



PREFABRICATED BRIDGE ELEMENTS & SYSTEMS

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Acronyms

□ ABC	Accelerated Bridge Construction
□ ABCT	Accelerated Bridge Construction Technologies
□ ACTT	Accelerated Construction Technology Transfer
□ ADT	Average Daily Traffic
□ CIP	Cast In Place
□ DOT	Department of Transportation
□ EDC	Every Day Counts
□ FHWA	Federal Highway Administration
□ HFL	Highways for Life
□ NCHRP	National Cooperative Highway Research Program
□ PBES	Prefabricated Bridge Elements and Systems
□ SHRP	Strategic Highway Research Program
□ SPMTs	Self-Propelled Modular Transporters
□ UDOT	Utah Department of Transportation

Agenda

- Definition of PBES
- Introduction
- Historical Background
- Main Components
- Benefits of Using PBES
- Challenges
- Fabrication and Transportation
- Considerations for Selecting a Prefabricated Bridge
- Success Stories
- Resources
- Review
- Conclusions

Definition of PBES

- What is PBES?
 - ▣ Bridge structural elements and systems that are built off the bridge alignment to accelerate on-site construction time relative to conventional practice



Introduction

The Idea

Introduction

- Increased emphasis on:
 - Improving work zone safety
 - Minimizing impact on roadway closure time
 - Maintaining construction quality
 - Reducing life-cycle costs
 - Reducing environmental impact
- Significant advantages over onsite CIP construction



Historical Background

How it Begins

History

- 1930: first modular prefabricated steel bridge
- 1945: prefabricated concrete decks
 - ▣ Precast pre-stressed technique
- 1990: quasi-total prefabrication of concrete bridges
- 2001: PBES selected as an innovative technology
 - ▣ Improve work zone safety
 - ▣ Minimize impact on roadway closure time
 - ▣ Maintain construction quality
 - ▣ Reduce life-cycle costs
 - ▣ Reduce environmental impact
- 2010: selected as an EDC initiative





Main Components

PBES Elements Definitions

Prefabricated Elements

□ Superstructure

1. Prefabricated Concrete Decks
2. Beams: More efficient shapes
3. Composite Units

□ Substructure

1. Pier Caps, Columns
2. Abutment Walls, Wing Walls, and Footings
3. Bent Caps

Prefabricated Concrete Decks

Partial Depth Deck Panels

- Provide precast portion of the deck thickness
- Serve as stay in place forms
- Increases the strength
- Require a composite CIP concrete topping

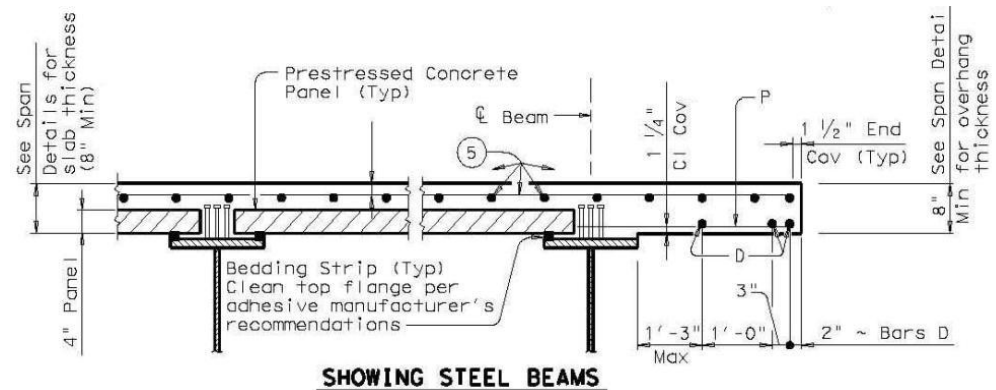


Fig. 1: Partial Depth Deck Cross Section (www.fhwa.dot.gov)

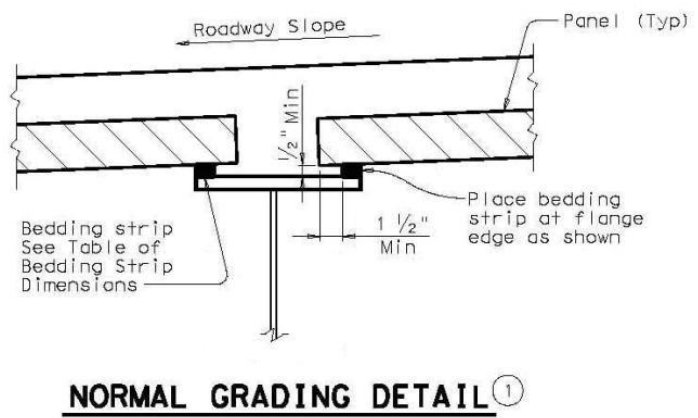


Fig. 2: Partial Depth Deck Grading (www.fhwa.dot.gov)

Prefabricated Concrete Decks

Full Depth Deck Panels

- ❑ Prefabricated with their full thickness
- ❑ Don't require CIP
- ❑ May include:
 - ❑ Concrete
 - ❑ Steel
 - ❑ Fiber-reinforced polymers
 - ❑ Aluminum

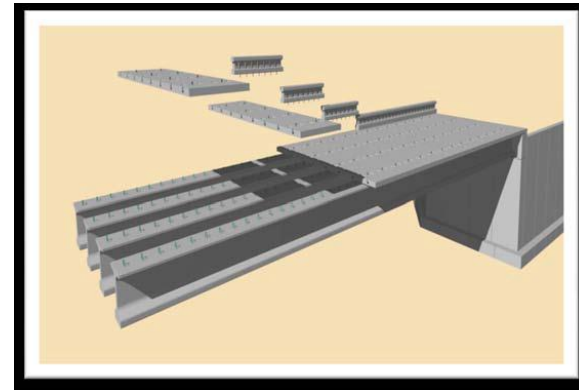


Fig. 3: Precast Decks on Pre-Stressed Beams (www.fhwa.dot.gov)

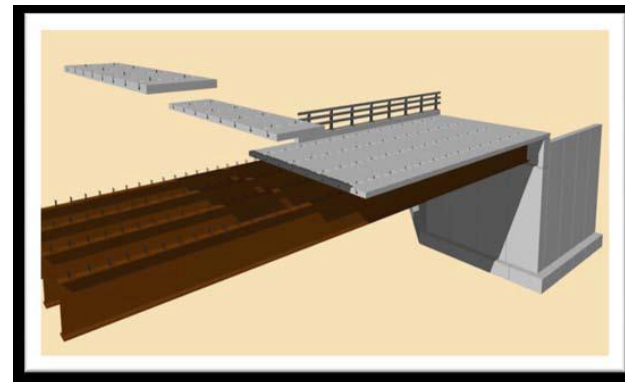


Fig. 4: Precast Decks on Steel Framing (www.fhwa.dot.gov)

Prefabricated Concrete Decks

Fiber Reinforced Polymer Deck Panels

- No internal tensile reinforcement
- Corrosion free
- Durable during transportation and handling
- Sustain larger loads

