Preliminary Bridge Design Topics

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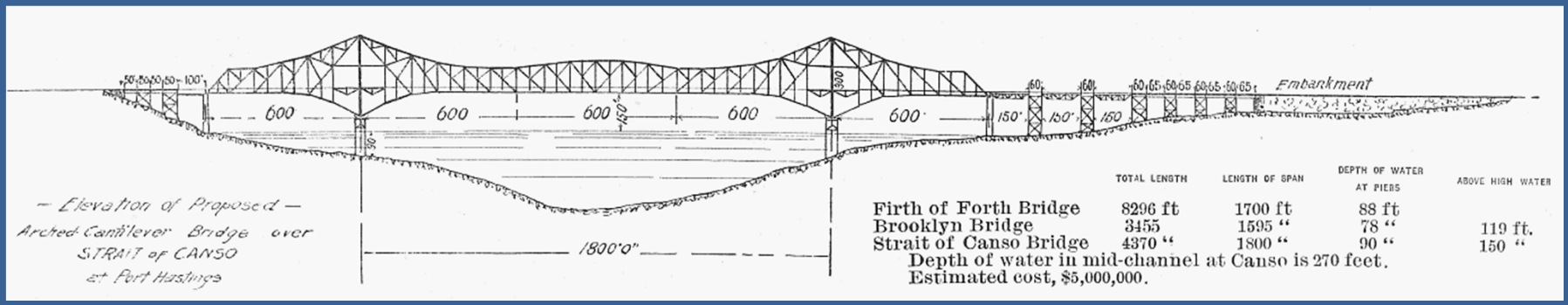
Preliminary Bridge Plans Engineer

Preliminary Bridge Design Topics

- Preliminary Bridge Plans – Overview
- Context Sensitive Design Approach
- Bridge Standards and 13 Critical Design Elements
- Case Study/Featured Projects

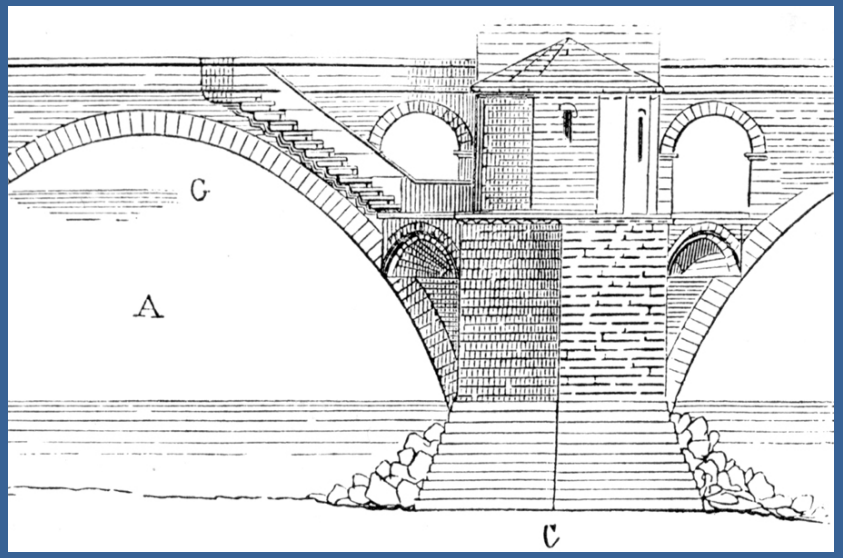
The fundamental decisions required for Preliminary Bridge Plans. . .



	TOTAL LENGTH	LENGTH OF SPAN	DEPTH OF WATER AT PIERS	ABOVE HIGH WATER
Firth of Forth Bridge	8296 ft	1700 ft	88 ft	
Brooklyn Bridge	3455	1595 "	78 "	119 ft.
Strait of Canso Bridge	4370 "	1800 "	90 "	150 "

Depth of water in mid-channel at Canso is 270 feet.
Estimated cost, $5,000,000.

