

WisDOT Structural Engineers Symposium

Program Agenda June 7, 2016

		11:55 a.m.	Lunch
7:30 a.m. 8:00 a.m.	Registration Welcome & Secretary's Office Remarks – Mark Gottlieb, WisDOT	1:00 p.m.	South 1 st Street Bascule Bridge – Michael Delemont, AECOM
0.10	Secretary	1:25 p.m.	Construction Topics – Bill Dreher, Design Chief; Joe Balice, FHWA
8:10 a.m.	BOS Director's Perspective – Scot Becker, BOS Director		Division Bridge Engineer
8:20 a.m.	Consultant Review Topics – Najoua Ksontini, Design Supervisor; Dan Breunig, Consultant Review Engineer; Matt Allie, Hydraulic Design Engineer	2:05 p.m.	Ancillary Structures – Ben Koeppen, Maintenance Engineer; Anthony Stakston, Regional Ancillary Structure Inspection Engineer; Vu Thao, Design Engineer
9:20 a.m.		2:35 p.m.	Break (Beverages and Snacks)
9.20 a.III.	Structures Estimating — Fred Schunke, WisDOT Estimating Engineer	2:55 p.m.	Research Updates – Bill Oliva, Development Chief
9:35 a.m.	Design & Construction of Post- Tensioned Integral Pier Caps – Randy Thomas, CH2M	3:10 p.m.	Accelerated Bridge Construction – James Luebke, Development Engineer; Bill Oliva, Development Chief
10:00 a.m.	Break (Beverages and Snacks)	3:35 p.m.	Interactive Survey & Q/A
10:20 a.m.	Bridge Management – Philip	-	,
	Meinel, Development Engineer; Josh Dietsche, Development Supervisor; Bria Lange, Development Engineer	4:00 p.m.	Adjourn
10:55 a.m.	Automation, Policy, and Standards – Dave Kiekbusch, Development Supervisor; James Luebke, Development Engineer; Andrew Smith, Development Engineer		

Conference Location:
University of Wisconsin-Madison Union South
1308 West Dayton Street
Madison, WI 53715

For today's presentations, agenda, and proof of attendance, please visit:

BOS Director's Perspective

Scot Becker
Wisconsin DOT
June 7, 2016



Director's Perspective Overview

- Welcome to the 2nd Transportation Structural
 Symposium
- BOS Accomplishments / Looking Forward
- National Trends and Challenges



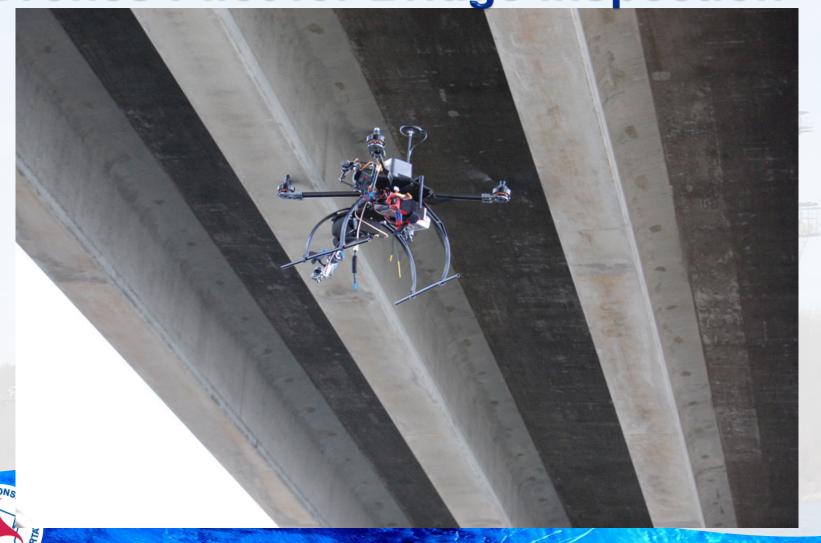
Fun Facts – The last 2 years Since our First Symposium

- How many bridges were built? Other structures?
- How many bridges were designed? Other structures?
- How many bridges were rated by BOS?
- How many bridges were inspected?





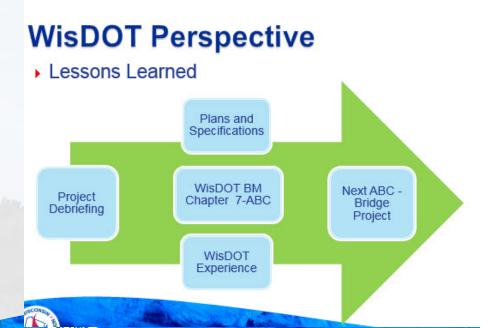
Drones Pilot for Bridge Inspection

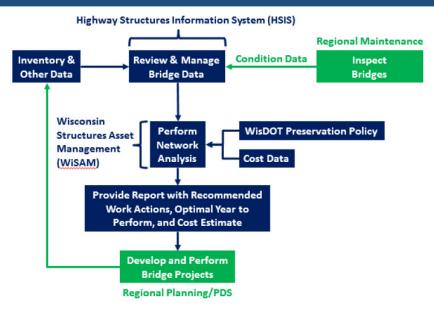


Today's Agenda

- Consultant Presentations
- Bureau Items

5- WISAMS





BOS Accomplishments - Looking Forward

- New Improved Bureau Web Site
- Bridge Aesthetics
- Fiber Reinforced Polymer (FRP) Policy
- Timeliness Initiative
- Implementation of Bridge Preservation Policy & Updated WisDOT/FHWA PM Agreement



BOS Looking Forward

- Ancillary Structures Program
- WiSAM (Wisconsin Structures Asset Management)
- Fabrication Phase II Project
- MASH Research and Implementation
- Accelerated Bridge Construction Program Development



National Trends and Challenges

- New 3 year frequency of LRFD Manual Versions with no interims
 - Wisconsin led this effort
- Interstate Truck Weight Exceptions FAST Act
- LRFD Sign Structures
- National Tunnel Inspection Program
- Bridge Information Modelling



Wisconsin Transportation Structures Program

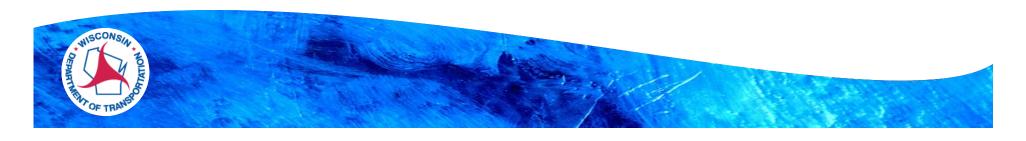
- We want your Feedback and Input
- BOS How are we doing?
- ▶ 3rd Symposium?
- Innovations?





Consultant Review Reports and Consultant Performance

Najoua Ksontini
Supervisor - Consultant Review and Hydraulics
Bureau of Structures
June 7, 2016



Goals of Presentation

- Provide an overview of some consultant review business metrics
- Discuss consultant performance and plan submittal timeliness

Consultant Review Metrics

- BOS provides reviews for all bridge, culvert, and retaining wall preliminary plans and some sign structure preliminary plans
- BOS provides QA reviews for some, not all submitted final structure plans



Consultant Review Metrics

Preliminary Plans Reviewed (Bridges and Culverts)





Consultant Review Metrics

Final Plans Reviewed

(Bridges and Culverts)





Consultant Review- Reviewers

- BOS utilizes a mix of in-house staff and consultant staff to perform preliminary and final plan reviews
- Currently BOS has seven staffing contracts providing for consultant review services on a parttime or as needed basis.
 - 3 staffing contracts for preliminary plan review services
 - 2 staffing contracts for final plan review services
 - 2 staffing contracts for sign structure plan review services



Consultant Plan Submittal Timeliness and Performance

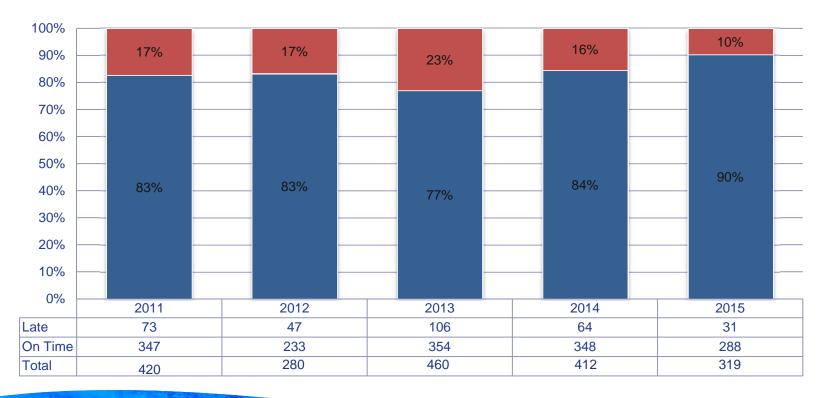
- BOS tracks and compiles consultant plan submittal timeliness and performance data
- Consultant performance data is based on the consultant evaluations completed by BOS reviewers for each preliminary and final plan review.



Plan submittal Timeliness

Preliminary Plan Submittals - On Time vs. Late*

*Late = received less than 3 months prior to PSE date





Plan submittal Timeliness

Final Plan Submittals - On Time vs. Late*

*Late = received less than 2 months prior to PSE date



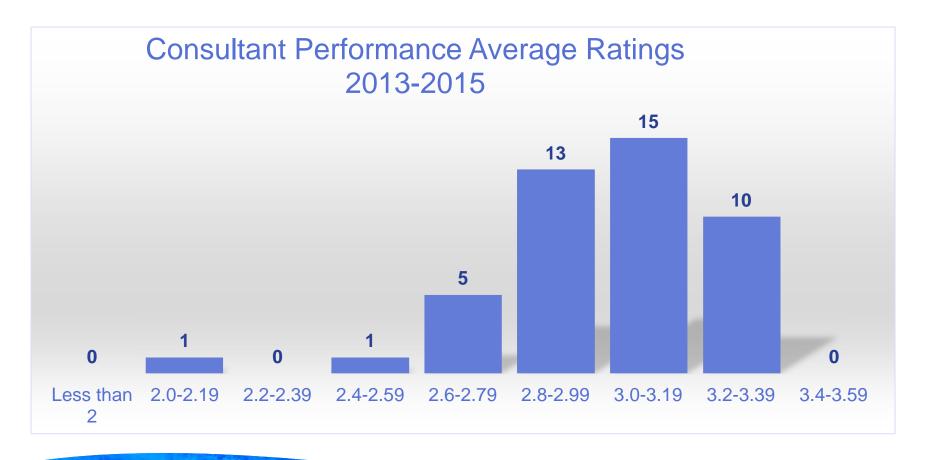


Consultant Performance Ratings

- The consultant evaluation rating uses a scale of 1 through 5, with a rating of 3 reflecting a satisfactory performance that meets expectations.
- Data from 2013 through 2015, showed BOS had completed consultant evaluation ratings for 45 consultant firms.
- The compilation of the data results in a single average rating for each of the consultant firms



Consultant Performance Ratings



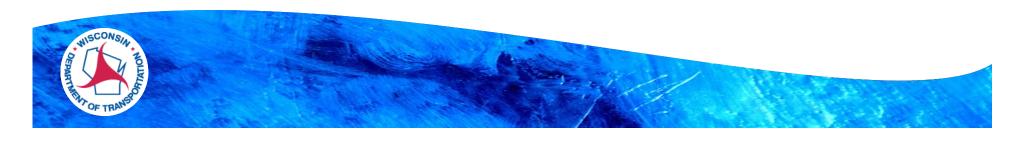


Questions?



Recent and Upcoming Changes to Consultant Review Process

Najoua Ksontini
Supervisor - Consultant Review and Hydraulics
Bureau of Structures
June 7, 2016



Goals of Presentation

- Discuss implementation of the On-Time Plan Submittal Improvement form
- Discuss upcoming improved documentation of review processes and expectations
- Discuss changes to consultant review evaluations



On-Time Plan Submittal Improvement Form

- Policy was set forth in a memo dated March 2nd, 2016.
- Form is intended to gather information about the reasons for past-deadline final structure plan submittals.
- BOS will categorize those reasons and will be able to provide suggestions to Region and consultant staff about process improvements.



On-Time Plan Submittal Improvement Form

- Form is required when:
 - Final structure plans are submitted past due date (i.e. 2month prior to PS&E date), or
 - Each time a revised final structure plan is submitted after the due date, unless the revised submittal in is response to a BOS QA review.
- Form is <u>not</u> required for structure addenda and post-let revision submittals



On-Time Plan Submittal Improvement Form

- Form is available on the BOS web site and would need to be E-submitted along with the plan submittal
- Form should include a detailed description of the reasons that caused the past due date submittal and what could have been done differently to achieve the required two-month window prior to PSE



Documentation of Review Processes and Expectations

- Several policy items related to consultant plan submittals and review processes are currently provided in BOS design policy memoranda that are found on the BOS web site
- BOS will incorporate these policies in Chapter 6 of the Bridge Manual



Documentation of Review Processes and Expectations

- The documentation in the Bridge Manual will cover:
 - Consultant preliminary structure plan submittal expectations and review process
 - Consultant final structure plan submittal expectations and review process
 - Structure plan addenda submittal expectations and process
 - Structure plan post-let revision submittal expectations and process



Consultant Evaluations

- Currently, BOS provides consultant performance evaluations for all preliminary and final plan reviews
- Evaluations are returned to design consultants and Region contacts when reviews are complete



Consultant Evaluations How are they used?

- Consultant evaluation "average scores" are incorporated by Region Project Managers or Local Program Management Consultants into the consultant contract close-out evaluation
- Consultant evaluation "average ratings" are used by BOS to develop a consultant performance ranking



Consultant Evaluation- Preliminary

Review

Project LD,		Structure:		
Highway:		County:		
Project Name:		•		
District Contact:		Region:		
Consultant				
Type of Structure:	Stream Crossing Rehabilitation	Grade Separation Retaining Wall Other		
	Ave	verage Rating		
	4 - Above Aver	nance 2— Be low Average 3 = Satisfactory rage Performance 5 = Outstanding rating system in FDM 8-25-5)		
Preliminary Submitta	d Reviewer. Hours:	r. Date:		
Completenes	ss and clearness Preliminary p	plan submittal		
 Hydrologic a 	and Hydrautic Calculations			
 Preliminary 5 	Structure selection			
4 Profiminary I	Preliminary Plan details and Engineering			
4. Helininary		for review		



Consultant Evaluation- Final Plan

Review

FINAL PLAN SUBMITTAL PORTION OF THE DESIGN CONSULTANT PERFORMANCE EVALUATION REPORT

Project LD.		Structure:
Highway:		County:
Project Name:		•
District Contact:		Region:
Consultant:		•
Type of Structure:	Stream Crossing G Rehabilitation G	rade Separation Retaining Wall ther Retaining Wall
	Average Rating	
	1 = Unacceptable Performance 2= Be 4 = Above Average Performanc (See rating system in	e 5 = Outstanding
Final Submittal	Reviewer(s):	Date:
	Hours:	
I.	Preliminary Plan Review Comments Add	inessed
2.	Bidability	
3.	Quality of Final Design Thoroughness	
4.	Constructability/Plan Detail Thoroughne	SS
5.	Completeness of Final Structures Plans S	Submittal
6.	Plan Submitted on Time – 2 Months prio (1 if not on time, 2 if with late with justif	1475
	Final Review Comments Addressed App	ropriately/Thoroughly



Consultant Evaluations-Upcoming Changes

- In the future, BOS will not provide performance evaluations for preliminary plans for "minor" rehabilitation work.
- Minor work may include polymer overlays, painting, slope repairs, etc..
- Preliminary plans for this type of work will still be reviewed and comments will be provided.
- BOS will indicate when an evaluation is not provided.



Consultant Evaluations-Upcoming Changes

In the future, average rating for final review evaluations will reflect a weighted average that places more weight on the more significant aspects of the submittal such as design and plan quality.



Contacts and resources

- Questions regarding structure plan submittals and review processes should be directed to:
 - Najoua Ksontini <u>Najoua.Ksontini@dot.wi.gov</u>
 (608) 266-2657



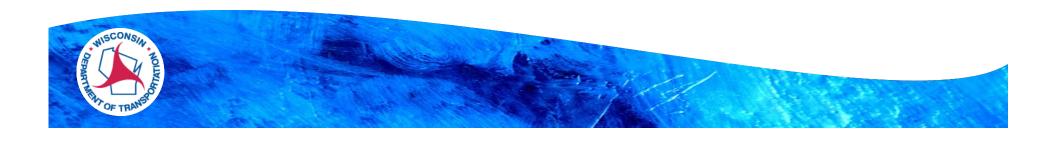


Questions?



Common BOS Review Comments

Dan Breunig
Consultant Review Engineer



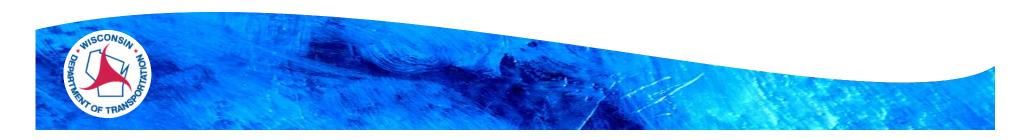
Comments largely related to detailing and constructability concerns, but design errors are important

- ▶ 80% Constructability Comments
 - Dimension errors
 - Bar steel callout errors
 - Not enough information to build
- ▶ 10% Bidability Comments
 - Incorrect bid items
 - Work detailed in plans but no bid item for work
- ▶ 10% Design Comments
 - Insufficient designs or overly conservative designs



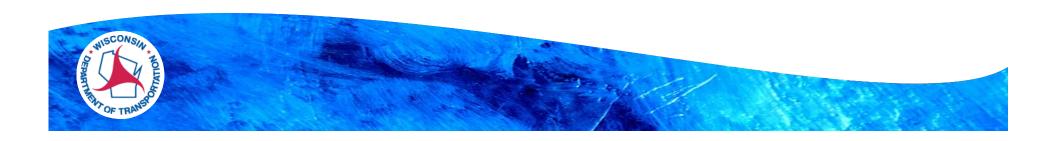
Most Common Review Comments

- Geotechnical Reports and Piling Design
 - Several examples of misunderstandings of how to interpret the geotechnical reports and translate that to a modified gates piling design.
 - Some borings are not going deep enough, and skin friction piles cannot develop enough resistance within the boring depth. Has resulted in designs with too many piles, not driven deep enough, and driven to a resistance less than the pile's maximum driving resistance.
 - Incorrect subsurface exploration border sheet.



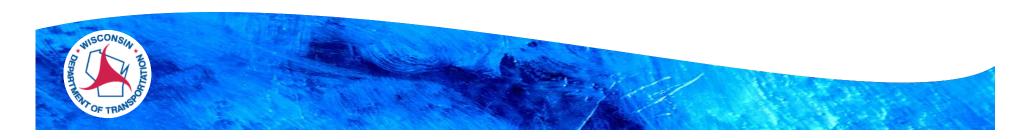
Most Common Review Comments

- Ratings Different programs, different results
 - Several different design/rating programs are used in the design community.
 - BOS has access to many of these, but uses an in-house program to actually rate structures (culverts, prestress, steel, slabs).
 - Occasionally, design changes are requested in order to satisfy BOS' in-house software.



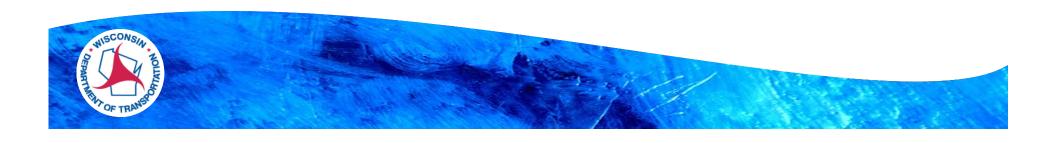
Other Common Review Comments

- Drafting Program Errors incorrect dimension scales - dimensions all off by a constant factor.
- Design computations somehow not making it through to the final plan, typically due to a drafting error or error in an automated process.
- Construction Joint Locations and Bar Couplers
 - For staged construction and widenings, it is preferable to lap transverse deck bars rather than use bar couplers.
 Saves \$\$\$ and reduces bar congestion.



SSR Training Resources

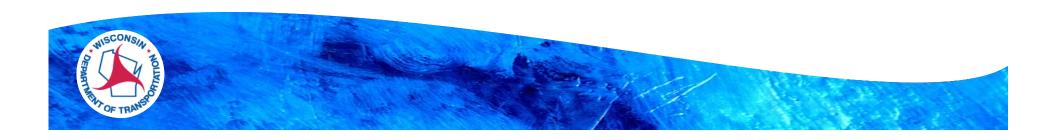
Matt Allie
Hydraulic Design Engineer
WisDOT Bureau of Structures



Outline

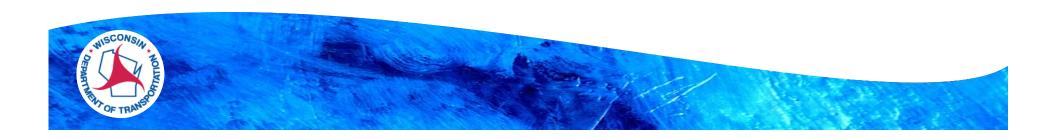
- Objective
- Background
- Resources
- Support





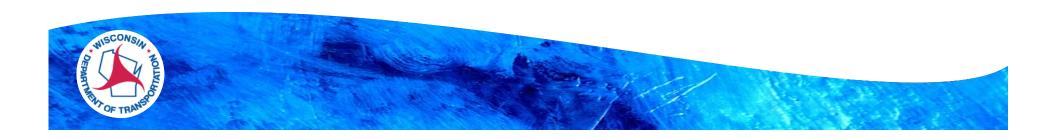
Objective

- Provide comprehensive SSR resources for:
 - Region when submitting structure for BOS design
 - Consultants when submitting preliminary structure plans for BOS review or design
- SSRs are most valuable when containing complete and accurate information

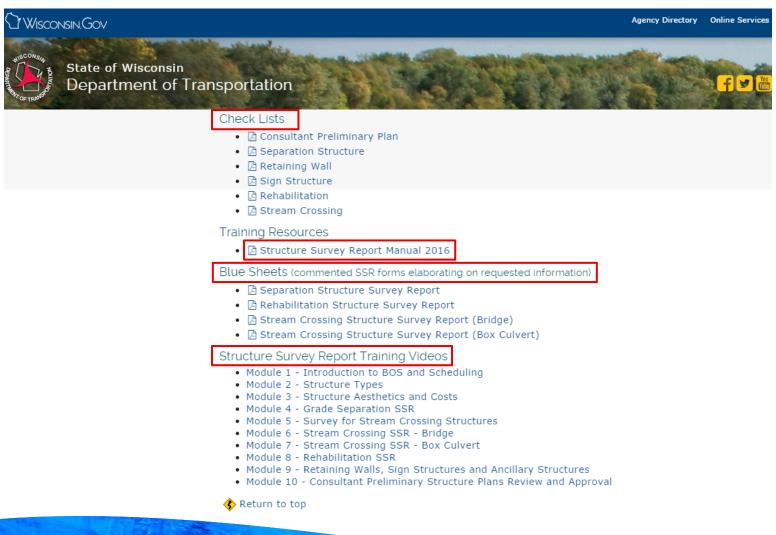


Background

- Previously, SSR training presentations given at WisDOT Region offices
- SSR forms updated in 2012
- Update and expand upon SSR training materials
- Recommended by the BOS Timeliness Initiative Final Report



Resources





Submittal Checklists

E-SUBMIT CHECKLIST CONSULTANT PRELIMINARY PLANS AND STRUCTURE SURVEY REPORT SUBMITTAL 1 STRUCTURE SURVEY REPORT ☐ Complete Structure Survey Report - SSR Workshop Manual and Videos - Bridge Manual Chapter 6.2.1 Bridge Manual Chapter 6.5 2 PRELIMINARY SUBMITTAL PDF Files: □ Project Location Map - structure location and number - other proposed structures within project limits □ Preliminary Roadway Plans - existing and proposed profile grade line - horizontal and vertical curve data (grades to nearest thousandth) - structure location, typical section, super transition locations □ Preliminary Structure Plans dimensions, plan view, elevation view, section through roadway, subsurface information ☐ Geotechnical Report - boring logs and foundation recommendations - If report is not included with submittal, state on SSR who is doing this work □ Labeled Photographs - existing structures, utilities, buildings, etc. ☐ Other Documentation - summary of design considerations and alternatives evaluated; see Bridge Manual Section 6.2.2.2 - existing and proposed contours, if available 3 ADDITIONAL SUBMITTAL FOR STREAM CROSSINGS PDF Files: - labeled contours, location of new and/or existing structure(s), proposed contours, proposed riprap limits, north arrow, stream direction and scale 1":20'. ☐ Hydraulic Report - discussion of hydraulics, nature of previous flooding, scour information, design considerations and alternatives considered; see Bridge Manual Chapter 8 Appendix 8-A, for example ☐ Hydraulic Model existing conditions and proposed conditions hydraulic model (preferably HEC-RAS); see Bridge Manual Section 8.3.2 ☐ FEMA Floodplain Map - location of structure(s) relative to any mapped floodplain ☐ DNR Initial Review Letter 4 SUBMITTAL □ E-Submit - STRUCTURE SURVEY REPORT, PRELIMINARY SUBMITTAL, ADDITIONAL SUBMITTAL (if necessary) and SUPPORTING DOCUMENTATION are submitted using the E-Submit process (as "PRELIMINARY") - E-Submit - E-Submit Help



SSR Blue Sheets

Stream Crossing	☐ Box Culvert ☐ Box Cu	lvert Extension:	Right		
Other:			Left		
For guidance see: http://dotnet	/dtid bos/extranet/structures/repo	orts-checklists.htm			
Design Project ID	Construction Project ID	Highway (Project Na	me)		
	,		,		
Final Plan Due Date	Preliminary Plan Due Date	Town Villag	e City		
PS&E Date	Letting Date	County			
New Structure Number	Existing Structure Number	Section	Town	Rang	ge
Station	Latitude:	☐YES ☐NO	Structure Located	on National Highway	y System
For Survey and CADD Files	Longitude:	_	Traffic For	ecast Data	-
Horizontal Coordinate System:			Average Daily	Roadway	
Vertical Datum: Feature On		Design Year	Traffic (ADT)	Design Speed	Functional Class
reduce on				mph	
Feature Under Waterway:		☐ Other:			
Region Contact:		Consultant Contact:			
(Area Code) Telephone Number(s):		(Area Code) Telepho	ne Number(s):		
Email:		Email:			
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SSR Training Manual

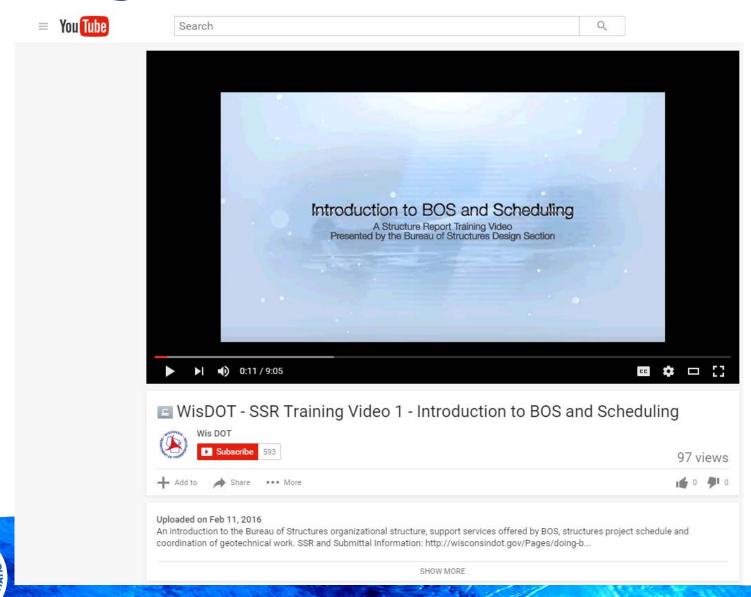
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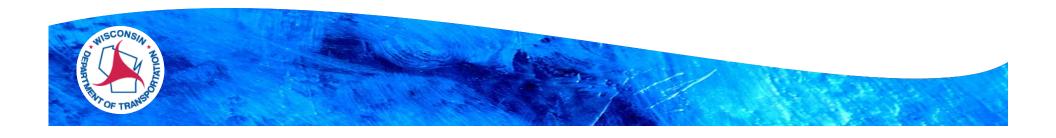


Training Videos

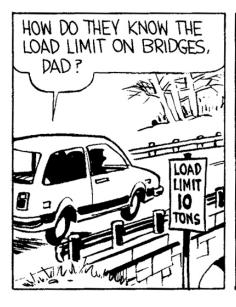


Support

- BOS continues to provide support for filling out SSR forms and using training materials
- Please direct inquiries to Najoua Ksontini
- Questions?



Cost Estimating for Structures











Estimating Engineer

- Estimating Engineer for WisDOT since January 2015
- What estimating engineer does.
 - Review estimate development processes and find ways to improve estimate accuracy.
 - Make updates to FDM 19-5 for Estimates and Estimating Page.
 - http://wisconsindot.gov/rdwy/fdm/fd-19-05.pdf
 - http://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/tools/estimating/default.aspx
 - Develop updated training materials, make presentations like this, and join any meetings when project estimates are discussed.
 - Organize and run quarterly Estimating User Group meetings.
 - Members are from Planning, Design, Program Control, and Bureau of Structures.
 - Review the bids and estimates for a Letting to prepare for the awards meeting, and reviewing estimate documentation and major items in PS&E estimates before the Letting.



Topics being Discussed

- Engineering Estimate Accuracy (EEA) Performance Measure
- Construction Cost Index
- Estimator Files
- Bid items that cause inaccurate estimates
- Mobilization
- Bascule Bridge Projects
- Lump sum bid items
- Special Provision Items (SPVs)



Engineering Estimate Accuracy (EEA) Performance Measure

- FHWA/WisDOT Stewardship Agreement (Sept 2010) goal
 - 50% of estimates should be within 10% of low bid
- WisDOT goal
 - 60% of estimates within 10% of low bid
 - 75% of estimates within 15% of low bid
 - Goals tracked in Estimate accuracy report
- WisDOT external MAPSS measurement—

http://wisconsindot.gov/Pages/about-wisdot/performance/mapss/measures/accountability/on-budget.aspx



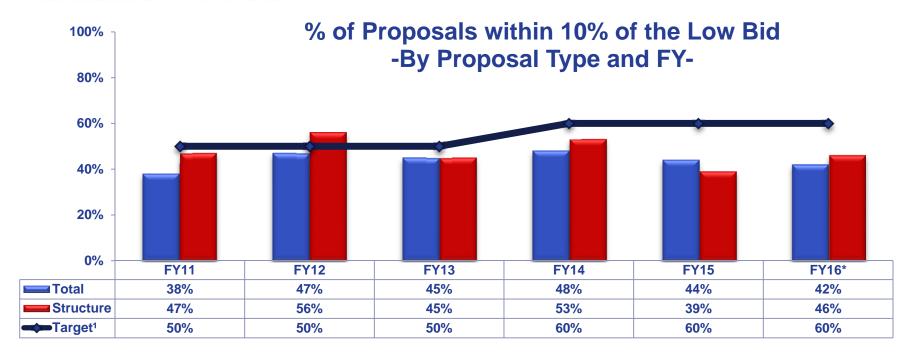
Engineering Estimate Accuracy (EEA)Performance Measure

- Estimate results for last six years
- Includes breakdown by region, number of bidders, funding category, and work type.
- Structure projects make up 30% of the entire program since 2011.
- Available on online:

http://wisconsindot.gov/Documents/doing-bus/eng-consultants/cnslt-rsrces/tools/estimating/estimate-accuracy.pdf



Bridge Project Estimateswithin 10%



^{*} Data through May 2016 Bid Letting

¹ The performance measure target was 50 percent for FY09-FY13. As part of WisDOT's continued efforts to strive for continuous improvement, the target was increased to 60 percent in FY14.



