

New Bridge Designs & State Aid Bridge Resources

**2008 Minnesota Public
Engineers Technology
Conference & Tradeshow**

Dave Conkel & Petra DeWall
Mn/DOT Bridge Office
State Aid Bridge & Bridge Hydraulics Unit

Overview

- **Accelerated Bridge Construction (ABC)**
- **FHWA Sponsored ABC Workshops**
- **Local Bridge Innovation Across the Country**
- **Mn/DOT Inverted Tee Beam Bridge**
- **MN Local Demonstration Project, Blue Earth County Box Beam Bridge**
- **State Aid Bridge Resources**

What is ABC?

- **Innovative methods to decrease bridge construction time**
- **Build elements offsite/outside traffic area**
- **Transport to site and install rapidly**

Benefits of ABC

- **Reduce construction time**
- **Minimize traffic disruption**
- **Improve safety**
- **Reduce environmental impact**
- **Enhance constructability**
- **Improve quality & life-cycle costs**

Congestion Impact

- **Congestion robs our nation of productivity and quality of life**
- **4 billion hours/year time delay**
- **2.7 billion gallons of wasted gas/year**
- **\$73 billion in 75 urban areas**

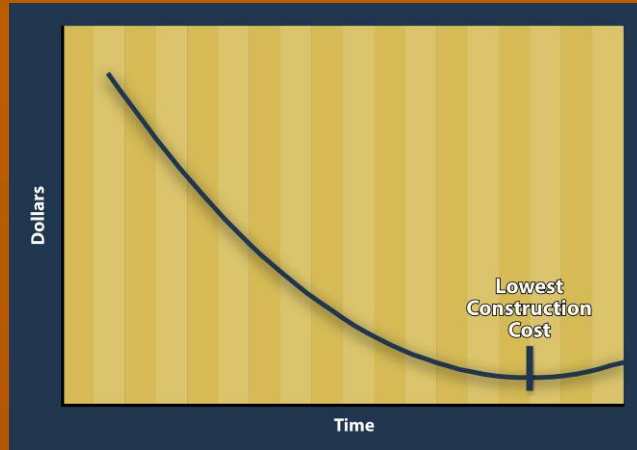
▪ **Slide Courtesy FHWA, IDOT ABC Workshop**

Cost to Families and Civic Life



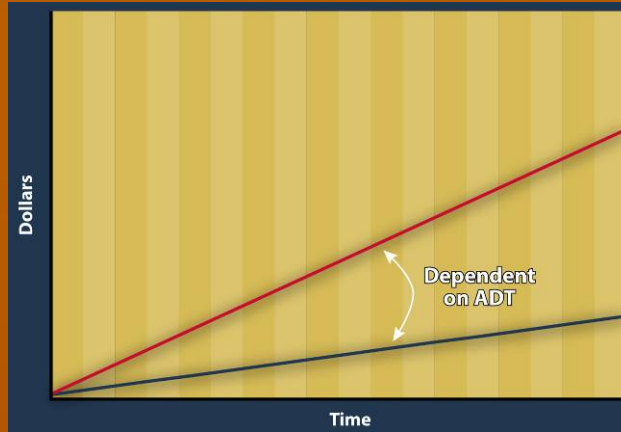
- Americans have less time to spend with their families and friends.
 - 55% miss one or more family functions per week.
 - 85% would spend more time with their family.
- Congestion negatively impacts the country's social fabric.

▪ Slide Courtesy FHWA, IDOT ABC Workshop



Traditional Business Model

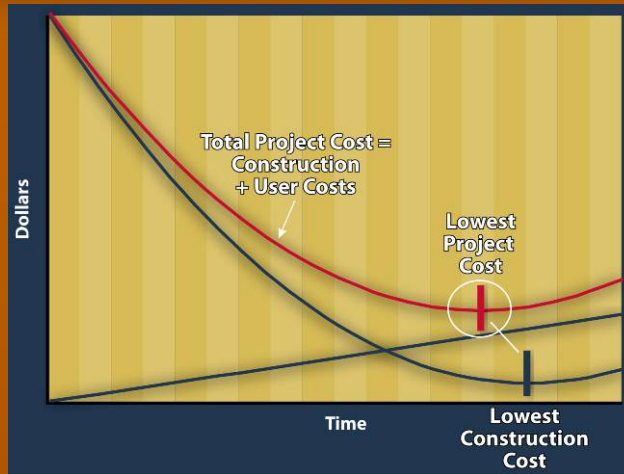
- **Successful business model**
- **Existing interstate was constructed**
- **Competition determines the lowest construction cost**
- **Contractors select time and method**



Societal Costs

- Linear relationship
- Cost depends on volume of traffic
- Longer construction duration = increased impacts to users

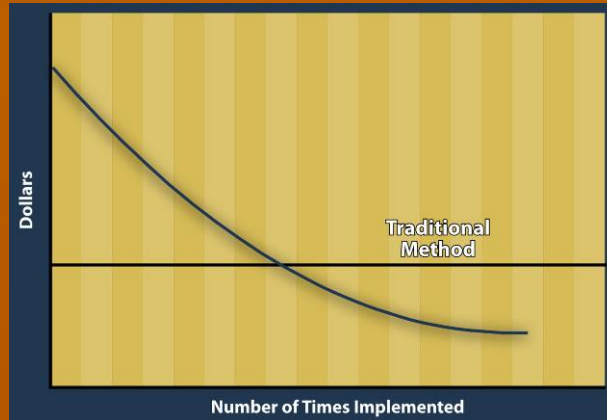
▪ Slide Courtesy FHWA, IDOT ABC Workshop



New Business Model

- New paradigm
- Lowest construction cost = lowest project cost
- Societal costs minimized
- Political capital
- Public praise