1. TYPE
2. SIZE
3. LOCATION
4. AESTHETICS
5. COST ESTIMATE



Type /Size – Bridge Type Inventory

- Culverts
- 3 Sided Boxes
- Slab spans
- Inverted T (PCSSS)
- PCB - new long span shapes
- Steel Beam
- Concrete Box
- Post-tensioned Concrete Box
- Precast Tub (would like to have)
- Arches – (including new free-standing)
- Trusses – lots of inventory, rehabilitation opportunities
- Extradosed !
- Cable Stay/Suspension ?

Small Type bridges… from 10′ to 45′

A new small bridge/culvert: Upsula, MN

TYPE/SIZE/Materials - 200' span range

Structural System

- Slab
- Beam
- Box Girder
- Others

Materials

- Timber
- Concrete
- Steel

Granite City Bridge – 345′ main span

Context Sensitive Design Approach

Context | Sensitive Solutions

- **Home**
- Overview
- Benefits
- CSS Toolbox
- Workshops & Forums
- Research
- Contacts

Context Sensitive Solutions

Context sensitive solutions (CSS) is a collaborative, interdisciplinary approach that involves all stakeholders in providing a transportation facility that fits its setting. It is an approach that leads to preserving and enhancing scenic, aesthetic, historic, community, and environmental resources, while improving or maintaining safety, mobility, and infrastructure conditions.

MnDOT's CSS E-Learning Program

MnDOT offers an interactive hour-long online learning module about CSS. A full session takes 60 to 80 minutes to complete and includes:

- What CSS is and isn't
- Why integration of CSS is important as a business model
- What approaches and principles need to be integrated
- What agency and customer benefits can be expected
- What principles are most important for attaining specific benefits
- How CSS can be integrated into your daily work
- Options for how you can measure CSS effectiveness
- A stop in each MnDOT district to learn about an award-winning CSS case study

View MnDOT's CSS E-Learning Program

For CSS questions and assistance contact:

Scott Bradley, FASLA
Director of Context Sensitive Solutions
Minnesota Dept. of Transportation

Stakeholder Input Needed

- Early project planning, discussion of needs
- Interagency Coordination
- BRT – Stations/Met Council
- Cities, counties, DNR, SHPO, job specific

- All projects will have some type of visual impact – and a result visual quality

- But before we get to visual quality, there are other project drivers….

- Context Sensitive Project Drivers include:

Bridge Hydraulics

Bridge Size/Low Steel = Hydraulic Letter

Keep piers out of water where possible

Consider Scour Requirements

New Riprap Details coming
Matrix Riprap -
now there's context sensitive!

Riprap

- Standard Riprap
  - Use Standard Plan 5-397.309
- Matrix Riprap
  - Previously known as “Partially Grouted Riprap”
  - May be specified on upcoming projects where vandalism is a concern or where local stone sources are of poor quality.
  - Special Provision should be obtained from Bridge Hydraulics Unit
    - 15% - 40% of voids filled with a special grout mix

Keep Bridge Hydraulics Informed

- Note any design changes from Preliminary Design to Final Design
  - Pier Size
  - Pier Shape
  - Substructure Orientation
- Deck Drains (especially on rehabs)
- Scour Code on Survey Sheet
- Conflicts with utilities (wet utilities) – refer to new Provisions 2.4.1.6.2 Buried Utilities

  (MnDOT LRFD Bridge Design Manual)

Early Communications with RR

- Definitely need early communications with RR to keep project on track
- MnDOT utilizes a “single contact approach”, ie meeting will be set up with Office of Railway and Freight so to allow building relationships and trust with the RR
- Meeting often result in “negotiations”, based on project needs and consideration of Railroad “Design Guides”
- Must satisfy AREMA and consider any add’l needs

Coast Guard Requirements

- Preliminary Bridge Plans Unit responsible for obtaining Coast Guard Permits
- Maintains Coast Guard Files – Centralized Coordination to provide single Contact for Coast Guard Permits; ie keeps BMT directly involved

1) Establish Project Specific Criteria -
   Normal Pool (1912 datum & Nav88)
   2% Flowline (1912 datum, Nav88
2) Low Steel Requirements
3) Channel Opening Requirements, Pier Locations
4) Vessel Impact Studies are project specific and are often completed as 1st step in Final Design Phase