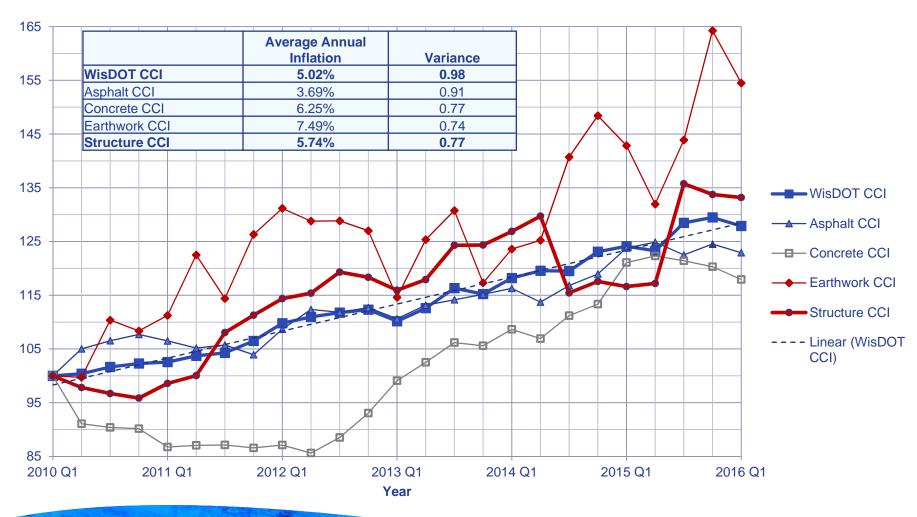
Construction Cost Index(CCI)

- The Chained Fisher Construction Cost Index
 - Accounts for changes in type and usage of items
 - Eliminates issue of updating the base period
 - Able to accommodate usage for the current year and base year
 - Performs better than fixed-weight indices when prices and quantities are volatile
- The Federal Highway Administration (FHWA) uses a Chained Fisher approach—

http://www.fhwa.dot.gov/policyinformation/nhcci.cfm



Construction Cost Index





Construction Cost Index

- The CCI does not include SPVs items.
 - If enough is spent on special provision items instead of standard items, there will be a dip in the index.
- The CCI does not include Lump Sum items such as Mobilization and Traffic Control Project.
- ▶ The WisDOT CCI is consistent with other states.



Estimator Files



- A lot of you are using Estimator for estimating your structures.
- We have made a user guide to merge Estimator files.
 - http://wisconsindot.gov/Documents/doing-bus/eng-consultants/cnslt-rsrces/tools/estimating/estimator-merge-estimates.pdf
- Recommend sharing your Estimator files with project designers along with this user guide.
 - Decrease the chances for errors from reentering items.
 - Decrease the workload with reentering items.



Bid items that cause inaccurate estimates

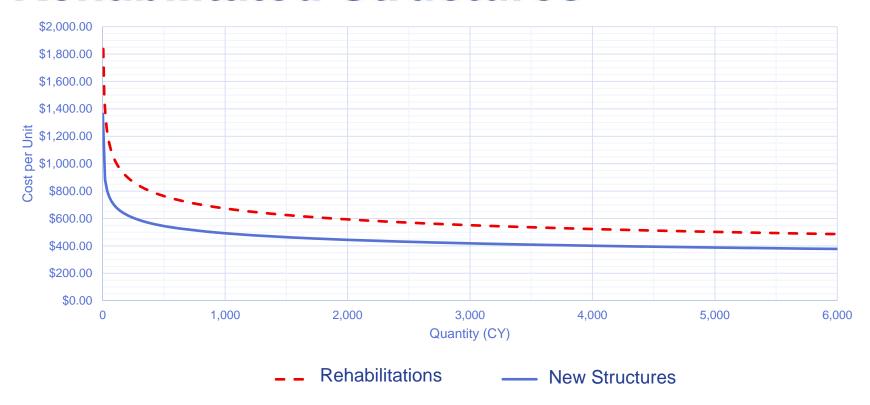
Weighted Percentage

Item Number	Item Description	1% or greater	10% or greater	Occurrences
502.0100	Concrete Masonry Bridges	59%	7%	295
203.0600.S	Removing Old Structure Over Waterway With Minimal Debris	43%	5%	182
206.1000	Excavation for Structures Bridges	15%	0%	461
203.0200	Removing Old Structure	14%	1%	463
509.2500	Concrete Masonry Overlay Decks	46%	3%	71
505.0605	Bar Steel Reinforcement HS Coated Bridges	12%	0%	258
517.1800.S	Structure Repainting Recycled Abrasive	9%	1%	77
504.0100	Concrete Masonry Culverts	25%	5%	56

Data includes July 2013 to March 2016



Concrete Masonry: New vs. Rehabilitated Structures



Includes statewide low bids of Concrete Masonry (502.0100) from January 2014 to March 2016



Concrete Masonry Bridges

- Concrete Masonry Bridges is about \$100 to \$200 more expensive on Rehabilitated Structures
 - Lower production rates (higher costs) when work is on the superstructure only.
 - Formwork may be more difficult to complete against existing beams, especially when preserving existing concrete girders.
 - Staged construction increase costs.
- Prices seem to have lowered since the cement shortage, but can vary according to contractor bidding.
 - Most recent prices show certain contractors bid around \$500/CY and others bid \$600/CY.
 - It is difficult to always know who is going to bid on your project but the large complex projects will often include Kraemer North America, Lunda and Zenith Tech.



Earthwork Items

Item	Description	Estimate	Bid	Accuracy
205.0100	Excavation Common	\$148,449,667	\$140,538,768	5%
208.0100	Borrow	\$32,900,927	\$23,043,401	30%
206.1000	Excavation for Structures Bridges (structure)	\$8,605,129	\$18,708,900	-117%
206.2000	Excavation for Structures Culverts (structure)	\$3,567,601	\$4,441,862	-25%
206.3000	Excavation for Structures Retaining Walls (structure)	\$1,508,045	\$3,218,972	-113%

Data includes July 2013 to March 2016

- Contractors will bid cubic yard earthwork items at a low cost and increase their prices for related lump sum items.
- The total amounts for earthwork is closer when total project costs are considered.
- Designers need to evaluate the total project cost and should not get worried about larger lump sum items or low bids for earthwork.
- The department has a comprehensive Unbalanced bid Analysis that is detailed in CMM 2.10.2.1
 - http://wisconsindot.gov/rdwy/cmm/cm-02-10.pdf#cm2-10.2.1



Mobilization

- Roadway Designers use a percentage of the total estimate.
 - The mobilization tool on the estimating page allows designers to get more specific percentages.
 - http://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/tools/estimating/est-tools.aspx

Structures

Type:	2011 -2015	2011	2012	2013	2014	2015
Sample Size	361	84	72	55	69	81
1 st Quartile	5.6%	5.0%	6.0%	5.7%	6.7%	6.1%
Median	7.8%	6.7%	7.5%	7.9%	8.3%	8.7%
3 rd Quartile	9.9%	8.8%	9.3%	10.6%	10.9%	10.6%
High Outlier Bound	20.8%	18.0%	17.3%	22.4%	21.0%	22.1%
Trimean	7.8%	6.8%	7.6%	8.0%	8.5%	8.5%



Mobilization

- Structure engineers typically don't dictate to the roadway designers what percentage to use.
- Could provide recommendations on projects.
 - The project designer should be made aware of project requirements that would increase mobilization costs.
- Specialty bridge projects such as bascule bridge projects, should be using higher than average mobilization prices.





- Complex Design or Construction
- Barges required
- Very large cranes required
- Tall piers
- Long girders
- Staging or number of Mobilizations
- Over freeways and railroads
- Limited work area, such as an urban environment



Bascule Bridges

 WisDOT needs to do a better job estimating these types of projects.

Proposal #	Project #	Estimate	Bid	Accuracy
20110809017	4998-02-71	\$13,299,135	\$13,477,696	1.3%
20120710015	4140-23-71	\$3,441,312	\$4,811,300	28.5%
20130611009	4065-15-71	\$5,650,016	\$4,639,146	-21.8%
20140408014	1302-00-71	\$1,303,408	\$1,367,058	4.7%
20150512040	4990-03-71	\$1,377,089	\$1,534,911	10.3%
20150714022	9995-03-60	\$1,751,571	\$2,808,515	37.6%
20150811009	4140-20-74	\$2,367,450	\$3,616,663	34.5%
20160510027	9210-17-60	\$1,140,848	\$1,750,825	34.8%



Bascule Bridges

- BPD has started to look into these types of projects more closely.
- WisDOT needs to monitor the number of bascule bridge projects each year.
 - There are only a few contractors for this type of work.
- Industry has stated that the provisions for these specialty bridges are so stringent, that the cost of the items continue to rise.



Lump Sum Items

- Many of the following points come directly out of AASHTO: Practical Guide to Cost Estimating.
 - https://bookstore.transportation.org/collection_detail.aspx?ID=122
- Lump sum items should only be used when an item of work can be easily defined but not all the components or details can be clearly determined.
- The more breakdown of a lump-sum item there is, the greater the likelihood that an accurate lump-sum estimate can be developed.
 - Easier to verify estimate prices with similar items.
 - Use units that reduce risk from the contractor.



Lump Sum Items

- Using lump-sum items typically transfers the unknowns to the contractor.
 - Girder Surface Repair in linear feet or square instead of each unit. Contractor is then paid for work completed instead of bidding higher price when amount of repair is not
- We need to do a better job of balancing risk between the contractor and the DOT.
 - Risk = Cost
 - Try not to be prescriptive for the means of construction and materials.
 Specify the requirements for the final item.
- Most lump-sum items are very different from one project to another. Using past bid history is often not a good indicator for future bid price of lump-sum items.



Why we should avoid SPVs

- ▶ Bid history is difficult to obtain. Estimate prices are less accurate.
- Contractors have to interpret the SPVs, increasing risk and cost.
- Non-standard items may be in short supply and are more expensive.
- Old special provision items may not reflect changes to General Requirements in the Standard Specifications.
- New special provision items may not have been approved by tech committees.
- WisDOT spends about 25% of its program on special provision items and that is too much.



Why we should avoid SPVs

- If the result for a task is the same for an SPV and a standard bid item, then use the standard bid item.
 - The bid item is consistent for all projects.
 - Bid history is much easier to find.
 - Experience with common items reduces costs and risk.
 - Standard bid items are more available.
- If you must use an SPV, use SPV libraries maintained by the Bureau of Structures.



Feel free to contact us with your ideas to improve WisDOT Estimates. Thank You!

Fred Schunke, PE

Estimate Engineer

Phone: (608) 266-9626

Scott Lawry, PE

Proposal Mngmt. Chief

Phone: (608) 266-3721

Website:

WisDOT Employees -

http://dotnet/consultants/estimates/index.shtm

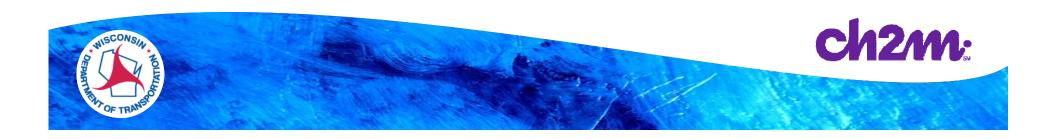
Consultant -

https://trust.dot.state.wi.us/extntgtwy/consultants/estimates/index.shtm



Design and Construction of Post-Tensioned Integral Pier Caps

Randy Thomas, PE Senior Structural Engineer CH2M



Learning Outcomes

Today's talk is on the design and construction of posttensioned concrete integral pier caps used for steel Igirder bridges on the Zoo IC Project. At the end of the session, you will be familiar with:

- Fundamental design parameters
- Benefits of a collaborative design approach
- Design and detailing considerations affecting constructability and quality of finished product





Presentation Outline

- Introduction
- Case Study:Zoo IC Project
- Design & Detailing Considerations
- Closing
- Questions





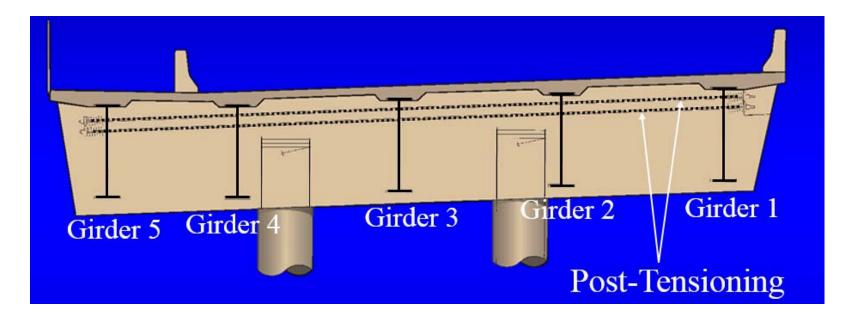


Introduction



Definition of Integral Pier Cap

- Cap resides entirely or mostly within the depth of the girder framing
- Integrally connected into girder framing system
- Can be any material (steel, concrete, PT concrete)







Why consider an integral pier cap?

- If site geometry is restrictive
 - Clear span prohibitively long/expensive
 - Pier cap overhangs roadway
 - Project economics and/or roadway geometrics favor a shallow superstructure
- Eliminate joints & bearings
 - As compared to using an inverted Tee Pier
- Common applications
 - Heavily skewed ramps
 - Low level viaducts





Integral Cap Type Selection

- Steel
 - Box beam likely required complicated connections
 - Non-redundant for NBIS condition inspections
- Mildly Reinforced Concrete
 - Concern for cracking and corrosion
 - Tends to sag over time (creep)
- Post-Tensioned Concrete
 - Internally redundant
 - Small deflections / no sag
 - Clean look, similar to adjacent conventional piers
 - Concern for corrosion of hidden elements can be mitigated through proper detailing



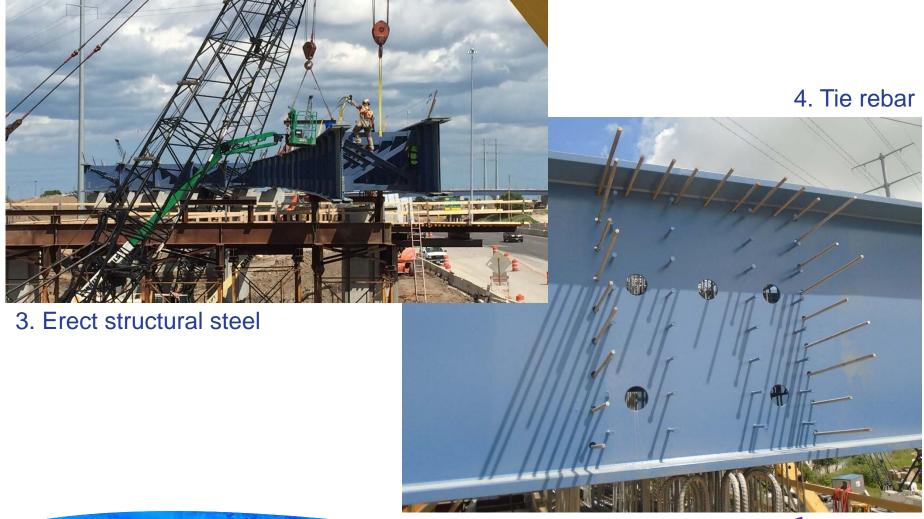




1. Form, pour, and strip columns









5. Place ducts





6. Set side forms

8. Strip forms



7. Pour concrete



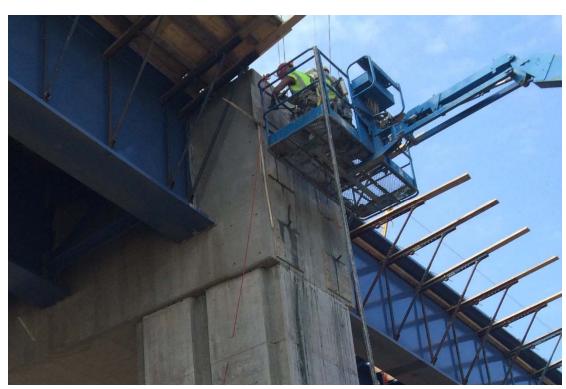


10. Jack strand





12. Pour deck and parapet



11. Grout tendons and cast pour-backs







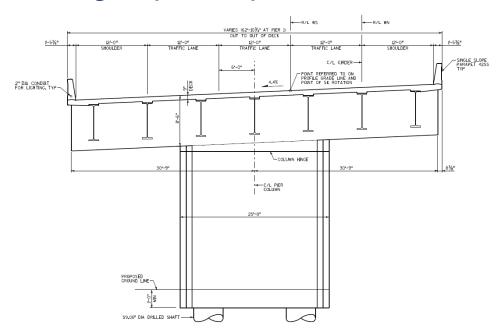
Case Study: Zoo IC Project





Zoo Interchange Project

- 2 Steel I-girder bridges with integral pier caps
- 2 designers
 - BOS
 - CH2M
- 2 construction lets
 - Zoo Core1 FPSE May 2014
 - Zoo Core2 FPSE May 2015
- 2 design schedules
 - Prelim: Concurrent
 - Final: Staggered



INTEGRAL HAMMER HEAD PIER
SHOWN AT PIER 1 PIER 3 SIMILAR





Bridge B-40-852 (SW Ramp)

- ▶ 3-lane, 3-span, 550-ft long
- ▶ 1900-ft radius curve
- ▶ 84-in webs
- 1 straddle pier
- Designed by BOS







Bridge B-40-787 (WN/WS Gore)

- 3-lane, 5-span, 750-ft long,1450-ft radius curve, tapered
- ▶ 1 straddle pier, 2 hammerheads, 69-in webs
- Designed by CH2M as part of Forward 45







Zoo IC – Design Schedule

- The Zoo structures design team recognized the potential for collaborative design early in the process
- Preliminary Plans (Jan 2013)
 - Integral cap locations identified, specifics TBD
- Design Workshop (May 2013)
 - Review example CH2M designs
 - Establish design criteria, fundamental design decisions, design methodology/tools
- Final Plans Esubmit staggered by 1 year
 - B-40-852: Feb 2014 (May 2014 FPSE)
 - B-40-787: Feb 2015 (May 2015 FPSE)





Facilitating Collaborative Design

- Forward 45 advanced the final design of B-40-787 PT integral straddle pier, to match B-40-852 schedule and capture synergies
- Design teams co-located at Barstow project office in Waukesha
- Over-the-shoulder reviews
 - No direct responsibility for checking each other's work
 - Provide opinion/advice
 - Identify common or similar elements of design
 - Adopt consistent design approach (evolves over time)
 - Trouble shoot together





Benefits of Collaborative Design

- Design Efficiencies 2 birds with 1(+) stone
 - Selection of analysis tools
 - Approach to detailing
 - Special provisions
- "Incidental" Quality Control
 - 2 design teams offer a degree of independent thought
 - Qualitative comparisons Why are things different?
 - Quantitative comparisons proportional gut check on size, qtys
- Consistency
 - End products look very similar (uniformity within interchange)
- Constructability
 - Lessons learned during bidding/construction of 1st bridge can be applied to 2nd bridge in real time





Fundamental Design Parameters

- Prestress Type
 - HS Bars: good for short, straight tendons; lower PS losses; shallow blockout
 - HS Strand: higher capacity; easy to curve tendons; higher PS losses; deeper blockout
- Depth of Cap
 - Aesthetics, structural depth, tendon pathways
- Articulation
 - Bearings, hinges, pins?
 - Accommodate PT shortening, cap torsion
- Design Methodology/Tools
- Corrosion Protection Measures





Outcomes of Design Workshop

- PS Type: TBD during final design case-by-case
- Increase vertical clearance to 17'-0" (normally 16'-9")
 - Protect against vehicle collision/repairs
- Articulation
 - Straddle: Use pin detail (rebar cluster)
 - Hammerhead: Use hinge detail (rebar row)
 - Rotational release alleviates constraint forces
- Analysis platform: 3D FEM (LARSA 4D)
 - Irregular geometry; integral framing; staging analysis; timedependent material effects
- Design PT for zero tension (AASHTO allows LL tension)
 - Section remains uncracked; more difficult for salt to penetrate
 - Keep cap "clamped" tightly at girder/cap interface





Corrosion Protection Measures

- Cap replacement would require major construction
 - Severe traffic impacts
 - Expensive
- Pier Cap
 - Stainless steel rebar
- PT Anchorage
 - Galvanized or plastic fittings
 - Grouted anchor end caps
 - Pour-back
 - Exterior surface protection
- Girders
 - Zinc Metalized
- Exposed to salt spray







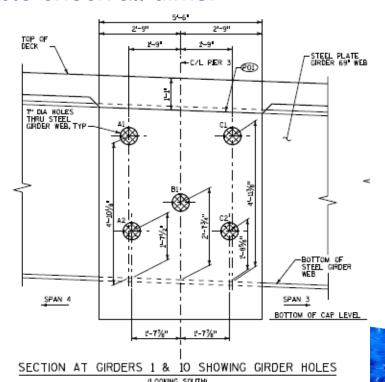


Holes thru girder webs

Lesson Learned: Leave ample room for construction tolerance

(7" hole for 4" or 5" duct) (1 7/8" hole for #6 rebar)

 Offsets unique for each girder -Double check all dims!

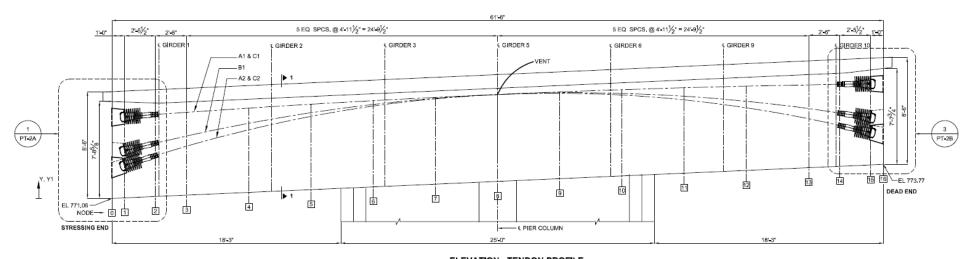








- Duct layout dimensions
 - Clearly distinguish between CL duct and c.g. strand (vertical offset)
 - Craft labor will measure from bottom cap
 form to bottom of duct, in fractional inches. Requires clear
 communication between design, fabrication & construction.



ELEVATION - TENDON PROFILE

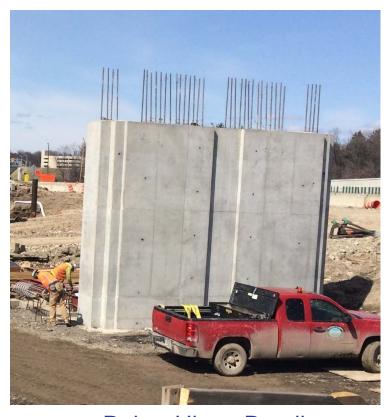




DUCT

LOW POINT

Cap connection to columns



Rebar Hinge Detail



Rebar Pin Detail





- End Anchorages
 - Ensure adequate real estate for anchor hardware and rebar spiral
 - Ensure shape of jacking pockets provides adequate room for common jacks









- Recommend locating X-frames 10' from face of cap
 - Provides room for formwork
 - Avoids large stresses in x-frames and/or lateral flange bending due to PT shortening (we want PT force in the cap, not the steel)







Feedback from Construction Eng

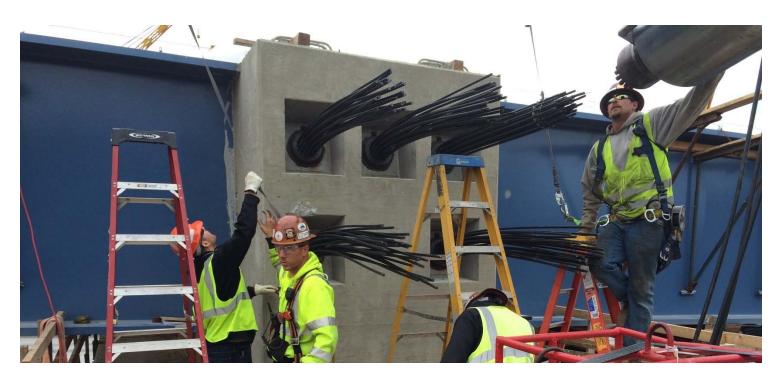
- Concrete Mix for Pier Cap dense reinforcement
 - Use 6" to 8" slump and ¾" max aggregate
 - Consider requiring super-plasticizer
- PT duct splices
 - Spec should specify heat shrink seal (don't want duct tape!)





Feedback from Construction Eng

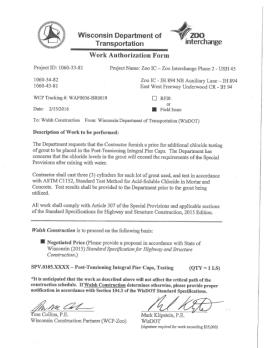
- Qualifications for supervisor of stressing operations
 - Spec is not clear how the qualifications of the "qualified individual" will be assessed/approved; suggest requiring PTI certification





Feedback from Construction Eng

- Surface treatment on pour backs
 - Suggest using a stainable or custom pigmented sealing product over the non-shrink grout
- Duct Grout
 - Include testing for chloride levels (ASTM C1152)
 - Consider adding specific content requirements for the contractor's Grouting Plan







Closing



Parting Thoughts

- ▶ B-40-787 is currently under construction. Despite its complex geometry, parts are fitting together nicely.
- A collaborative approach can contribute to higher quality, more efficient designs.
- Feedback from the field is essential for improved designs moving forward.





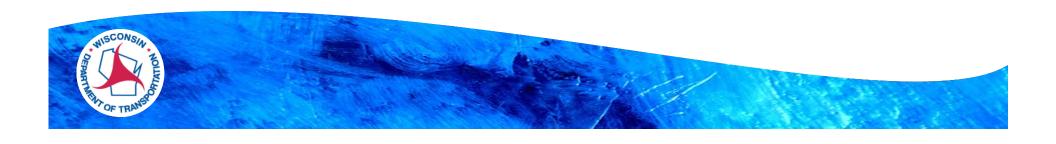
Questions



Wisconsin Structures Asset Management System (WiSAMS)

Philip Meinel

Structures Asset Management Engineer
BOS – Development – Bridge Management Unit

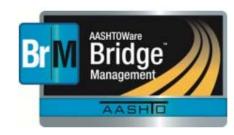


Bridge Management History

- National issue
 - Early 1990s







- Goals:
 - Database for inventory and inspection data
 - Deterioration modeling
 - Network-level asset management/planning



Bridge Management History

"Pooled-fund" software



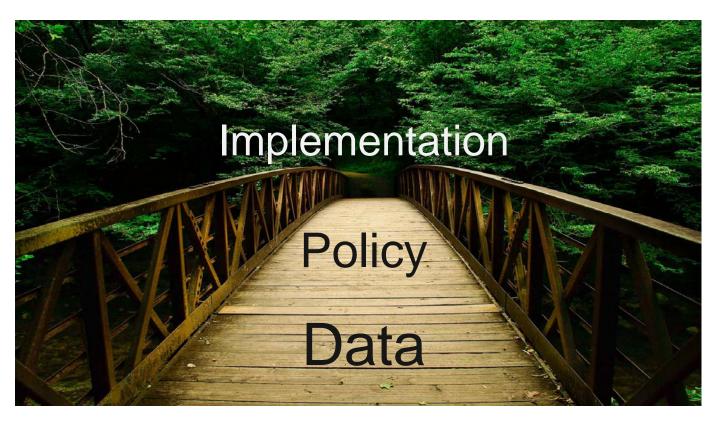


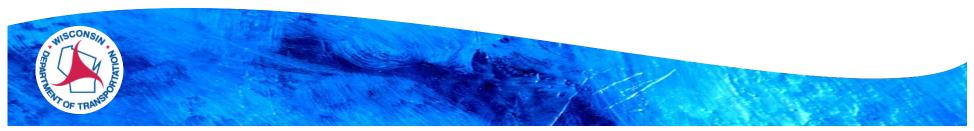
- Pros: Collaboration, eliminate duplication of effort
- Cons: Can be slow developing...hard to please everyone

- WisDOT moves forward in parallel with BrM
 - HSIS database 2003
 - WiSAMS planning tool 2015



Structure Asset Management





Structure Asset Management

Implementation

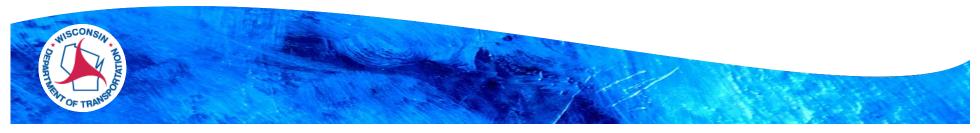
• Wisconsin Structures Asset Management System (WiSAMS)

Policy – WisDOT Bridge Preservation Policy

• Bridge Preservation Policy Guide

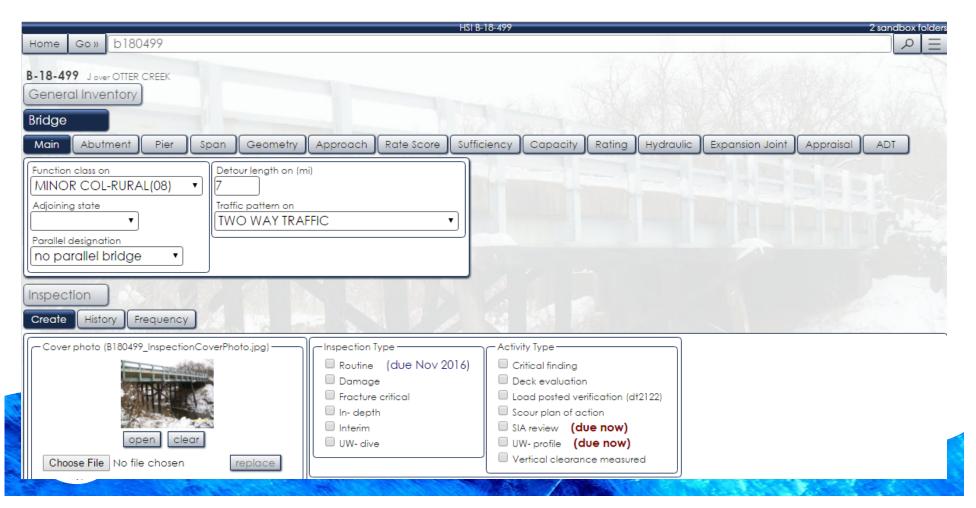
Inventory and Condition Data

Highway Structure Information System (HSIS)



HSI Database

Major upgrade 2014



HSI Database

- Strive for accuracy
 - Inspections
 - Structure Inventory Data forms

STATE OF WISC	OF TRANSP	ortation n Report fo	or		
STH 13/16/23-BF		ST over WISC 03,2016	ONSIN RIVE	R 16	
Туре			Prior	Frequency (mos)	Performed
Routine			04-02-14	24	
Fracture Critical			04-02-14	24	
Interim				0	X
Uw-Dive			09-18-13	60	
Deck Evaluation			02-03-16	0	X
Uw-Profile			10-24-12	60	
SI&A			05-07-12	48	
Latitude 43°37'40.09"N		Owner	STATE HIGHWA	V DEDT	
Longitude 80°46'43.65"W			STATE HIGHWA		
30 TO TO.OC TY		_	O.METHORN		
Time Log	Team memb	ers			
Hours Minutes	AECOM				
1 0					
Name	Number	Signature			Date
Inspector	Number	orginature			Date
Katzner, Steven D	1011	Completed by HSIS	vstem Account/HSD		1
Reviewer		Sumposed by Horo	y stem - section (rion)		
	_			11-	