▪ Slide Courtesy FHWA, IDOT ABC Workshop



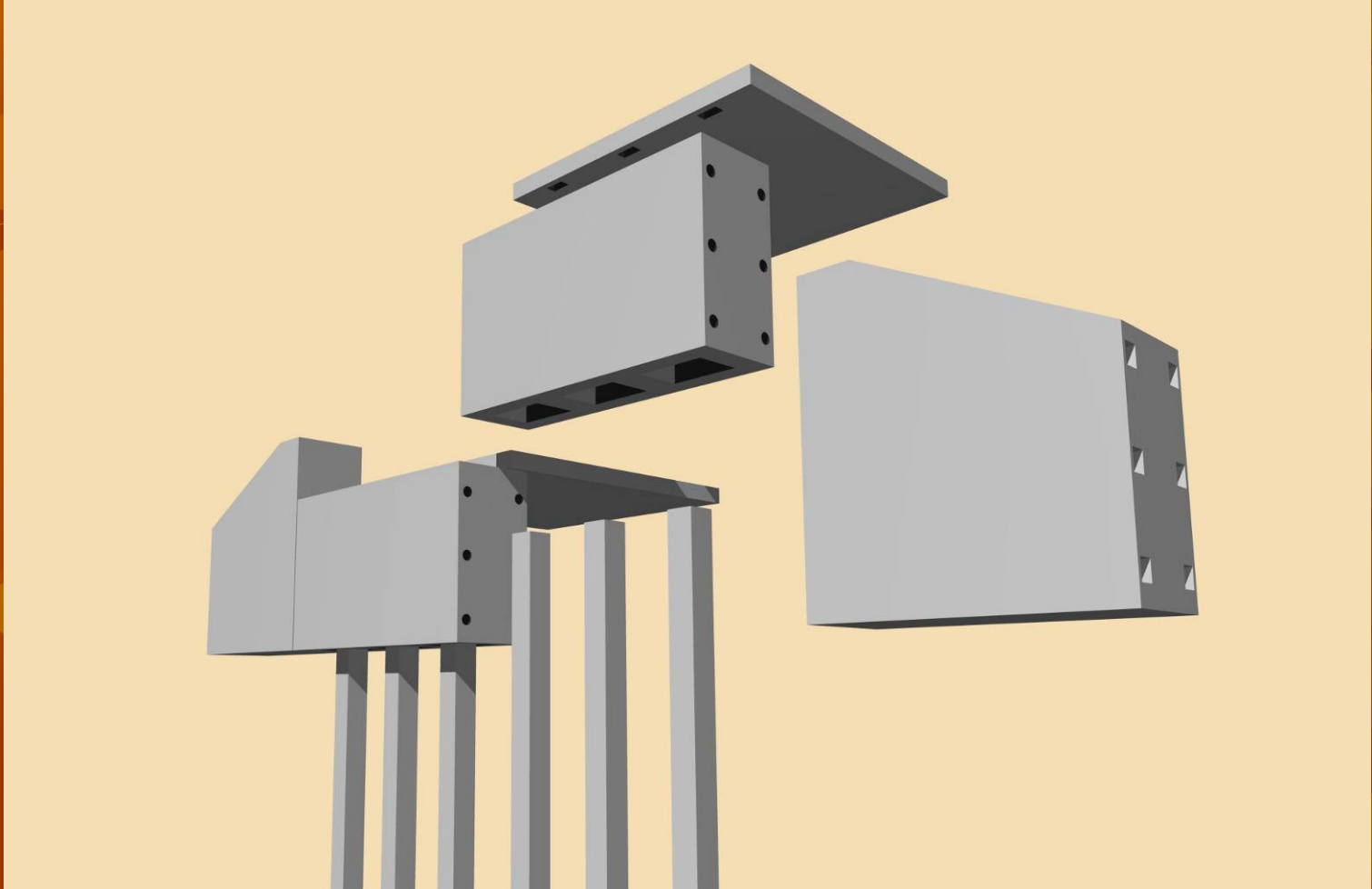
Innovative Technology

- First implementations cost more
- Potential for new methods to cost less
- Promise of time savings
- Positive cost-benefit ratios

ABC Elements & Methods

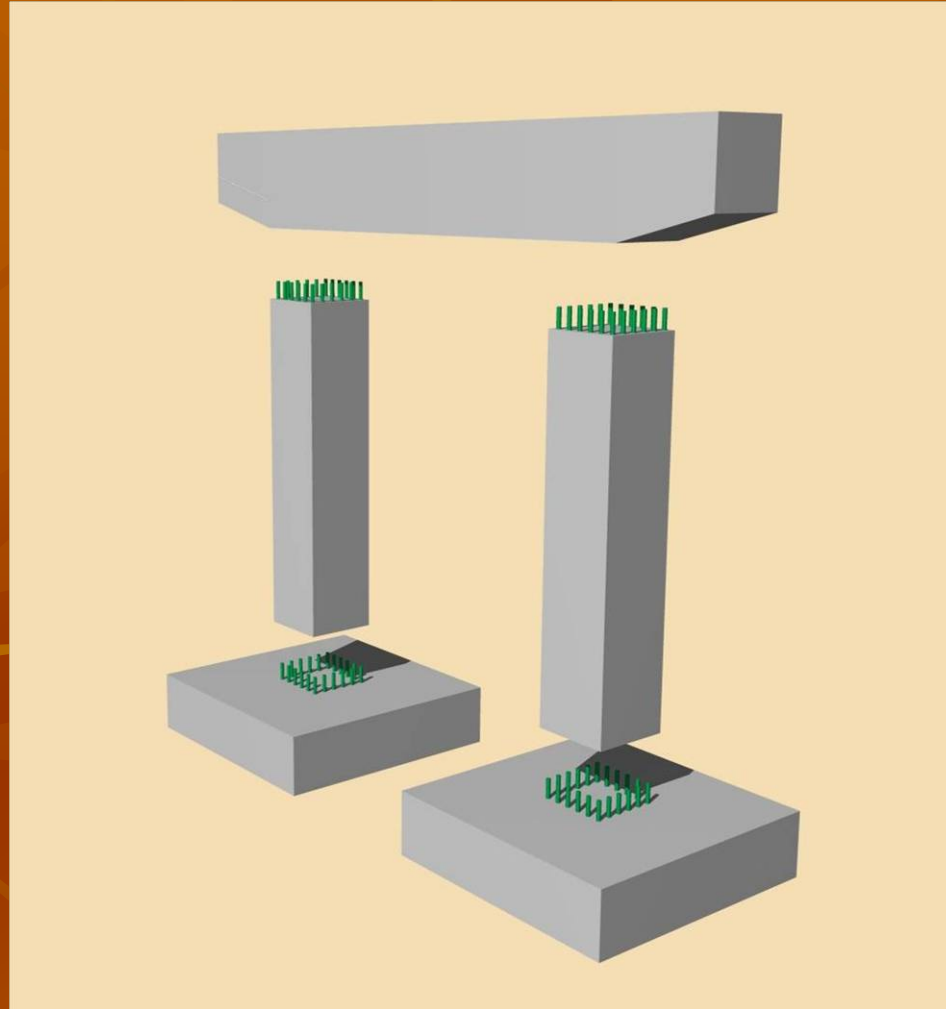
- **Precast Concrete Elements**
- **Modular Construction**
- **Structure Placement Methods**
- **Innovative Contracting**