Navigation Span Requirements – Wakota Bridge 465' max spans

Foundation Requirements

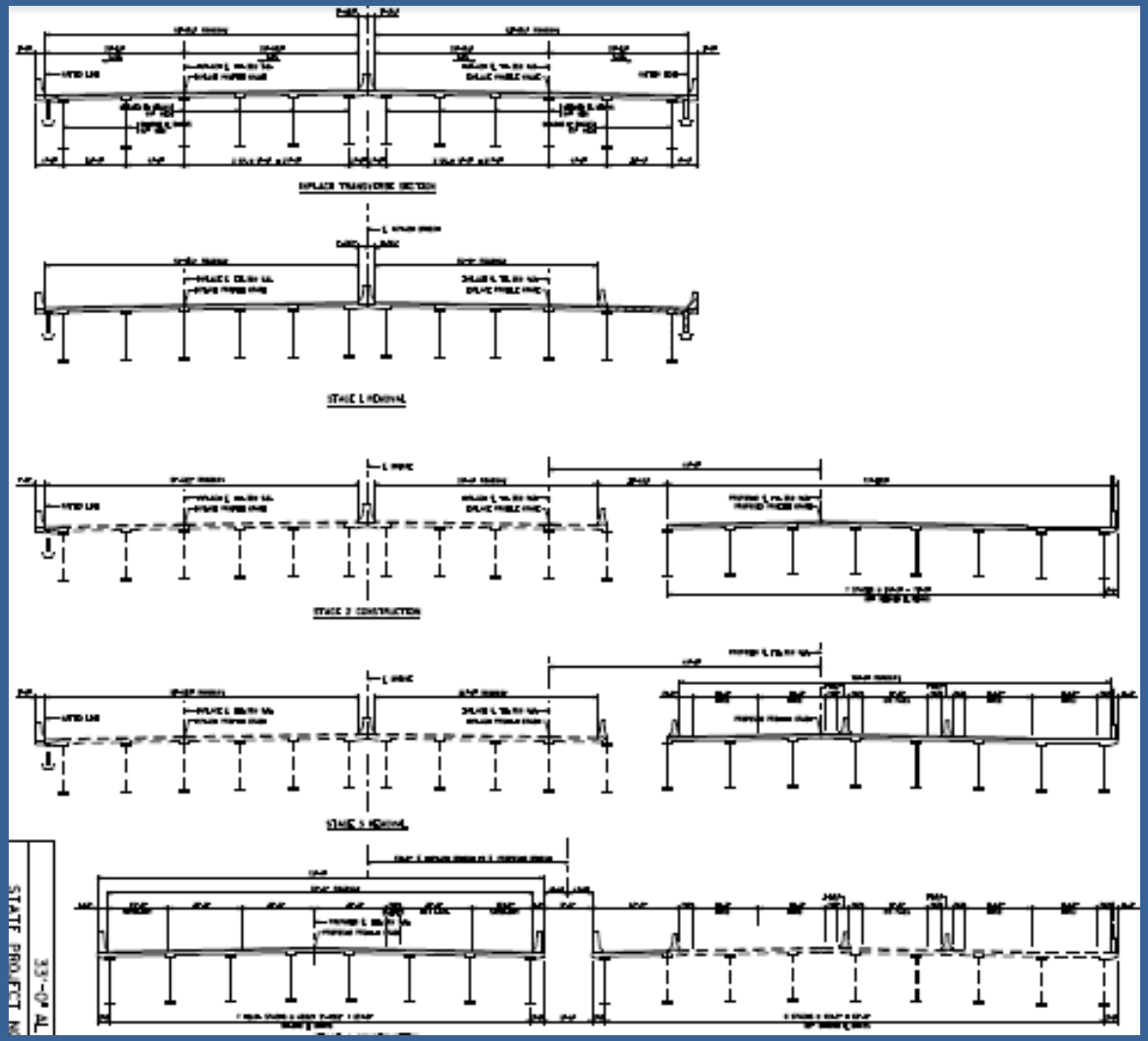
ONCE SUBSTRUCTURES ARE LOCATED, DRAFT PRELIMINARY BRIDGE PLAN ARE SUMBITTED TO MNDOT FOUNDATIONS UNIT FOR RECOMMENDATIONS.

Apply lessons learned: Are there any Artesian Conditions ?