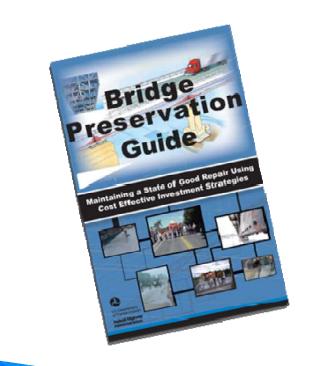
TO: FROM		EVELOPMENT SECTION						()	(2014)
		ntory Data (Complete all o			plete	only chang	ed DATA fo	or Rehab.)	
STRU	UCTURE NO.	Municipality	Section	Town		Range	Maintaining	g A gency	Owner
Repla	aced Structure No.	Historical Sig. 5	Latitude	Longitud	e		10-State 30-County	40-Town 41-City	42-Vil
	ABUTMENT DA	<u>TA</u>		G. B.					
1.	Abutment Type Sill, Rect.	☐ Full Retaining		CAPAC	CITY	DATA			
	Sill, Rect., Semi	Exp. Pile Encased		32.	Desig	gn HS/HL_			
2	Semi Retaining Pile Type	Other		33. 34.		ntory HS /RI			
2.	☐ Timber ☐ 5	Steel Cast in Place		34. 35.		ating HS/RF Veh. Wt.	250 Kips		Kips
3.	Pile Size			36.	Load	Rating Basi	s - LFR/LRF	R (Check On	
	□ 8" □ 12" □ 1	10" or 10 3/4" Other		37.	Load	Governing	Member		
4.	Slope Protection Typ				H	Deck Girder Other	Slab		
	Rip Rap	Heavy Rip Rap	•	38.			n Concre	te	Bituminous
	Asphalt over Stor	ne Solid Concrete					Other		
5.	Rdwy, Width	_ ft. (Face to face of curb or	rail)	39.		Membrane Surface	Yes Concr		one ituminous
6.	Deck Width	_ ft. (Outside edge to outsid	e edge of		LECK	Stirrace	Conce	ene 🗀	ituminious
	concrete.)				HYL	DRAULIC	DATA		
7.A	Wing Type Parallel to Rdwy.	Skewed-							
	Perpendicular to	Rdwy.		40. 41.	Desig	gn Flood Fre	quency		yrs.
.B	Applicable for INTI	EGRAL WINGS		41. 42.	Max	gn Discharge Velocity	·		cu-ft/sec.
	South or West Direct			43.	Drain	nage Area			sq. miles
	Wing1 - Length Wing2 - Length		ft e	44.	High	Water Elev.			ft.
	Wings - Longit	.tt. rringr-rangemen		45. 46.	Scou	r Critical Co	de		NO
	GEOMETRIC DA	ATA		40.	Scou	r Calculated	? YES	ш	NO
8.	Structure Length_ Along Rdwy, Centerl	ft (Back to Back line)	Abuts.		STR	UCTURE	SERVICE	DATA	
9. 0.	No. Lanes On No. Lanes Under			47.		On Detour			mile
1.	L. Sdk. Width On	ft		40			our Length		mile
2.	R. Sdk. Width On	ft.		48.		Service On	RR 🗆	Dedactrian	
3.	Median Type				H c	ngnway L Other	_ KK	Petersuran	
4.	Median Width Skew Angle	ft. Deg.		49.	Type	Service Une	der		
6.	Direction Skew Angl	e: None Left	Right			lighway Vaterway	Ļ	RR Bike Trai	
7.	Horizontal Curve	Radius, ft.	reign.			Vaterway Other	L	Bike Trai	1
8.	DirHor. Curve:	Left Right	C			Aut.			
9.	of abutments along si	Met (Y if over 20') between t kew ☐ Yes ☐ No	ront taces		PLA	NNING D	ATA		
	APPROACH DAT	ГА		50	Thomas	" and Classic	C 6 O		
20.	App. Pavement Widt	h ft.		50. 51			fication On _ fication Unde	r	
11.	Rt. Shoulder Width	ft.		21	I une	dolar Casso	IRanon Com		
2.	Left Shoulder Width Total Width (Sum Al	bove) ft.			Inters	state Rural (1) I	nterstate Urb	an (11)
24.	Guardrail Terminatio	n: Y			Other	r Art-Rural (2) (Other ArtUr	ban (14)
25.	Guardrail Adequacy:	Y		52	Traff	l-Rurai (9) ic On:	¬ None □	1-Way	(19) 2-Way
16.	Railing Attachment T	Type: 5-7/8" Bolts		53	Traffi	ic Under:	2) C	1-Way	2-Way
27.	Other Rail Design Year-190	65 AASHTO							
28.	Left Outer Railing Ty								
29.	Right Outer Railing	Type							
80.	Left Inner Railing Ty	pe							
31.	Right Inner Railing T								
	Conc. LF (91) C Type M (93) C	Other							



Policy

- FHWA and MAP-21
 - No more Sufficiency Rating (SR) driven program
 - Emphasis on justification for infrastructure investment
 - Data- and performancedriven goals and approach

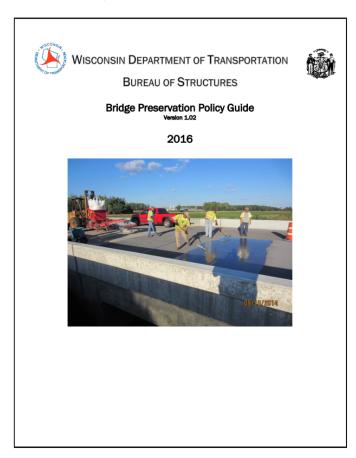






Policy

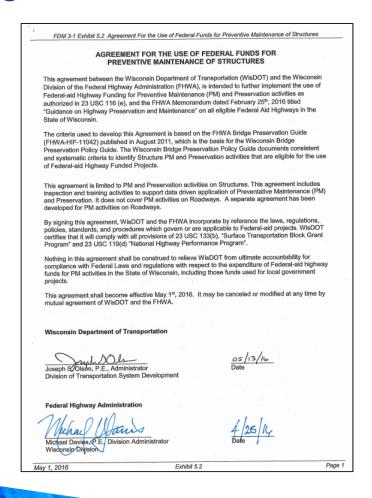
- WisDOT Bridge Preservation Policy Guide
 - First draft 2015
 - Bridge MaintenanceEngineering Judgement& Research
 - Maximize the useful life of bridges in a costeffective way





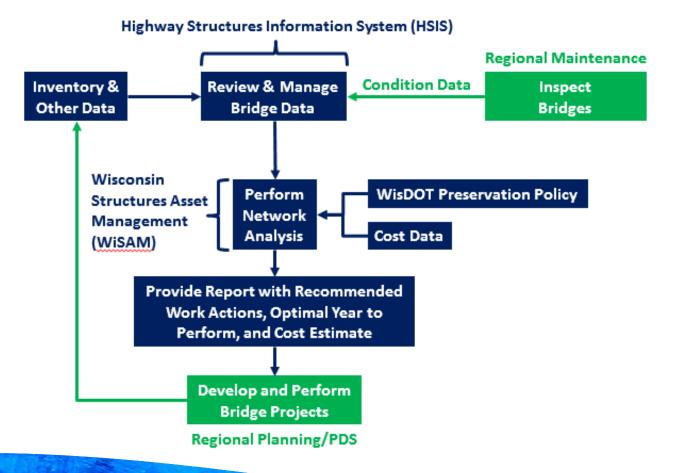
Policy

- Preventative Maintenance Agreement
 - Updated in 2016
 - Establishes which maintenance activities are eligible for federal funding
 - More work types are eligible for federal funding





Implementation





Implementation

- WiSAMS Wisconsin Structures Asset Management System
 - Systematic network-level analysis
 - Planning tool

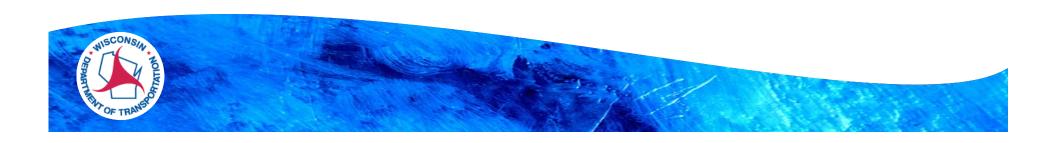








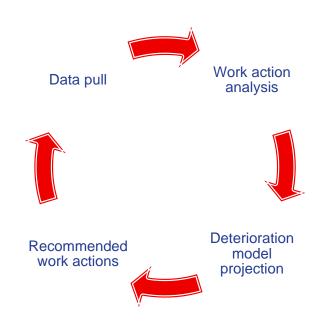
- Where is it at?
 - Coordination and main development in 2015
 - Draft reports released to regions in April 2016
 - Production version of reports to be released July 2016
 - Exciting list of future refinements and new possibilities







- How does it work?
 - Data pull
 - Work action analysis
 - Deterioration model projection
 - Recommended work actions

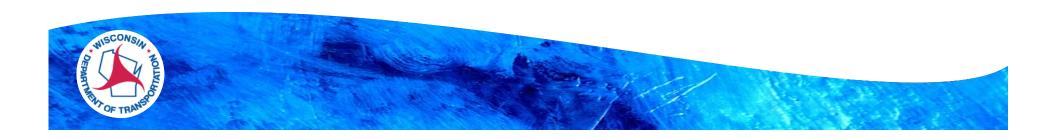








- How does it work?
 - Rule 4
 - If Substructure NBI < 3, and
 - Deck NBI < 3
 - Then, Replace Structure
 - Rules increase in complexity as program runs through the rule sequence (currently about 60 rules)

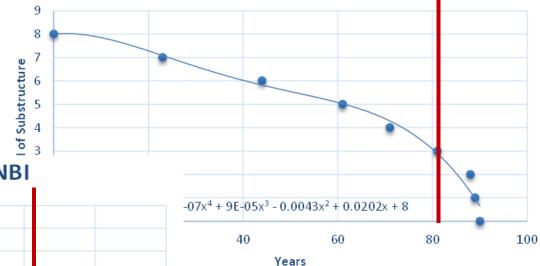


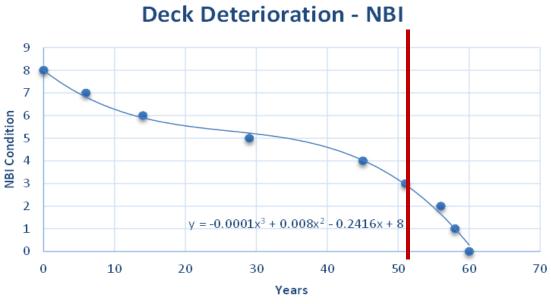
WISAMS



Substructure Deterioration

- How does it work?
 - Deterioration models
 - Rule 4









WISAMS

- How does it work?
 - Recommended work actions

B110001		YEAR	AGE	NO ACTION	OPTIMAL IMPROVEMENT SCENARIO					FIIPS PROGRAM	
				CAI	PRIMARY WORK ACTION	CAI	COST: PRIMARY WORK ACTION	EST. LIFE EXTENSION (YRS)	INCIDENTAL WORK ACTIONS	PROGRAMMED WORK ACTION; PROJECT ID	CAI
FEAT ON/UNDER:	STH 13/16/23-BROADWAY ST over WISCONSIN RIVER 16	2017	62	71.8	(99)OVERLAY DECK - THIN POLYMER / NEW JOINTS	79.9	381310	15		(99)OVERLAY DECK - THIN POLYMER / NEW JOINTS; 61310061	79.9
STRUCTURE TYPE:	DECK GIRDER	2018	63	70.8		78.5	C	0			78.5
MATERIAL:	CONT STEEL	2019	64	69.6		77	C	0			77
NUM SPANS:	5	2020	65	68.2		75.3	C	0			75.3
TOT LENGTH (FT):	680	2021	66			73.6	C	0			73.6
INVENTORY RATING:	HS19	2022	67	61.5		67.9	C	0			67.9
OPERATING RATING:	HS30	2023	68	60.2		66.3	C	0			66.3
LOAD POSTING:		2024	69	59		64.9	C	0			64.9
LAST INSPECTION:	4/27/2016	2025	70) 58	(07)PAINT (COMPLETE)	70.8	1101125	27	(12)REPAIR RAILING OR PARAPET; (14)REPAIR SUBSTRUCTURE - RESTORE CONDITION AND CAPACITY;		63.6
CONSTR HIST:	(1955)NEW STRUCTURE (1972)REPAIR SUBSTRUCTURE (1975)REPAIR SUPERSTRUCTURE (1982)OVERLAY - CONCRETE (1992)NEW DECK	2026	71	57.1		70.1	C	0			62.5







B110001	
FEAT ON/UNDER:	STH 13/16/23-BROADWAY ST over WISCONSIN RIVER 16
STRUCTURE TYPE:	DECK GIRDER
MATERIAL:	CONT STEEL
NUM SPANS:	5
TOT LENGTH (FT):	680
INVENTORY RATING:	HS19
OPERATING RATING:	HS30
LOAD POSTING:	
LAST INSPECTION:	4/27/2016
CONSTR HIST:	(1955)NEW STRUCTURE
	(1972)REPAIR SUBSTRUCTURE
	(1975)REPAIR
	SUPERSTRUCTURE
	(1982)OVERLAY - CONCRETE
	(1992)NEW DECK

- Inventory Data
 - Pulled from HSI
 - History of past work
 - Planning
 - Help prioritize structure work within the region





- Do-nothing Scenario
 - Condition Assessment Index (CAI)
 - See deterioration of CAI value
 - Planning
 - See negative effect of postponing important structure work



	YEAR AGE		NO ACTION				
			CAI				
	2017	62	71.8				
	2018	63	70.8				
	2019	64	69.6				
,	2020	65	68.2				
)	2021	66	66.8				
	2022	67	61.5				
	2023	68	60.2				
	2024	69	59				
•	2025	70	58				
	2026	71	57.1				





- Improvement Scenario
 - Primary and possible work to combine
 - Cost & life extension estimates
 - Planning
 - More information early in the process = better decisions

OPTIMAL IMPROVEMENT SCENARIO				
PRIMARY WORK ACTION	CAI	COST: PRIMARY WORK ACTION	EST. LIFE EXTENSION (YRS)	INCIDENTAL WORK ACTIONS
(99)OVERLAY DECK - THIN POLYMER / NEW JOINTS	79.9	381310	15	
	78.5	0	0	
	77	0	0	
	75.3	0	0	
	73.6	0	0	
	67.9	0	0	
	66.3	0	0	
	64.9	0	0	
(07)PAINT (COMPLETE)	70.8	1101125	27	(12)REPAIR RAILING OR PARAPET; (14)REPAIR SUBSTRUCTURE - RESTORE CONDITION AND CAPACITY;
	70.1	0	0	



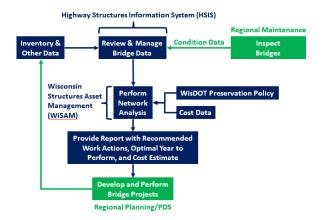




- Future Development
 - Scoping report
 - Eligible work within existing project limits
 - Prioritization factors
 - Criticality, vulnerability, etc.
 - Element defect deterioration modeling
 - Ex. Delaminations (defect 1080) in deck elements



Questions?





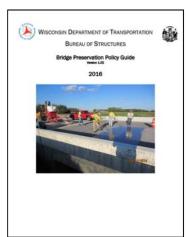


Philip Meinel

Structures Asset Management Engineer BOS – Development – Bridge Management Unit

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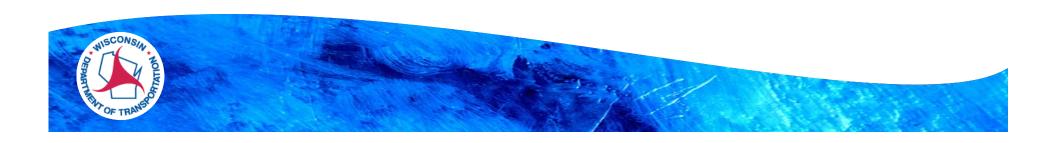
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Chapter 45 Re-Organization

Structural Engineers Symposium June 7, 2016



Why does Chapter 45 exist?

- Design isn't rating, and vice versa
 - Some design considerations aren't applicable for rating
 - Construction checks
 - Some rating considerations aren't applicable for design
 - Deterioration
- ▶ In 2015 let projects (State and Local):
 - New bridge construction: 54%
 - Bridge rehabilitations: 46%



Purpose of this Effort

- Create better organization
 - Give everything a home
- Document current practice
 - Not much is new...but new to Bridge Manual

This Presentation

- Raise awareness on pending updates
- Give a sense for what to expect
 - Highlight some specific policies/procedures
- DRAFT, DRAFT, DRAFT!!!



Table of Contents

- Better organization
- Better flow
- Easier to find information on specific policies and procedures for your project

Table of Contents

- ▶ 45.1 Introduction
- 45.2 History of Load Rating
- ▶ 45.3 Load Rating Process
- ▶ 45.4 Load Rating Computer Software
- ▶ 45.5 General Requirements
- ▶ 45.6 Policy and Procedure Superstructure
- ▶ 45.7 Policy and Procedure Substructure
- ▶ 48.8 Policy and Procedure Culverts



Table of Contents

- 45.9 Documentation and Submittals
- ▶ 45.10 Load Postings
- ▶ 45.11 Over-Weight Truck Permitting
- ▶ 45.12 Construction Loading



Applicability

- ▶ 45.1.2 Scope of Use
 - State <u>and</u> Local

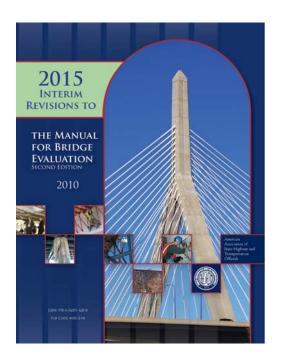
45.1.2 Scope of Use

All requirements presented in this chapter are to be followed by WisDOT Bureau of Structures (BOS) staff, as well as any consultants performing load rating or load posting work for WisDOT BOS. Local municipalities and consultants working on their behalf should also follow the requirements of this chapter.



Primary Load Rating References

- 45.1.3 Governing Standards for Load Rating
 - AASHTO Manual for Bridge Evaluation (MBE)
 - Wisconsin Bridge Manual, Chapter 45
 - LRFD design code (LRFR)
 - 2002 Standard Spec (LFR)





When a Rating is Required

- ▶ 45.3.2.1 When a Load Rating is Required (Existing In-Service Bridge)
 - Removal and replacement of existing overlay
 - Thin epoxy overlay
 - Quality control for the rating process
 - Review inspection reports for deterioration



What to Load Rate

- 45.3.3 What Should be Rated
 - Example: Steel trusses

Steel truss structures

Primary elements for rating include truss chord members, truss diagonal members, gusset plates connecting truss chord or truss diagonal members, floor beams (if present), and stringers (if present).

Secondary elements include splices, stringer-to-floorbeam connections (if present), floorbeam-to-truss connections (if present), lateral bracing, and any gusset plates used to connect secondary elements.



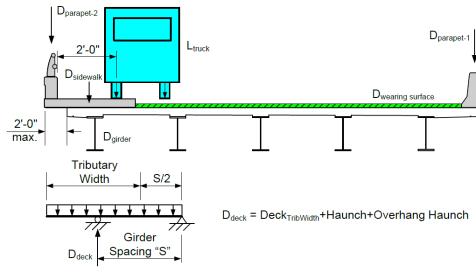
Load Rating Software

- ▶ 45.4.1 Rating Software Utilized by WisDOT
 - Steel girder: SIMON, AASHTOWare BrR
 - PS girder: In-house, BrR
 - Slab: In-house, BrR
 - Truss: BrR
 - Other: MDX, CSI Bridge, LARSA, Conspan
- Submittal requirements
 - Typical
 - Complex



Live Loads

- ▶ 45.5 General Requirements
- Live load placement
 - Truck on sidewalk
 - Striped lanes



Use Tributary Width for Deck Load

Figure 17.2-18

Distribution of Loads to Exterior Girder for Girder Structure with Raised Sidewalk Design Case 2



Material Properties

- ▶ 45.5.2 Material Structural Properties
- Old information is still there
 - Rebar, concrete, PS strands, structural steel
 - See also AASHTO MBE
- Added information for timber
 - Superstructures (possibly)
 - Substructures (likely)



Policy - Superstructure

- 45.6 WisDOT Policy and Procedure -Superstructure
- Separated by superstructure type
- ► Example: PS girder superstructures (45.6.1.1)
 - Different girder spacings by span (1&4, 2&3)
 - With a "made-continuous" deck



Policy - Superstructure

- ► Example: steel girder superstructures (45.6.3.1)
 - Plastic analysis M_Y vs M_P
 - Curvature



Policy - Superstructure

- ► Example: steel truss superstructures (45.6.3.2)
 - Gusset plates



Policy - Substructure

- ▶ 45.7 WisDOT Policy and Procedure Substructure
- Separated by substructure type
- ▶ Timber piles (45.7.1)

Load Posting (45.10)

- General clarification
 - What vehicles to use
 - LL factors
 - Distribution factor (multi vs. single)
- ▶ SHVs...



Construction Loading (45.12)

- Refer to Wisconsin Standard Specification
 - Section 108.7.3
- "If the engineer directs, submit stamped and signed copies of analyses and associated calculations performed by a professional engineer..."
- "If a PE's analysis is required..."



Stay tuned...

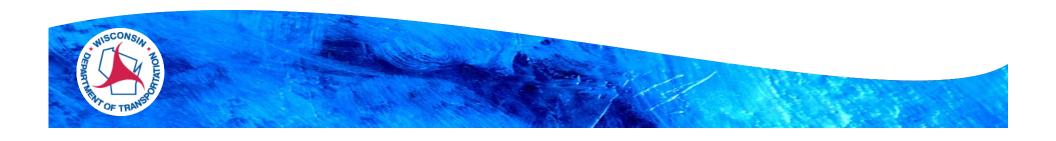
- Raise awareness on pending updates
- Give a sense for what to expect
 - Highlight some specific policies/procedures

▶ 45.8 - Policy and Procedure – Culverts



Load Rating Culverts

Structural Engineers Symposium June 7, 2016



Culverts: Are Load Ratings Required?

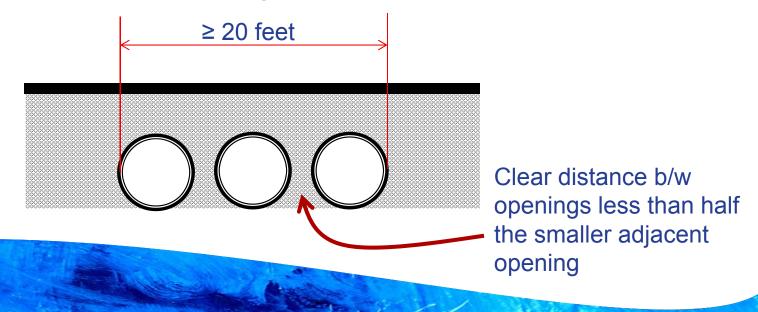
- Wisconsin Bridge Manual:
 - Chapter 36 (Box Culverts), 36.1.2:
 - "Current WisDOT policy is to not rate box culverts. In the future, rating requirements will be introduced as AASHTO is updated to more thoroughly address box culverts."
 - Chapter 45 (Bridge Rating):
 - Load Rating Summary Form not required for culverts
 - Insert "placeholder" ratings on plans



Culverts:

Are Load Ratings Required?

- FHWA requires documented load ratings for all bridges. But when is a *culvert* a *bridge*?
- ▶ NBIS-23 CFR 650 Subpart C:



Culvert Rating Methods

- 2013 Interim Revisions to MBE
 - Article 6A.5.12 Rating of RC Box Culverts (LRFR)
- 2016 Interim Revisions to MBE
 - Article 6B.7.1 assigns rating factors of Inventory HS20 & Operating HS33 for concrete culverts with...
 - Fill depths of 2.0 ft or greater with known details, or
 - With unknown components (such as culverts w/o plans)
 - ... if they have been **carrying normal traffic** for an appreciable period and are in **fair or better condition**.



Culvert Rating Methods

- MBE does not currently provide explicit direction for other types of culverts.
- Other references:
 - 2002 AASHTO Standard Specifications
 - Current AASHTO LRFD Specifications
 - National Corrugated Steel Pipe Association (NCSPA)
 - Design Data Sheet No. 19 (free download) Load Rating and Structural Evaluation of In-Service, Corrugated Steel Structures



Ongoing Research

- NCHRP 15-54:
 - Proposed Modifications to AASHTO Culvert Load Rating Specifications
 - Goal Completion Date: July 2018



Ratings Based on Engineering Judgment & Field Evaluation

NBI Culvert	Over-	Element in CS4	Inventory	Operating	MVW	Load
Condition Rating	burden	Under Traffic Lanes?	Rating	Rating	(kips)	Restriction
≥ 5	n/a	n/a	HS20	HS33	190	NONE
4	n/a	n/a	HS12	HS20	190	NONE
3	≥ 6 <u>ft</u>	n/a	HS12	HS20	190	NONE
	< 6 <u>ft</u>	NO	HS12	HS20	190	NONE
		YES	HS06	HS10	40	20 TON
2	≥ 6 <u>ft</u>	n/a	HS12	HS20	190	NONE
	< 6 <u>ft</u>	NO	HS06	HS10	40	20 TON
		YES	HS02	HS03	10	5 TON
0-1	n/a	n/a	HS00	HS00	0	CLOSURE



Exceptions:

- Postings and Inventory Ratings were not increased based on the new criteria.
- Inventory RF1.00, Operating RF1.67, MVW 190k
- If calculated LRFR ratings provided on plans or in submitted calculations, they were not changed.



Exceptions:

Alternate ratings could be determined through judgment and/or calculations with consideration of:

Condition	Age		
Construction Type	Redundancy		
Design Load	Live Load History		
Similar Structures	ADTT		

Requires Load Rating Summary Form with written justification submitted by professional engineer.



Ratings for New Culverts

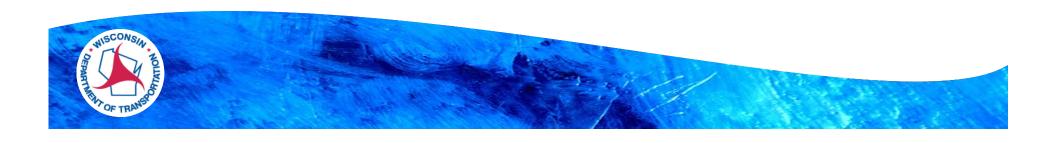
- Concrete box culvert requirements:
 - Accurate Load Ratings on Plans
 - Calculation Submittal
 - Per MBE, need not be rated if:
 - Single-span, 8 ft or more of fill
 - Multiple-span, depth of fill exceeds distance b/w faces of end walls
- Pipe culvert requirements:
 - Plans must include design vehicle (HL-93)
 - Load Ratings may be calculated or assigned







Thank you!

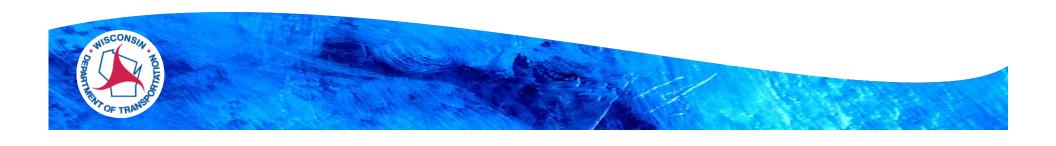


Specialized Hauling Vehicle (SHV) Rating

Bria Lange

Development Bridge Rating Engineer

WisDOT – Bureau of Structures



What are SHVs?

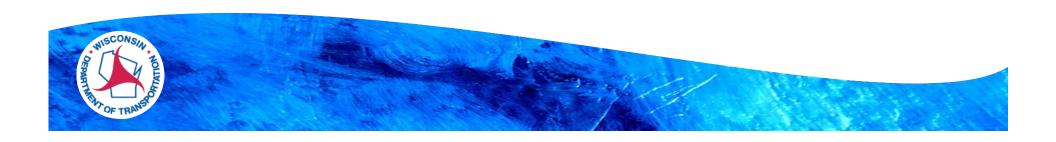
- Dump trucks, construction vehicles, solid waste trucks, etc.
- Cause forces exceeding HS20 by up to 22 percent.
- Shorter bridges at higher risk for overstress.
- Four (4) single unit posting vehicles: SU4, SU5, SU6, SU7





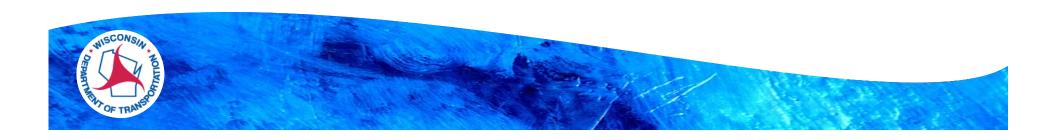
Important dates

- December 31, 2017
 - All bridges with shortest span less than 200'
- December 31, 2022
 - All other bridges



SHV rating is NOT required when:

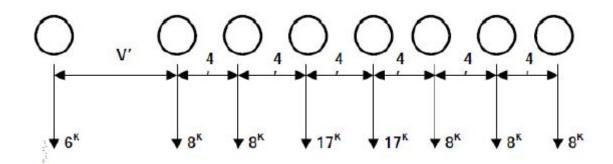
- ▶ LFR/ASR HS20 Operating RF>1.2
- ▶ LRFR HL-93 Operating RF>1.0
- ▶ LFR/ASR AASHTO legal truck Operating RF>1.35
- ▶ LRFR AASHTO legal truck Operating RF>1.35
 - SU4 and SU5 for all spans
 - SU6 for spans above 70 feet
 - SU 7 for spans above 90 feet



NRL screening tool:

Run Notional Rating Load (NRL):

▶ Operating RF>1.0 – Need not to be rated for SHVs



V = VARIABLE DRIVE AXLE SPACING — 6'0" TO 14'-0". SPACING TO BE USED IS THAT WHICH PRODUCES MAXIMUM LOAD EFFECTS.

AXLES THAT DO NOT CONTRIBUTE TO THE MAXIMUM LOAD EFFECT UNDER CONSIDERATION SHALL BE NEGLECTED.

MAXIMUM GVW = 80 KIPS

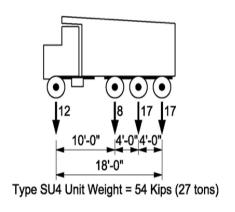
AXLE GAGE WIDTH = 6'-0"

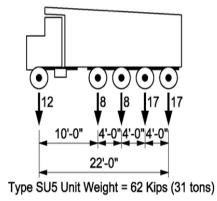


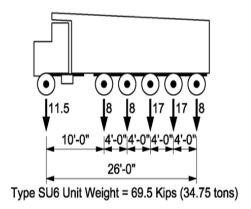
SHV posting analysis

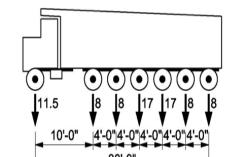
Run four (4) SHV vehicles:

▶ Operating RF>1.0 – Posting not controlled by SHVs









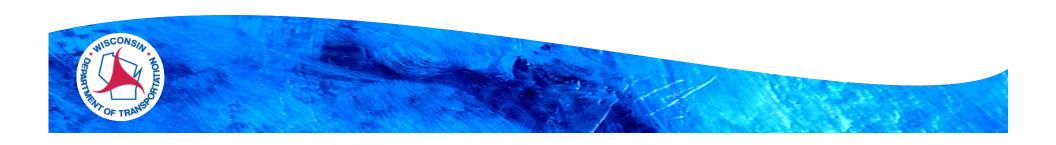
Type SU7 Unit Weight = 77.5 Kips (38.75 tons)



Policy and Standards Updates

Dave Kiekbusch, P.E.

Supervisor – Automation, Policy and Standards Unit
WisDOT Bureau of Structures



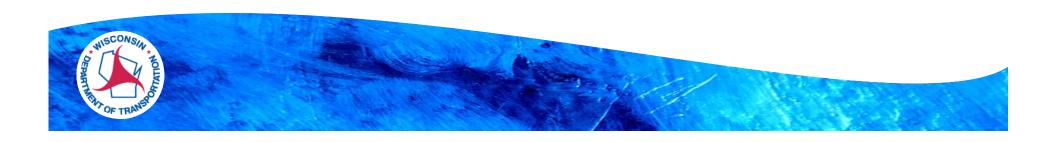
Updating the Bridge Manual to be Compliant with AASHTO

- Design according to the Bridge Manual. A BOS approval prior to beginning design is required if wanting to implement AASHTO changes prior to Bridge Manual updates.
- ▶ 7th Edition, 2016 Interims
 - Published November, 2015
 - Probable Bridge Manual updates by January, 2017
 - Wind speed
 - Increased compressive stress limit for prestressed girders
 - Increase in Fatigue I load factor
 - Strut-and-tie methodology



AASHTO Updates (continued)

- ▶ 8th Edition (2017)
 - Likely published later this year, or early next year
 - Updates to Bridge Manual: July, 2017 and beyond!
 - Fairly substantial changes
 - Complete reorganization of Section 5: Concrete Structures
 - Elimination of the simplified method for determining shear resistance of prestressed concrete (no more Vci, Vcw)
 - Changes to bolt shear strength and friction values on the faying surfaces
 - New, simplified field splice design



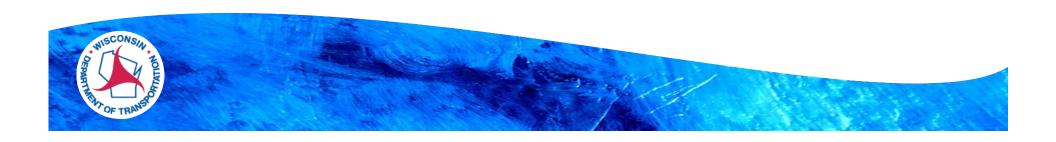
Future AASHTO Updates

- Every 3 years (2020, 2023, etc.)
- No more interims
 - Meaning no more pink interim sheets!
- BOS is working on generating a work plan for current and future updates, especially with regards to the AASHTO updates being every 3 years
 - Bridge Manual text
 - Bridge Manual standard drawings and insert sheets
 - Bridge Manual design examples
 - In-house software
 - Understanding timeline of proprietary software updates



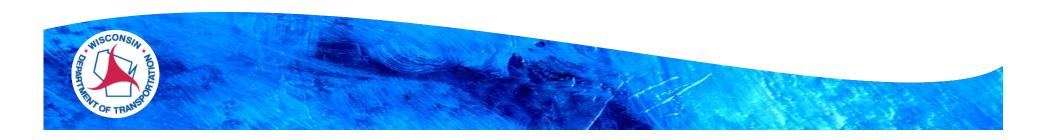
Aesthetics Policy – BM Chapter 4

- Bridge Manual policy discusses lettings and SMA's before/after August 15, 2016
 - There may be a newer, sooner date
 - Non-geometric (e.g. rocks) formliner and stain are CSS
 - Staining
 - Initial staining cost can be fairly reasonable
 - Re-staining cost can be very high (\$20+/SF when considering traffic control)
 - Plain concrete looks better in 20 years than poorly maintained stain



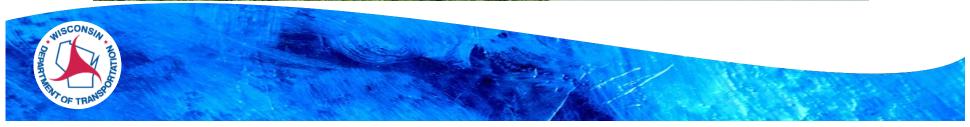
Aesthetics Policy (continued)

- Any railing/parapet in the Standards is <u>not</u> considered CSS
 - Maintenance of paint will be the responsibility of the community and should be defined in the SMA
- Not yet known the impact to:
 - Current projects under construction
 - Impending major/mega projects
- Stay tuned for updated policy, including a memo from Bill Dreher!



