours in stressing inspection, and minimum 100 hours in grouting inspection

PTI Plant Certification Program

Single-strand unbonded tendons are produced in plants that are certified by an ANSI-accredited PTI Plant Certification Program. This process certification ensures the materials and components meet the requirements of the specifications including material, qualification testing, and QA/QC during production.

Single-strand unbonded tendons consist of Grade 270, 7-wire, low-relaxation, ASTM A416 strand that is coated with PT coating, a high-grade grease, with seamlessly extruded plastic sheathing. These tendons are used primarily for building structures but can also be used for bridge and containment structure applications.

As the ANSI-accredited provider of the certification program, PTI will apply the same rigorous procedures to the PTI CRT-70 PT System Qualification Testing and Certification Program that is in preparation, with anticipated release in the second half of 2020.

Additional information on the PTI Plant Certification Program is on the PTI website at: www.post-tensioning.org/certification/plantcertification/programoverview.aspx

RESOURCES FROM OTHER SOURCES

This section will contain a list of important concrete bridge related resources from other sources such as

- National Cooperative Highway Research Program (NCHRP)
- American Concrete Institute (ACI) – reference relevant reports, but note that they are included in the Manual of Concrete Practice (MCP); also list technician training & certifications
- AASHTO & ASTM International (ASTM) Standards

RESOURCES ORGANIZED BY TOPIC

This section will contain a list of resources presented by topic that will include the items previously listed by organization. This section will be constructed after resource lists are finalized.

TERMINOLOGY LISTING

This section will be developed later.

APPENDICES

This section may contain items such as:

- Cross reference between AASHTO & ASTM specs & standards in PCI BDM chap 2.12. Also in AASHTO Materials Specifications and Test Methods.
- AASHTO LRFD Section 5 Crosswalk between 7th and 8th Editions – from ASPIRE website.