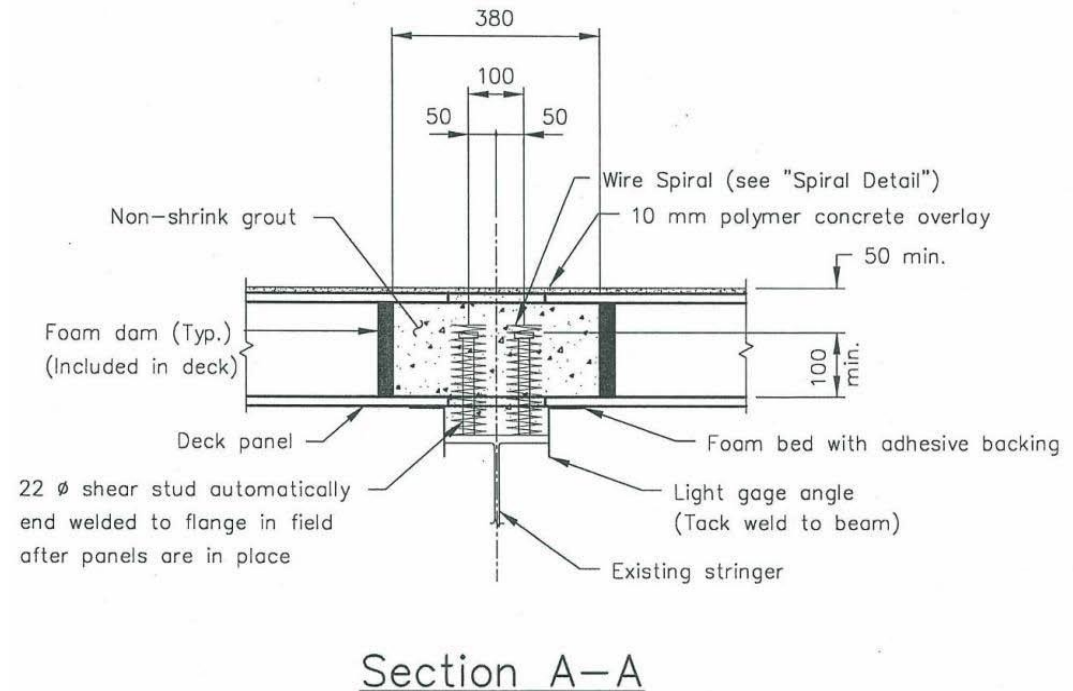


Fig. 5: FRP Concrete Deck Panel Section (www.fhwa.dot.gov)

Prefabricated Beams

More efficient shapes

- ❑ Precast spliced tub girders
- ❑ Adjacent precast beams with CIP deck
- ❑ Adjacent inverted tee beams
- ❑ Adjacent deck bulb tees with partial CIP decks



Fig. 6: Precast Spliced Tub Girder(www.adaptsoft.com)



Fig. 7: Adjacent Deck Bulb Tees (www.cprestress.com)

Pier Caps, Columns and Footings

- Combination of precast and CIP concrete interior support elements
 - Pier cap with CIP column(s)
 - Pier cap and precast column(s) with CIP cap footing
 - Spread footing with CIP column(s)



Fig. 8: Precast Piers (www.fhwa.dot.gov)



Fig. 9: Precast Pier Cap (www.fhwa.dot.gov)

Abutment Walls, Wing Walls, and Footings

- Combination of precast and CIP concrete abutment elements
 - ▣ Abutment wall with CIP wing walls
 - ▣ Abutment wall and precast wing walls with CIP footing
 - ▣ Footing with CIP abutment wall

- Geosynthetic reinforced soil abutment

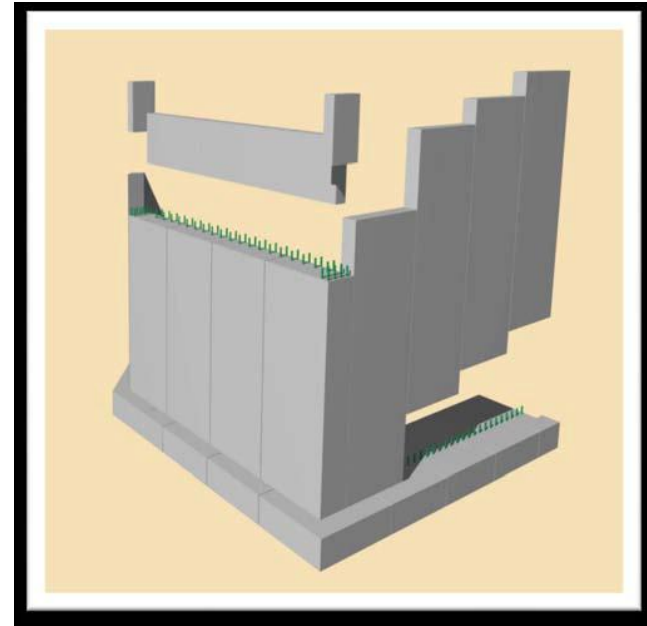


Fig. 10: Precast Abutment (www.fhwa.dot.gov)

Prefabricated Systems

- **Total Superstructure**
 - Entire segments
- **Total Substructure**
 - Individual elements into one prefabricated unit
- **Total Bridge**
 - All bridge elements prefabricated

Superstructure Systems

- Adjacent slab and box beams
- Deck bulb tees beams
- Composite units
- Precast segmental box systems
- Truss spans and arch spans
- Total superstructure



Fig. 11: Superstructure Span on SPMT (www.fhwa.dot.gov)

Substructure Systems

- Non-prefab deck or substructure
- Prefab interior supports that are connected to precast or CIP foundations if multiple span
- Precast or CIP abutments



Fig. 12: Precast Integral Abutment (www.fhwa.dot.gov)

Total Bridge

- Bridges with
 - Superstructure as defined previously or superstructure consist spread prefab and prefab deck
 - Prefab interior supports that are connected to precast or CIP foundations if multiple span
 - Precast or CIP abutments