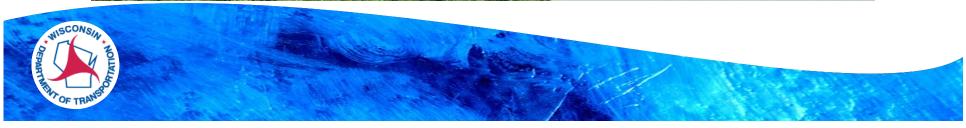
No matter the date, you can use either Type I...





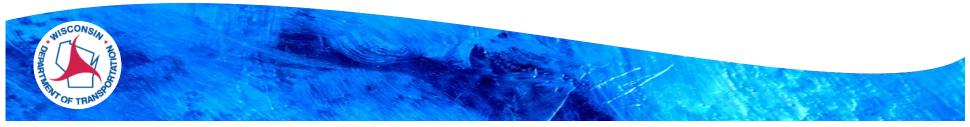
Type II





Type III





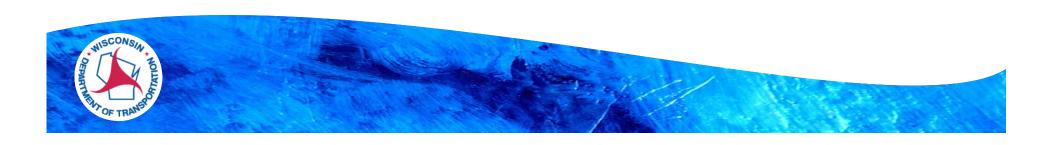
AASHTO Manual for Assessing Safety Hardware - MASH 2016

From Chapter 30 of Bridge Manual:

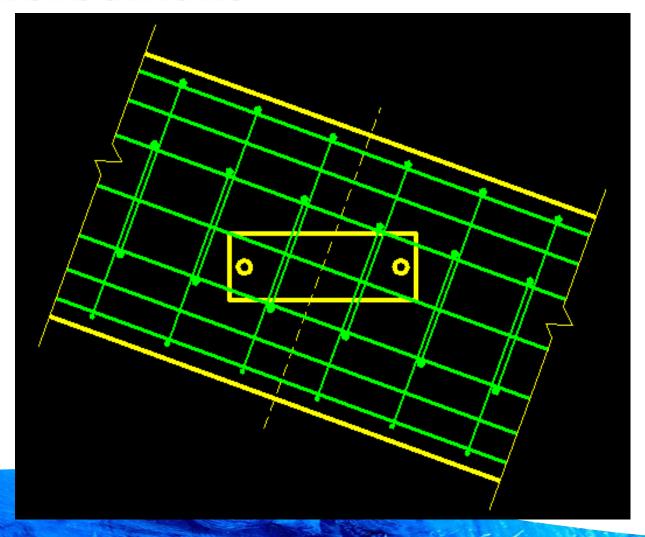
Notice: All contracts with a <u>letting date after</u>

<u>December 31, 2019</u> must use bridge rails and transitions meeting the 2016 Edition of MASH criteria for new permanent installation and full replacement.

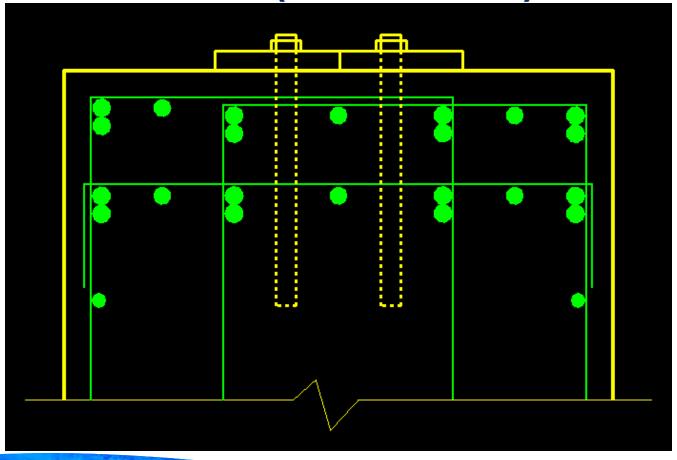
BOS understands the urgency of getting approved parapets and railings available for your use!



Anchor bolt conflicts with reinforcement



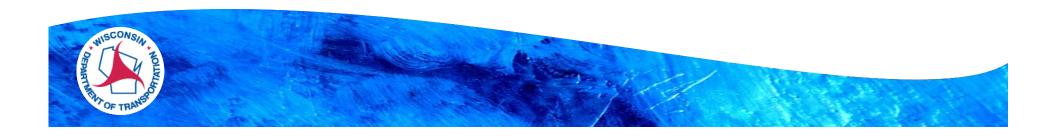
Anchor bolt conflicts with reinforcement (continued)





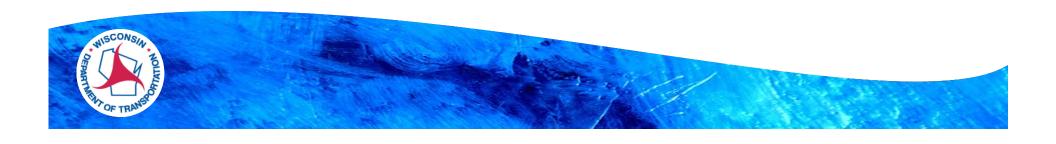
Anchor bolt conflicts with reinforcement

- Layout reinforcement with thought to anchor bolt placement
- Provide 4" clear between anchor bolt and rebar
- 5" to 6" clear between bars for tremie and concrete vibration
- Detailing multiple layers is acceptable (use correct structural depth)



Automation, Policy and Standards (Updates)

James Luebke
Development Engineer – APS Unit
WisDOT Bureau of Structures



Piling - Usage

2012-2014 Costs Data

75% H-Piles

- 31% HP12x53
- 30% HP10x42
- 14% HP14x73

25% CIP Piles

- 9% 12 ¾ x 0.375-Inch
- 6% 10 ¾ x 0.365-Inch
- 10% other CIP Piles

Note:

Wisconsin has relatively shallow depths with hard bearing layers.
Generally making end bearing H-piles an attractive choice.

Note:

H-piles have the potential to accommodate downdrag forces.

Note:

Drilled shafts and spread footings represent very few projects, but are becoming more popular.



Piling - ASP 6 Updates/2017 Spec.

- ▶ 550.5.2 Piling
 - Adjust pay under the Piling Quantity Variation administrative item if total driven length of each size is less than 85 percent of, or more than 115 percent of the contract quantity

Percent of Contract

Length Driven

< 85

> 115

Pay Adjustment

(85% contract length - driven length) x 20% unit price (driven length - 115% contract length) x 5% unit price



Piling - PDA

- Pile Driving Analyzer (PDA)
- Advantages
 - More accurate method
 - Potential cost savings
 - Provides other useful information
- Limitations:
 - Time (24 hours) for analyses and feedback
 - Subcontractor
 - Savings vary

Note:

PDA has saved the department over \$3 million over the past years



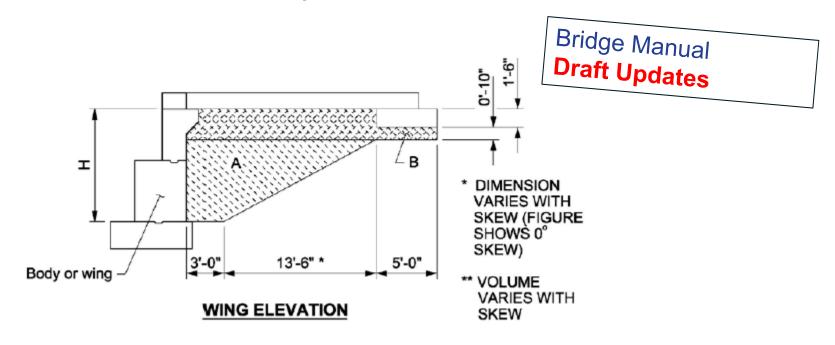
Structure Backfill - Quantities

- Issues:
 - Backfill payment disagreements (some cases 2 times)
 - Inconsistencies (bid items and graduations)
 - Units
- Design Considerations:
 - Show pay limits on plans
 - Add notes for payment (backfill pay limits only)
 - Better communicate quantities (roadway and structures)



Granular - Quantities

- Abutments, Walls, Culverts, etc.
- Show pay limits on plans
- Note contractor is responsible for excavation limits





Structure Backfill - Gradations

- Plan Inconsistencies:
 - Structural Backfill
 - Structural Backfill w/ 209.2.2 Gradations
 - Granular Backfill

Bridge Manual

Draft Updates

- ▶ 2017 Specifications:
 - Structural Backfill Type A (New Gradations)
 - Structural Backfill Type B (Old Gradations)



Structure Backfill - Units

2017 Specifications:

- Field Disagreements with "CY" Unit
- Added "Tons" Unit

Standards

Draft Updates

- BOS Recommends "Tons"
 - Unless Region directs otherwise
 - Similar to Structural Approaches Slabs (Base Aggregate)
 - Assume 2.0 tons/CY conversion factor



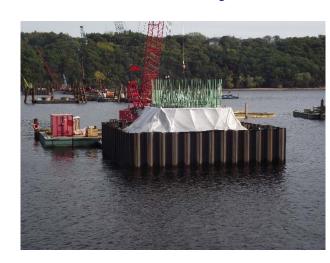
MSE Walls

- Clearly identify wall payments
- Be careful with "Incidental to MSE Wall" for unknown subgrade improvements



Allows substructures to be poured in the dry

Construction Protection



Controls Sediment







Abutment – Poured Dry





Pile Encased Pier – Tremie Poured (Protected)





Pile Encased Pier – Tremie Poured (Assumed Unprotected)



- Site and structure conditions vary greatly
- Ensure quality and minimize field disagreements
- Designer Coordination
 - Regional personnel (environmental representative)
 - BOS
 - DNR and others as needed
- Design Options
 - Cofferdam & Dewatering
 - Cofferdam (noted: underwater pour allowance)
 - No Cofferdam (noted: underwater pour allowance & Roadway covers erosion control measures)



Pile Encased Piers:

- Historically haven't been required
- Cofferdams are expensive
- Better protection than open pile bent
- Simple forming and pouring operations (compared to a spread footing)



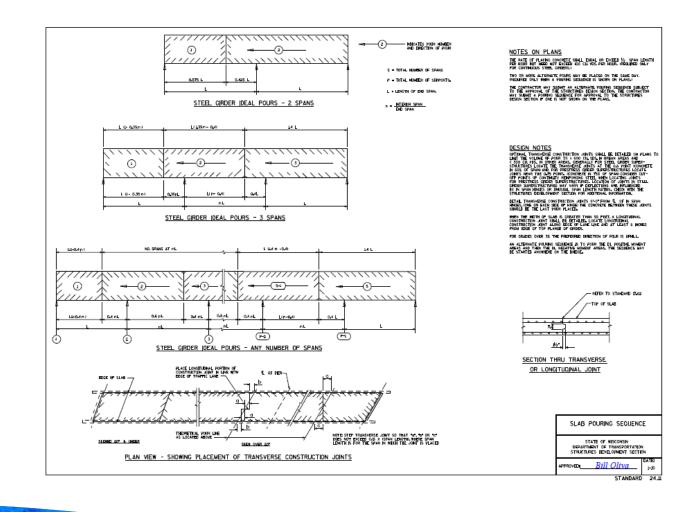
Cofferdams – Plan Preparations

- Cofferdam vs. Excavation for Structures
- Underwater pours
 - Difficult to pour structural concrete underwater
 - Strength and long term durability
 - Recommend note to clarify allowances
- When to Include a Cofferdam bid item?
 - Substructure to be poured in the dry
 - Water depths greater than 5 ft (pile encased subs)
 - Other cases



Slab Pouring Sequence

> Std. 24.11





Slab Pouring Sequence

Optional

- Limits pour volume < 600 CY Urban (< 300 CY)
- Acceptable Continuous Pour

Required

- Serviceability (minimize deck cracking and deflections)
- Stresses (sequential pours)
- Section properties (sequential stages)

Standard 24.11

Draft Updates



PS Girder - Diaphragm

- Standards 19.34-19.38 Updates
- ▶ Length measured from girder ends (1/16)
- Revised notes (7/16)
 - 2017 Standard Spec updates
 - Connection requirements

Standards 19.34-19.38

Draft Updates



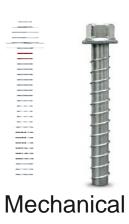
- Types: CIP, Adhesive, and Mechanical
- Design: New vs. Rehabilitation
- Type S or Type L?
- Field substitutions for Type S anchors
- Mechanical types (Screw vs. Expansion)
- Testing



- Types: CIP, Adhesive, and Mechanical
- Design: New vs. Rehabilitation
- Type S or Type L?
- Field substitutions for Type S anchors
- Mechanical types (Screw vs. Expansion)
- Testing









Mechanical Anchors

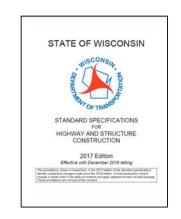
- Design Memo 10/21/15 Moratorium
- Removed from 2017 Specifications
- Bridge Manual Updates July 2016





Adhesive Anchors

- Updated 2017 Specifications
 - Eliminated Type L and Type S
 - New Bid Items: Adhesive Anchors (Size)
 - Removed proof loads table
- Added CMM Guidance (5-15.7)
 - Added proof load tables
 - Noted railing attachment testing
- Bridge Manual Updates July 2016









Adhesive Anchors on Plans:

- MASONRY ANCHORS TYPE S X/X-INCH. MIN.
 EMBED XX" IN CONCRETE.
- ADHESIVE ANCHORS X/X-INCH. MIN. EMBED XX" IN CONCRETE.

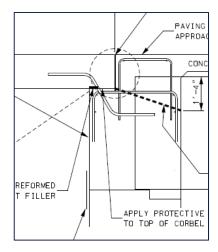
Standards & WBM

Draft Updates



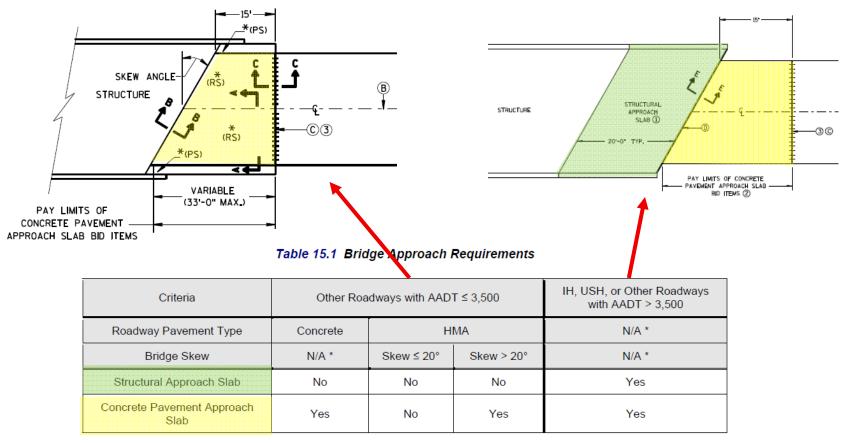
Structural Approach Slabs

- Usage: All bridges with AADT > 3500
- Not required on: Buried structures, Culverts, and Rehabilitation Projects
- Contact BOS for detail/pour modifications





Structural Approach Slabs



Structural Approaches: See Bridge Manual Chapter 12 Standard Drawings Concrete Pavement Approaches: See FDM 14-10-15 and SDD 13B2

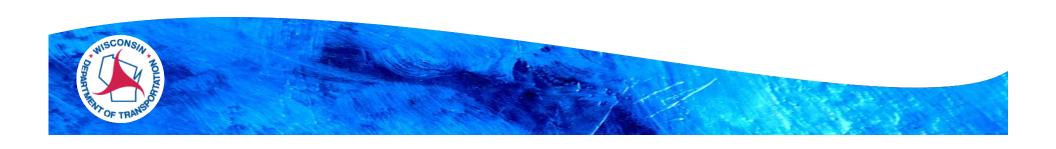


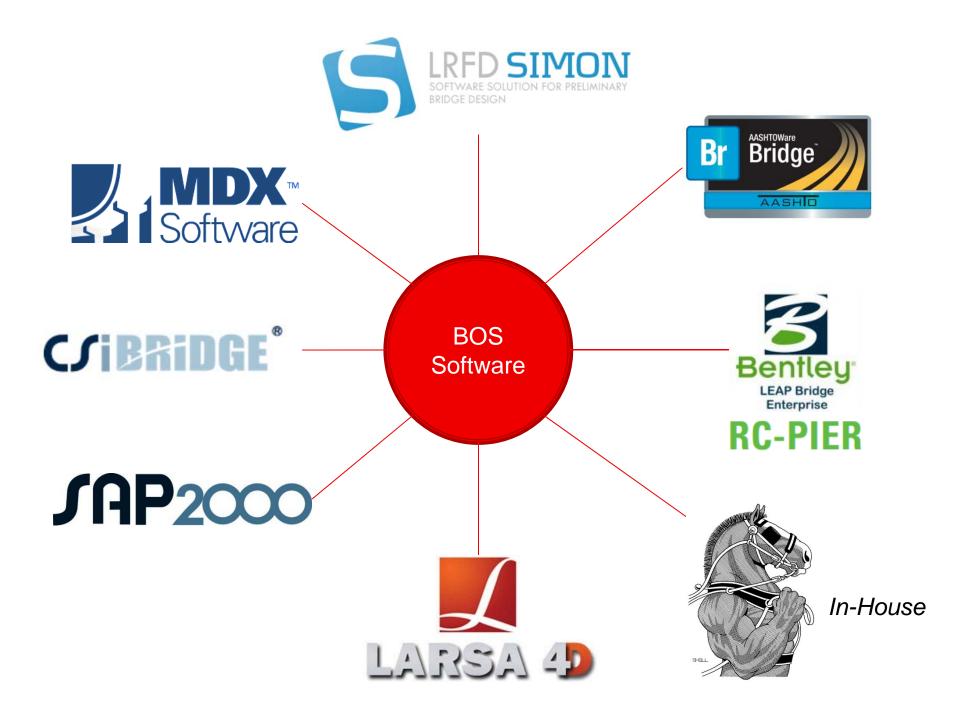
Commercial Bridge Design (& Rating) Software

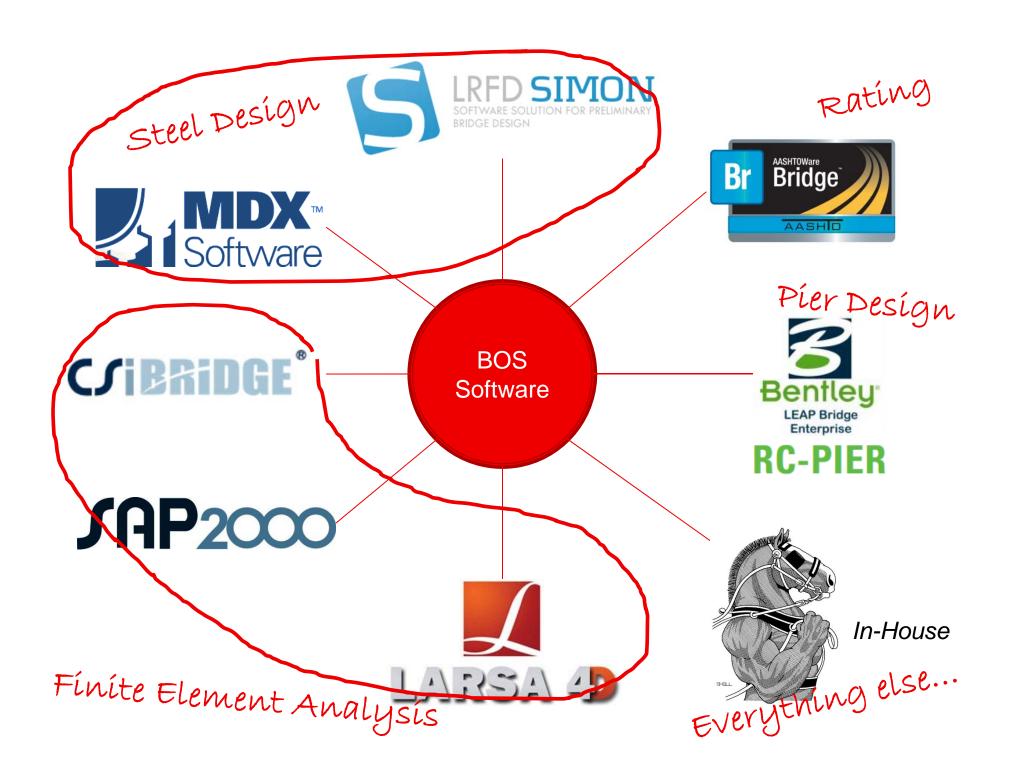
Andrew Smith, P.E.

Development Engineer

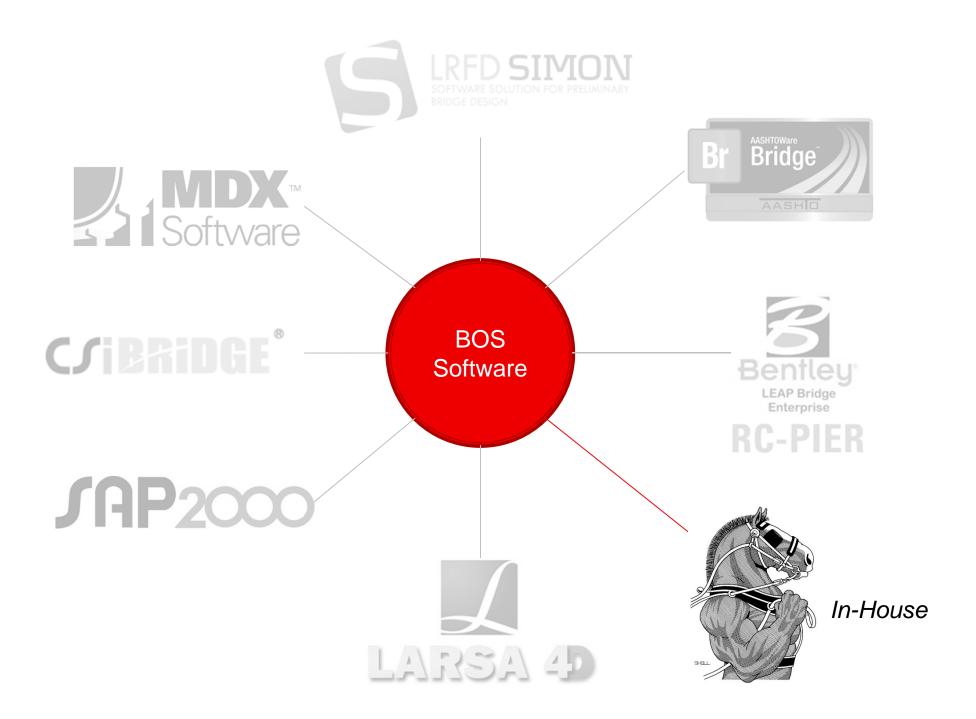
WisDOT – Bureau of Structures











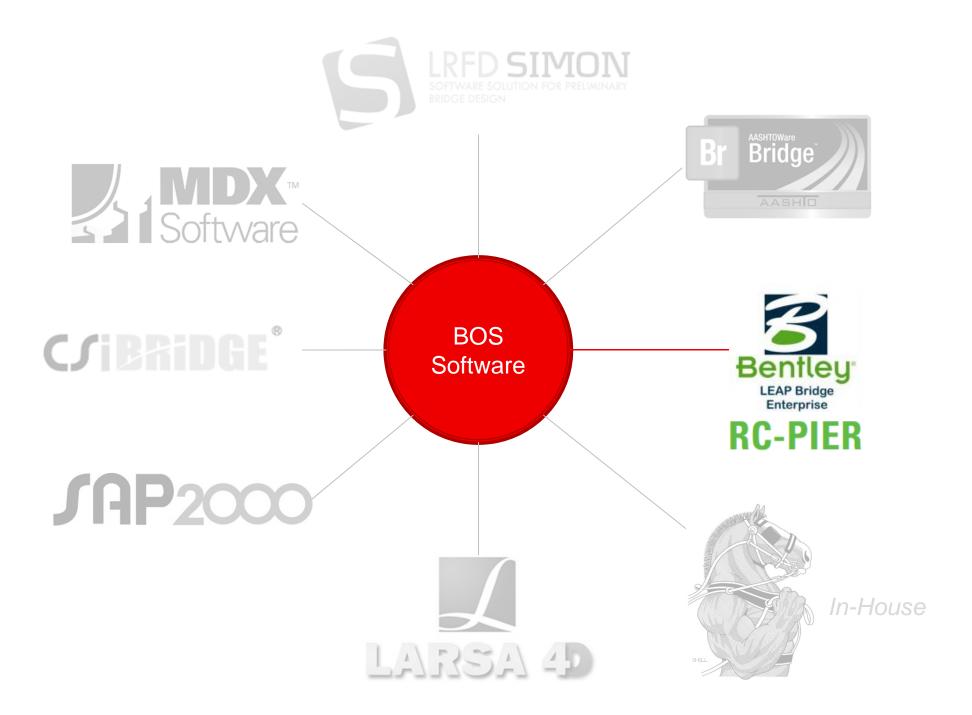
In-House Software

- Work Horse for Design and Rating of
 - Prestressed Girders
 - Steel I-Girders*
 - Concrete Slabs
 - Culverts

Structure types make up ~ 90% State and Local

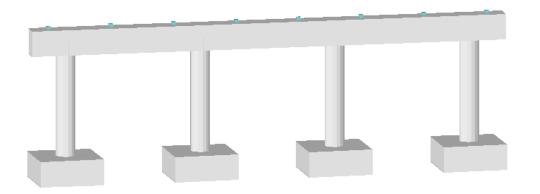
Inventory

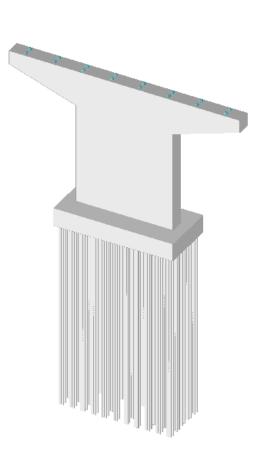




RC-Pier (LEAP Bridge)

- Multi-Columned and Hammerhead type pier design
- Spread footing or footing on piles







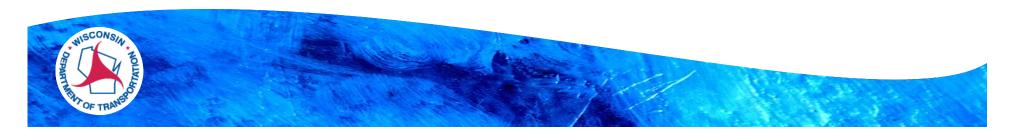
RC-Pier

The Good...

- User friendly interface
- Useful for most common pier (multi-column on piles)

...



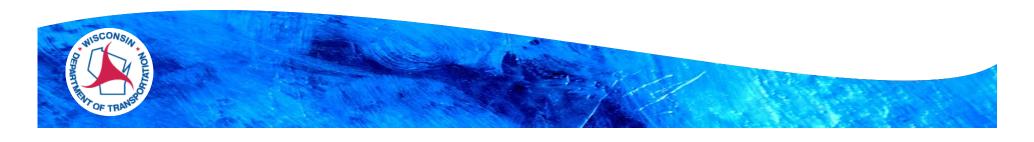


RC-Pier

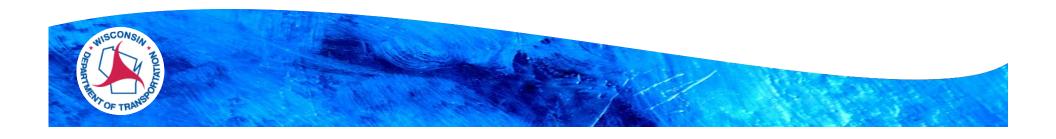
The Bad...

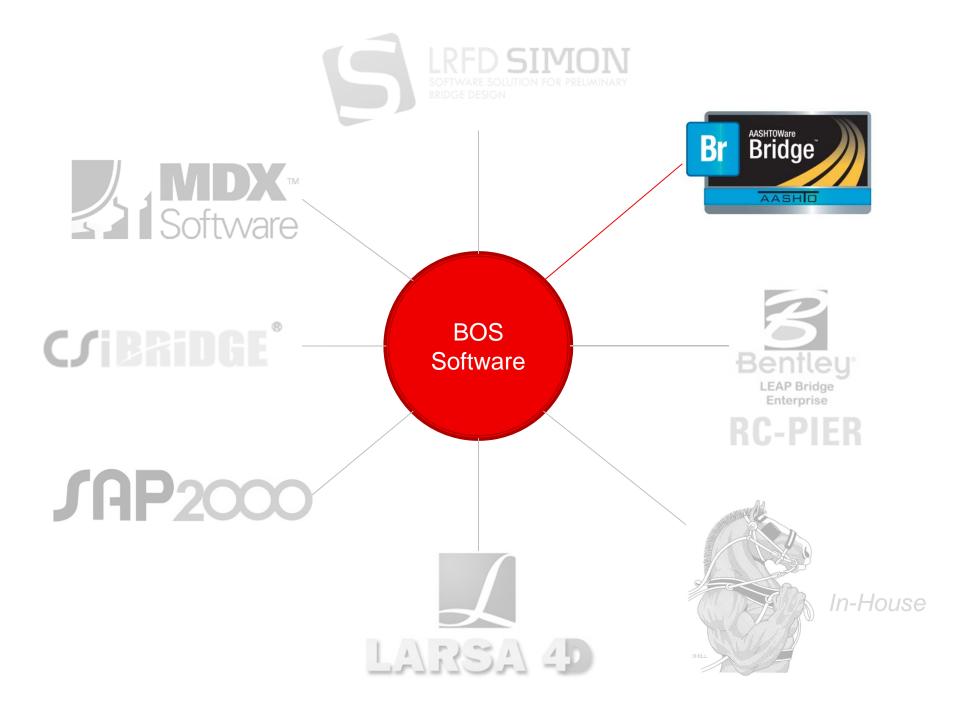
- Tedious to enter loads and modify
- Automated designs not constructible
- Problems with strut-and-tie modeling
- No pile uplift redistribution





Comments on RC-Pier or Substructure Design Software?

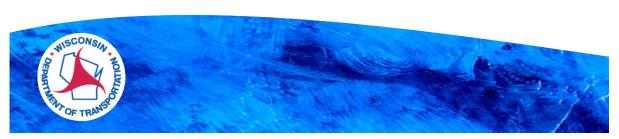


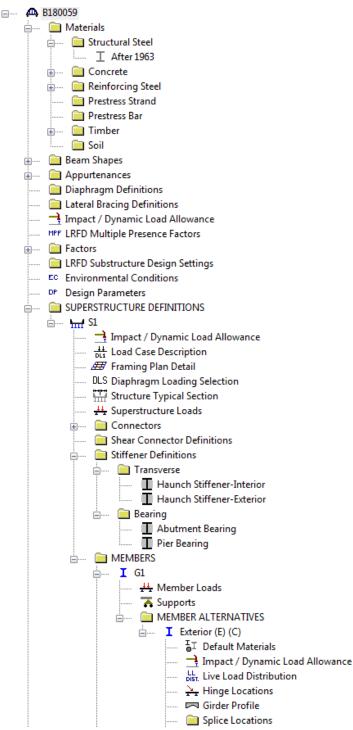


AASHTOWare BrR

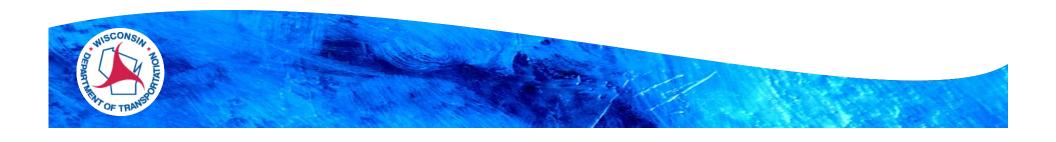
Very Good...