Other Foundations Considerations

- Limits of Rock Profile if encountered
- Very Poor Soils may require soil improvements
- Pile supported embankments may interface with bridge and/or may reduce bridge length
- MSE Wall Considerations – interface with abutments
- Global Stability Considerations
- Consolidation / Down Drag
- Sheet Pile Requirements
- Soil/Structure Interaction where needed such as Group/Lpile Analysis

Stage Construction considerations…



Consider ABC – I-80 Echo Jct. Utah

Expansion Joints Considerations

- Expansion Joint Size should be considered in preliminary design process
- Use integral or semi-integral abutments where possible
- Strive to minimize joints for future maintenance, start with Type 4 joints, consider type 5 for large skews
- Modular required for long span bridges – pier placement, end span location consideration
- Include in Preliminary Plans Cost Estimate

St. Croix River Crossing – 480′ spans

Signature Bridge /Signature Location

Conduct comparative cost studies…

- Straight alignments preferred
- Minimize skew
- Keep it simple !
- MnDOT Bridge Office Leads Bridge Type Selection
- Complete Prelim Plans 1 year prior to letting.

Prelim Bridge Plans Check List

- Preliminary Bridge Plans Checklist is available upon request.
- Consultants performing preliminary bridge plan design services expected to comply with checklist.
- Microstation/Cadd Drafting Standards apply
- Get input from Bridge Architectural Specialist for visual quality/aesthetic concepts
- Early communication preferred prior to submitting 100% complete prelim plans, or risk substantial rework

Design Flexibility – RDM sect 2-1.01

Design Flexibility has become a Department wide initiative….

- "MnDOT's obligation to reflect societal values in its work necessitates a flexible approach to road design that supports balance among safety, mobility, economy, design consistency, community, environmental concerns, and aesthetics."

Bridge Standards – Revisited

- Design Flexibility / Performance Based Design

  Department wide Flexible Design Initiatives:

  Benefits of flexible design allow greater sensitivity to the design needs of the local community and surrounding environment, increase safety system-wide by considering return on investment, and provide opportunity to stretch the limited dollars to more miles of highway.

  Performance Based Design….stay tuned

13 Critical Design Elements

- 1) Design Speed
- 2) Stopping Sight Distance : (LRFD Manual to be updated)
- 3) Grades
- 4) Horizontal Alignment
- 5) Vertical Alignment
- 6) Cross Slopes
- 7) Superelevation
- 8) Lane Width ← (review in progress)
- 9) Shoulder Width ←(review in progress)
- 10) Structural Capacity on Bridges
- 11) Bridge Widths ←(review in progress)
- 12) Vertical Clearance ← *Tech Memo – 11-16-B-07*
- 13) Horizontal Clearance to Obstruction ← RDM (12-01)

Vertical Clearance Tech Memo

- MnDOT Standard V.C.for Trunk Highway Bridges were reviewed with respect to:

- AASHTO Standard = 16.0’
- Construction tolerances
- Standards of neighboring states
- Extra clearance requirements along special corridor routes

Vertical Clear – Midwest States

State	Vertical Clearance Standard For New Bridges	After Pavement Reconstruction under Existing Bridge	State-Aid Routes/Local
Minnesota	16'-4"	16'-0"	14'-6" (State Aid/Local)
North Dakota	16'-6"		
South Dakota	17'-0"	16'-4"	14'-4" low volume
Iowa	16.5'		15'-0" low volume
Wisconsin	16'-9" Desirable 16'-4" Min.	16'-0"	15'-3" low volume
Illinois	16'-9"	16'-0" reconstruction	16'-6" rural new construction
Missouri	16'-6" Interstates/Arterials 16'-6" State Routes>1700 vpd 15'-6" State Routes<1700 vpd		14'-'6" other streets/local Rds

Vertical Clearance Tech Memo

Guidelines

Table 2.1.3.1 - Vertical Clearances for Underpass type bridges in the MnDOT LRFD Bridge Design Manual in Section 2.1.3 shall be superseded by the following table:

Structure Type	Minimum Vertical Clearance for New Bridges [1,2]	Minimum Vertical Clearance Under Existing Bridges (for Pavement re-construction projects) [3]
Trunk Highway Under Roadway or Railroad Bridge (Super Load OSOW Corridors) [4]	16' – 6"	16' – 6"
Trunk Highway Under Roadway or Railroad Bridge	16' – 4"	16' – 0"
Trunk Highway Under Pedestrian Bridge [5]	17' – 4"	17' – 0"
Trunk Highway Under Sign Bridge [5]	17' – 4"	17' – 0"
Railroad Under Trunk Highway Bridge [6]	23' – 0"	NA
Portal Clearances on Truss or Arch	20' – 4"	20' – 0"

Table 2.1.3.1 Vertical Clearance for Underpasses

Vertical Clearance Tech Memo

- Future bituminous overlays ranging from 3” to 6”
- Future 9” to 12” unbonded concrete overlays
- Consider other bridges along the corridor so that new structures are not set as the new lowest structure along a corridor

Vertical Clearance Tech Memo

- Alternative route availability (check with the Oversize/Overweight Permits Section, for designated and protected alternate routes, including oversized/overweight (OFCVO) loads.
- House moving routes (specific corridors have been identified, check with the Oversize/Overweight Permits Section).
- Clearance requirements for future LRT corridors must be maintained per statute (398A) and coordinated with the appropriate agencies.

Vertical Clearance –non T.H.

- Per Minnesota Rules, Chapter 8820, Local State-Aid Route Standards, the minimum vertical clearance for highway underpasses (including construction tolerance) is 16'-4" for rural-suburban designs and 14'-6" for urban designs.

- For trunk highways crossing local roads or streets at a freeway interchange, the minimum vertical clearance with construction tolerance, is 16'-4".

Vertical Clearance Tech Memo

- A minimum vertical clearance of 16’ – 6” is required on designated Super Load OSOW Corridors. Super Load OSOW Corridors are designed to accommodate an envelope size of 16’ wide; by 16’ high; by 130‘ long, traveling along the corridor. Contact the MnDOT Office of Freight and Commercial Vehicle Operations for specific corridor locations and requirements.

Bridge Improvement/Preservation

- For Bridge Preservation and Improvement Projects and Roadway Reconstruction Projects, the vertical clearance requirements shall remain as specified in the separate document "Bridge Preservation Improvement and Replacement Guidelines".
- The required "Vertical Clearances over Waterways" shall remain as specified in the current MnDOT LRFD Bridge Design Manual.

Why do care so much about VC?

Bridge Hits!

TH 7 EB over 494 WB in MTKA

16.5′ vert clear

Xerxes Ave over 494

April 13, 2006 – Vertical Clearance: 15.1′ to 15.4′

TH 95 over TH 169

Princeton 16.4′ v.c.

Kansas Backhoe Hit

Design Exceptions:

- If we just can't get 16'-4" of vertical clear…

  Over Interstate:

  on SOME few and far between Highly congested urban AREAS that were previously built to lower standards…

  Some few and far between interstate access locations…

  If we have the above resulting in Right of Way Impacts…

  Management of RISK – consider traffic impacts during repairs – extreme commuter delay result from impact on an INTERSTATE overpass!

Stopping Sight Distance

MnDOT Road Design Manual

Chapter 3: Alignment and Superelevation

- Section 3-2.05 Sight Distance on Horizontal Curves
  1. The vertical curve/profile plays an integral part (i.e. Seeing over the barrier)
  2. MnDOT LRFD Bridge Design Manual – allows 10ft maximum inside shoulder width