Precast Abutments



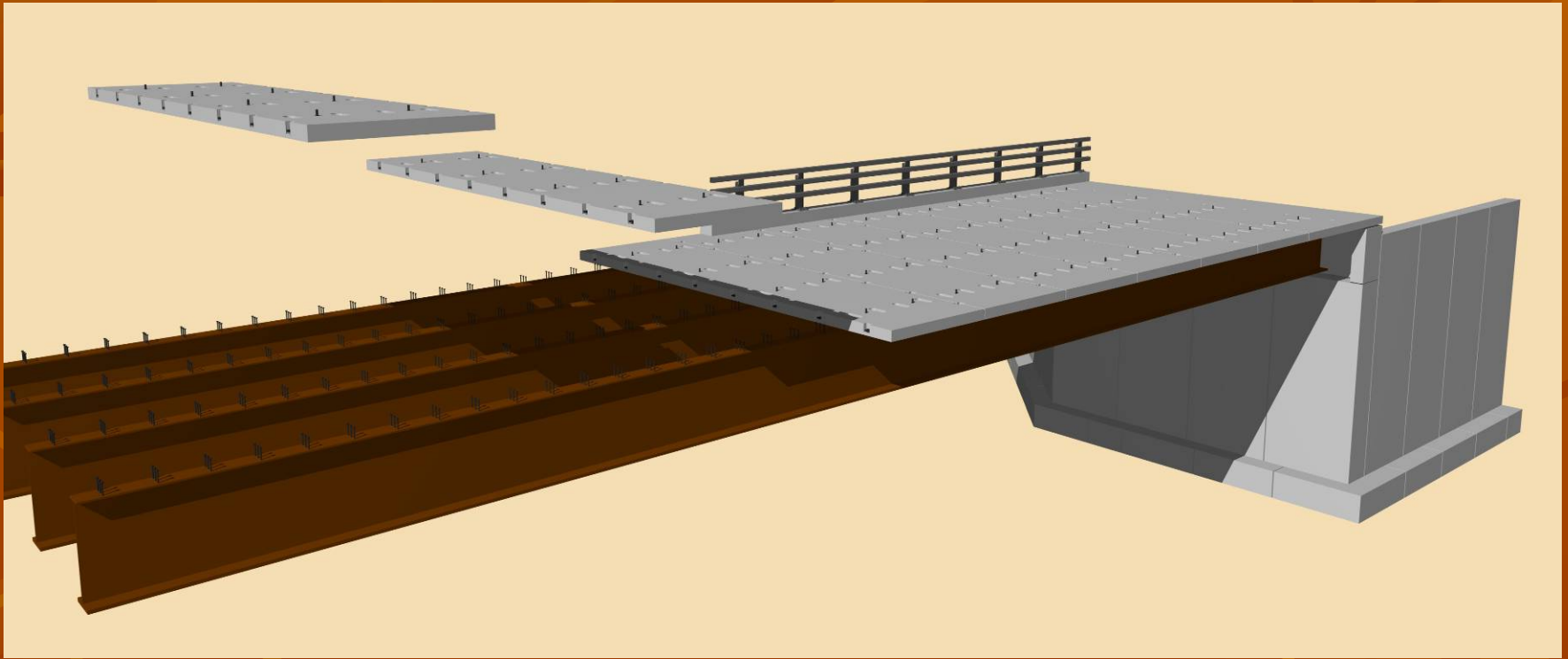
▪ Slide Courtesy FHWA, IDOT ABC Workshop

Precast Piers



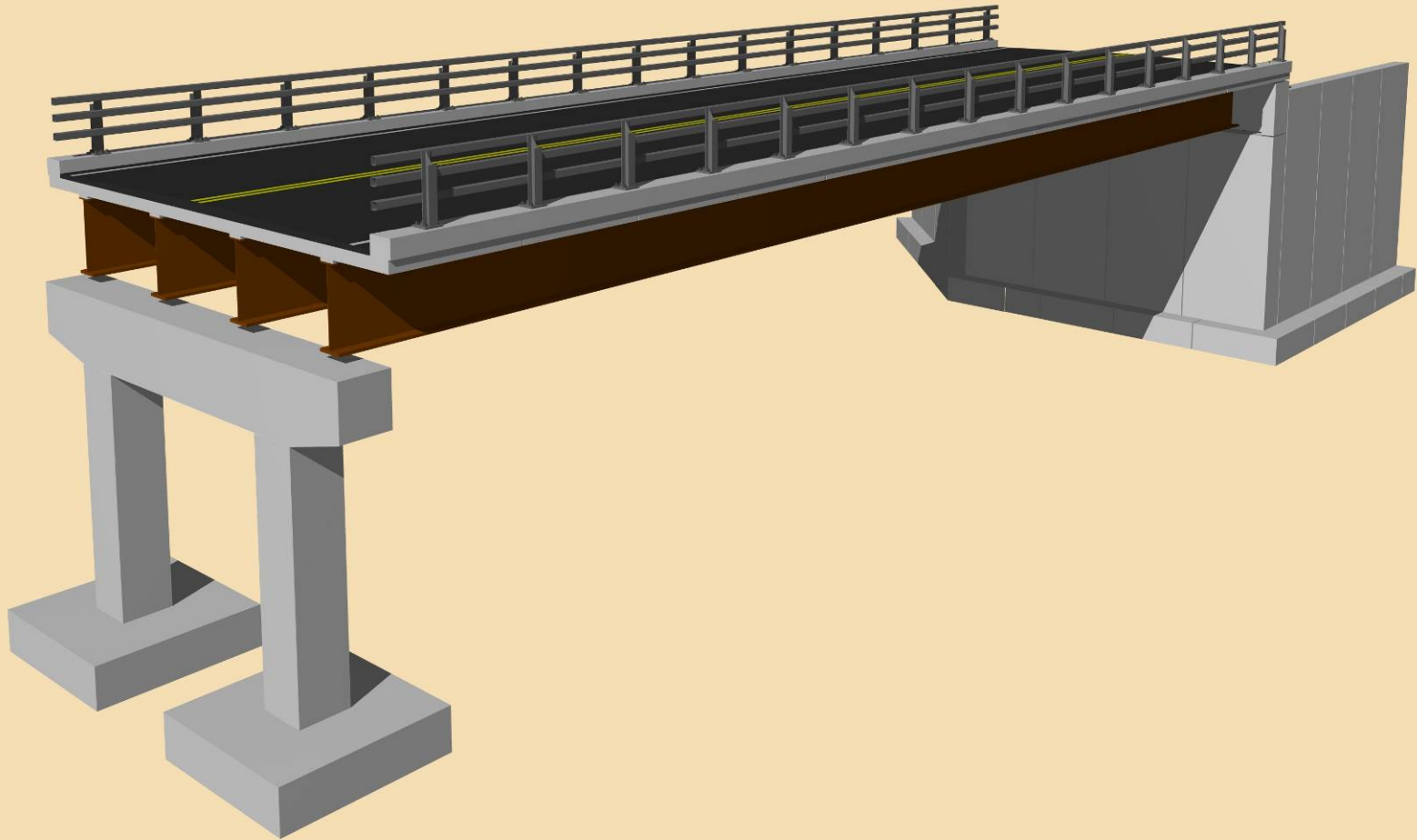
■ Slide Courtesy FHWA, IDOT ABC Workshop