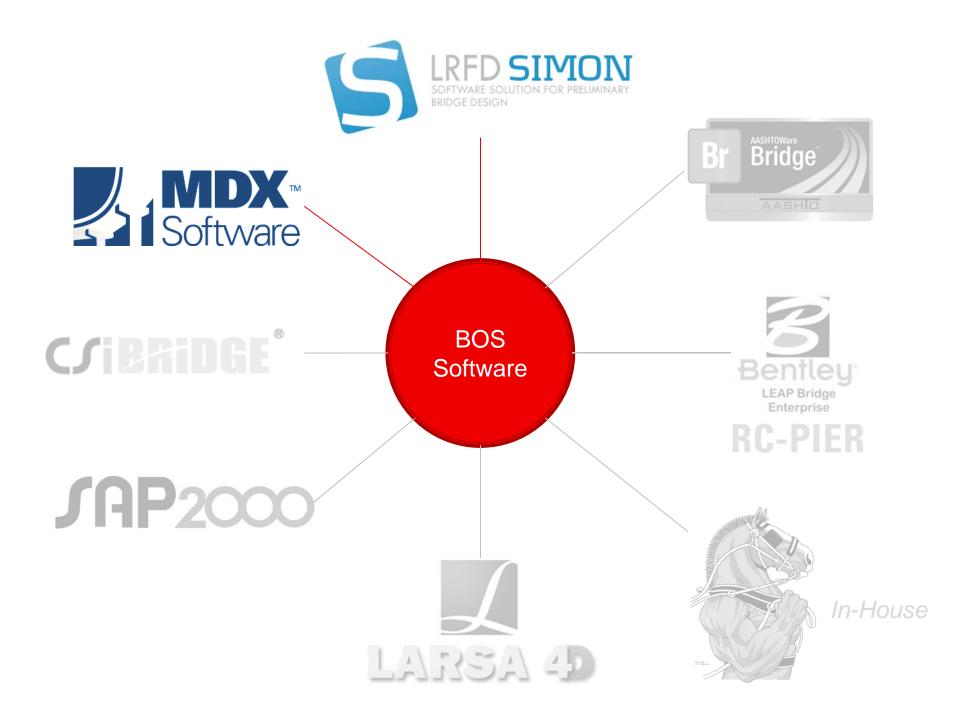
- "Crowdfunded" software
- R" for Rating
 - Supports LRFR, LFR, and ASD
- Multiple Structure Types: Common types + Timber, floorsystems, trusses, & more
- BrD version for Design BOS early stages of evaluation
- 3D analysis capabilities





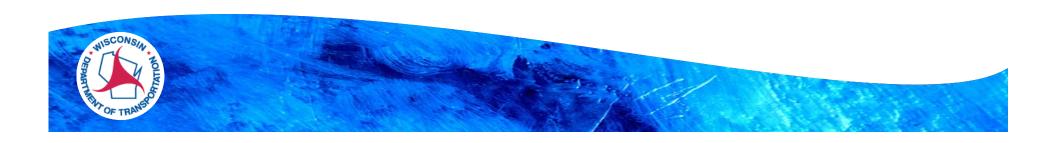
Comments on AASHTOWare or Other Rating Software?





Steel Design (& Rating)

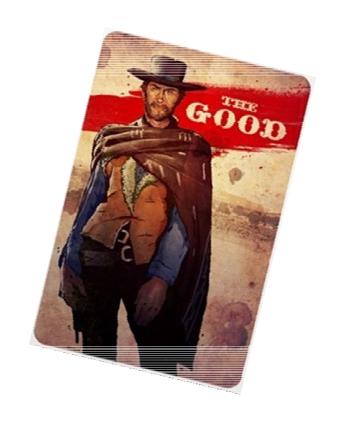
- Simon
 - Straight, Line-girder Analysis
 - Long history beginning with WisDOT
 - Many older steel ratings maintained in Simon
 - Shifting to BrR for steel rating
- MDX
 - Curved Girders
 - Steel I and Box (Tub) Girders
 - 2D Grid and PEB methods

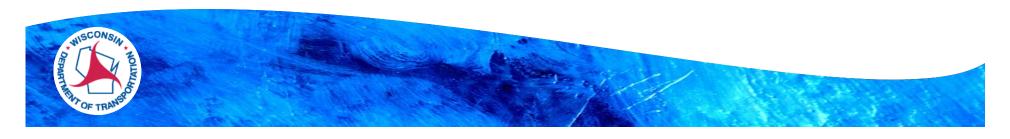


MDX

The Good...

- Fast
- Prompted for information
- Design and Rating
 - LRFD/R and LFR
 - Curved Steel Structures
- LL DFs calculated based on relative stiffness
- Manageable output





MDX

The Bad...

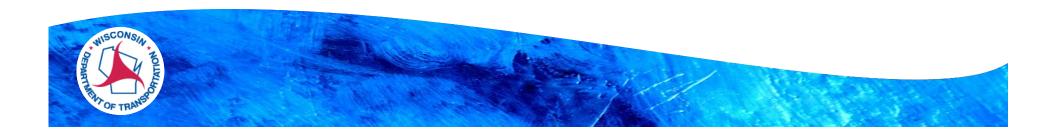
- "Bad" as it relates to curved and highly skewed structures
- Simplified cross frame analysis
- Neglects I-girder warping stiffness
- Not rigorous enough for
 - Design of bracing members
 - Predicting deflections accurately

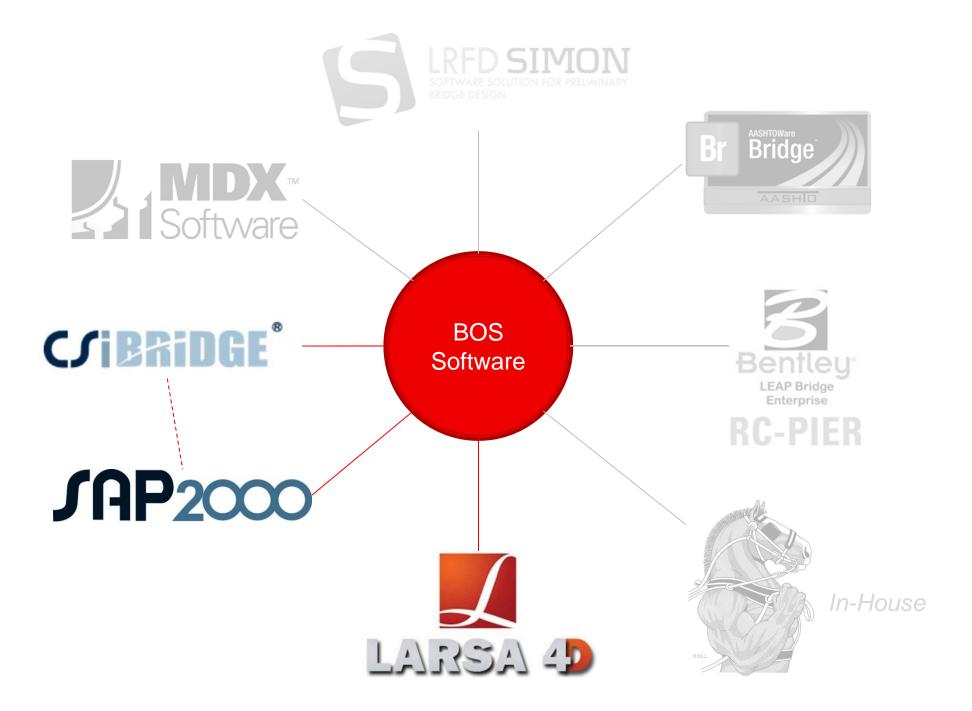




5/13/16	Class 3: Top flange weight was being doubled in girder output weight table for closed box girders. Self weight calculations used for the analys
5/6/16	Class 2: Possibility of LRFD splice location greater than 0.20 unbraced length from brace not reducing Cb. [6.5.3048]
4/29/16	Class 3: Possible problem with slab tension stress in LRFD pour tables. [6.5.3041]
4/2/16	Class 2: The permanent deflection control allowable stress table may not have included the hybrid girder reduction factor. [6.5.3014]
3/30/16	Class 3: The LRFD service moment table may not have included the effect of two trucks plus lane over the pier for max effect. Stress tables ar
3/24/16	Class 1: In some cases composite dead loading effects were inadvertently zeroed in single girder project force tables. [6.5.3005]
3/23/16	Class 2: Bracing forces from sidewalk loading if number of exterior girder braces exceeded number of tenth points. [6.5.3003]
2/27/16	Class 2: Problem with use of PINVRAT to generate an LRFD Strength II inventory rating. [6.5.2979]
2/17/16	Class 3: Some locations in LFD Max Performance Labels table given in inches. [6.5.2970]
2/17/16	Class 1: Possible LFD strength at a pier based on the strength of compression flange. [6.5.2969]
2/10/16	Class 2: Possible LRFD rating problem where a s
1/30/16	Class 2: An entry for bending in Maximum Perf
1/30/16	Class 3: Incorrect messages generated concerni
1/27/16	Class 3: Possible problem with LRFD "Design put moment values near inflection points. [6.5.2948]
1/12/16	Class 2: Possible problem with LRFD Cb value are significantly different. [6.5.2933]
1/2/16	Class 2: Possible problem with LRFD reaction
12/31/15	Class 2: LRFD Service II rating table was n
12/24/15	Class 3: LRFD reactions in hinges tables lis
12/14/15	Class 3: A stress violation message in the I
12/2/15	Class 1: Problem with live load effects in projects when permit truck and HL93 truck are used in combination
11/24/15	Class 2: Possible LRFD shear strength p
10/28/15	Class 3: Permit loading used HL93 fact
10/14/15	Class 3: Only the LRFD 1/3 pouring st
10/12/15	Class 3: Block shear resistance to rupture in boice. House plants [1]
9/28/15	Class 2: Possible problem with shear capacity at splice location. [6.5.2828]
9/18/15	Class 3: Problem with listed capacities in the LFD rating table. Ratings unaffected. [6.5.2817]
9/16/15	Class 2: Possible slight increase in LRFD stud spacing at a few locations. [6.5.2815]
9/11/15	Class 2: Possible problem with cover plated single girder dead deflections. [6.5.2811]
8/24/15	Class 2: Some Service II rating table strengths did not reflect the allowables in the Factored Bending Stress table. [6.5.2793]
8/5/15	Class 3: The amplification factor STEELFACT was not reflected in the weight table. [6.5.2774]
8/3/15	Class 3: Some bottom flange segments in the LFD girder weight table used the top flange thickness. Analysis unaffected. [6.5.2772]
7/25/15	Class 2: The factor STAGFCT was not being used in the rating table. [6.5.2763]
7/23/15	Class 2: The factor WHEELS used in LFD line girder data for amplifying stresses also was being applied to reactions. [6.5.2761]
50105	C1 2 T1 TDCD 1 1 4 40 1 35 44 11 11 41 1 1 1 1 64 4 4 1 6 T1 1401 11 64 1 4 4

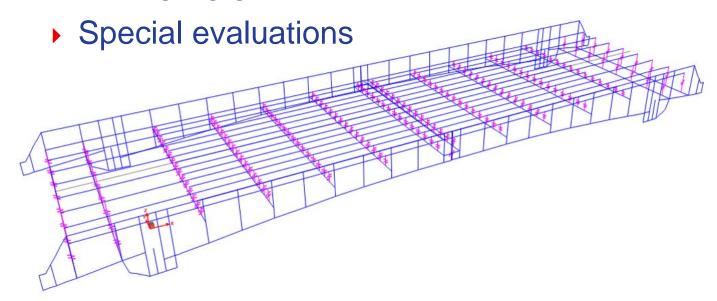
Comments on Simon, MDX or Other Steel Design Software?

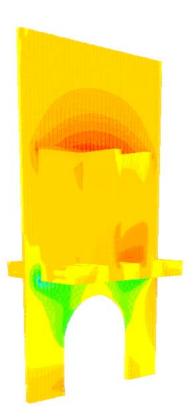




CSI Bridge

- BOS preferred Advanced Finite Element Software
- Complicated structure design and/or rating
- Validation of results from other programs
- Avoid posting using refined analysis see MBE 6A.3.3





CSI Bridge

The Good...

- Parametric Bridge Modeling, but also supports general modeling features
- Visually Appealing
- Selectable Data Output... directly to Excel
- Extensive Support (due to relationship to SAP)
- Steel Frame Design





CSI Bridge

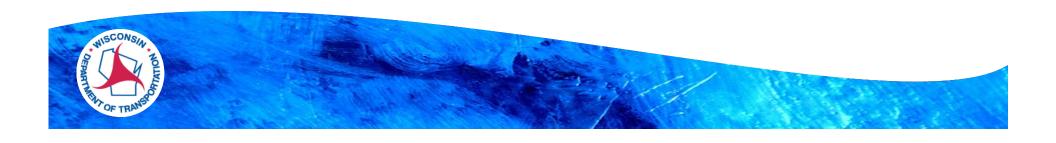
The Bad...

- Parametric Bridge Modeling
- Automesh feature not great
- Design feature only works with linked model
- Rating feature only works with certain structure types
- Vehicle Response Component
- Files not backward compatible
- Cannot save file as older version



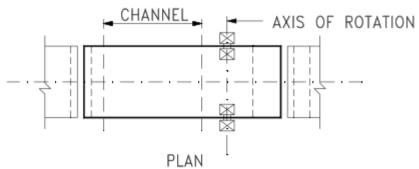


Comments on CSI Bridge or Other FEA Software?





City of Milwaukee Department of Public Works Infrastructure Services Division

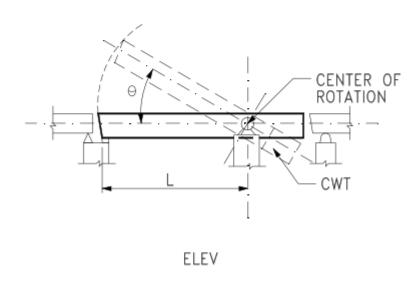


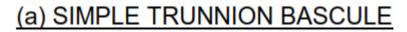


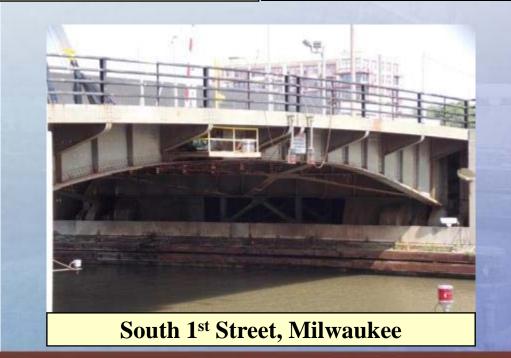


Lawe Street, Appleton

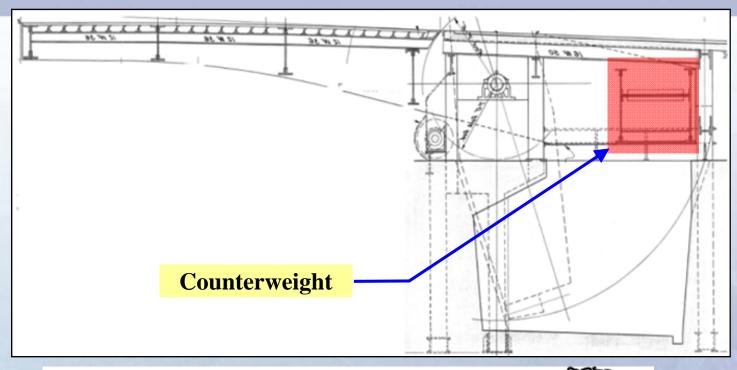
Water Street, Milwaukee

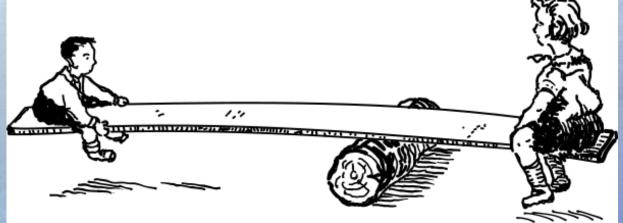


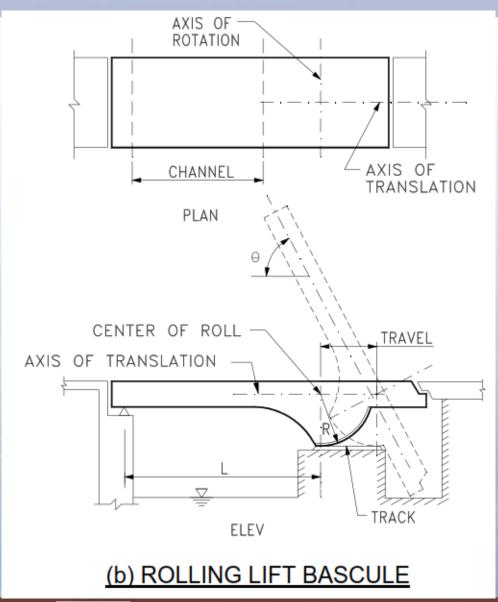




Simple Trunnion Bascule Bridge

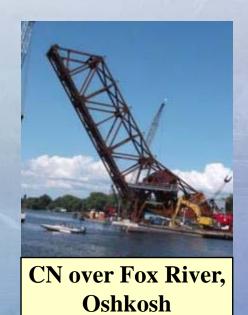






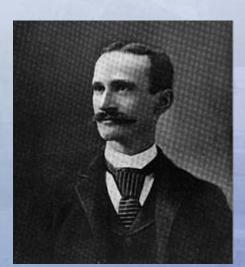


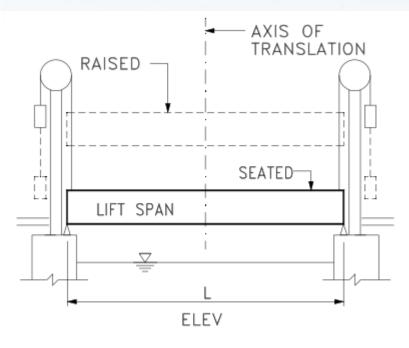
17th Street, Two Rivers



Scherzer Rolling Lift

- William Scherzer (January 27, 1858 July 20, 1893) invented rolling lift bascule bridge (patent filed May 29, 1893, granted in December)
 - In 1897, Albert Scherzer founded Scherzer Rolling Lift Bridge Company (until 1936)
 - 1936 Hazelet + Erdal
 - 1995 Dames and Moore
 - 1999 URS
 - 2014 AECOM