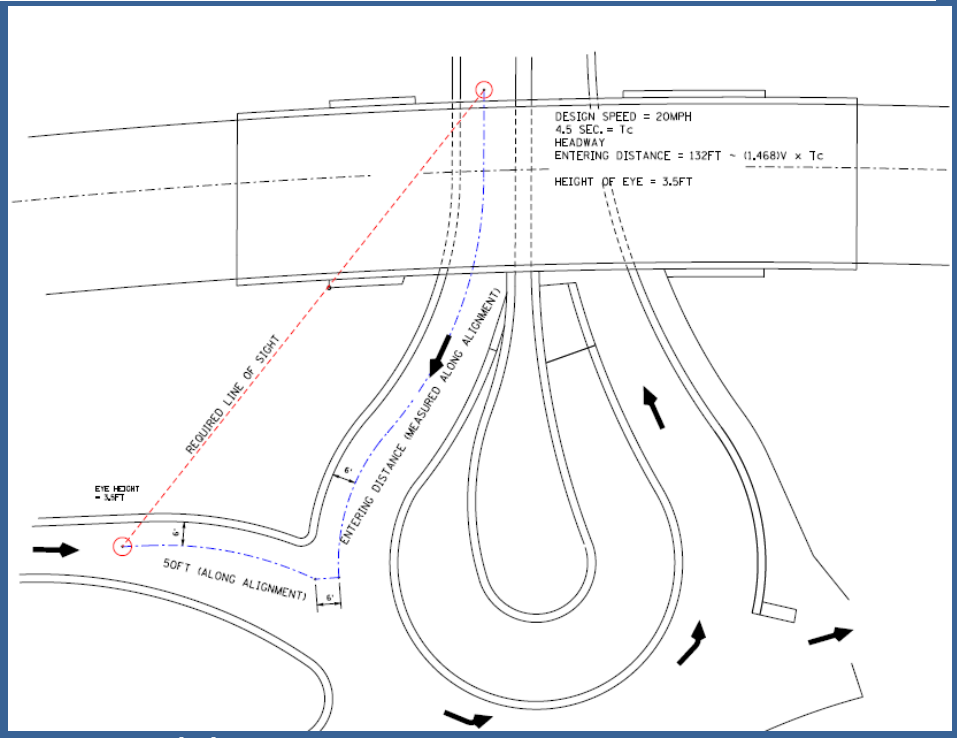
MnDOT LRFD Bridge Design Manual

Chapter 2: General Design and Location Features

- Table 2.1.2.1 Shoulder Width Requirements for Curved Bridges
  - Out of date, as it references the 1994 AASHTO Geometric Design Standards
    - In Process of being revised.

Roundabout Sight Distance

SIGHT TRIANGLE
FOR ENTERING TRAFFIC

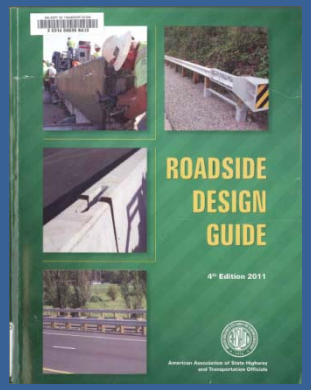


MnDOT Road Design Manual
Chapter 12: Design Guidelines for Modern Roundabouts
- Section 12-4.05.01 modifies it to values based on a t_c of 3.5 to 4.5 seconds

NCHRP Report 672
Roundabouts: An Informational Guide
- Sections 6.7.3.2 through 6.7.3.4 and Exhibits 6-58 & 6-59

Roadside Design Guide

- New 2011 AASHTO Roadside Design Guide just released



- 1) Remove Obstacle
- 2) Redesign obstacle so can be safely traversed
- 3) Relocate obstacle where less likely to be struck
- 4) Reduce impact severity by using appropriate break away devices
- 5) Shield obstacle with longitudinal traffic barrier designed for redirection or use as crash cushion
- 6) Delineate the obstacle ….