Precast Decks on Steel Framing



▪ Slide Courtesy FHWA, IDOT ABC Workshop

Total Bridge Prefabrication



▪ Slide Courtesy FHWA, IDOT ABC Workshop

Innovative Contracting

- **Design Build**
- **A + B**
- **Lane Rental**

FHWA Sponsored ABC Workshops

- **These one-day events provide information on how to accelerate construction and where to find additional information on ABC**
- **FHWA has conducted ABC workshops in Rhode Island, Utah, Florida, Montana, Oregon, Alabama, Virginia, New York , Pennsylvania, and Iowa.**
- **MnDOT also held an ABC showcase in 2005 featuring the new inverted tee beam bridge**

2008 IDOT FHWA Sponsored ABC Workshop

- **Roadblocks to Accelerated Construction**
- **Examine prefabricated bridge component design details**
- **Discuss accelerated bridge construction practices in other states**
- **Workshop participants developed steps for ABC implementation to real DOT projects**

2008 IDOT FHWA Sponsored ABC Workshop

- **Roadblocks to Accelerated Construction**
 - **Need for Quality Details**
 - **Durability**
 - **Design Methodologies and Training**
 - **Construction Methodologies**

2008 IDOT FHWA Sponsored ABC Workshop

- **Examine prefabricated bridge component design details**
 - **Is the connection durable?**
 - **Has it performed well under traffic and in an exposed environment?**
 - **Gather details that have been used on ABC projects across the country**
 - **Is it cost effective and easy to construct?**

2008 IDOT FHWA Sponsored ABC Workshop

- **Examine prefabricated bridge component design details**
 - **Investigate transfer of technology from other markets into the bridge market**
 - **Parking Garages**
 - **Stadiums**
 - **Buildings**

2008 IDOT FHWA Sponsored ABC Workshop

- **Discuss accelerated bridge construction practices in other states**

Cottonwood Creek Bridge Williamson County, Texas

- Shallow depth
- Longer span
- Long detour route
- Phased replacement not feasible



Minimum On-Site Construction

- **Before road closure:**
 - **Beam, cap, and abutment fabrication**
- **After road closure:**
 - **Retaining wall construction**
 - **Demolition of existing structure**
 - **Bridge and approach construction**







UDOT 4500 South over I-215E Bridge Replacement - 2007

removal



**4-lane, 173-ft long,
1,750 ton span
installed over
weekend**

installation



**with no
Impact to
rush-hour
traffic**

UDOT 4500 South over I-215E Bridge Replacement - 2007

- **Costs:**

- Additional \$800,000 for use of SPMTs

- **Benefits:**

- I-215E closed 53 hours over a weekend
(versus 6-month conventional construction)
 - 4500 South Bridge closed 10 days
 - Delay-related user cost savings of \$4M

Robinson Road - Bridge Replacement – Boise, Idaho



- **10-27-2008 Collapse**
- **Failure unknown, currently under investigation, forensics' looking at falsework, deck forming, girder shops, and etc..**

ABC, Contractor's Perspective

- Fast track needs to be reserved for when it is needed
- If it is a new design that could be used for mass use or production pending successful testing, it needs to be communicated.
- Fast track projects can and should use incentive/damages clauses
- The fewer new operations that start on a project, the more time there is to spend refining on-going operations