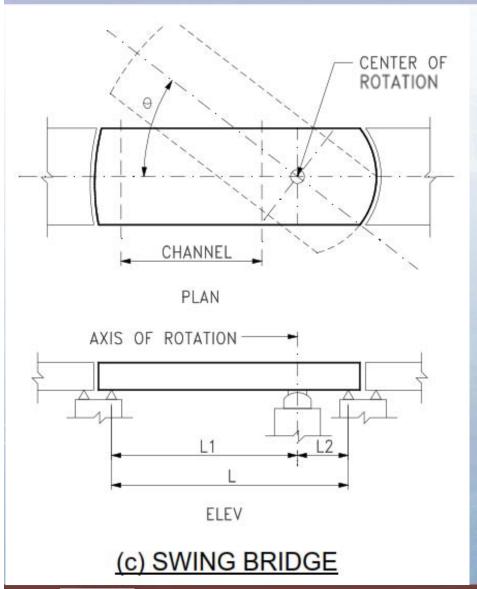


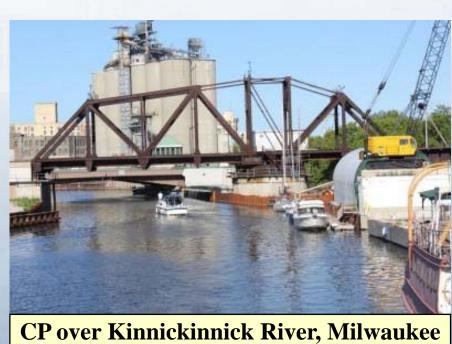
(e) VERTICAL LIFT BRIDGE

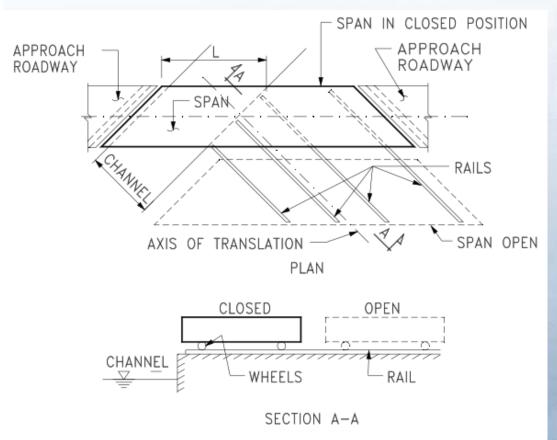




Clybourn Street, Milwaukee

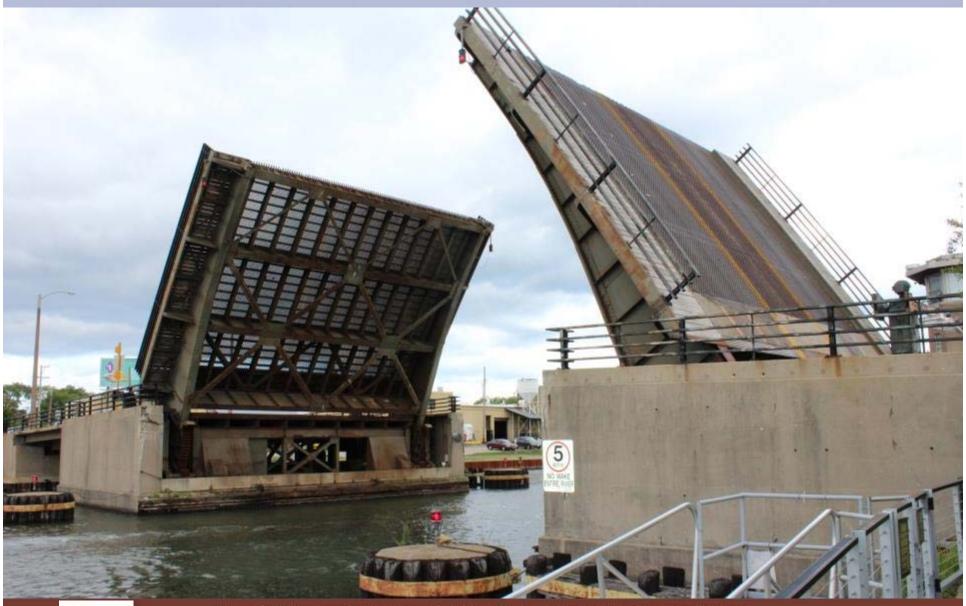




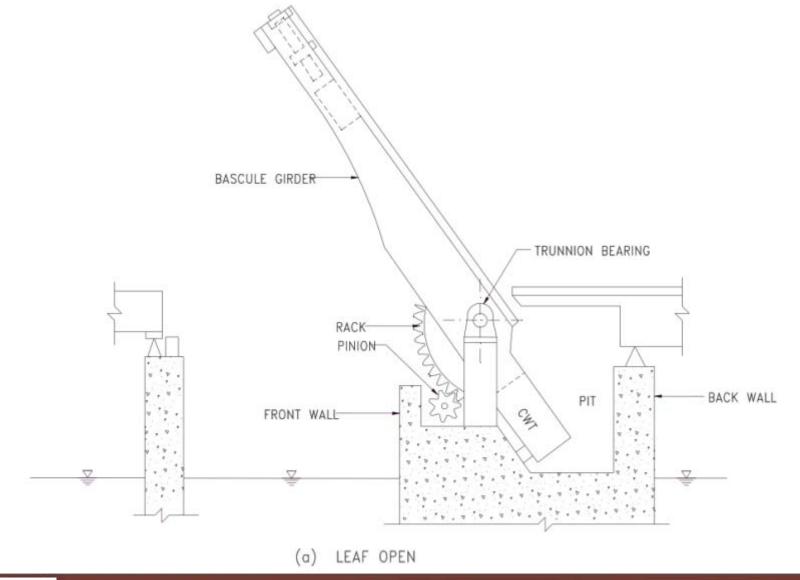




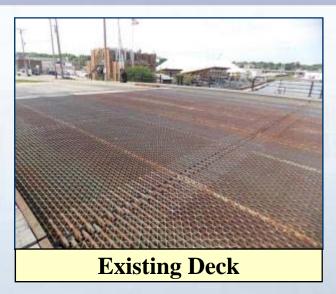
South 1st St. Bascule Bridge



Simple Trunnion Bascule Bridge



Steel Grid Deck





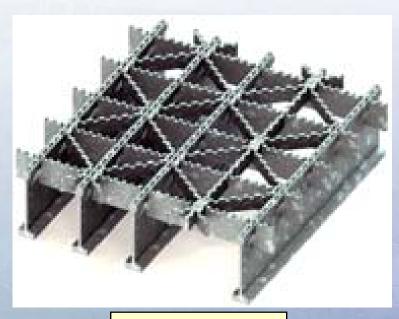




Steel Grid Deck – Riveted vs. Welded

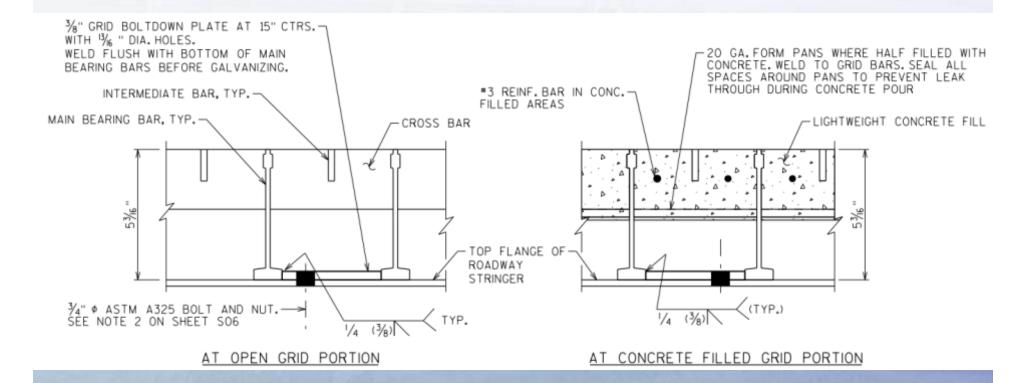


Heavy Duty Riveted



4-Way Welded

Steel Grid Deck – Half Fill



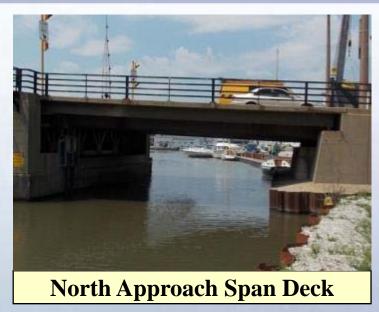
13

Concrete Decks



Deck over Machinery & Counterweight Pits







Sidewalk and Railing Systems





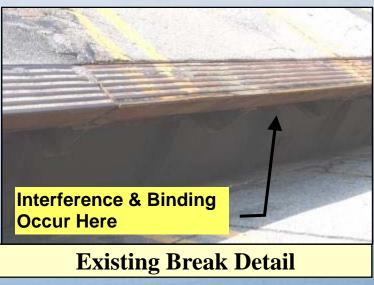
Galvanized Bridge Railing

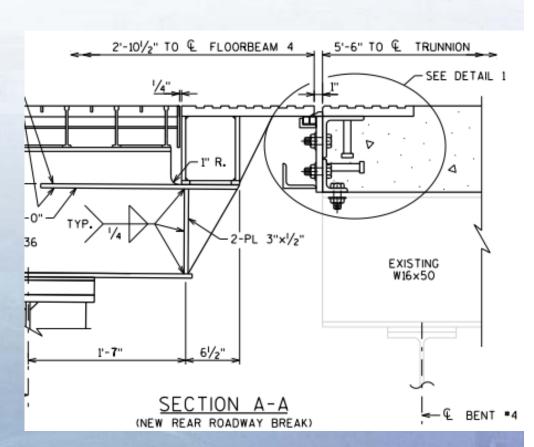


Slip Resistant Steel or Fiberglass Plate

Rear Break Details







Improved Break Detail

Bascule Steel Repair & Replacement



Replace Grid Floor Framing



Heel Portion

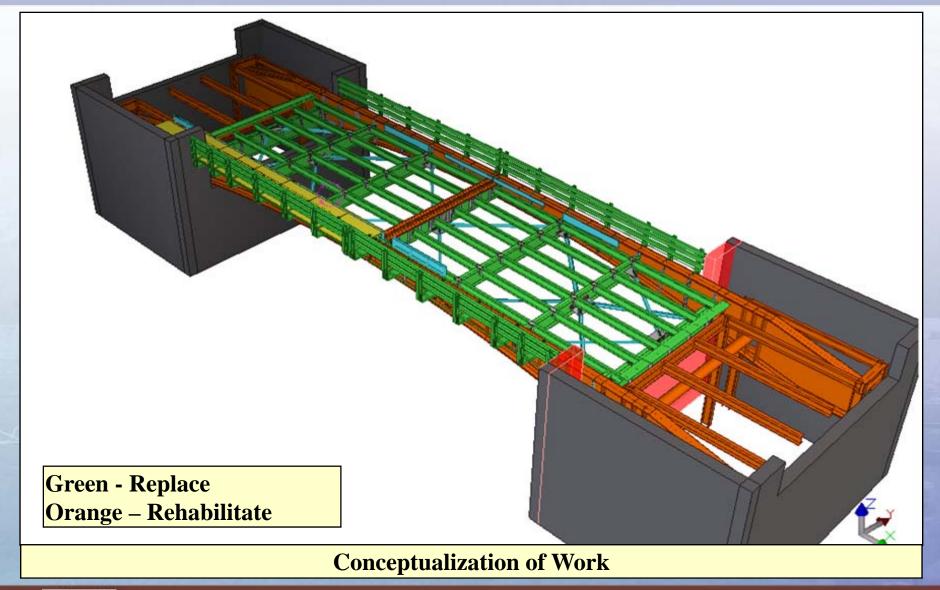


Galvanized & Painted Steel





Bascule Steel Repair & Replacement



Pier Repairs

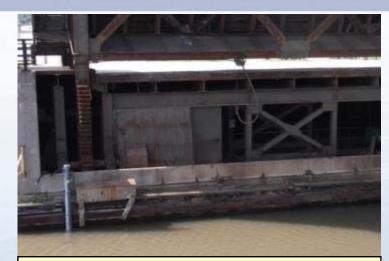








Fenders & Protection Cells



Existing Timber Fender

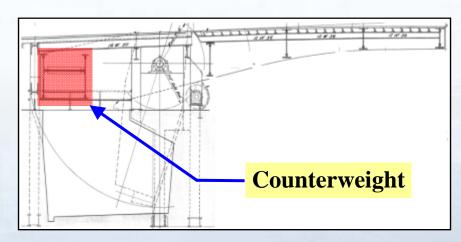


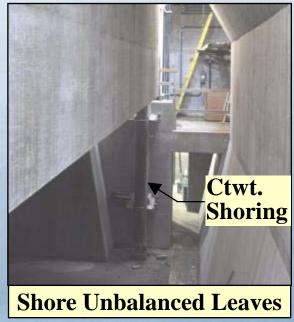
Existing Fender Pier



Rehabilitated Fender Pier

Counterweight & Span Balance

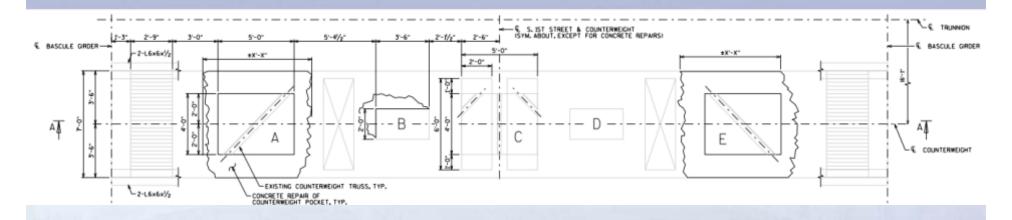




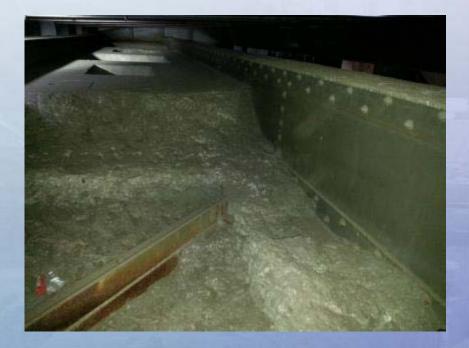


Existing Counterweight with Pocket Space

Counterweight & Span Balance





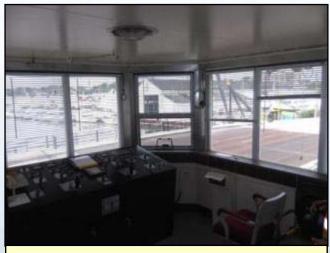


Balance Calculations

Roadway Grid		Item	Veight	X-dist	Y-dist	Z-dist	X-mom	Y-mom	Z-mom
Carid-Floorboom Welds								$\overline{}$	
Grid-Stringer Welds 1-924 24.317 3.750 -0.3653 -1021 -158 4 4 58 5 53 52 52 52 53 52 53 53								$\overline{}$	
Sidewalk Grid									
Floorbeam 7, 6, 5								-	
Floorbeam 4									
Sidewalk Curb Pitete -900 24.237 4.374 10.047 -19438 -3438 -8038 Sidewalk Curb Clip Angle -356 24.237 4.316 10.146 -8650 -1752 -4517 Sidewalk Grid Support Angle -361 27.223 4.325 13.344 -3630 -1742 -4517								$\overline{}$	0
Sidewalk Curb Clip Angle								$\overline{}$	
Sidewalk Grid Support Angle -361 27.223 4.825 13.344 -3830 -1742 -4871								$\overline{}$	
Sw Grid Post Angle								-	
## Safety Walls Curb Plate								-	
Pailing Posts								-	
Bottom Rails		_							0
Top Rail								$\overline{}$	0
QY Safety Walk Checkered Plate -24 -0.021 4.350 12.750 1 -104 -306 Safety Walk Checkered Plate -284 2.646 4.482 -12.750 -751 -1273 362* Safety Walk Checkered Plate -484 2.646 4.435 -12.750 -111 -166 526* Stringer Horiz, Support Angle -434 25.094 2.460 -0.363 -10891 -1066 42* FB7 Stiffeners -111 44.714 2.908 0.000 -4963 -323 0 FB4 Stiffeners -534 5.625 0.353 0.000 -3441 -210 0 FB4 Shim Plates -63 5.625 0.353 0.000 -3441 -210 0 FB4 Shim Plates -63 5.625 0.353 0.000 -3381 -140 67 FB4 Shim Plates -63 5.625 0.351 0.000 -3581 -60 1436 -62 -1418 -60 -60 -60	7							$\overline{}$	0
QY Safety Walk Checkered Plate -24 -0.021 4.350 12.750 1 -104 -306 Safety Walk Checkered Plate -284 2.646 4.482 -12.750 -751 -1273 362* Safety Walk Checkered Plate -484 2.646 4.435 -12.750 -111 -166 526* Stringer Horiz, Support Angle -434 25.094 2.460 -0.363 -10891 -1066 42* FB7 Stiffeners -111 44.714 2.908 0.000 -4963 -323 0 FB4 Stiffeners -534 5.625 0.353 0.000 -3441 -210 0 FB4 Shim Plates -63 5.625 0.353 0.000 -3441 -210 0 FB4 Shim Plates -63 5.625 0.353 0.000 -3381 -140 67 FB4 Shim Plates -63 5.625 0.351 0.000 -3581 -60 1436 -62 -1418 -60 -60 -60	-								0
QY Safety Walk Checkered Plate -24 -0.021 4.350 12.750 1 -104 -306 Safety Walk Checkered Plate -284 2.646 4.482 -12.750 -751 -1273 362* Safety Walk Checkered Plate -484 2.646 4.435 -12.750 -111 -166 526* Stringer Horiz, Support Angle -434 25.094 2.460 -0.363 -10891 -1066 42* FB7 Stiffeners -111 44.714 2.908 0.000 -4963 -323 0 FB4 Stiffeners -534 5.625 0.353 0.000 -3441 -210 0 FB4 Shim Plates -63 5.625 0.353 0.000 -3441 -210 0 FB4 Shim Plates -63 5.625 0.353 0.000 -3381 -140 67 FB4 Shim Plates -63 5.625 0.351 0.000 -3581 -60 1436 -62 -1418 -60 -60 -60	6							-	
QY Safety Walk Checkered Plate -24 -0.021 4.350 12.750 1 -104 -306 Safety Walk Checkered Plate -284 2.646 4.482 -12.750 -751 -1273 362* Safety Walk Checkered Plate -484 2.646 4.435 -12.750 -111 -166 526* Stringer Horiz, Support Angle -434 25.094 2.460 -0.363 -10891 -1066 42* FB7 Stiffeners -111 44.714 2.908 0.000 -4963 -323 0 FB4 Stiffeners -534 5.625 0.353 0.000 -3441 -210 0 FB4 Shim Plates -63 5.625 0.353 0.000 -3441 -210 0 FB4 Shim Plates -63 5.625 0.353 0.000 -3381 -140 67 FB4 Shim Plates -63 5.625 0.351 0.000 -3581 -60 1436 -62 -1418 -60 -60 -60	\approx							-	
QY Safety Walk Checkered Plate -24 -0.021 4.350 12.750 1 -104 -306 Safety Walk Checkered Plate -284 2.646 4.482 -12.750 -751 -1273 362* Safety Walk Checkered Plate -484 2.646 4.435 -12.750 -111 -166 526* Stringer Horiz, Support Angle -434 25.094 2.460 -0.363 -10891 -1066 42* FB7 Stiffeners -111 44.714 2.908 0.000 -4963 -323 0 FB4 Stiffeners -534 5.625 0.353 0.000 -3441 -210 0 FB4 Shim Plates -63 5.625 0.353 0.000 -3441 -210 0 FB4 Shim Plates -63 5.625 0.353 0.000 -3381 -140 67 FB4 Shim Plates -63 5.625 0.351 0.000 -3581 -60 1436 -62 -1418 -60 -60 -60	6							$\overline{}$	
Safety Walk Checkered Plate	2						1		
Staf W Chkrd PL Support L -42 2.646 4.435 -12.750 -111 -166 536	ш						-751	$\overline{}$	
Stringer Horiz, Support Angle									
FB7 Stiffeners								-	
Rail Bracket Fill Plate								-	
FB4 Stiffeners									0
FB4 Shim Plates								$\overline{}$	0
Centerlock Casting & Bar								$\overline{}$	
Curb PL-Stringer Weld Saf Wilk Curb PL-Girder Cvr PL Weld -3 26,379 4,312 -11,364 -243 -444 106 Center Break Welds -24 41,771 4,153 -0,369 -1003 -100 23 Rear Break Welds -21 3,755 3,614 -0,369 -1003 -79 -76 20 Roadway Grid Grid Connxn PL & Bolts 1062 24,042 3,714 -0,369 336896 64431 -1580* Grid Connxn PL & Bolts 1062 24,042 3,714 -0,369 35533 3344 -1023 Longit, Trim Bars 343 24,333 3,351 -0,369 3494 1373 -338 Transv, Trim Bars 193 24,333 3,351 -0,369 34697 763 -187 Floorbeam 7 2601 44,563 3,007 0,000 115308 7821 0 Floorbeam 6&5 5,200 25,034 2,412 0,000 130533 12543 0 Floorbeam 4 2364 5,625 0,415 0,000 130533 12543 0 Center Break Plate 1072 44,563 4,158 -0,369 47815 4531 -1035 Center Break Shims 374 44,563 4,158 -0,369 16667 1555 -362 ### August Break Break 1072 14,564 1,565 0,369 1216 1043 -293 Diaphragms 68 4,052 3,438 -0,369 1216 1043 -293 Diaphragms 68 4,052 3,438 -0,369 1216 1043 -293 Bottom PL 110 4,052 3,310 -0,369 53 443 -135 FB4-Stringer Bolts 13 4,052 3,271 -0,369 53 43 -135 FB4-Stringer Bolts 13 5,625 2,624 11,031 748 343 1467 Safety Walk Bent PL Curb 110 4,052 3,271 -0,369 53 43 -135 FB4-Stringer Bolts 13 5,625 2,624 11,031 748 343 1467 Safety Walk Bent PL Curb 110 20,833 4,576 12,074 1667 366 -366 Safety Walk Clip Angles 80 20,833 4,576 12,074 1667 366 -366 Safety Walk Clip Angles 80 20,833 4,576 12,074 1667 366 -366 Safety Walk Clip Angles 80 20,833 4,576 12,074 1667 366 -366 Safety Walk Clip Angles 80 20,833 4,576 12,074 1667 366 -366 Safety Walk Clip Angles 80 20,833 4,576 12,074 1667 366 -366 Safety Walk Clip Angles 80 20,833 4,576 12,074 1667 366 -366 Safety Walk Clip Angles 80 20,833 4,576 12,074 1667 366 -366 Safety Walk Clip Angles 80 20,833 4,576 12,074 1667 366 -366 Safety Walk Clip Angles 80 20,833 4,576 12,074 1667 366 -366 Safety Walk Clip Angles 80 20,833 4,576 12,074 1667 366 -366 Safety Walk Clip Angles 80 20,833 4,576 12,074 1667 366 -366									
Saf Wilk Curb PL-Girder Cvr PL Weld -3 26.979 4.912 -11.984 -243 -44 108 Center Break Welds -24 41.771 4.153 -0.969 -1003 -100 23 Rear Break Welds -21 3.755 3.614 -0.969 -79 -76 20 20 20 20 20 20 20 2			-					-	4
Center Break Welds									
Rear Break Welds								-	
Roadway Grid									
Grid Connxn PL & Bolts 1062 24.042 3.714 -0.969 25533 3344 -1023		rical Dical II clas		0.100	0.014	0.000	10	10	
Grid Connxn PL & Bolts 1062 24.042 3.714 -0.969 25533 3344 -1023		Boadway Grid	16307	24.339	3 951	-0.969	396896	64431	-15801
Longit, Trim Bars								-	
Transv. Trim Bars 133 24.333 3.951 -0.969 4697 763 -187 Floorbeam 7 2601 44.563 3.007 0.000 115908 7821 0.000 Floorbeam 68.5 5202 25.094 2.412 0.000 130503 12543 0.000 Floorbeam 4 2364 5.625 0.415 0.000 13410 383 0.000 Center Break Plate 1072 44.604 4.282 -0.969 47815 4591 -1033 Center Break Shims 374 44.563 4.158 -0.969 16667 1555 -362 Rear Break								-	
Floorbeam 7									
Floorbeam 68.5 S202 25.094 2.412 0.000 130539 12549 0.000 130539 12549 0.000 130539 12549 0.000 13410 383 0.000 0.000 13410 383 0.000 0.00			_					$\overline{}$	0
Floorbeam 4						_		-	0
Center Break Plate 1072 44.604 4.282 -0.969 47815 4591 -1033 Center Break Shims 374 44.563 4.188 -0.969 16667 1555 -366					_				0
Center Break Shims				_				-	
Rear Break Top PL S61 3.719 3.675 -0.369 2086 2062 -544								-	
Top PL S61 3.719 3.675 -0.969 2086 2062 -544									
Side PL 300 4.052 3.498 -0.969 1216 1049 -291			561	3,719	3.675	-0.969	2086	2062	-544
Diaphragms									
Safety Walk Bent PL Curb 1126 20.854 4.672 -12.026 23482 5260 -1354 5261	느								-66
Safety Walk Bent PL Curb 1126 20.854 4.672 -12.026 23482 5260 -1354 5261	6							-	
Safety Walk Bent PL Curb 1126 20.854 4.672 -12.026 23482 5260 -1354 5261	世							-	-107
Safety Walk Bent PL Curb 1126 20.854 4.672 -12.026 23482 5260 -1354 5261	2								-15
Safety Walk Bent PL Curb 1126 20.854 4.672 -12.026 23482 5260 -1354 5261	兴								-13
Safety Walk Bent PL Curb 1126 20.854 4.672 -12.026 23482 5260 -1354 5261	φ								-18
Safety Walk Bent PL Curb 1126 20.854 4.672 -12.026 23482 5260 -1354 5261	4								
Safety Walk Bent PL Curb 1126 20.854 4.672 -12.026 23482 5260 -1354 5261	ቨ								
X Safety Walk Clip Angles 80 20.833 4.576 -12.074 1667 366 -366 Sdwlk Stringer C10 1400 27.336 4.536 14.807 38354 6435 20730	Ш							-	
Sdwlk Stringer C10 1400 27.396 4.596 14.807 38354 6435 20730		_						$\overline{}$	-366
	_							$\overline{}$	20730

CON	CR	ETE BLOCKS	(fxfxf)									
		EXIST.	# BLKS	FINAL	CAPA-	WT. BLKS	X	Υ	Z	MX	MY	MZ
		# BLKS	REMOVED	# BLKS	СПҮ	(kips)	(distanc	e from Pt	O,feet)		(kip -feet)	
BLO	CK	S IN COUNTE					,				` '	
Α		0	0	0	4	0.00	-14.54	-3.92	0.00	0.00	0.00	0.00
В		0	0	0	30	0.00	-11.04	-2.92	0.00	0.00	0.00	0.00
С		8	8	0	24	-1.84	-12.54	0.26	0.00	23.08	-0.47	0.00
		TOTAL	8			-1.84	k			23.08	-0.47	0.00
STE	EL	BLOCKS (3°3										
			# BLKS	FINAL	CAPA-	WT.	X	Y	Z	MX	MY	MZ
			ADDED	# BLKS	CITY	(kips)	(distanc	e from Pt	O,feet)		(kip -feet)	
BOTT	. RC	DW BLOCKS										
		EAST	0		43	0.00	-16.13	-2.94	0.29	0.00	0.00	0.00
		WEST	0		43	0.00	-16.13	-2.94	-0.29	0.00	0.00	0.00
TOPE	ROV	V BLOCKS										
		EAST	0		43	0.00	-16.13	-1.94	0.29	0.00	0.00	0.00
		WEST	0		43	0.00	-16.13	-1.94	-0.29	0.00	0.00	0.00
TOP	n n	MPARTMENT										
		EAST	180		192	5.51	-12.54	0.33	6.38	-69.14	1.84	35.14
		WEST	0		192	0.00	-12.54	0.33	0.00	0.00	0.00	0.00
		TOTAL	180			5.51	k			-69.14	1.84	35.14
STE	FL	PLATE (1.5° c	ы									
			‡PL		WT/PL		X	Υ	Z	MX	MY	MZ
			ADDED	SIZE	(lbs.)	WT.(kips)		e from Pt			(kip -feet)	
-	ā	Outer	2	5.5×1.25	421.09	0.84	-15.750	-0.314	3,420	-13.26	-0.26	7.93
	TOP	Inner	1	5.5×1.25	421.09	0.42	-15.688	-0.314	3.180	-6.61	-0.13	1.34
	-	Outer	3	5.5'xf	336.88	1.01	-15.813	-2.229	9.420	-15.98	-2.25	9.52
East	E E	Inner	2	6'x1.83'	673.63	1.35	-15.750	-2.604	3.180	-21.22	-3.51	4.28
.Cr.	\vdash	Block Support	1	6'x.5'x1"	122.45	0.12	-16.125	-3,479	3.180	-1.97	-0.43	0.39
"	UNDER	Outer	3	5.5x2.33	786.03	2.36	-12.540	-4.563	7.733	-29.57	-10.76	18.24
Ш	5	Inner	4	5.5x2.75	926.41	3.71	-12.540	-4.625	4.801	-46.47	-17.14	17.79
\vdash	а	Outer	1 1	5.5°x1.25°	421.09	0.42	-15.688	-0.314	-9.420	-6.61	-0.13	-3.97
	TOP	Inner	2	5.5×1.25	421.03	0.84	-15.750	-0.314	-3.180	-13.26	-0.26	-2.68
	-	Outer	1	5.5'xf	336.88	0.34	-15.688	-2.229	-9.420	-5.28	-0.75	-3.17
West	вотт.	Inner	2	6'x1.83'	673.63	1.35	-15.750	-2.604	-3.180	-21.22	-3.51	-4.28
of	%	Block Support	1	6'x.5'x1"	122.45	0.12	-16,125	-3.479	-3.180	-1.97	-0.43	-0.39
.CL.	UNDER	Outer		5.5°x2.33°	786.03	0.00	-12.540	-4.375	-7.733	0.00	0.00	0.00
	š	Inner	1	5.5x2.75	926.41	0.93	-12.540	-4,438	-4.801	-11.62	-4.11	-4.45
							.2.070	7.700				
		STRAPS	8		11.89	0.10	-16.479	-2.573	0.000	-1.57	-0.24	0.00
		TOTAL	24			13.80	k			-195.05	-43.67	40.55

Control House Architectural



Lighting

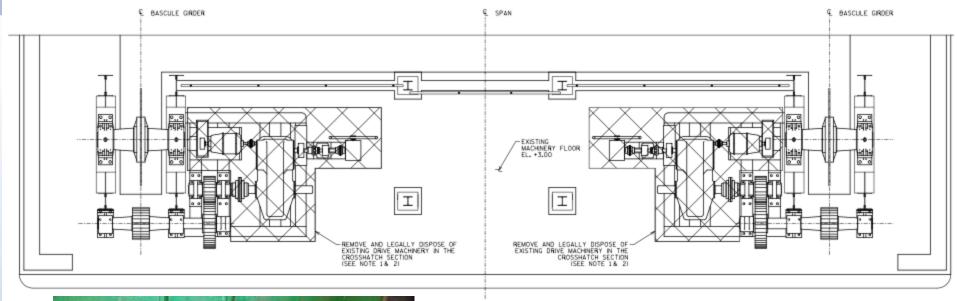


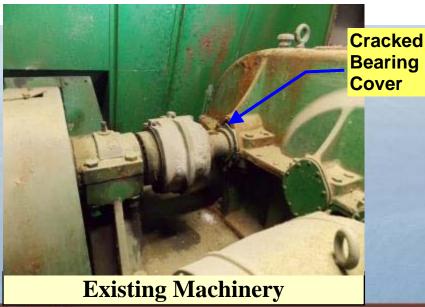


Doors and glass block windows





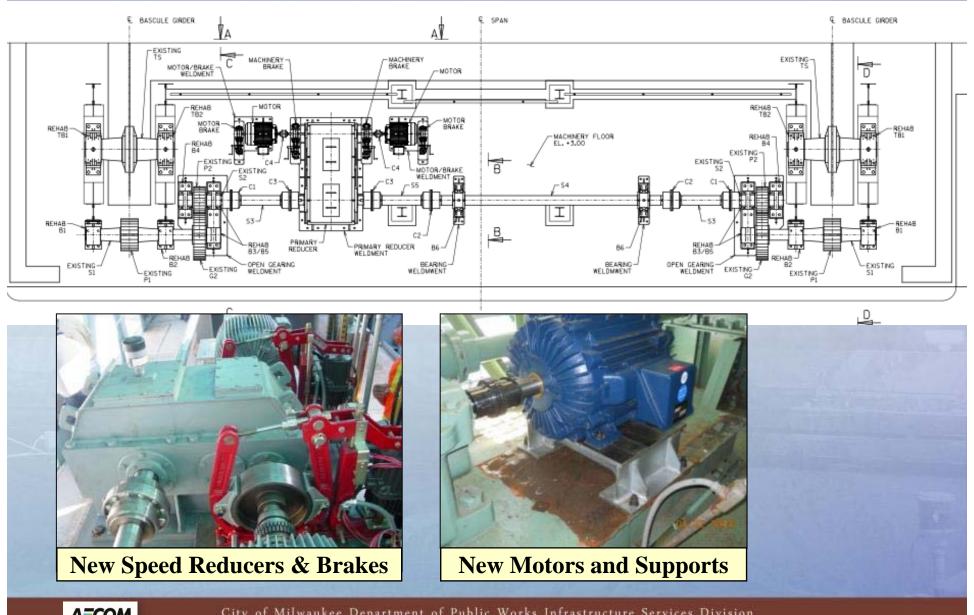


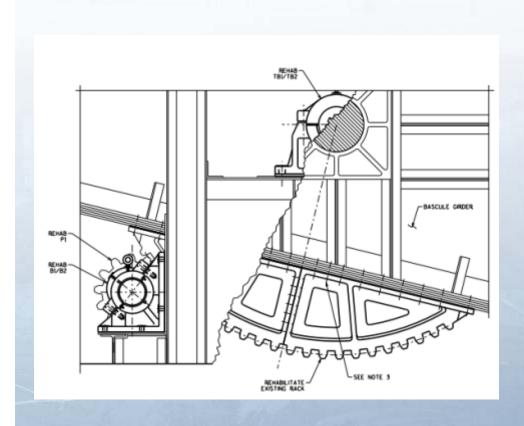




Existing Machinery Brake

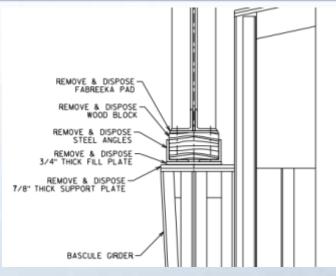
AECOM





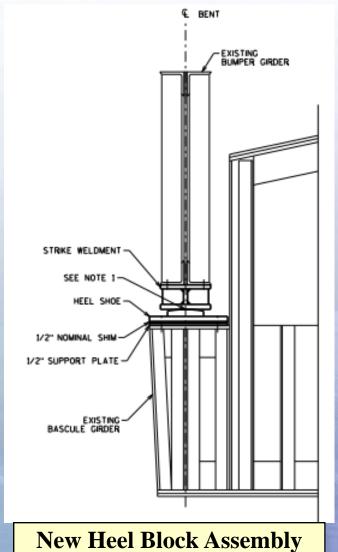


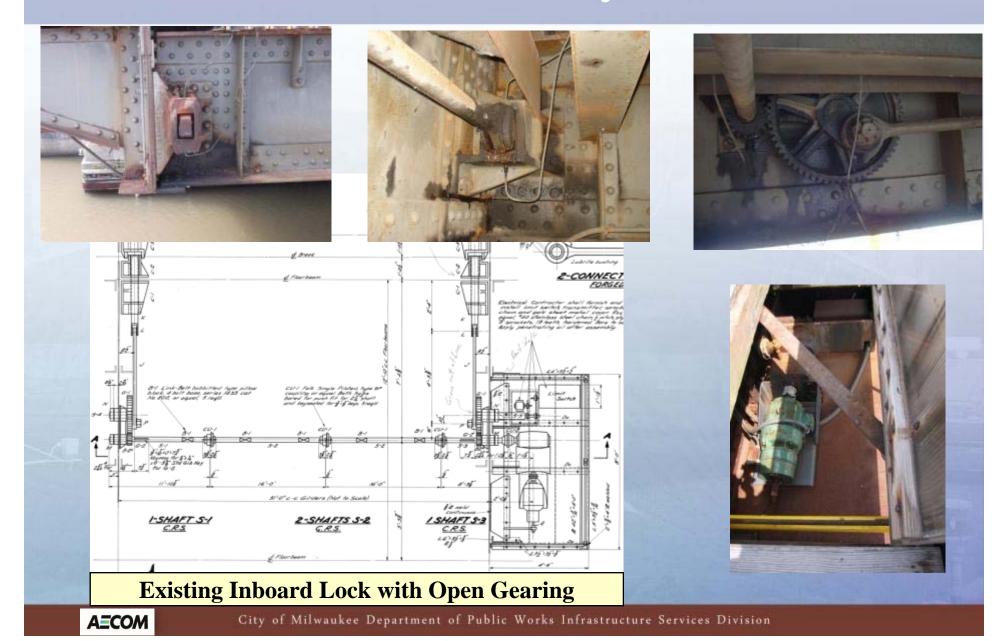


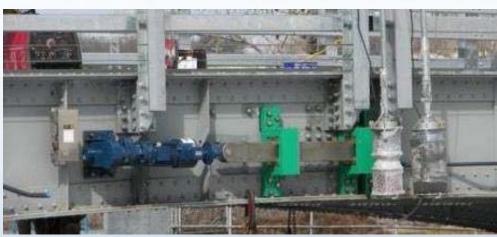


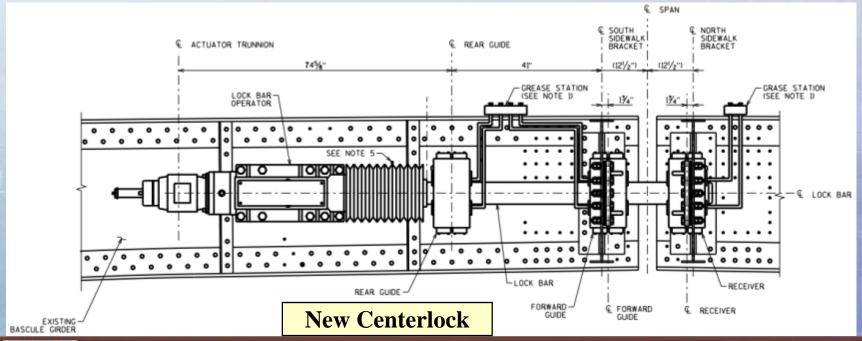


Existing Heel Block Assembly









Electrical System

Dual Power Feeds Submarine Cables Relays & PLC Motors





Remote Operation

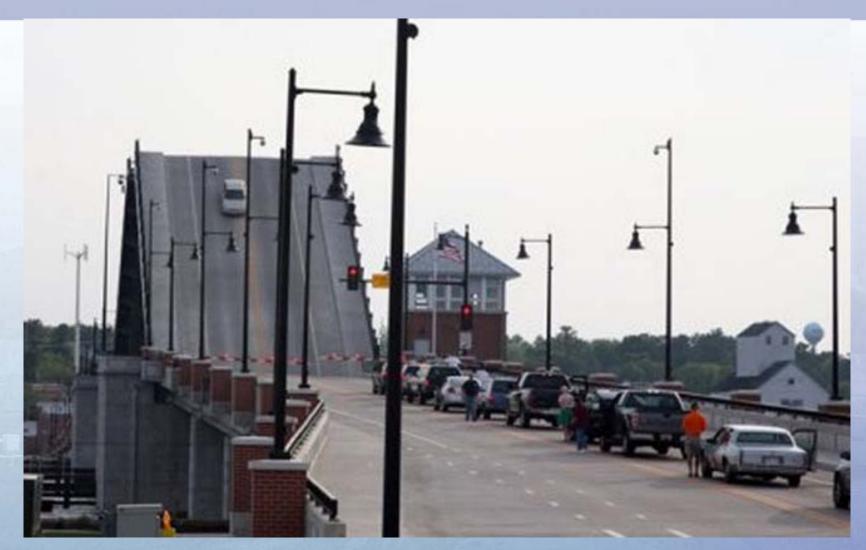
Can operate locally or from KK bridge





Upgrade communications and console at KK bridge

Traffic Gates



"Motorist gets a lift in Sturgeon Bay"

Maintaining Navigation



Active Waterway during Nav. Season



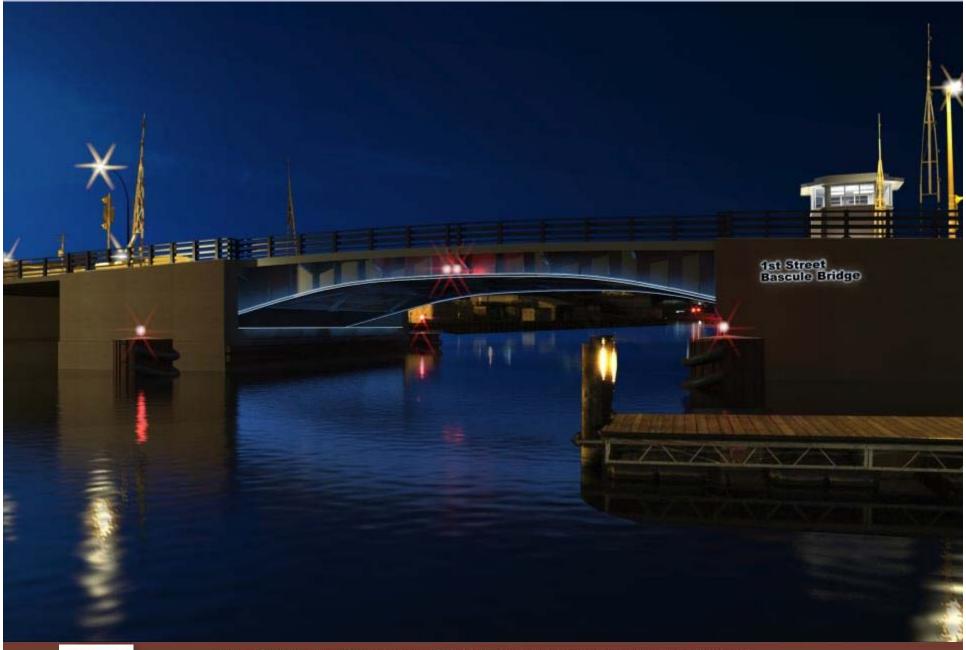


Enhancements

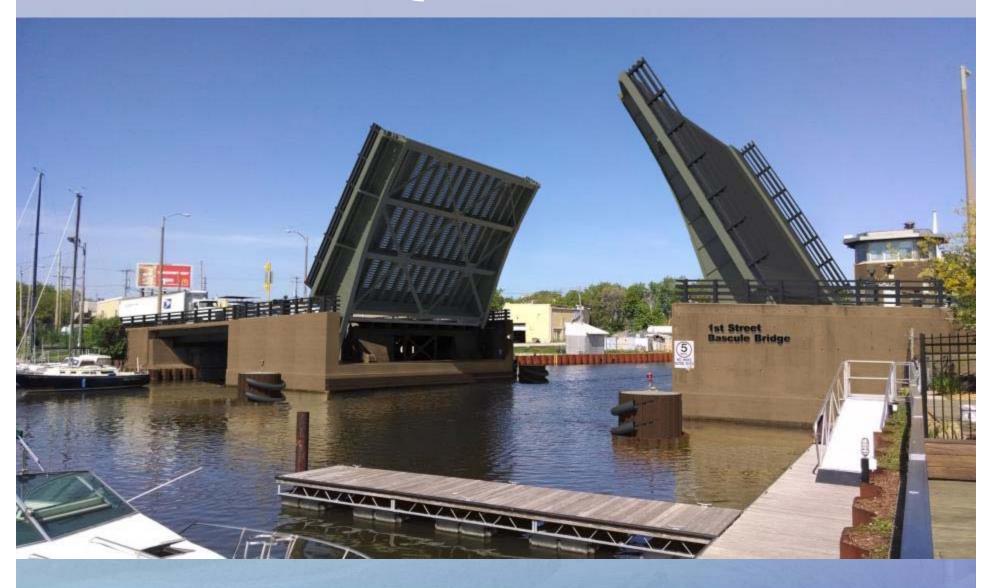
- Solid surface bicycle accommodations
- Concrete stain
- Steel painting
- LED architectural lighting
- Bridge railing



Night Rendering

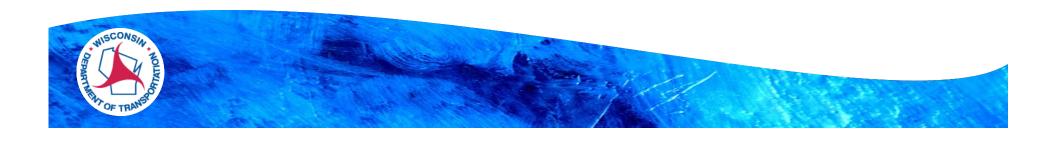


Questions?