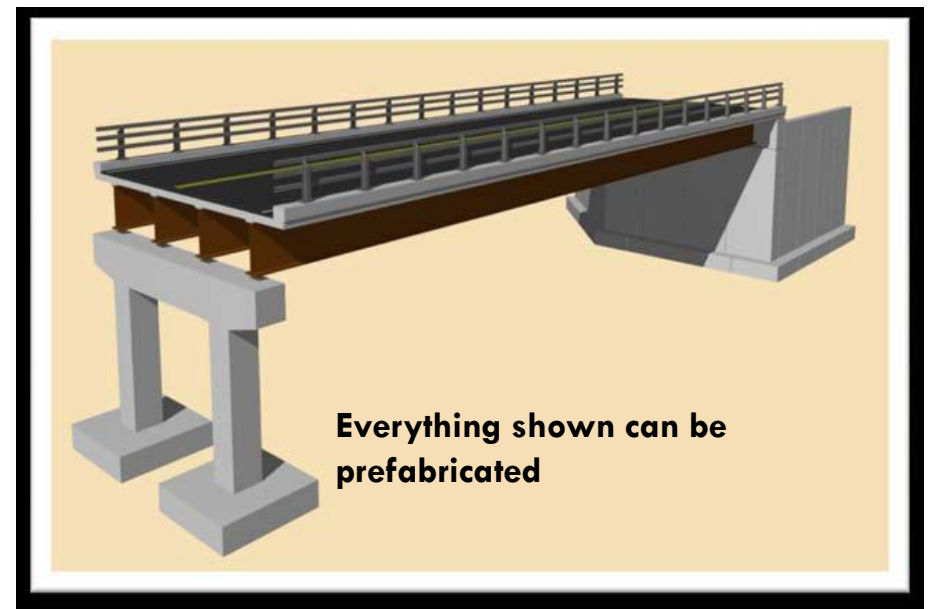


Fig. 13: Total Bridge Prefabrication (www.fhwa.dot.gov)

Total Bridge (cont.)

- Prefabricated culverts
- Geosynthetic reinforced soil integrated system



Fig. 14: Prefabricated Culverts (www.ci.palm-springs.ca.us)



Benefits of Using PBES

Significant Advantages

Benefits

Minimizes Traffic Disruption

- Minimizes traffic delay and community disruption
- Reduces detours, lane closures, and narrow lanes



Fig. 15: US 59 under Dunlavy, TX (www.fhwa.dot.gov.com)



Fig. 16: I-59 and I-65 Interchange, AL (www.fhwa.dot.gov)

Benefits

Increases Work-Zone Safety

- Minimizes work near traffic and power lines, at high elevations, or over water

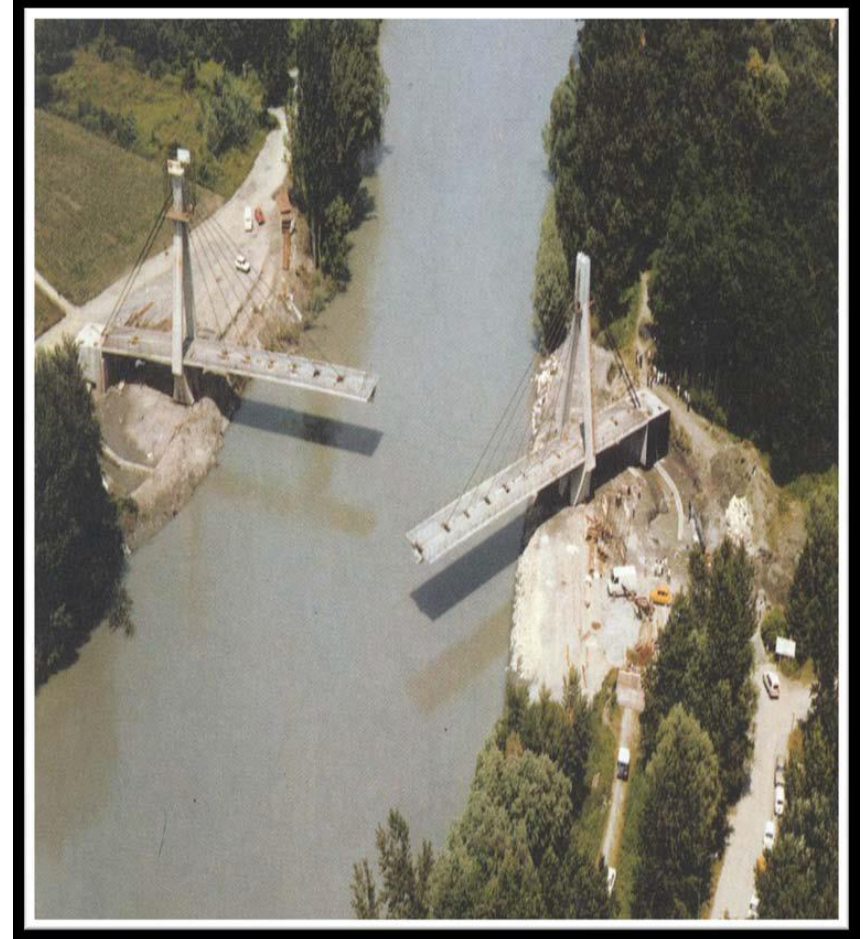


Fig. 17: Meylan Pedestrian Bridge, France
(www.fhwa.dot.gov)

Benefits

Reduces Environmental Impact

- Keep heavy equipments out of sensitive environment



Fig. 18: Linn Cove Viaduct, NC (www.fhwa.dot.gov)

Benefits

Improves Constructability

- Minimal impact from environmental constraints
- Relieves constructability pressure



Fig. 20: San Mateo-Hayward Bridge, CA (www.fhwa.dot.gov)

Benefits

Increases Quality & Lower Life Cycle Costs

- ❑ Prefabricated in a controlled environment
- ❑ Increases quality control
- ❑ Controlled environment
 - ❑ Reduced dependence on weather
 - ❑ Established materials suppliers for consistent quality materials
 - ❑ Standardized plant operations for consistent quality of production
 - ❑ Optimum concrete curing

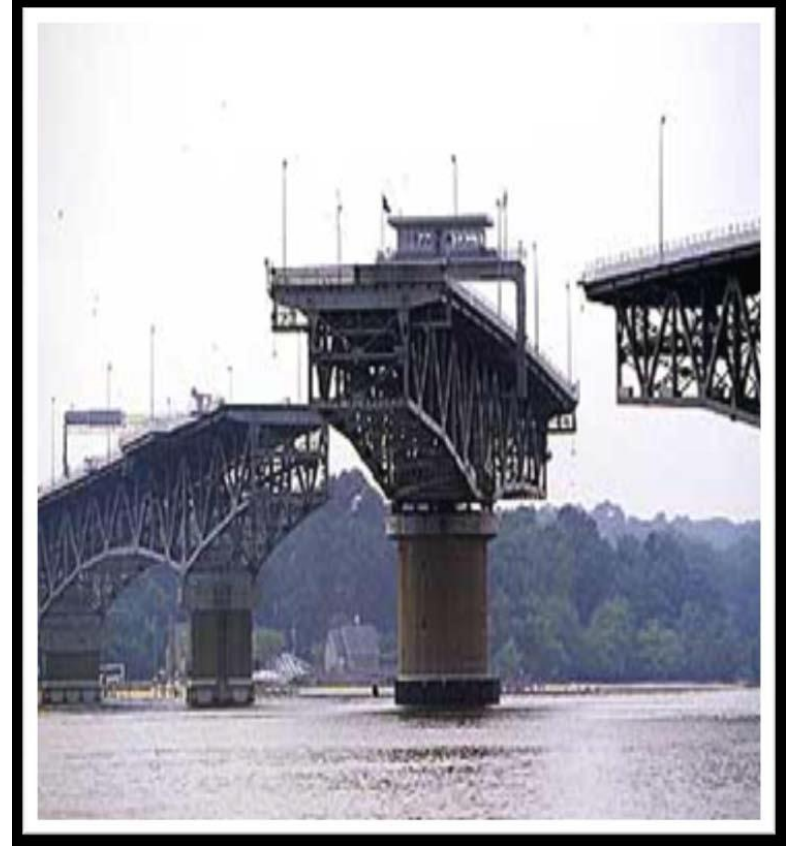


Fig. 21: George P. Coleman Bridge, VA (www.fhwa.dot.gov)