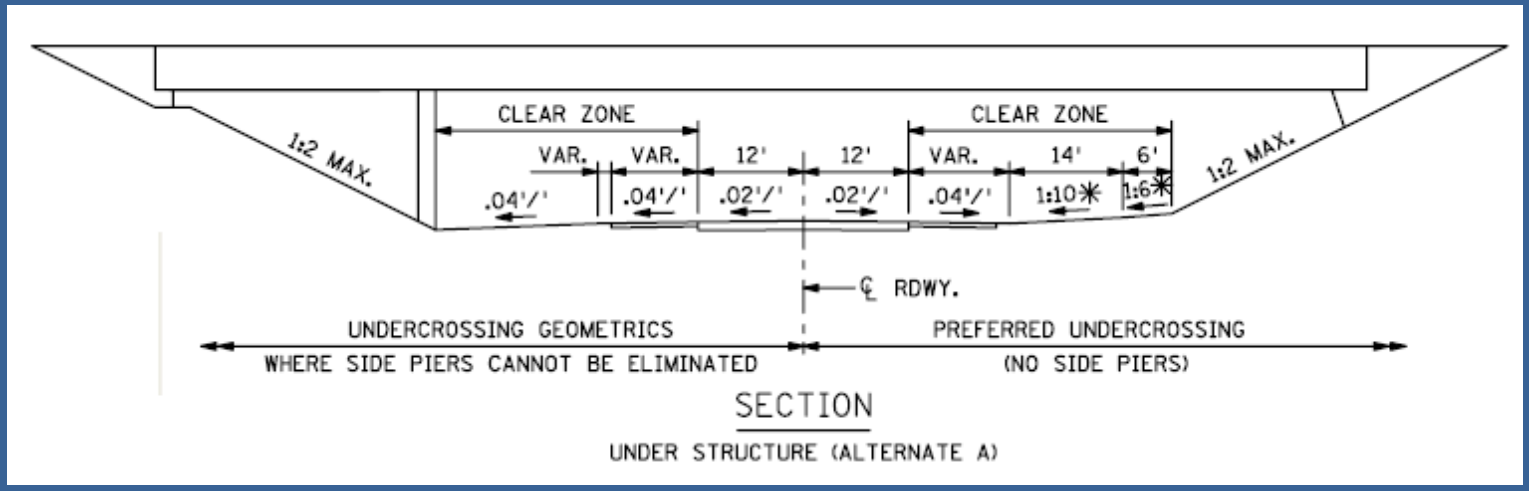
- Suggested Clear Zone Table 3-1 unchanged

Preferred Undercrossing Geometrics

Table 3-1 – Note a)

"When a site specific investigation indicates a higher probability of continued crashes…. Designer may provide clear zones greater than the clear zone shown in table 3-1. Clear zones may be limited to 30' for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance."

Preferred Undercrossing (no side piers)



- MNDOT BRIDGE LRFD MANUAL – "Preferred Undercrossing Required –
- ie 30' min clear zone, unless approved by Preliminary Bridge Plans Engineer

NOTE:
14' AND 6' DIMENSIONS PROVIDE A 30' CLEAR ZONE WITH A 10' SHOULDER. MODIFY FOR DIFFERENT SHOULDER WIDTHS AND CLEAR ZONES.

* IN LIEU OF THE 1:10 AND 1:6 SLOPES THE .04'/' SLOPE MAY BE EXTENDED TO THE 1:2 SLOPE (SAME AS OTHER SIDE).

Design Exceptions

- Vertical Clearance
- Stopping Site Distance (especially inside shoulder on curve)
- Shoulder Widths
  - 4’ minimum shy distance
  - Drainage Requirements
    - Water on shoulders vs. High Maintenance Bridge Drainage System
    - As new studies evolve, we will consider and be flexible where it makes sense
    - FHWA : recent input is 6’ shoulders give wrong impression as they look large enough for pulling over, but the limited space does not provide adequate refuge from traffic – too small.
- Current LRFD Does Still Apply
- Design Exceptions vs. Design Variances considered, but on hold.
- For general information on Design Exceptions, refer to
- http://www.dot.state.mn.us/design/geometric/formal-design.html

Project Challenges:

Eagles nest in the vicinity impacts the duration of construction season (total 75 days) and possibly include two construction seasons.

The project needs to be **built in stages and maintain traffic** with 3 lanes open to traffic.

Superelevated curved alignment (5.7 % existing) with roadway on curvature

Design with trail connection **under the bridge** and potentially along the roadway **extending wing wall (about 80 ft)**to maintain 2:1 ground cross slopes

Include **boat traffic envelope** similar to adjacent Arcade Ave bridge
No roadway grade raise feasible, profile and alignment not available yet
Estimate the cost of bridge to share with external partners for final **cost participation discussion.**

Aesthetics play an important role because of the visibility of the bridge from public areas and the trail underneath.