Construction Topics

Bill Dreher
WisDOT Structures Design Chief



Piling

- CAUTION
- H Piles for displacement piles
 - H piles tend to drive considerably longer than plan length
 - Work with Geotech engineer



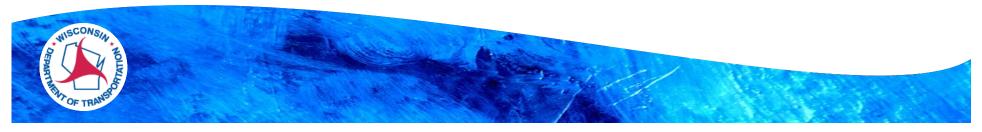




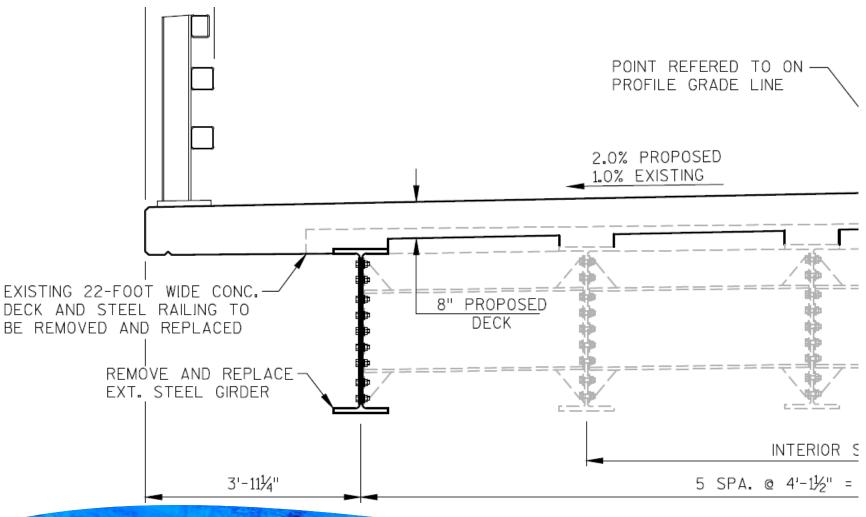
Haunches

- ▶ Limit haunch heights added DL
 - 54W & 72W





Exterior Girder Deflections

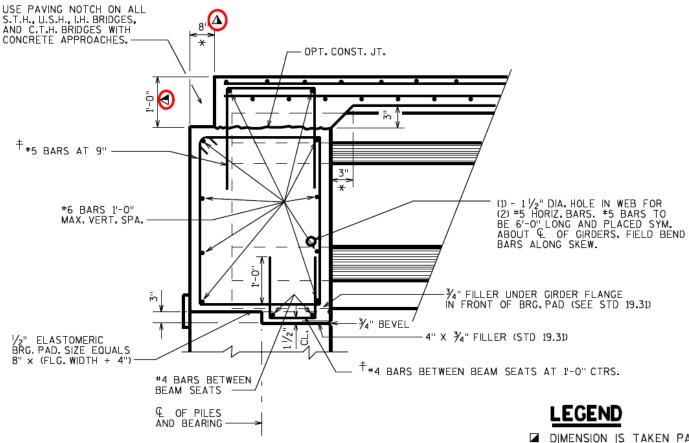




Rustications and Formliners



Structural Approach Slabs

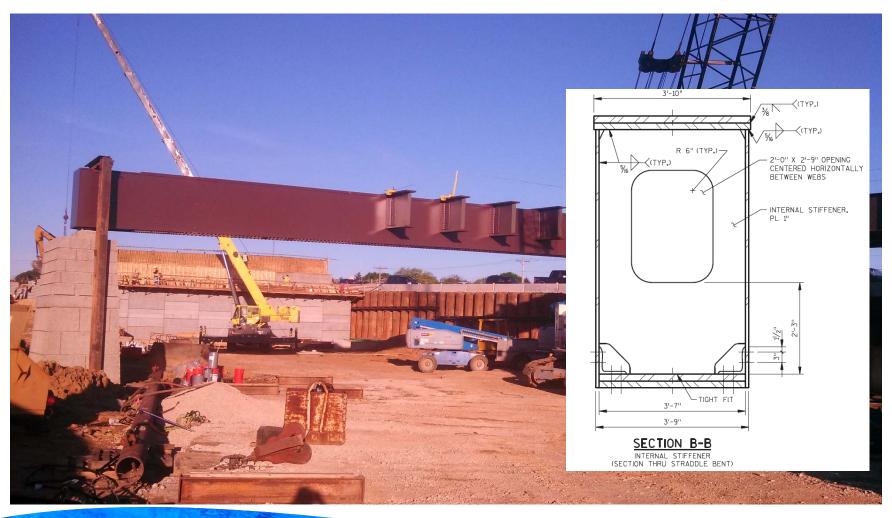


PRESTRESSED GIRDER WITH SEMI-EXPANSION SEAT

- ☑ DIMENSION IS TAKEN PARALLEL TO € GIRDER.
- * DIMENSION IS TAKEN NORMAL TO € SUBSTRUCTURE UNITS.
- PAVING NOTCH IS 1'-0" WIDE BY 1'-4" DEEP IF STRUCTUAL APPROACH SLAB (STD. 12.10) IS USED.
- # BARS PLACED PARALLEL TO GIRDERS. SPACING PERPENDICULAR TO & GIRDERS.



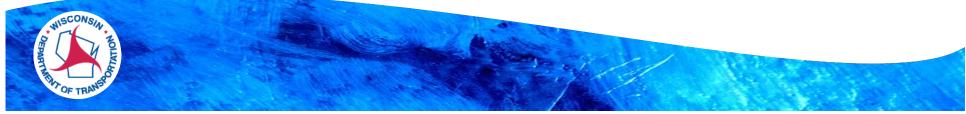
Member Availability





Inspection Access





- 502.2.11 Crack and Surface Sealers
 - Clarifies materials for crack, deck, and parapet sealing (from the approved products list)





- 502.2.11 Crack and Surface Sealers
 - Crack Sealer?
 Low Viscosity Crack Sealers for Bridge Decks



- ▶ 502.2.11 Crack and Surface Sealers
 - Protective surface treatment?
 Concrete Protective Surface
 Treatment





- 502.2.11 Crack and Surface Sealers
 - Pigmented surface sealer?

Cure & Seal Compounds for Non-trafficked Surfaces on Structural Masonry

For use on the

inside face and top of parapets





- ▶ 505.5 Payment (Steel Reinforcement)
 - Eliminates separate bid items for bridges, culverts, and retaining walls
 - 3 new bid items:
 - Bar Steel Reinforcement Structures
 - Bar Steel Reinforcement HS Structures
 - Bar Steel Reinforcement HS Coated Structures





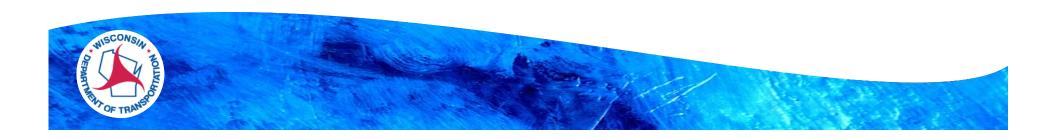
- 513.4 Measurement & 513.5 Payment (Railing)
 - All railing bid items now measured by linear foot
- 2018: look for revisions to 513 including addition of galvanized and painted steel railings (Combination Railings Types "C1-C6")





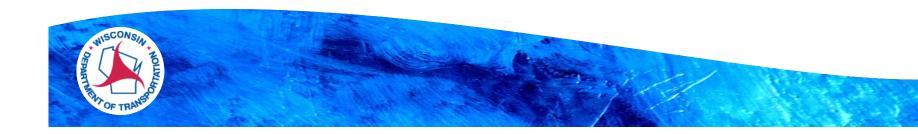
SPV Reduction

- SPV's create variability in plans, specifications, and estimates
- SPV's make up approximately ¼ of contract dollars
- Affects bidding, plan review, and construction
- Develop standard bid items for SPV items that are utilized frequently



SPV Reduction

- **BOS**
 - SPV to STSP
 - 6 complete
 - 18 sent to BPD
 - 40 ready soon
 - SPV to Historic File
 - 29 complete
 - SPV to Standard Specification
 - 3 complete
 - 4 sent to BPD



- Self-Consolidating Concrete (SCC)
 - Eliminate problems associated with vibration
 - Less labor
 - Faster construction
 - Improved quality and durability
 - Higher strength
 - WHRP: prestressed concrete girders
 - Investigate material properties (modulus, shrinkage, creep)
 - Related to time-dependent characteristics, flexural stiffness change, prestress losses

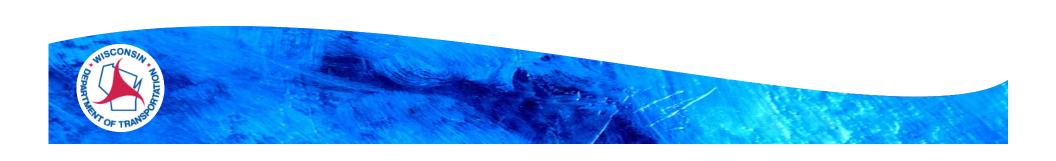




- Polyester Polymer Concrete (PPC)
 - Mixture of aggregate, polyester polymer resin and initiator
 - Placed as a deck overlay using conventional concrete

mixing and placement equipment

- Thickness of ¾" to 1"
- 4 hour cure time
- Practically impermeable
- Expected service life of 20-30 years
- Estimated cost of placing PPC overlay is \$12/SF



- Fiber Reinforced Polymer (FRP)
 - Composite material consisting of glass or carbon fibers in resin matrix
 - High strength and stiffness; lightweight and thin
 - Installed relatively quickly; minimizes impact on traffic
 - Corrosion protection (pier columns)
 - Strengthen existing structures (shear and flexure)
 - BM Chapter 40 July release

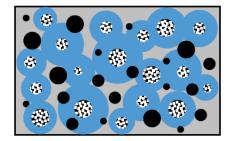


- Internally Cured Concrete
 - Supplies additional curing water throughout the concrete mixture
 - Uses water absorbed in lightweight aggregate
 - "Curing concrete from the inside out"
 - Prevents early age shrinkage, increases hydration of

cementitious materials

Lowers the permeability of the concrete

- Normal Aggregate
- ☼ Prewetted LWA
- Cured Zone



Internal Curing with Prewetted Lightweight Aggregate (LWA)

Lead Paint on Steel Girders

Paint is not a hazardous waste until it is removed from the steel

If contractor takes possession of steel with paint attached, they are responsible for safe handling

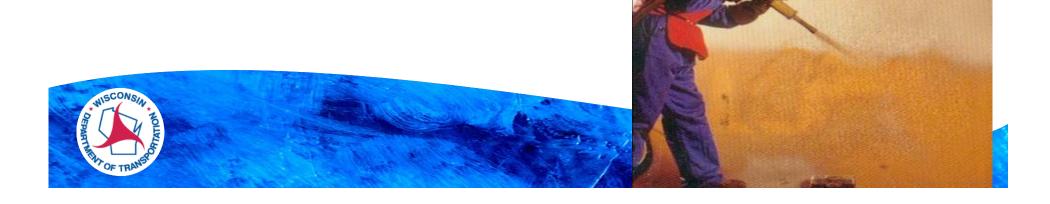
and disposal



Lead Paint on Steel Girders

- If paint is removed for repainting, waste must go through DOT disposal process
 - Always assume there is lead paint present
 - Labeling and Disposal of Waste Material
 - Portable Decontamination Facility
 - Cleaning by blasting with grit: Negative Pressure Containment and Collection of Waste Materials
 - Cleaning by hand or power tools: Containment and





Staging Considerations

- Staged construction joint locations on plans must allow working room for contractor/field staff
- Work with roadway designers to ensure adequate clearances are provided









Bridge Deck Construction

Great River Road

Wisconsin Division Office

FHWA WisDOT Joint Program Review













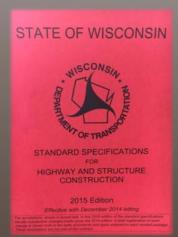


Review Purpose

Great River Road

- Determine if Standard Specifications are consistently administered throughout the Regions
- Identify best practices/opportunities for improvement











Team Members

Great River Road

- FHWA
- WisDOT
 - NE Region Construction
 - Bureau of Project Development
 - Bureau of Technical Services
 - SE Freeways/SE Region
 - Bureau of Structures: Design/Maintenance







Scope & Methodology

Great River Road

- 2015 Construction Season
 - Full-depth concrete bridge decks & Grade E overlays
 - Four Regions NE, NC, SE, & SW
 - 22 State and local bridge projects
 - Compare program to neighboring states IL, IA
 - Contractor interviews







Some Observations

Great River Road

- Application of fogging/continuous, wet, curing is not timely – Grade A, HPC
- Inadequate length of finishing machine rails results in unnecessary hand finishing





Curing, Finishing Machine Rails

Great River Road

Wisconsin Division Office





HPC doesn't mean "Hey, Postpone Curing!"







More Observations

Great River Road

- Roles & responsibilities aren't well understood
 - Inspector Quality Assurance
 - Dry runs not performed in consistent manner
 - No written notification to proceed with deck pour
 - Contractor Quality Control
 - Ineffective contingency plans
 - Unacceptable burlap condition







Dry Runs, Poor Mix Designs, & Holy Burlap!











Observed Best Practices

Great River Road

- Use of stainless steel in decks for Mega/Major projects and complex structures
- Quality Management Plan
 - Material testing and sampling procedures
 - Verification testing program (QV)
 - Independent Assurance (IA)







Recommendations

Inspection Participant Guide

Wisconsin Division Office

- Need for training
 - Expand 1-day Bridge Construction Inspection course
 - Refer to WisDOT Construction Critical Inspection guidance
 - Update pre-pour meeting checklist in CMM
 - Inform industry of findings at Bridge **Technical Committee meetings**

FHWA Final Report mid-June







Take Aways

Great River Road

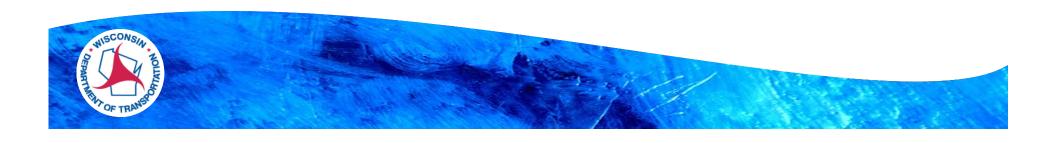
- Remember C.E.R.T.
- ✓ Cure decks....continuously, timely
- ✓ Extend rails
- ✓ Review contingency plans
- ✓ Take the training





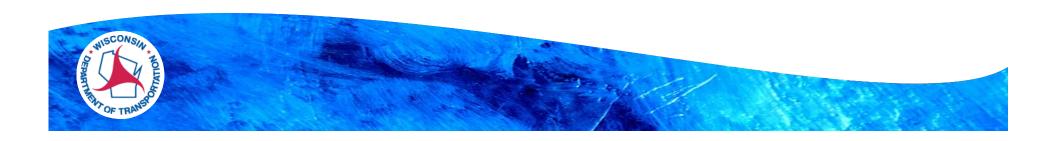
Ancillary Structures

Ben Koeppen – BOS Inspection Engineer Anthony Stakston – NC Ancillary Program Manager



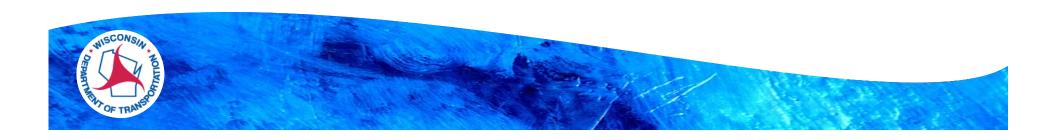
Program Creation

- Transportation Asset Management Plan (TAM)
 - Required for Pavement and Bridge Structures per MAP-21
 - Each State has to submit a TAM to FHWA to be certified by October 1, 2016



Transportation Asset Management

- ► TAM is a data driven decision-making framework that includes: Risk, Condition, Prioritization, Network, and Operation effects.
- Mission Statement:
 - The aim is to apply the appropriate treatments and activities at the proper time resulting in extended service life at an optimal life cycle cost.



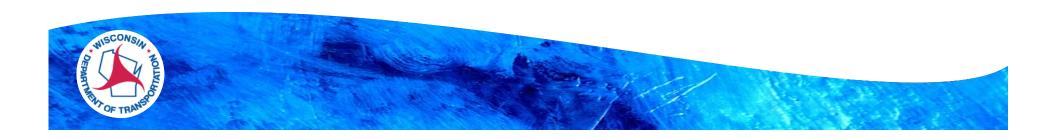
WisDOT Ancillary Program

- WisDOT took the federal mandate from MAP-21 and expanded it to other areas of operation
- Asset Management Groups for WisDOT include:
 - Traffic Features (Pavement Marking, Traffic Control Signs, Light Poles, Ramp Meters, etc.)
 - Roadside Facilities (Rest Areas, Waysides, SWEFs, Park & Rides, etc.)
 - Roadway Features (Salt Storage Facilities, Ramp Gates, Culvert Pipes, Cable Barriers, Crash Cushions, etc.)
 - Pavement & Bridge Structures
 - Ancillary Structures (Small Bridges, Retaining Walls, Noise Barriers, Overhead Signs, Signal Monotubes, and High Mast Lighting)



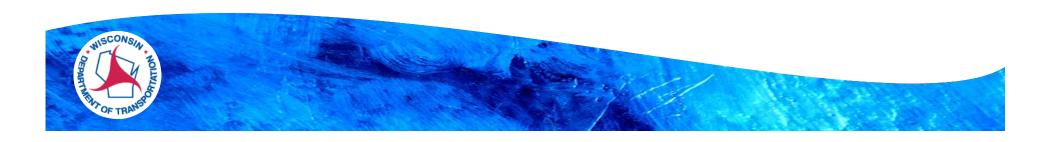
Ancillary Program Contacts

- Regional Ancillary Program Managers
 - NC Anthony Stakston
 - NE Brady Rades
 - NW Kyle Harris
 - SE Jason Zemke
 - SW-L David Bohnsack
 - SW-M Shiv Gupta
- Statewide Ancillary Inspection Program Manager
 - Travis McDaniel



Ancillary Program Contacts

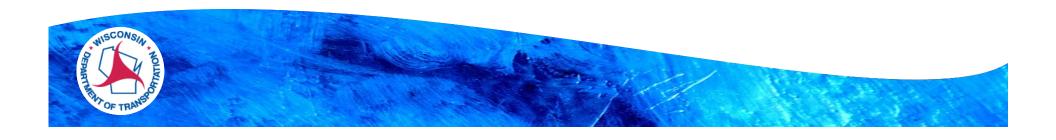
- BOS Design Contacts
 - Wind Loaded Structures Vu Thao
 - Sign Structures Alex Crabtree, Steve Doocy
 - Noise Walls Matt Coupar, Jon Resheske
 - Retaining Walls Emily Kuehne
 - Box Culverts Danielle DeTennis, Nick Rice
- And many other Bureau and Regional folks that work with these structures.



Ancillary Program Contacts

- Bureau of Structures
 - Maintenance & Inspection
 - Program Managers
- URL:

http://www1.wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/strct/inspection-pm.aspx



New Forms

- ▶ ID Request Form
 - Standard for all Regions

STRUC	TURE NUMBER REQUEST	FORM						
Fill out form and submit	to Regional DOT Structures Inspe	ction Program Manager						
Construction Project ID (Design Project ID if not available):								
Type of Structure (check one):								
Bridge (B)Overhead Sign (S)Retaining Wall (R)High Mast Light (L)	 □ Small Bridge (C) (≤ 20′, not pipe culvert) □ Signal Monotube (G) □ Noise Wall (N) □ Miscellaneous (M) (Please Describe): 							
Structure Type Description:								
Anticipated Construction Year:								
Will this replace an existing structo	re? Y/N Replaced ID:							
Regional Office:								
County:								
Owner/Maintainer:								
GPS Coordinates (if applicable and known)								
Section/Town/Range:								
Roadway (Carried or nearest, as applicable):								
Location Description:								
Estimated Structure Length (if applica	ole and known):							
Structure Description:								
Requested by:	Phone:	Date:						
Firm or Agency:	Email:							
For DOT use: ASSIGNED NUMBER:								
REGIONAL PM SIGNATURE:		DATE:						
]					



New Forms

- Inventory Form(s)
 - Structure Specific(C, R & N, S & G, and L)
 - Updated Directions on Back of Form
 - Consultant Designed –
 Submit via Esubmit
 - Contractor Designed –
 Submit to BOS and
 Regional PM

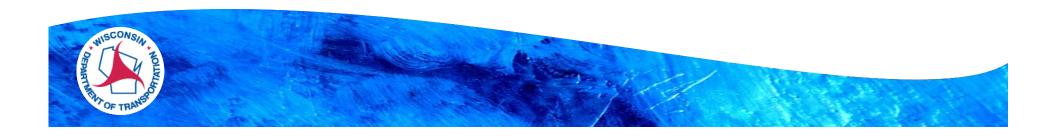
TO: STRUCTURES DEVELOPMENT SECTION					(January 2016)			
FROM:								
SUBJECT: High Mast Structure (L) Inventory Data (Complete all data fields applicable).								
1. Structure # 2. R	legion	3. County	4. Maintair	ner	5. Owner			
6. Municipality 7. L:	atitude	8. Longitude		Owner/Maintainer: 30 - County 40 - Tov	vn 41 - City 42 - Village			
CONSTRUCTION DATA STRUCTURE DATA								
9 Plans Completed Y 9a. Letting Date Y	TRMO TRMO	DAY DAY	<u>Pole 1</u> 28	<u>Data</u> Overall Pole Height (ft.):				
10 Year Built			29	Pole Material and ASTM	Grade:			
11 WORK Performed New Structure	WORK Performed New Structure Other			30 Number of Splices:				
			Foundation Data 31 Footing type: ☐ Caisson ☐ Pile ☐ Spread					
13 Fabricator:			32	Base Plate Thickness (in)):			
14 General Contractor:			33 # of Anchor Bolts:					
15 Project ID:	15 Project ID:			34 Diameter of Anchor Bolt (in):				
16 Cost:			35 Bolt Material and ASTM Grade:					
ROUTE NEAR INFORMATION			Luminaire (Lighting) Details					
17 General Location of Pole:			36 Manufacturer:					
18 Enter name of closest primary route under pole:		r nole:	37 Type/Style: 38 Number of Luminaires:					
		- pote.						
	outh	East West	FOR INTERNAL USE ONLY					
20 Designation: Mainl	_	Other	39	Type Service On: <u>High</u>	Mast Lighting			
21 Inventory Route:		Not on NHS	40	Type Service Under: <u>La</u>	<u>nd</u>			
22 Closest Distance from pole to route (tt): 23 Enter name of next closest route to pole, if applicable ———————————————————————————————————			41	Primary Route On: High	Mast Lighting			
		if applicable	42 Route on Designation: Water/Land/Other					
24 Direction: No	outh	East West						
25 Designation: Ma		Other						
26 Inventory Route:		Not on NHS						
27 Closest distance from pole to route (ft):								



New/Updated Forms

- Bureau of Structures
 - Maintenance & Inspection
 - Inventory & Rating Forms
- URL:

http://www1.wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/strct/inv-forms.aspx



C-Structures (Small Bridges)

- Redefined per 2015 Policy Memo
- Small Bridge Structures require a unique structural design and have a clear opening of 20 ft. or less measured along the centerline of the roadway. This includes:
 - Bridge like structures (i.e. Deck Girders, Flat Slabs, etc.)
 - Box Culverts (with openings 20 ft² or greater)
 - Rigid Frames
 - Arches
 - Structures without a floor slab (including arches on footings)
 - Metal Bolted Plate Structures

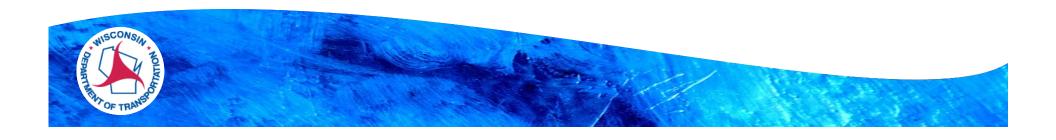


C-Structures (Small Bridges)

- Bureau of Structures
 - Maintenance & Inspection
 - Policy Memos
 - Small Bridge (C Structure) Definition

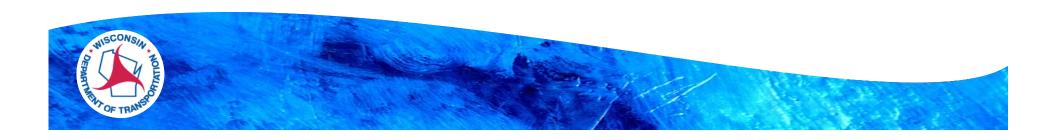
URL:

http://wisconsindot.gov/dtsdManuals/strct/policies/inspection/sml-brdg-def.pdf



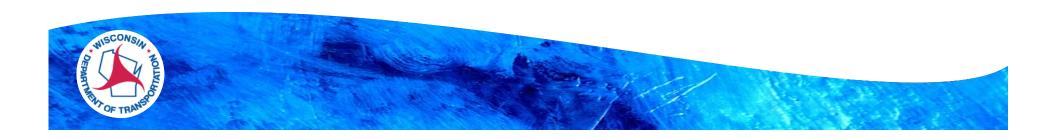
C-Structures

- Design Considerations
 - Box Culvert wing walls now require epoxy-coated rebar
 - Box Culverts shall be designed for a range of fill (not a single height) [See Bridge Manual 36.5]
 - This range should be detailed on the plans



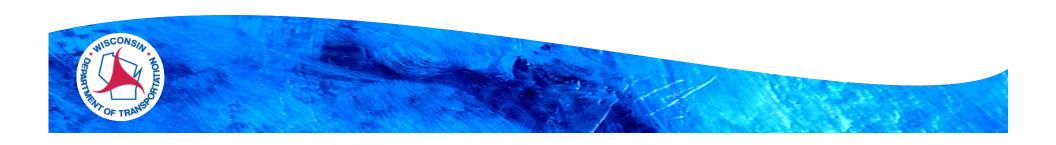
Walls (Noise and Retaining)

- Noise Barriers are structures constructed to alter the normal noise travel at a site
- Retaining Walls are structures used to provide lateral resistance for a mass of earth or other material to accommodate a transportation facility



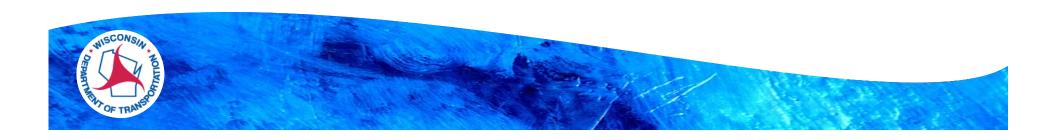
Walls (Noise and Retaining)

- Design Considerations
 - Noise Walls
 - If possible, designers should avoid attaching noise barrier to bridge railings [See Bridge Manual 30.3(4)]
 - Retaining Walls
 - Aesthetic and Constructability considerations with top of wall elevations and railings
 - Maintain awareness of right-of-way limits



Wind Loaded Structures

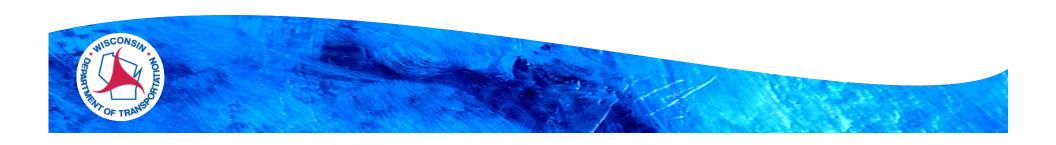
Presentation by Vu Thao



Wind Loaded Structures

Vu Thao

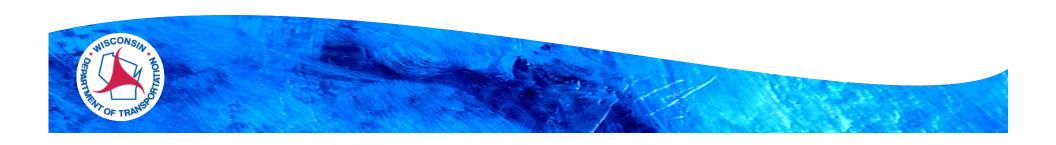
Structural Design Engineer
SE Region Liaison
Wind Loaded Structures Program Leader
WisDOT / BOS



- Wind Loaded Structures
 - Sign Structures
 - Sign bridges, overhead sign supports and road side sign supports
 - Traffic Signal Structures
 - Monotubes and signal supports (trombone arm)
 - Lighting Structures
 - High mast lighting towers
 - Light poles
 - Others
 - Camera poles
 - Ramp meter structures



- Design Manual Updates
 - WisDOT Bridge Manual
 - Chapter 39
 - Standard details
 - Standard insert sheets
 - FDM
 - Sections 11-55-20 design guidance for sign structures
 - Section 15-1-20.10 plan preparation for overhead sign supports
 - SDD plates for concrete bases



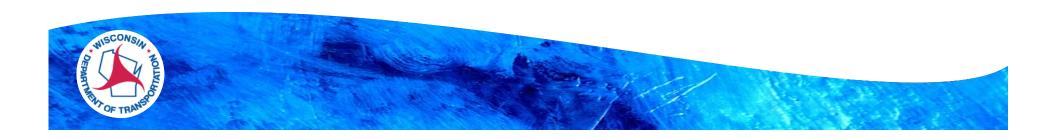
- Construction Specifications Updates
 - Standard Specifications
 - Repair SPV's to be completed later this summer
 - Construction Materials Manual (CMM)
 - Construction Inspection Checklist for Ancillary Structures,
 See Attachment 1
 - Major implementation in the construction area
 - Utilizing Direct Tension Indicator (DTI) washer in place of turn-of-the-nut method for H.S. bolt field installation
 - Utilizing turn-of-the-nut installation method for anchor rod
 - Eliminate field ROCAP tests data provided by H.S. bolt manufacturer only
 - Handling and storage



- Construction Resources
 - Installation Procedures
 - Form DT2322 Ancillary Structures Pre-installation Verification Test of H.S. Bolts
 - Pre-installation test procedure
 - Installation steps
 - QC & QA requirements
 - Form DT2321 Anchor Rod Installation Tensioning Record
 - Preparation and installation procedure
 - Verification Torque requirement
 - QC & QA requirements



- Construction Resource Cont'd
 - 2014 Training
 - All Region DOT staffs and consultants
 - Contractors



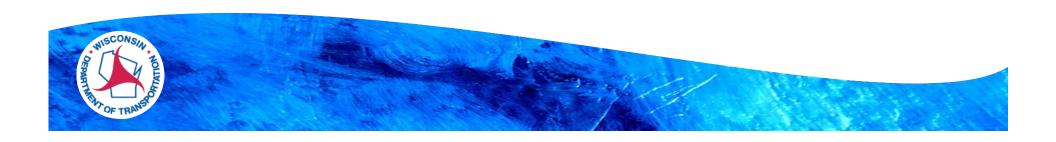
Contract Plan Development process

- Structure Plans (Structural Engineer)
 - Structure Types
 - Sign bridges
 - Overhead sign supports
 - Multiple structures
 - Unique structures, structure Mounted, and non-standard foundations
 - DMS roadside sign supports
 - Foundation for high mast lighting tower
 - Follow Bridge Design Process
 - Submittals
 - SSR, preliminary and final plans, design computations, PE stamp, structure inventory form, etc...



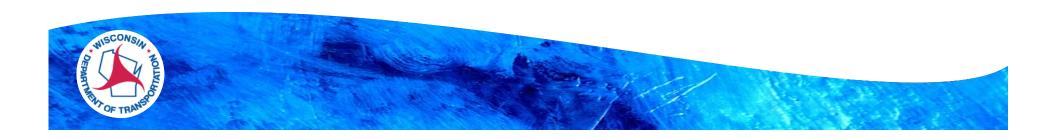
Contract Plan Development process

- Structure Plans Cont'd
 - Follow Bridge Design Process Cont'd.
 - Exceptions
 - Combined plan for multiple structures of the same type (WisDOT Bridge Manual 6.3.3.3)
 - SSR submittal timing further discussion
 - BOS Review
 - Optional
 - Sign bridges preliminary and final plans
 - Overhead sign supports concentrate on preliminary plans to ensure structure type and size are properly selected



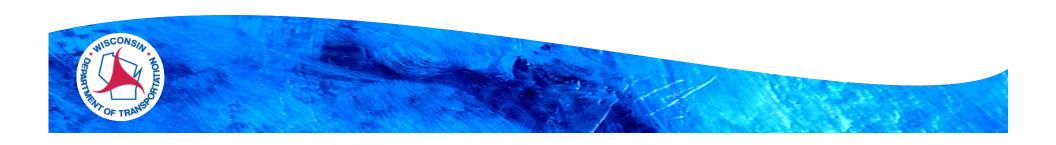
Contract Plan Development process

- Construction Details (Traffic Engineer)
 - Overhead sign supports (contractor design)
 - Standard overhead sign supports
 - Stand alone projects
 - Traffic monotubes (procurement process)
 - High mast lighting towers (contractor design?)
 - Other traffic signal supports and light poles (contractor supplied)



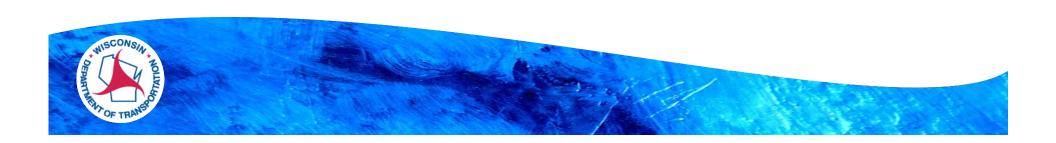
Highlight of Current Design Policy

- Design Specifications for Sign Structures
 - Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 6th Edition and 2015 Interim Revisions
 - Standard Specifications for Highway Bridges, 17th Edition
 - ASD Design until LRFD conversion project is complete
 - Design Specifications to be noted on plans
 - Material specifications to be note on plans, see latest Section 39.3 of the WisDOT Bridge Manual



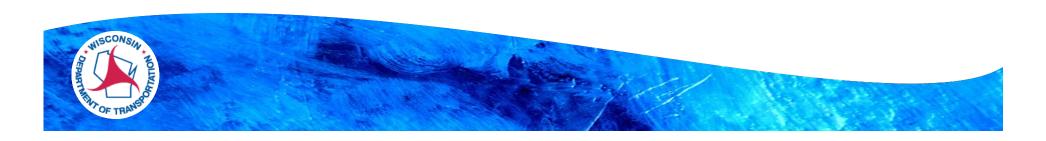
Highlight of Current Design Policy

- Design Specifications for Sign Structures Cont'd.
 - Fatigue Requirements
 - All wind loaded structures are designed with fatigue loads except the following structures
 - Four chord full span sign bridges carrying type I and II signs with truss type tower supported on concrete footings
 - Full span overhead sign supports on standard bases



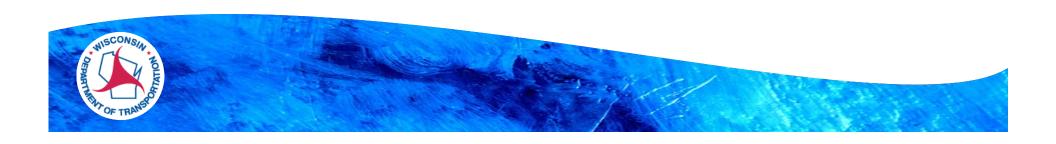
Highlight of Current Design Policy

- Sign Structures and traffic monotubes
 - Utilizing Minnesota four chord steel angle truss configuration for overhead DMS sign bridges
 - DMS roadside sign supports to be shielded, and not supported on break-away
 - No flat washer between faying surface of mast arm connection plates
 - Do not detail construction joint on drilled shaft foundation. Consult BOS for further guidance on drilled shaft with wings.
 - Maximum drilled shaft length is limited to 20-ft.