Benefits

Positive Cost-Benefit Ratios

- Cost effective in many cases
 - Depending on type of structure and element or systems used
- Many systems can cost less than conventional construction
- First implementation of new elements may cost more
- Life cycle cost analysis is favorable to PBES and provides a positive cost-benefit ratio when user costs are considered

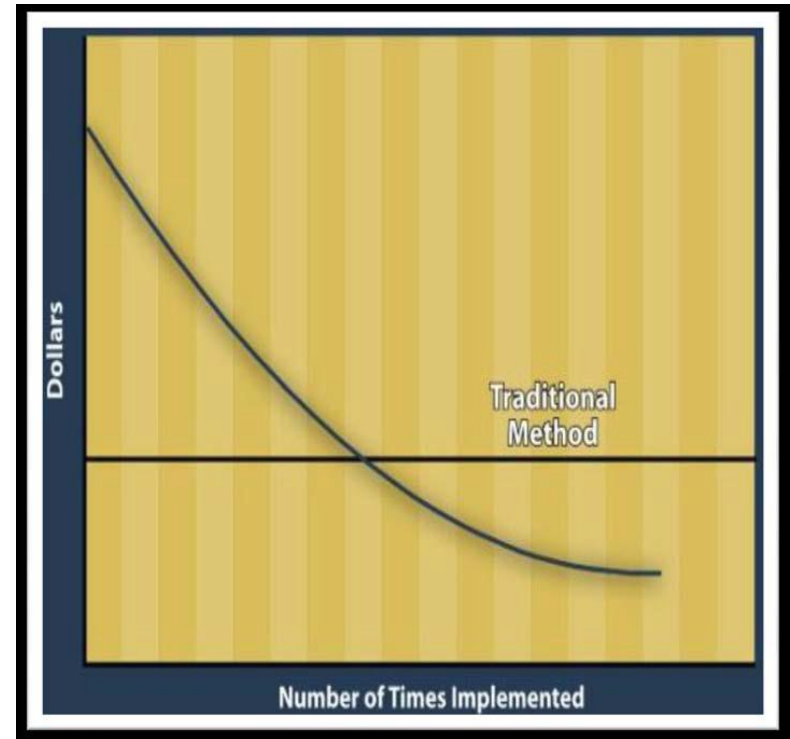


Fig. 22: Declining Cost of Deploying Innovative Technology
(www.fhwa.dot.gov)



Challenges

Barriers to implementation

Challenges

- The principal concerns in PBES construction are lack of knowledge and experience in prefabricated bridge systems design and detailing including;
 - ▣ Connections between components
 - ▣ Durability of the connection details
 - ▣ Ability of the prefabricated systems to accommodate curvilinear geometry
 - ▣ Details to develop negative moment continuity
 - ▣ Availability of prefabricators capable of producing the components

Challenges

- ▣ Limitations on component size
- ▣ Availability of equipment to erect components
- ▣ Knowledge/experience of local bridge contractors with techniques needed to construct bridges built of prefabricated components

Challenges

Common State Barriers

- ❑ Lack of education /training /experience
- ❑ Lack of standards & specifications
- ❑ Concern about durability or details
- ❑ Higher cost & limited resources
- ❑ Lack of perceived need for speed
- ❑ Construction industry not geared up for PBES

Needs

- ❑ Education/ training/ more projects
- ❑ Design & Construction standards & specifications
- ❑ Additional research to address concerns about durability or details
- ❑ Competitive cost & additional funding
- ❑ Appropriate projects that require speed
- ❑ Fabrication & construction equipment & methods

Fabrication and Transportation

Limiting Work at the Bridge Site

Fabrication

- Prefabrication proceeds in an established, repetitive, and systematic manner regardless of bad weather
- High-quality concrete can more easily be obtained
- The allowable tolerance is achieved by a systematic supervision of the fabrication process

Fabrication

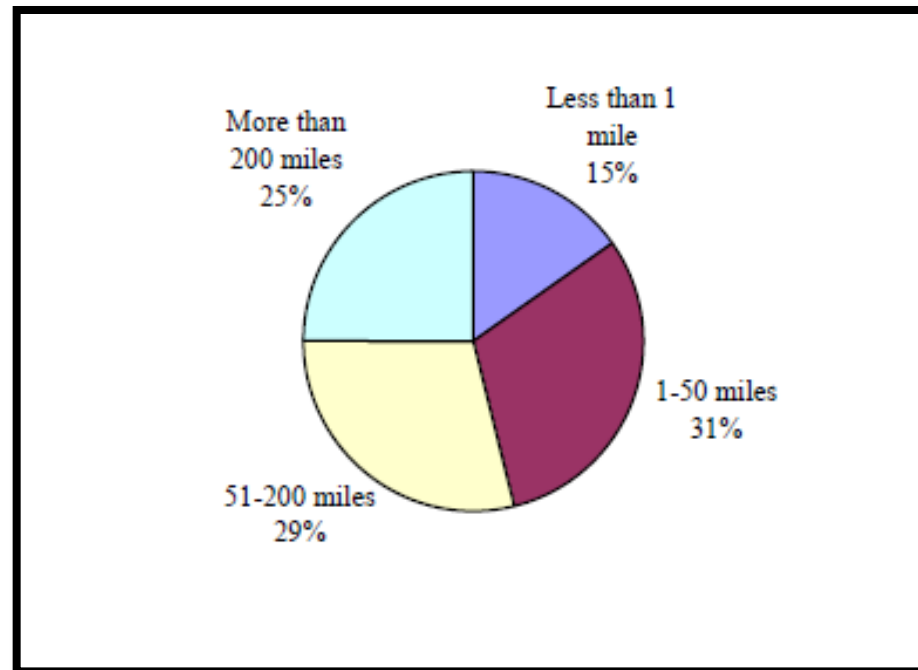


Fig. 23: Distance between prefabrication plant and bridge site
(NCHRP Synthesis 324)