▪Slide Courtesy FHWA, IDOT ABC Workshop

Lessons Learned and Best Practices

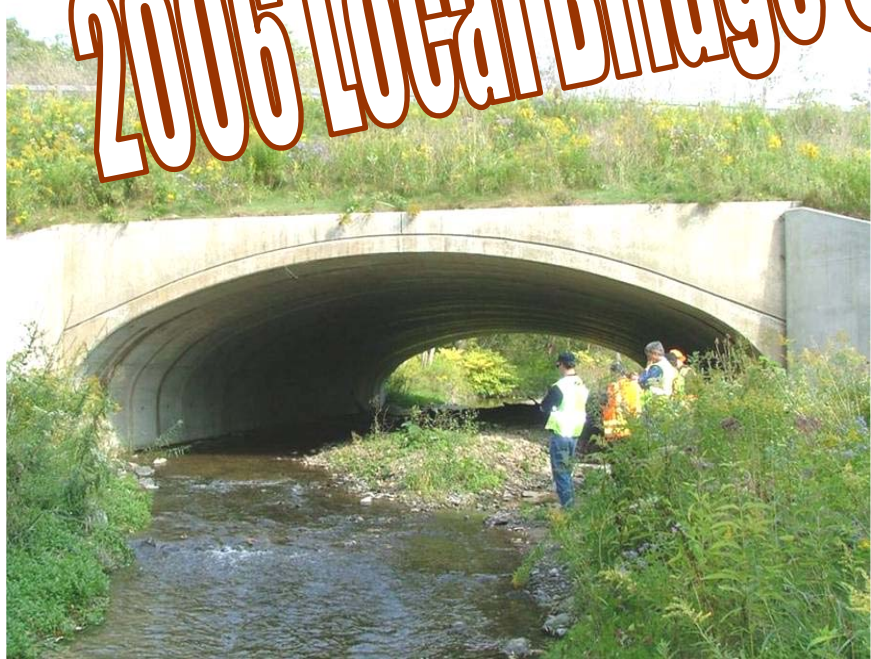
- **Identify a program of projects**
- **Perform scanning tours**
- **Get involved nationally**
- **Implement standardization**
- **Educate and communicate within the industry**

Local Bridge Innovation Across the World

- **FHWA/AASHTO 2004 International Scanning Tour on Prefabricated Bridge Elements and Systems**
 - **Netherlands**
 - **Japan**
 - **France**
 - **Germany**
 - **Belgium**
- **New York, 2006 Scanning Tour**
- **Washington, 2007 Scanning Tour**



2006 Local Bridge Scanning Tour of NY

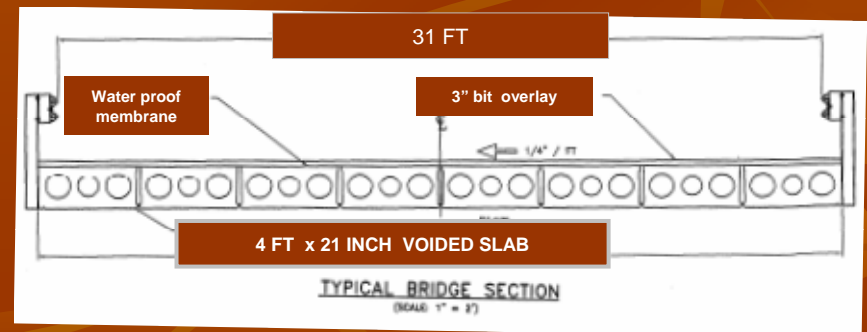


Adjacent Prestressed Concrete Beam (PCB) Units

- **General**
 - Most common bridge type in the short to medium spans
 - 3 types: solid slab, voided slab and voided box beam.
 - 4 foot wide, depths from 12 inches to 54 inches. Span range 25 feet to over 100 feet



Non Composite PCB Units, Steuben County

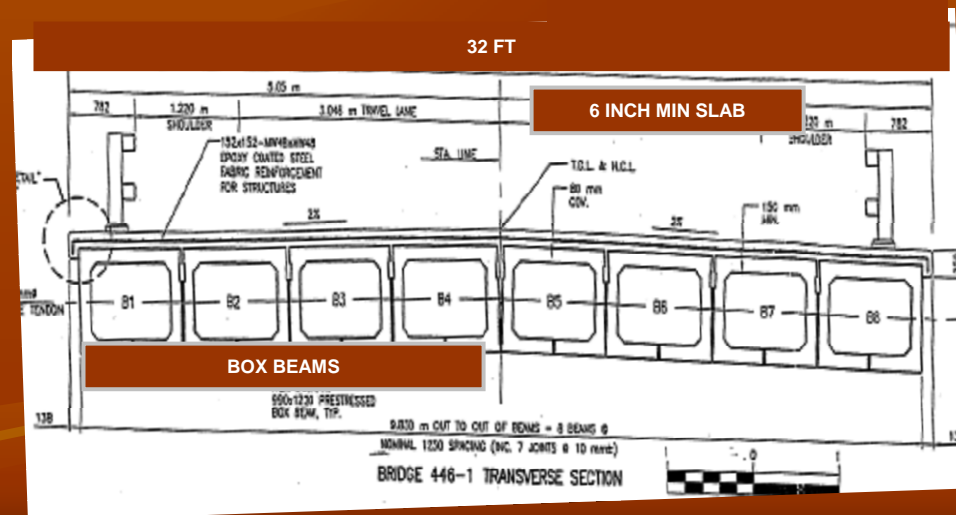


Adjacent Prestressed Concrete Beam (PCB) Units

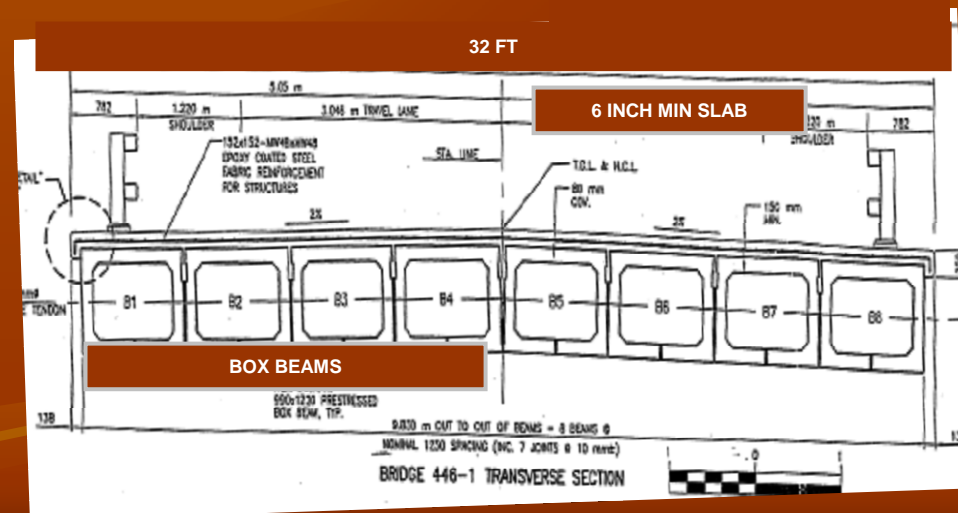
- **Advantages**
 - Continuous flat surface along the bottom
 - Shallow depth
 - No heavy false work