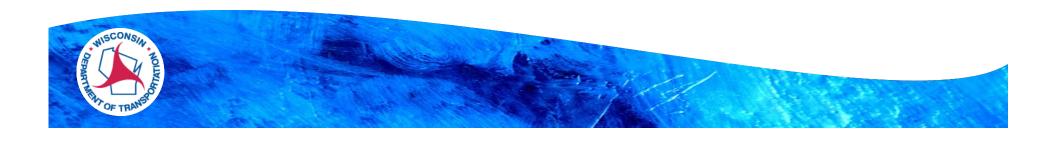


LRFD Conversion

- BOS will be working on LRFD design conversion plan between late 2016 and early 2019
- Tentative efforts
 - Evaluate each structure type and configuration for economic engineering and selection
 - Provide design guidance for various types of structure
 - Re-write Chapter 39 of the WisDOT Bridge Manual
 - Develop new design software
 - Develop new design standards

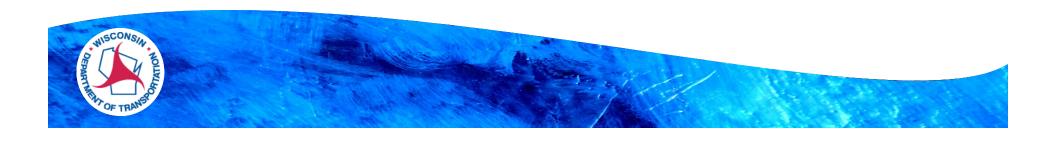


THANK YOU



Research Updates

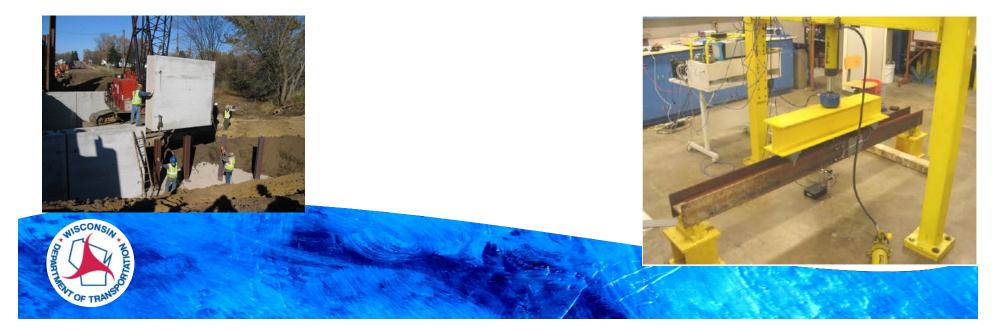
Bill Oliva
WisDOT Structures Development Chief



Research Updates – Bill Oliva

Our research explores and develops solutions to current and future transportation needs.

Research results help shape the practices, policies, and standards used to develop and maintain Wisconsin's transportation infrastructure.



Sources of research needs and opportunities

- BOS Initiatives (ABC, SCC, & others)
- Bridge Technical Committee Industry
- Other DOT's Pooled Fund (common benefit)
- Structures community & partners
 - Academia
 - FHWA
 - AASHTO
 - TRB (Transportation Research Board)



Research Programs

- Sources of research development
 - Wisconsin Highway Research Program (WHRP)
 - NCHRP Staff Participation
 - Center for Freight & Infrastructure Research and Education (CFIRE)
 - Transportation Pooled Fund Studies (TPF)
 - Research Programs (IBRD/IBRC/SHRP2) FHWA



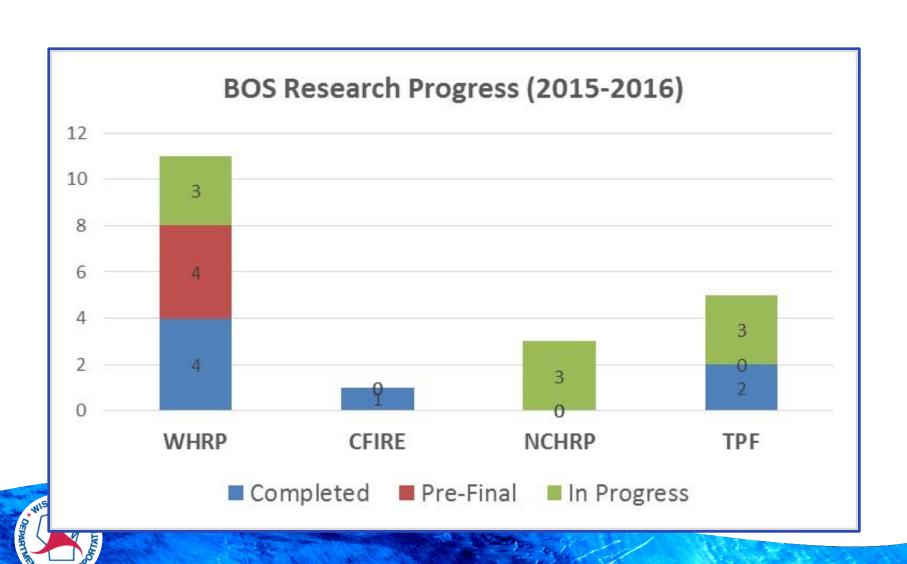








Where are we with Research?



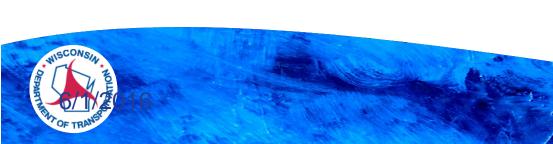
- The objectives of this research was to explore the effectiveness and durability of thin polymer overlays with respect to restoring and protecting bridge decks, improving safety, and extending service life
- Research program was performed to study and compare the performance of nine different overlay systems



Evaluation of Thin Polymer Deck Overlays and Deck Sealers - February 2016

- The overlay system with an epoxy resin provided the best overall performance.
- The polyester multi-lift overlay system delaminated from the concrete surface in all nine specimens utilizing that overlay type







Reflective Cracking between Precast Prestressed Box Girders

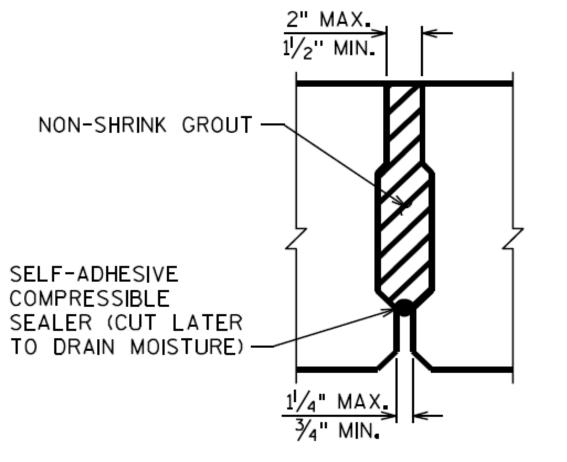
- Goal is to eliminate reflective deck cracking in adjacent box-beam bridges.
- Cracking at the shear key locations that reflects to the deck surface.
- Provided recommendations on box-beam and shear key geometry, shear key grout, cast-in-place deck slab concrete, transverse post-tensioning





Reflective Cracking between Precast Prestressed Box Girders

UpdatedStandard19.54





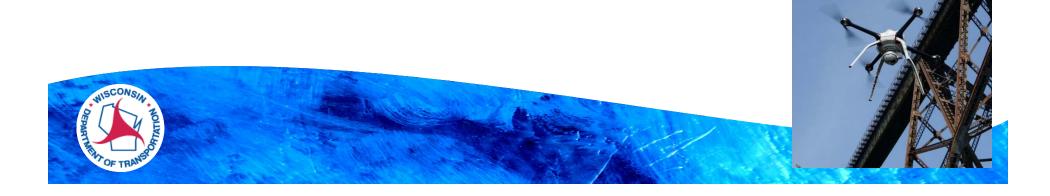


SHEAR KEY DETAIL



Where are we going with Research?

- Self Consolidating Concrete (SCC) Girders
- Staged Longitudinal Construction Joints
- Highly Skewed Girder Structures
- Damaged Prestressed Girders (deck removal and impact)
- Pilot Project to examine bridge Inspection with Unmanned Aerial Systems (UAS) "Drones"



Study of Over Sized Over Weight Vehicles on Complex Bridges











Study of Over Sized Over Weight Vehicles on Complex Bridges

The objective of this project is to simplify the overload permitting process executed by WisDOT engineers for complex bascule, arch and rigid frame bridges subjected to OSOW vehicles located on critical freight routes in Wisconsin.



A few requests of you

- As practitioners, we are interested in you ideas of needs and opportunity
- We are also interested in your participation in providing guidance and oversight to structures research
- Please consider providing ideas or getting involved with WHRP



WHRP - Structures Technical Oversight Committee

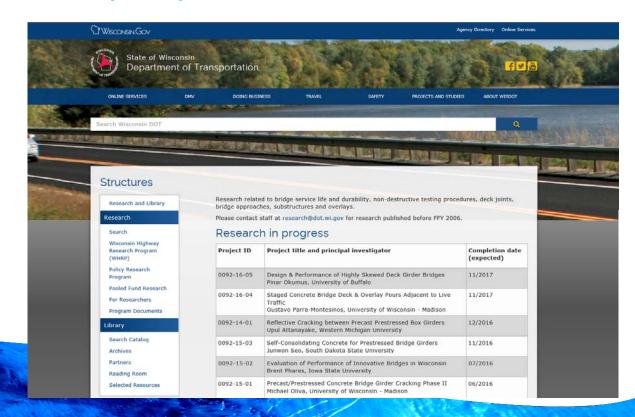
- William Oliva, Chair WisDOT
- Richard Marz WisDOT
- Darrin Stanke Zenith Tech, Inc.
- David Pantzlaff Ayres & Associates
- Travis McDaniel WisDOT
- Adam Dour Lunda Construction Company
- Professor Mike Oliva University of Wisconsin

- William Dreher WisDOT
- Dave Kiekbusch WisDOT
- David Bohnsack WisDOT
- Professor Baolin Wan Marquette Univ.
- Professor Al Ghorbanpoor University of Wisconsin-Milwaukee
- Tony Shkurti HNTB Corporation
- Joe Balice FHWA Bridge Engineer Wisconsin Division



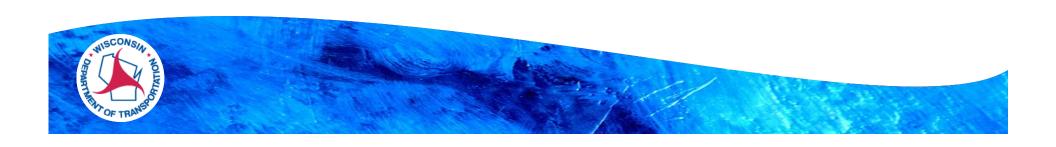
Where to find the results of the research:

http://wisconsindot.gov/Pages/aboutwisdot/research/whrp.aspx



Accelerated Bridge Construction

James Luebke
Structures Development Engineer
WisDOT Bureau of Structures



Accelerated Bridge Construction

ABC is bridge construction that uses innovative planning, design, materials, and construction methods in a safe and cost-effective manner to reduce the onsite construction time...

-FHWA



Accelerated Bridge Construction

ABC is bridge construction that uses innovative planning, design, materials, and construction methods in a **safe** and **cost-effective** manner to reduce the onsite construction time...

-FHWA



WisDOT ABC Projects

2005 - 2016



Overview

Precast Piers



- GRS Abutments and PS Box Girders
- Bridge Moves Slides





Source: VTrans



Precast Piers

- Past Usages:
 - 2013 (1) Custom Application
 - 2014 (1) Standardizing
 - 2015 (3) Standardizing/Institutionalized
 - 2016 (1) Standardizing/Institutionalized







Precast Piers

Current Policy

Evaluation and plan preparations for accommodating a noted allowance for a precast pier option as indicated in this section is only required for I-39/90 Project bridges.

Policy Direction

Stronger guidance for statewide evaluation

Considerations

- Limitations
- Project value
- Geometric compatibility



Precast Piers

- Standard 7.05
- Designer

To determine allowable precast elements

INCLUDE THE FOLLOWING NOTE ON AT LEAST ONE PIER SHEET FOR EACH PIER:

THE CONTRACTOR MAY FURNISH A PRECAST CONCRETE PIER (INSERT ALLOWABLE PRECAST ELEMENTS) IN LIEU OF THE CAST-IN-PLACE PIER WITH THE ACCEPTANCE OF THE SHOP DRAWINGS BY THE STRUCTURES DESIGN SECTION. THE PRECAST CONCRETE PIER SHALL CONFORM TO PRECAST DETAILS IN CHAPTER 7 STANDARDS OF THE CURRENT WISCONSIN DOT BRIDGE MANUAL AND SPECIAL PROVISIONS RELATED TO PRECAST ELEMENTS WITH THE EXCEPTION OF METHOD OF PAYMENT. PAYMENT FOR THE PRECAST PIER SHALL BE BASED ON THE QUANTITIES AND PRICES BID FOR THE ITEMS LISTED IN THE "TOTAL ESTIMATED QUANTITIES" FOR THE CAST-IN-PLACE PIER.

Contractor

Use precast segments at their discretion

THE CONTRACTOR MAY USE PRECAST SEGMENTS AT THEIR DISCRETION (E.G. PRECAST CAP ONLY) WITH APPROVAL BY THE BUREAU OF STRUCTURES. SEE STANDARD 7.07 FOR CAST-IN-PLACE BEARING BLOCK DETAILS AND ADDITIONAL NOTES.



Precast Piers

- ▶ In-House Tracking
- Geometric Compatibility

<u>Precast Pier Considerat</u>	ons							
Structure Number	B-40-810	B-13-727	B-13-702	B-13-703	B-13-709	B-13-707	B-45-112	B-45-113
Precast Pier	Mandatory	Mandatory	Mandatory	Mandatory	Mandatory	Mandatory	Optional	Optional
ADT (Adjacent)	97700	1747	71800	71800	71800	2950	44000	44000
Design Speed (Adjacent)	70	50	70	70	70	60	70	70
Pier Length (out to out)	137.17	77.50	95.50	37.00	40.00	61.50	61.25	61.25
Skew	0.88	39.48	4.00	2.04	22.05	0.00	0.59	0.59
PS Girder Width (inches)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Girder Spacing	10.08	6.25	7.00	6.58	6.67	11.50	8.17	8.17
Staged Construction?	No	No	No	No	No	No	No	No
Pier Width (feet, min.)	2.45	3.57	2.59	2.50	3.22	2.42	2.44	2.44
Pier BRG Spacing	10.08	8.10	7.02	6.59	7.19	11.50	8.17	8.17
Extra Column Required?	No	No	No	No	No	Yes	No	No
Designer Comments	None	None	None	None	None	None	Prelim	Prelim
Designer or Entered by:	JDL	JDL	JDL	JDL	JDL	JDL	RAC	RAC



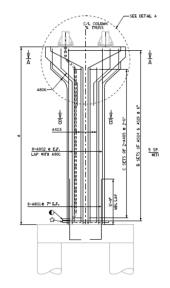
Precast Piers - Opportunities

- IH 39/90
 - SHRP2 Projects
 - Numerous noted allowances



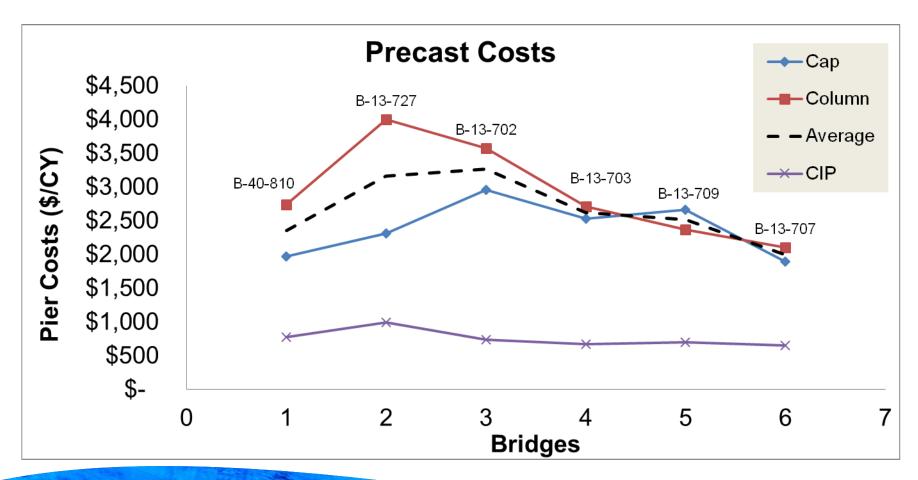


- Statewide Precast Piers
- Other Opportunities





ABC Costs – Precast Piers



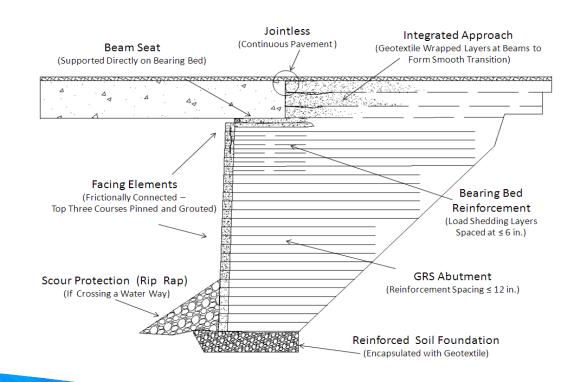


Updates



- Geosynthetic Reinforced Soil (GRS)
 - Reinforcement (Fabric)
 - Backfill
 - Facing Elements







- ▶ GRS History (2011 Current)
 - FHWA Every Day Counts (EDC1, EDC2, & EDC3)
 - Demonstration and AID Grants
 - Actively participating and promoting GRS Technology
 - Standard Details, specifications, and experience
 - New tool and not for every location









FHWA Efforts

States Constructed GRS Abutments?

- **5** States (2011)
- 44+ States (2016)
 200+ GRS Structures
- FHWA EDC 2011-2016





GRS Abutments - Chippewa Co.



Less Complex Construction Methods

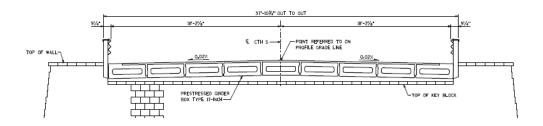
Reduced Construction Time





2016 Construction (February Let)

- Two Single Span Bridges
- Four GRS Abutments
- Prestressed Box Girders
- Cofferdams

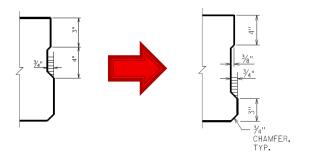


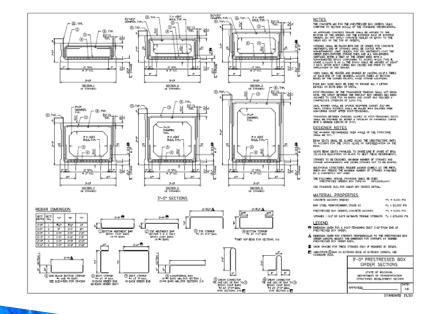




PS Box Girders
Improved shear key
Composite Details



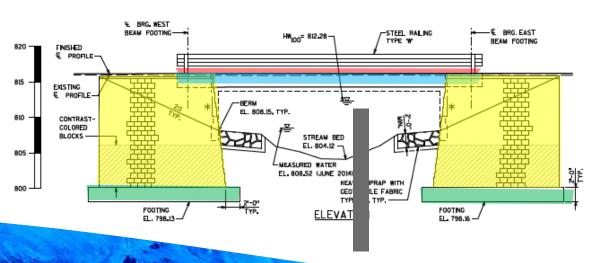






Construction Schedule:

- Remove Existing Bridge
- Install Sheet Piling
- Excavate for GRS Ftg.
- Install GRS Ftg. & Abutment
- Install PS Box Girders
- Pour Deck



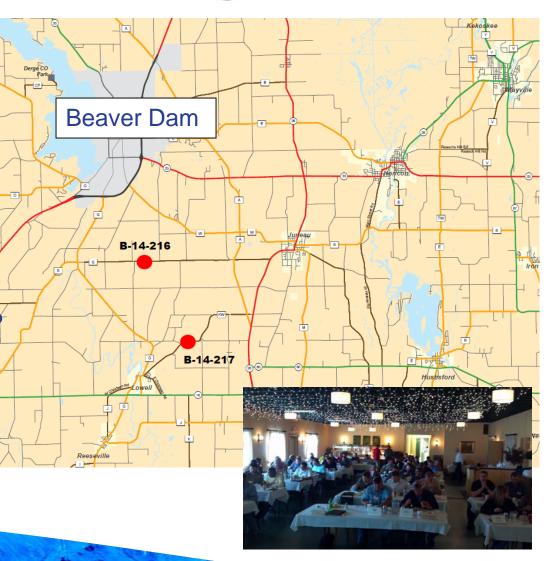




Schedule:

- ▶ B-14-216 July
- ▶ B-14-217 August
- Showcase
 - Beginning of August?

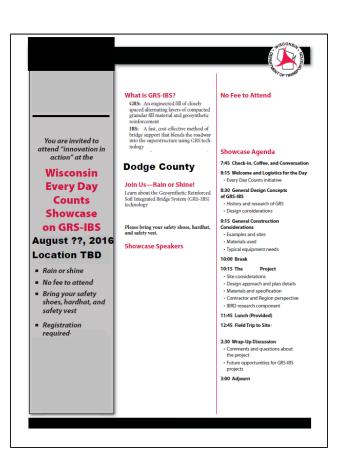






Showcase Tentative Agenda:

- General Overview
- Construction Considerations
- Project Breakdown
- Field Trip to Site
- Wrap-Up Discussion





Showcase Attendees:

- FHWA and WisDOT
- Consultant Designers
- Local Owners and others



WisDOT Future

- WisDOT Lessons Learned (Dodge County)
- Monitor Prestressed Box Girder Projects
- FHWA coordination and updates
- Continue to provide technical support





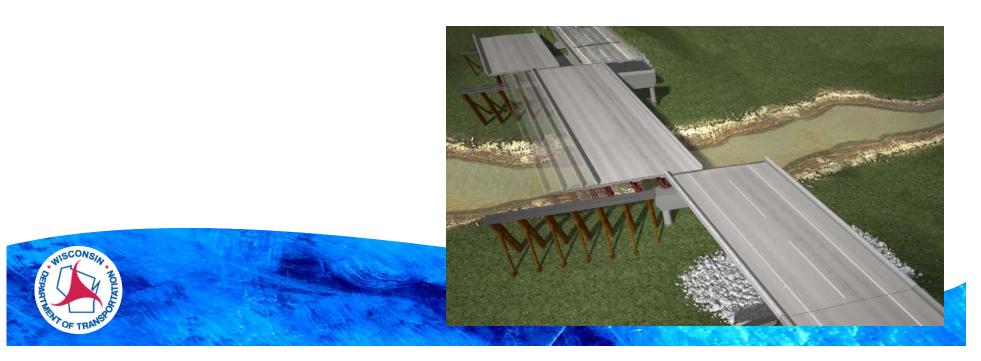




Accelerated Bridge Construction - Slides

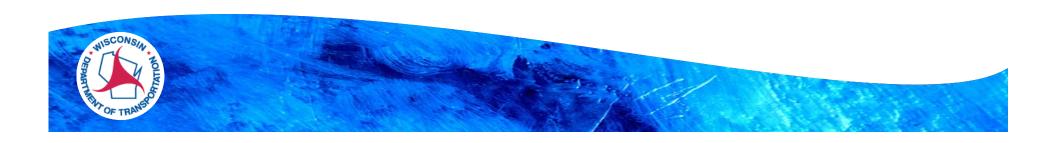
Bill Oliva, P.E.

Structures Development Chief
WisDOT Bureau of Structures



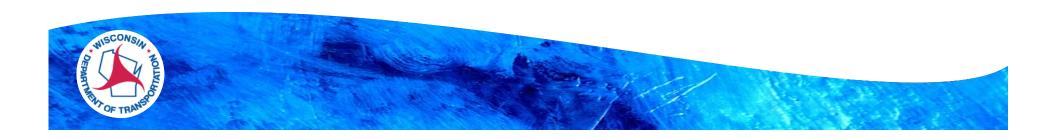
Why Slide in bridge construction?

- All the benefits of other ABC technologies
- Less traffic disruption
- Greater safety for motorists and construction workers (shortened work-zone durations)
- Greater quality and constructability
- May reduced Right-of-Way (FEE) needs



M-100 Bridge Slide in Potterville Michigan

- Permanent bridge deck will be constructed at the temporary location on temporary abutments
- Two-way traffic will be maintained on the temporary road and on new bridge superstructure with temporary abutments

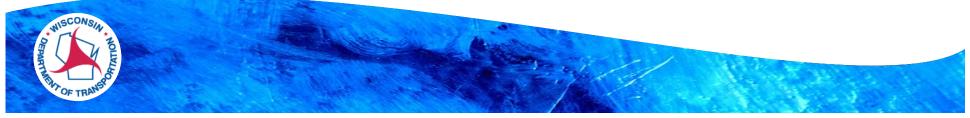


M-100 Bridge Slide

- Original Construction 1940
- •Length of Structure 157'
- •Width of Structure 40'

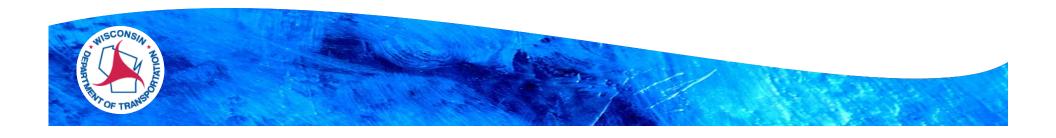




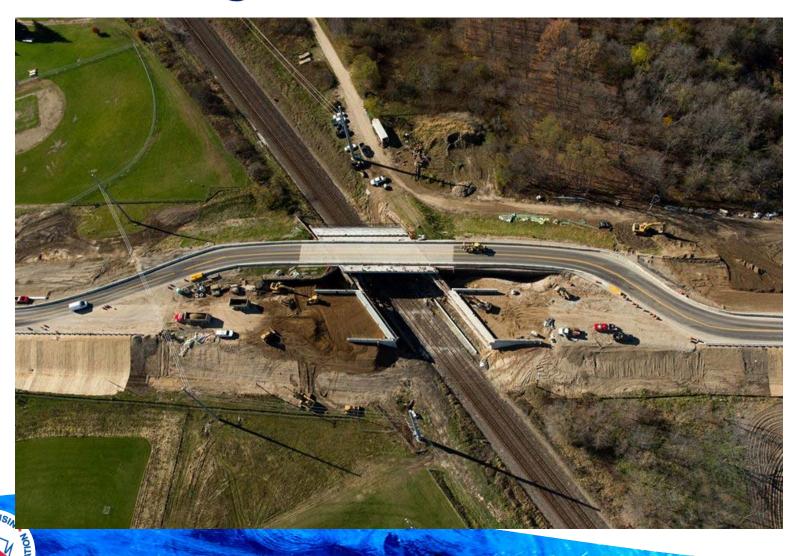


Maintenance of traffic









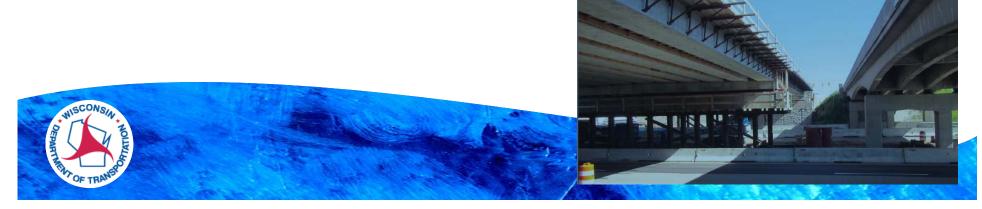


M-50 Bridge over I-96 Bridge Slide Design – Michigan

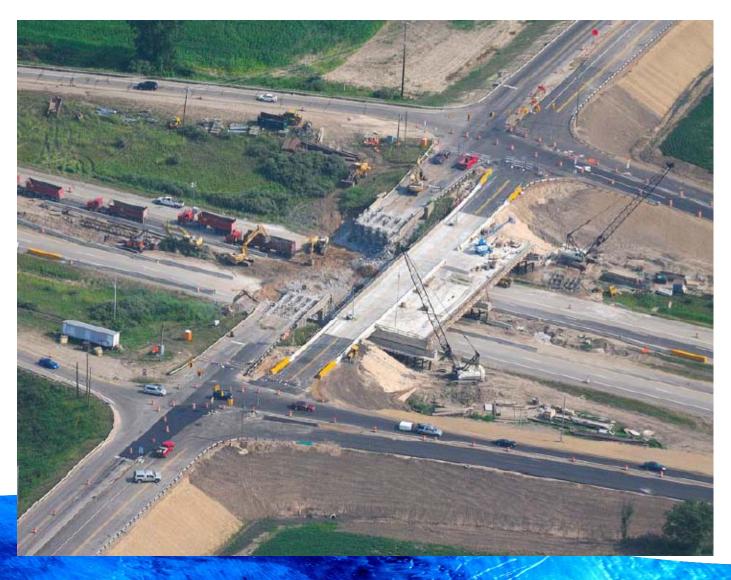
- Existing 4-span 200 foot
- Proposed 2-span 200 foot prestressed box beam

Demolish the bridge, that'll be a one-weekend

closure of I-96

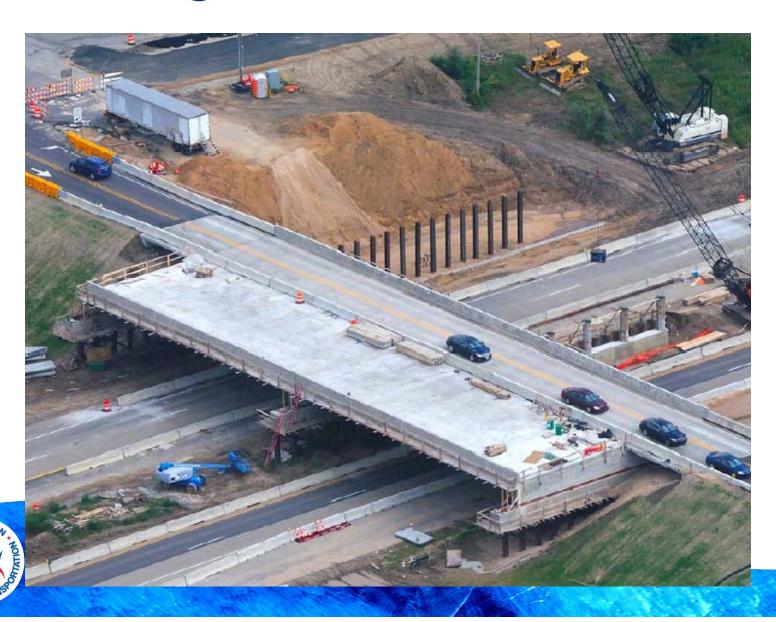


M-50 Bridge





M-50 Bridge



M-50 Bridge