Transportation

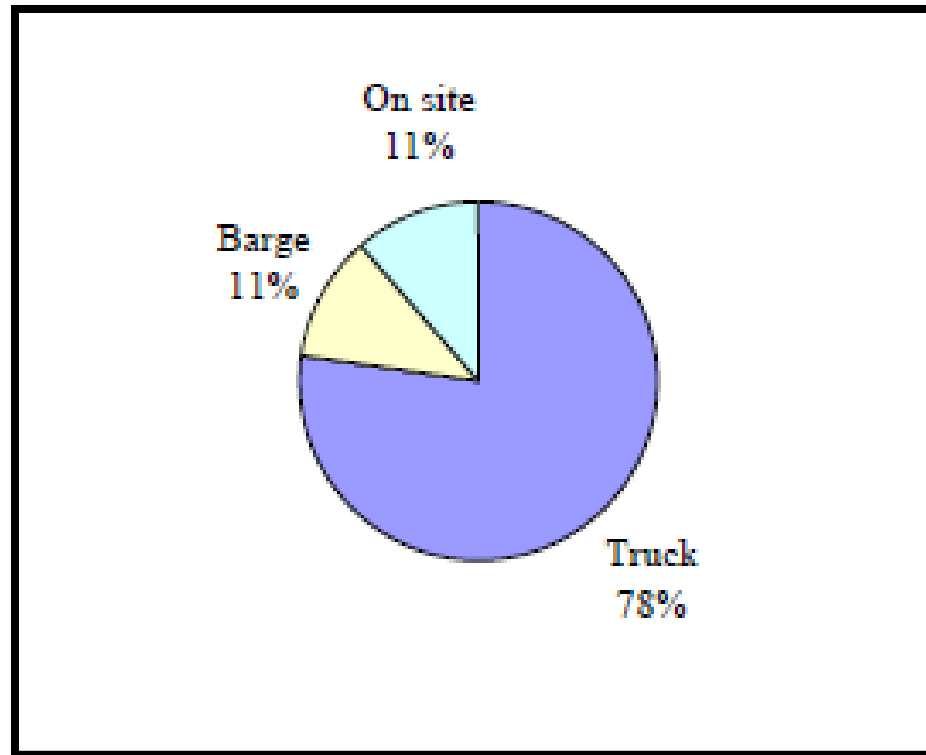


Fig. 23: Means of transportation of prefabricated elements (NCHRP Synthesis 324)



Structural Placement Methods

How it is Accomplished

Structural Placement Methods

- Self-Propelled Modular Transporters
- Longitudinal launching
- Horizontal siding or skidding
- Other heavy lifting equipment and methods

Self-Propelled Modular Transporters (SPMTs)

- Used to move heavy structures with fine precision
- Fully computerized hydraulic platform transporters
- 4 and 6 axle units- 30 to 40 ton/axle capacity
- Larger/Heavier the load- more units are coupled together



Fig. 24: SPMT components (www.fhwa.dot.gov)

Self-Propelled Modular Transporters (SPTMs)



Fig. 25: Bridge moving with SPTM (www.fhwa.dot.gov)

Longitudinal Launching

- Bridge is built behind one of the existing abutments and incremental launched across a valley or above an existing highway
- Employment of hydraulic jacking systems

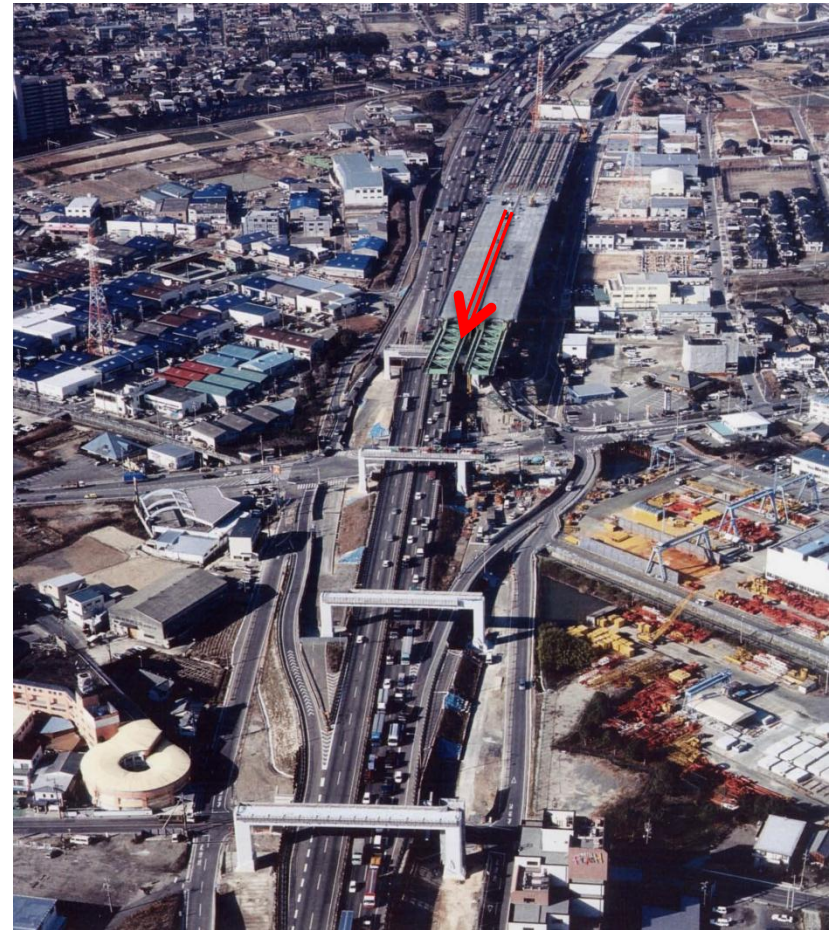


Fig. 25: Continuous longitudinal launching (www.fhwa.dot.gov)

Horizontal Sliding

- Bridge is prefabricated adjacent to an existing bridge and skidded into place
- Employment of hydraulic jacking systems

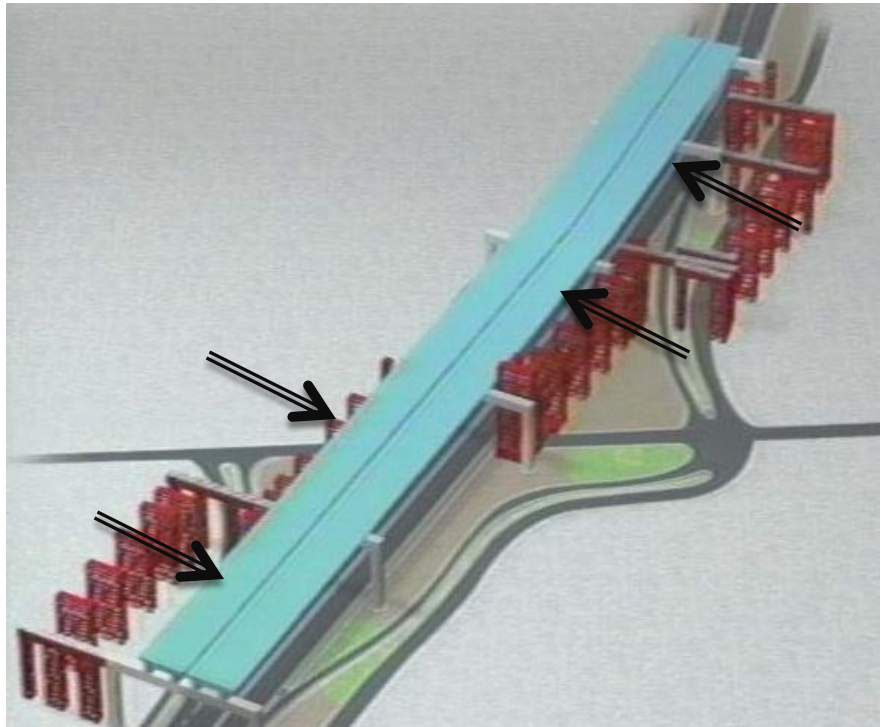



Fig. 26: Horizontal Sliding (www.fhwa.dot.gov)



Considerations for Selecting a Prefabricated Bridge

Decision Making

Rapid Onsite Construction

Table 1: Decision Making Matrix

Questions	Yes	Maybe	No
Average Daily Traffic?			
Emergency Replacement?			
Evacuation Route?			
Traffic Impact?			
Can the Bridge be Closed During Off-Peak Traffic Periods?			
Construction Time Restrictions?			
Local Weather?			