Composite PCB Units, Erie County



- **Advantages**
 - **Fast erection**
 - **The adjacent beam system has been around since the early 1950's**
 - **Relatively simple fabrication**



Eliminate the Slab False Work

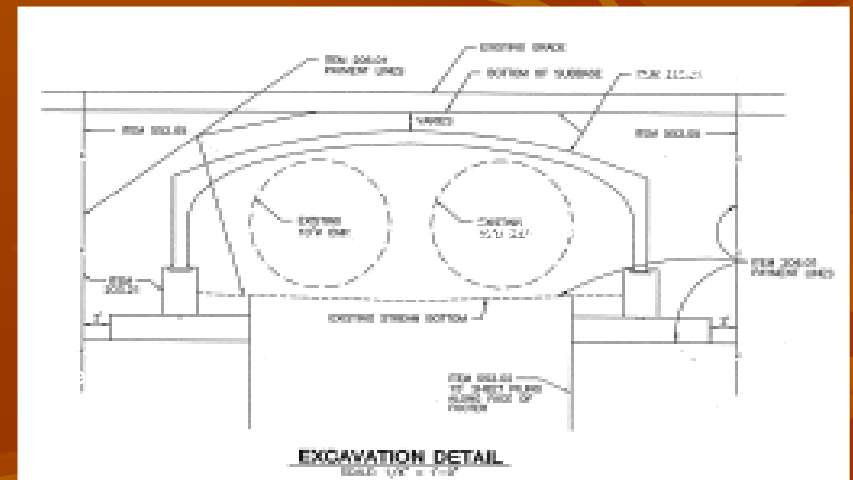


Precast Concrete 3-Sided Boxes

- **General**
 - The 3-sided box structure - local bridge of choice in NY
 - Technical memorandum on the use of 3 sided boxes



3 Sided Box, Cattaraugus County



■ General

-
- A group of people, some wearing safety vests, are standing on a concrete bridge over a river. They appear to be observing the water or the surrounding environment. The bridge has a metal railing. The river below is rocky and has some vegetation along the banks.

Metal Railings Systems

Advantages

- Allows deck drainage off the bridge without scuppers or floor drains
- Open railing increases visibility of traffic from intersecting roadways
- Helps reduce snow accumulation on bridge shoulders



4-Rail Unit, Erie County



2-Rail Unit, Cattaraugus County

Metal Railings Systems

Advantages

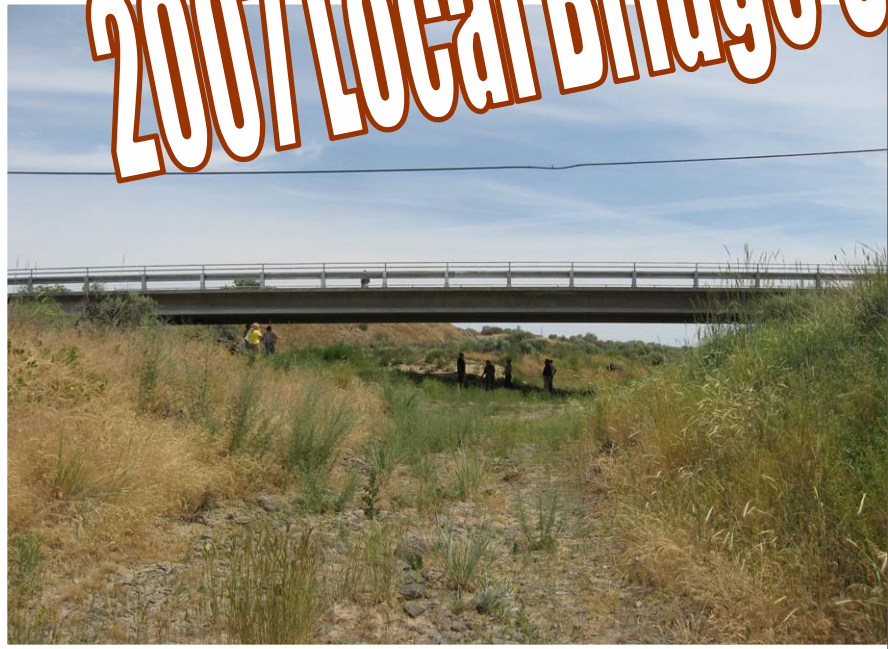
- Aesthetics, allows the view of scenic under features
- Sight distance improved on a curved bridge alignment
- Current NY/DOT standards
- TL-2, and TL-4 railing