Costs



- Maintenance of Traffic
- Contractor's Operations
- Owner Agency's Operations
- Service Life

Other Factors

- Safety Concerns
- Environmental Issues
- Standardization
- Sites Issues



Success Stories

What Success Looks Like

Success Stories

State Highway 86 Bridge over Mitchell Gulch, Colorado (2002)

- 46 hours weekend construction of 40 ft long, 43 ft wide single span bridge
- No impact to rush-hour traffic



Fig. 27: Colorado Department of Transportation's Highway 86 Bridge over Mitchell Gulch (www.fhwa.dot.gov)

Success Stories

State Highway 86 Bridge over Mitchell Gulch, Colorado – 2002

Early Saturday
morning



Precast concrete
abutments, wingwalls,
superstructure units with
railing, & steel H piles

Saturday
afternoon



Saturday afternoon

Success Stories


Belt Parkway Bridge over Ocean Parkway, New York City (Brooklyn)-2004

- ❑ Replaced existing 2-span, 149 ft long, 78 ft wide bridge with 3-span, 221 ft long, 134 ft wide bridge
- ❑ No lane closures during peak traffic hours
- ❑ Construction savings: \$4.5M



Fig. 28: New York City Department of Transportation's Belt Parkway Bridge over Ocean Parkway (www.super-slab.com)

Success Stories




**Belt Parkway
Bridge over
Ocean
Parkway
– 2004**

51 superstructure segments
in new 221-ft long x 134-ft wide
bridge (49'-107'-65')

Prefabricated:

- ⇒ Piles
- ⇒ T-Walls
- ⇒ Cap Beams
- ⇒ Superstructure
- ⇒ Parapets & Barriers
- ⇒ Approach Slabs



Success Stories

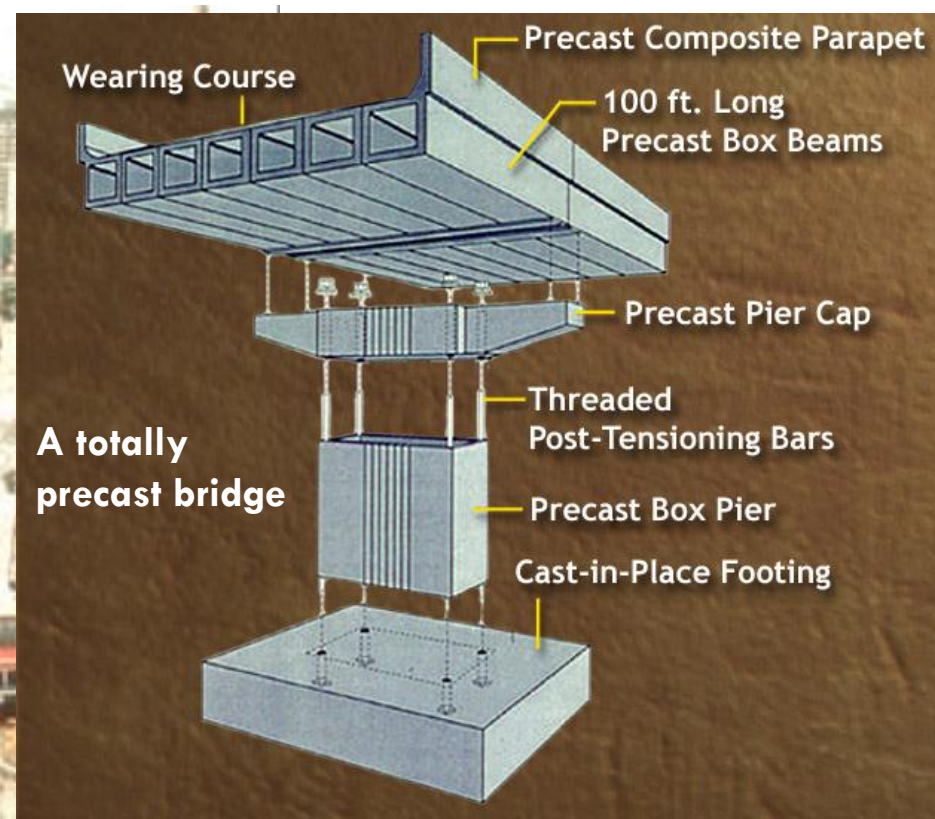
Baldorioty de Castro Avenue Bridge in San Juan, Puerto Rico- 1992

- ❑ 2 totally prefabricated bridges, 700 ft and 900 ft long
- ❑ Installed in 36 hours
- ❑ Construction savings: \$2.0M



Fig. 29: Baldorioty de Castro Avenue Bridge in San Juan, PR
(www.fhwa.dot.gov)

Success Stories

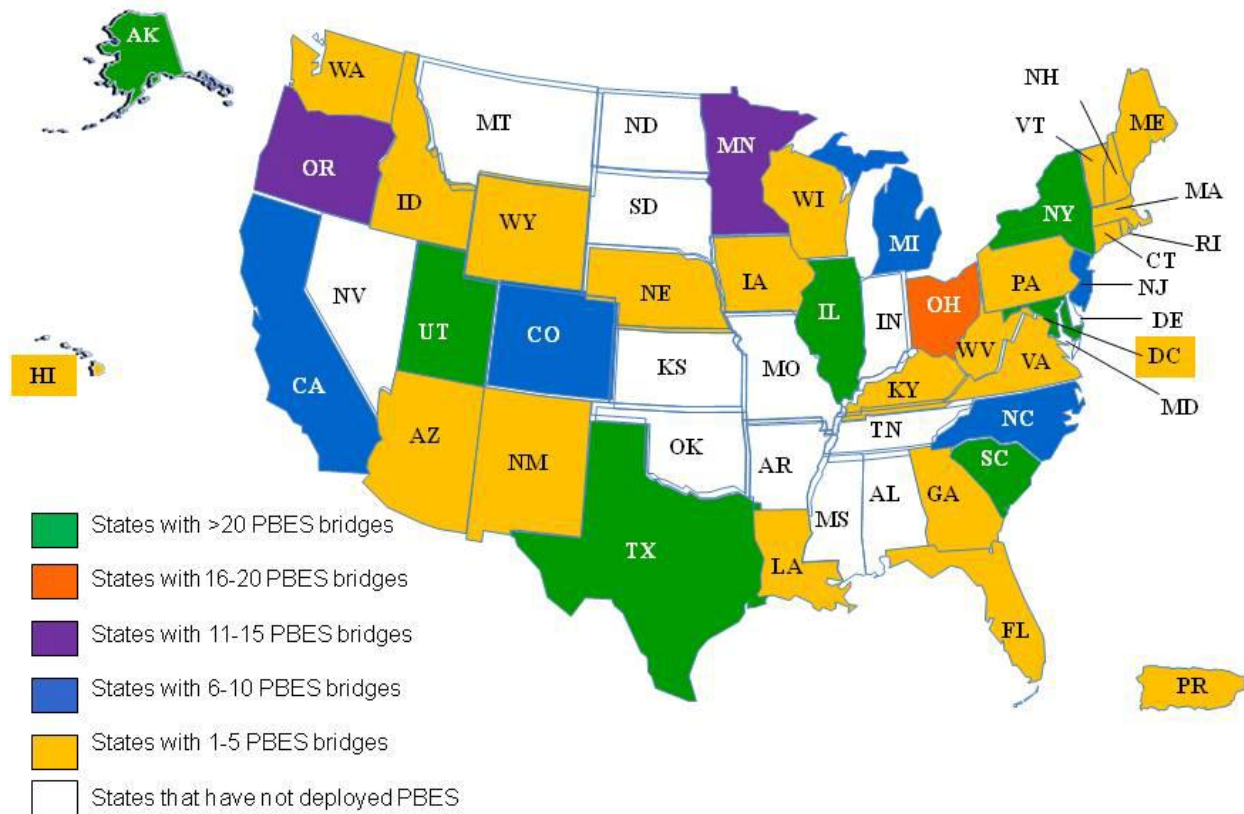


(www.fhwa.dot.gov)

State of the Practice

- Senior management is committed to Every Day Counts technology deployments
- 40+ States: 1 or more projects
- 7 States: 20+ projects
- 11 States actively pursuing as standard practice
- Opportunity for much greater PBES deployment

State of the Practice



(www.fhwa.dot.gov)

Resources

PBES Manuals, Specifications, Contract Drawings,
and Details

Resources

- Websites:
 - FHWA EDC site
 - FHWA PBES site
 - HFL projects site
 - ABCT site
 - ACTT site
 - State DOT bridge sites
- PBES Cost Study
- PBES Decision-Making Framework
- Manuals:
 - ABC Manual
 - FHWA SPMT Manual
 - PBES Connection Details Manual
 - UDOT ABC SPMT Manual & Guide
- NCHRP domestic scan report
- NCHRP & other research
- SHRP2 R04 Final Report

Resources

PBES Connection Detail Manual

- ❑ General Topics
- ❑ Superstructure Connections
- ❑ Foundation Connections
- ❑ Connection Design Examples
- ❑ Proprietary Products
- ❑ Sample Construction Specifications
- ❑ Case Studies

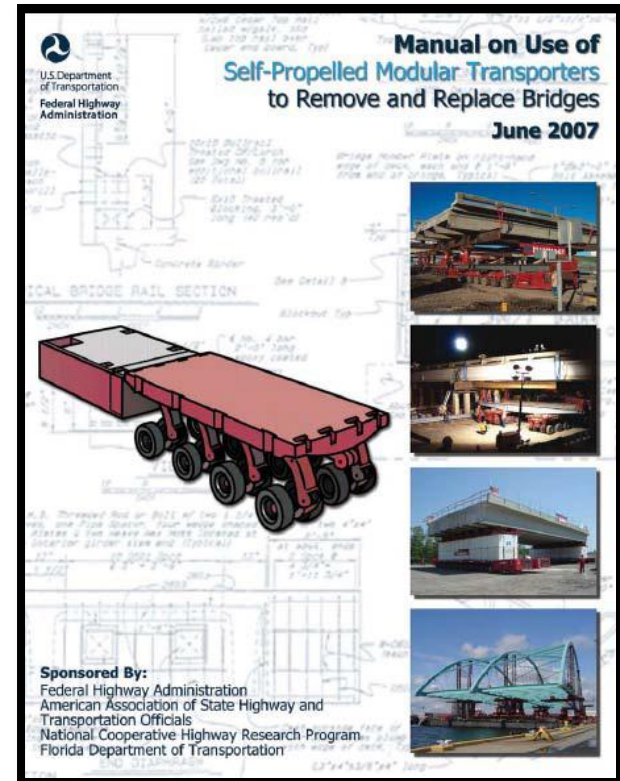


Fig. 30: Manual on Use of Self-Propelled Modular Transporter to Remote and Replace Bridges (www.super-slab.com)

Resources

FHWA SPMT Manual

- Benefits and Costs
- Planning
- Design
- Contracting Issues
- Contract Documents
- Case Studies

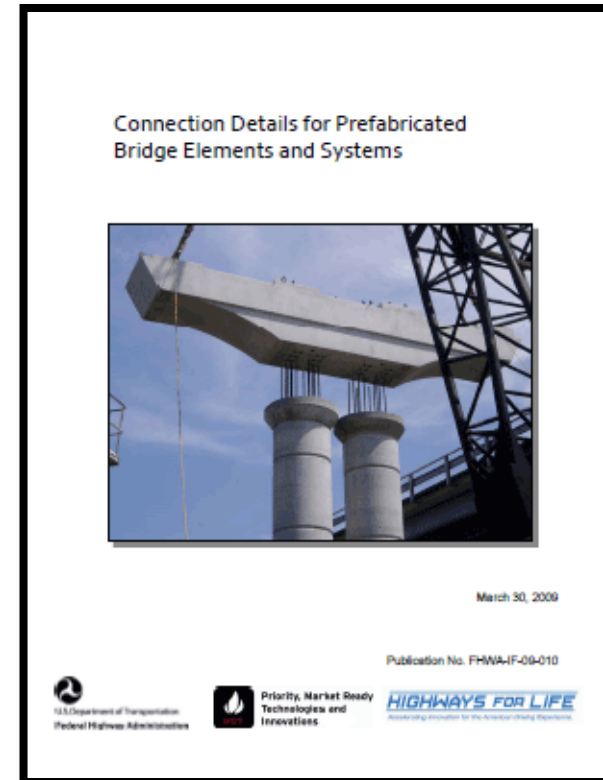


Fig. 31: Manual for Connection Details for Prefabricated Bridge Elements and Systems (www.super-slab.com)

Resources

UDOT ABC SPMT Manual and Design Guide

- Description of Equipment
- Scoping
- Engineer of Record
- Contractor
- Oversight
- Sample Special Provision
- Sample SPMT Submittals Review