4-Rail Unit, Erie County



2-Rail Unit, Cattaraugus County

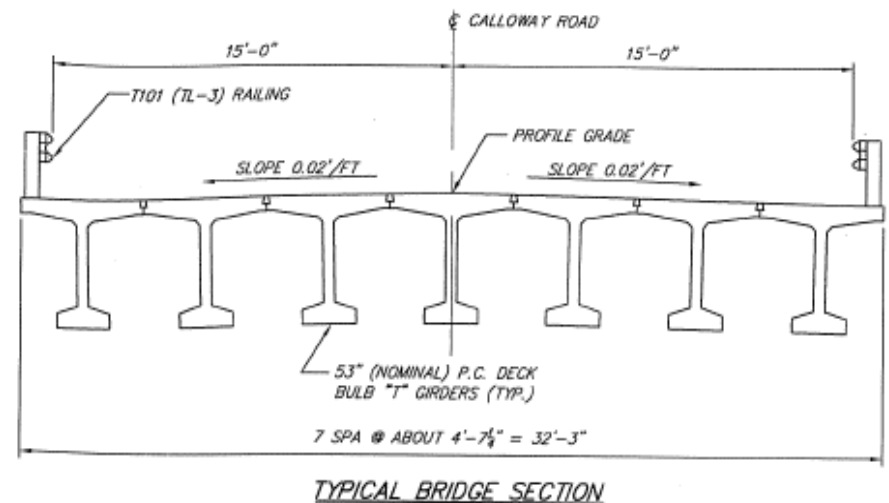


2007 Local Bridge Scanning Tour of WA

Adams Washington

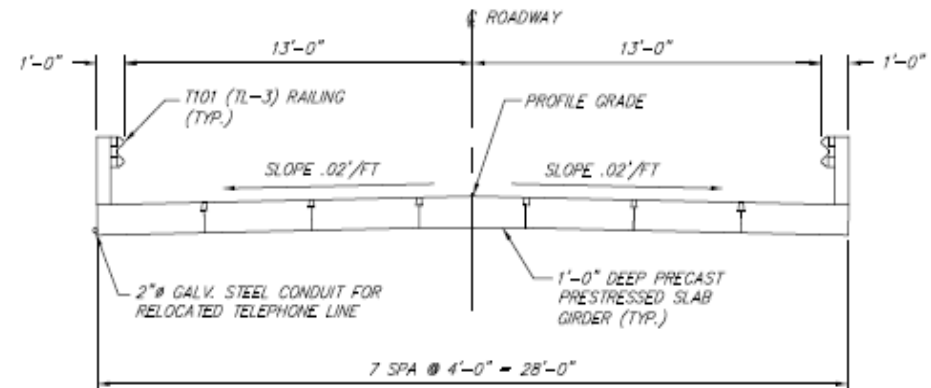
■ The Duck Pond Bridge

- The rural bridge is a 153' simple span with 55 deg skew that spans over East Low Canal
- Bridge cross section, includes two TL-3 metal traffic rails with a 30' rdwy.
- Superstructure, 53" deep X 4'-7" wide bulb tees with no overlay.



Adams Washington

- **The Leo Dyck Bridge**
 - The rural bridge is a 24' simple span that spans over Farrier Coulee Low
 - Bridge cross section, includes two TL-3 metal traffic rails with a 26' rdwy.
 - Superstructure, 12" deep X 4'-0" solid slabs with no overlay.



TYPICAL BRIDGE SECTION

LOOKING AHEAD ON STATIONING
CROWN CENTER GIRDER $\frac{1}{2}$ "

City of Twisp Washington

- **City of Twisp**
 - Small city near the foot hills of the Cascade Mountains
 - Hwy 20 over the Twisp River. This bridge is a 196' simple span using WSDOT "super girders"
 - Superstructure, 8'-0" deep post-tensioned spliced prestressed concrete girders
 - Each girder in 3 segments , 45'-101'- 45', were supported on shoring over the river



Mn/DOT

Inverted Tee Beam Bridge

- **Background/Development of System**
- **Advantages of MnDOT Precast Slab System**
- **Highlighted Projects to Date**

Background/Development of System

- **Poutre Dalle System Observed in France, 2004**
- **MnDOT Precast Slab System, 2005**



Background/Development of System

- A practical mode of construction, combining the advantages of Precast Girders + CIP Slab Span, without the falsework.



It's a fairly simple system, with many advantages.

MnDOT Precast Slab System



- Span lengths 20' to 65'
- Beam Depth:
 $(S+10)/30 \times 12$ - (4" to 6")
- Continuous for live load
- Fascia beam includes rail bars
- Generous interlocking steel
- Transverse P.T. not used

Advantages of MnDOT Precast Slab System

- **No Falsework**
- **Rapid Construction**
- **Environmental Advantages**
- **Controlled Precasting Environment Advantages**
 - Higher concrete strengths than C.I.P.
 - Factory reliability, better quality assurance.
- **Simple, Non-Specialized Construction Methods**

Inverted Tee Projects to Date

- T.H. 72 over Tamarac R. Waskish, Beltrami County, MN
- T.H. 8 over the Center Lake Channel near Center City in Chisago County.
- End Span Repair (Houston County, MN Bridge 6679)
- Br. 62049 -Larpenteur Ave. over RR (TH 280 project)



Inverted Tee Projects to Date

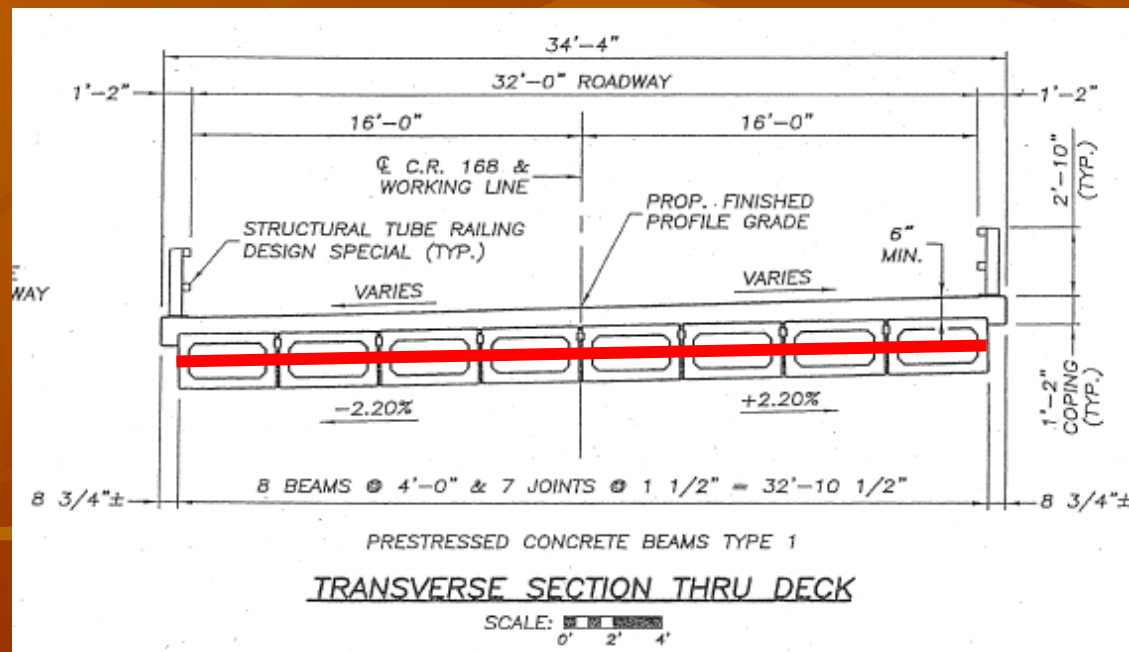
- I90 – 6 hollow Core Slab Replacements under consideration
- TH 175 – 5 superstructure replacements
- CSAH 6- West of Belle Plaine, Scott County