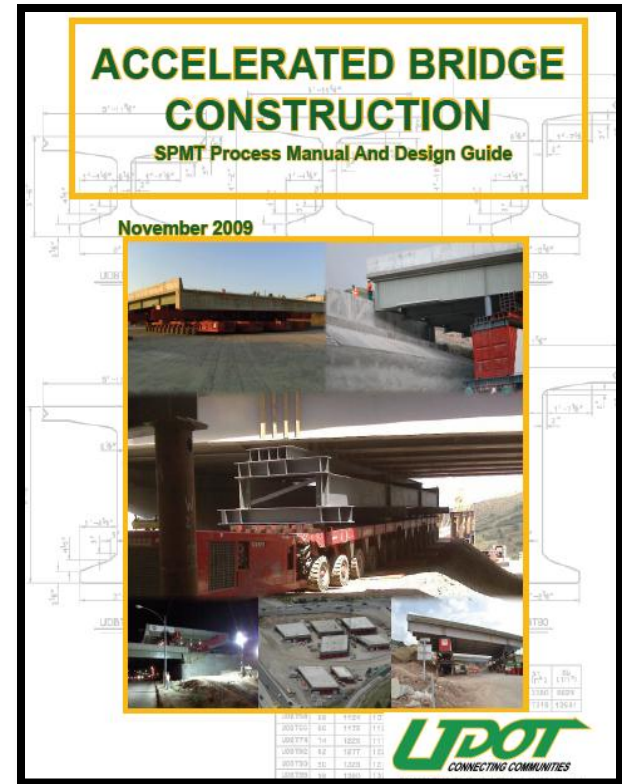


Fig. 32: Utah Manual for Accelerated Bridge Construction
(www.udot.utha.gov)

Resources

NCHRP Domestic Scan Report

- Best Practices in Accelerated Construction Techniques (2009)
 - Introduction
 - Emergency Accelerated Construction
 - Planned Accelerated Construction
 - Program Approach to Acceleration
 - Observations, Recommendations, and Implementation

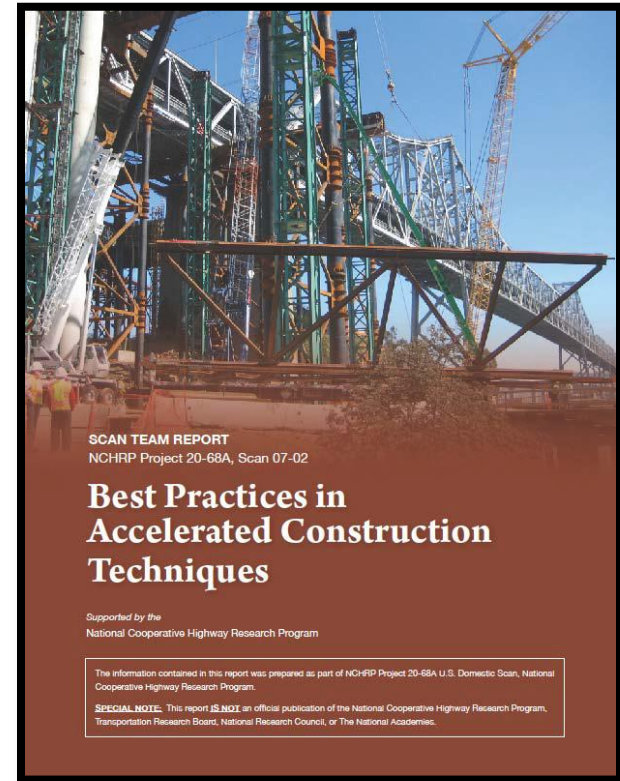


Fig. 33: Report on Best Practices in Accelerated Construction Techniques (www.super-slab.com)

Resources

ABC Manual

- ❑ Coming Soon!
- ❑ Draft Outline
 - ▣ Overview of ABC techniques and practices currently in use
 - ▣ Design Examples
 - ▣ Standard Products
 - ▣ Sample Construction Specifications
 - ▣ Erection and Transportation Equipment

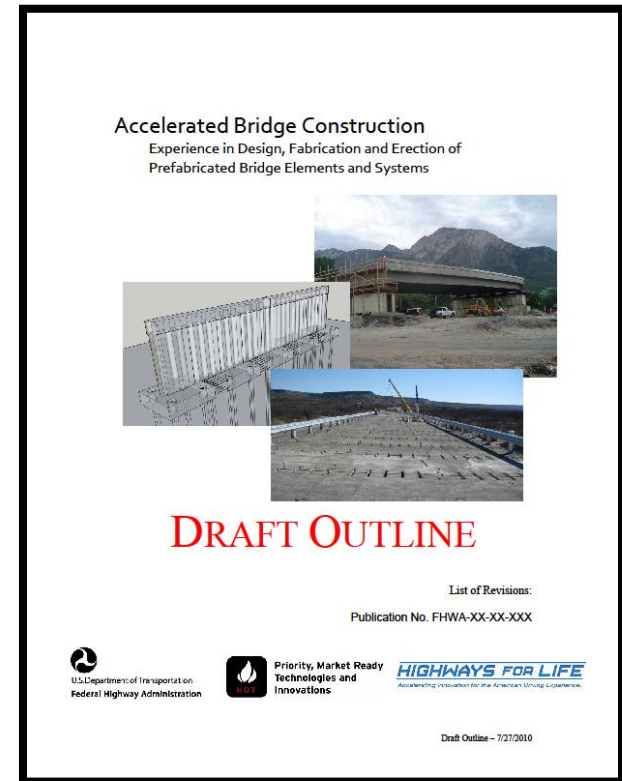


Fig. 34: Draft Outline on Accelerated Bridge Construction (www.super-slab.com)



Review



Review

- **What is the major reason owners are choosing PBES?**
 - Minimize impacts to the traveling public

Review

- **Why Use PBES technologies?**
 - It offers Major Advantages:
 - Faster (offsite & off critical path)
 - Safer (public, construction & inspection)
 - Better Quality (controlled environment)
 - Positive Cost Benefit Ratios when users costs are considered

Review

- **How can FHWA help you deploy PBES?**
 - ▣ State use of program funding for PBES projects
 - ▣ Highways for LIFE grants
 - ▣ Innovative Bridge R&D Program funds
- Technical Support
- Websites on ABC/PBES projects built

Review

□ **FHWA PBES Deployment Goals for U.S.**

- By December 2012, 100 cumulative bridges have been designed and/or constructed rapidly using PBES.
- By December 2012, 25 percent of single or multi span replacement bridges authorized using Federal aid, have at least one major prefabricated bridge element that shortens onsite construction time relative to conventional construction.




Conclusions



Conclusions

- User-costs matters!
- The current state of the technology is very good
- All elements of a typical bridge can be prefabricated
- Numerous connections between prefabricated elements have been developed and proved
- It is possible to “reverse engineer” conventional construction bridges with prefabricated elements
- Prefabricated systems have been developed and are becoming commonplace
- There are several references available to assist agencies with ABC/PBES implementation



Thank you...Questions?