Construction & Cost Data

- **Total Construction Cost Data**
 - **Waskish Bridge = \$83/S.F.**
 - **Center City Bridge = \$186/S.F.**
 - **Normal Slab Span = \$80-\$85/S.F.**
 - **Ann River (Skewed), Mora = \$100/S.F.**
 - **Groundhouse River, Mora = \$95/S.F.**

MN Local Demonstration Project



Blue Earth County Box Beam Bridge

Blue Earth County Box Beam Bridge

County Road 168 over Little Cobb River

- **Development of Project**
- **Design Features**
- **Fabrication**
- **Construction**
- **Lessons Learned**
- **Cost**

Blue Earth County Box Beam Bridge

- **Development of Project**
 - **Scanning Tour of Cattaraugus County, NY**
 - **Opportunity to Demonstrate:**
 - **Adjacent Precast Units**
 - **Steel Sheet Pile Abutments**
 - **Metal Traffic Rail**
 - **Speed of Construction (30 days)**

Blue Earth County Box Beam Bridge

■ Design Features

- Span 69'-0" X 32'-0" Rdwy
- 4'-0" X 2'-3" Box Units
 - 6,000 psi concrete
 - 20 -.60" straight prestressing strands

Blue Earth County Box Beam Bridge

- **Design Features**

- **Transverse post tensioning tendons**
 - **2-.60" straight prestressing strands**
 - **Each strand post-tensioned to 43 kips**
 - **5 locations**

Blue Earth County Box Beam Bridge

- **Design Features**

- **Composite Concrete Deck**

- **6" minimum thick**

- **4000 psi concrete**

- **1 mat of reinforcement**

- **3" cover**

Blue Earth County Box Beam Bridge

- **Design Features**

- **Metal Traffic Railing**

- **WS/DOT style structural tube railing**

- **TL-2, crash tested rail for low speed roadways.**

Blue Earth County Box Beam Bridge

■ Design Features

■ Steel Sheet Pile Abutments

- Grade 50**

- Coated with epoxy paint system to
1'-6" below grade**

- Cold Rolled**

- 1/16" Sacrificial steel**

Blue Earth County Box Beam Bridge

- **Fabrication**
 - **Box Beam Units**

Blue Earth County Box Beam Bridge



Blue Earth County Box Beam Bridge



Blue Earth County Box Beam Bridge

- **Construction**
 - **Bridge Removal**
 - **Sheet Pile Abutments**
 - **Box Beams**
 - **Grouting**

Blue Earth County Box Beam Bridge

- **Construction**
 - **Bridge Removal**
 - **Sheet Pile Abutments**
 - **Box Beams**
 - **Grouting**

Blue Earth County Box Beam Bridge



- Existing Bridge - Prestressed Channel Span
- Length 50'
- Year Built 1958

Blue Earth County Box Beam Bridge

- **Construction**
 - **Bridge Removal**
 - **Sheet Pile Abutments**
 - **Box Beams**
 - **Grouting**

Blue Earth County Box Beam Bridge



Blue Earth County Box Beam Bridge



Blue Earth County Box Beam Bridge



Blue Earth County Box Beam Bridge

- **Construction**
 - **Bridge Removal**
 - **Sheet Pile Abutments**
 - **Box Beams**
 - **Grouting**

Blue Earth County Box Beam Bridge



Blue Earth County Box Beam Bridge



Blue Earth County Box Beam Bridge



Blue Earth County Box Beam Bridge

- **Construction**
 - **Bridge Removal**
 - **Sheet Pile Abutments**
 - **Box Beams**
 - **Grouting**

Blue Earth County Box Beam Bridge



Blue Earth County Box Beam Bridge



Blue Earth County Box Beam Bridge



Blue Earth County Box Beam Bridge

- **Lessons Learned to Date**
 - **Fabricate Beams w/ SCC**
 - **Use Hold-Downs for Foam Core**
 - **Consider Hot Rolled Sheet Wall**
 - **Consider Thinner Gauge Sheet Wall**
 - **2 Sections of Sheet Wall for Test Pile**

Blue Earth County Box Beam Bridge

- **Lessons Learned to Date**
 - **Address Specifications for Neoprene Gaskets**
 - **Further Develop Post-Tensioned Grout Mixes**
 - **Bolted Seat Channels**
 - **Bolted Metal Rail Fabrication on super**
 - **Explore the need for Painting Sheet Wall**

Blue Earth County Box Beam Bridge

- **Construction Cost Data**
 - **BE County's first Box Beam Bridge**
 - Entire bridge cost = \$234/S.F.
 - Entire bridge cost without metal bridge rail and metal box beam guard rail = \$183/S.F.
 - **Mn/DOT's first Inverted Tee Beam Bridge**
 - Entire bridge cost = \$186/S.F.
 - **Mn/DOT's latest Inverted Tee Beam Bridge**
 - Entire bridge cost = \$120/S.F.

Blue Earth County Box Beam Bridge

- **Construction Cost Comparisons**
 - **Sheet wall abutment approximately 30% more expensive than a conventional pile supported concrete abutment**
 - **Box beam superstructure approximately 50% more expensive than a conventional prestressed concrete beam superstructure**
 - **Metal railing \$200/L.F., typical concrete F-barrier \$58/L.F.**

Conclusions

Box Beam Bridge

- **Trend in cost escalation of steel - increased cost**
- **ABC delayed start of project by 3 months - increased cost**
- **First time local fabrication of box beams - increased cost**

Conclusions

Box Beam Bridge

- **Crucial to have good coordination between the contractor, fabricator and engineer.**
 - **Timely shop drawing approval**
 - **Timely delivery of materials**
 - **Timely construction**
 - **Quality construction**

Conclusions

Box Beam Bridge

- **Pre-plan to avoid potential cold weather to reduce cost**
- **Incorporate lessons learned to reduce cost**
- **Continued use of box beams will breed competition amongst local and regional fabricators, and will reduce cost**

Conclusions

Box Beam Bridge

- **Continued use of box beams will breed competition amongst local bridge types, and will reduce cost**
- **ABC and alternative contracting methods will serve as additional tools to deliver local bridge projects.**
- **Opportunities to use prefabricated bridges will be encouraged**



Questions?