DECISIONS MADE

3 long Span Bridge with inverted Tee beams with trail underneath

Complete Bridge to be built in one construction season

Federal funding for innovative Accelerated Bridge Construction

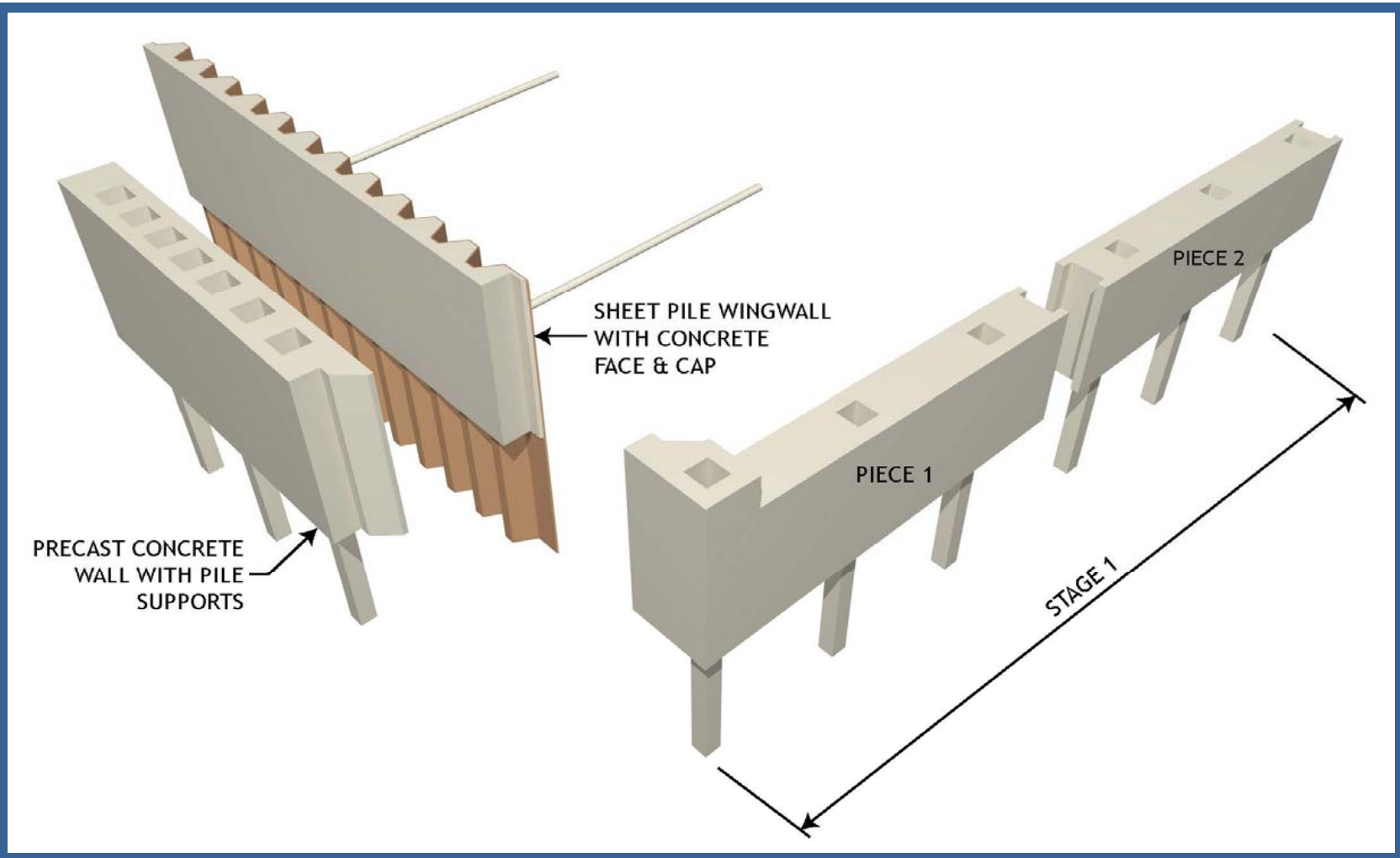
Integral Abutment – height exceeds standards, with Precast sub structure

1. Spilt the deck and modify profiles to reduce the severity of the cross slope and provide adequate clearance for trail underneath
2. Precast Square concrete piles for pile bent pier for aesthetic reason and for noise reduction

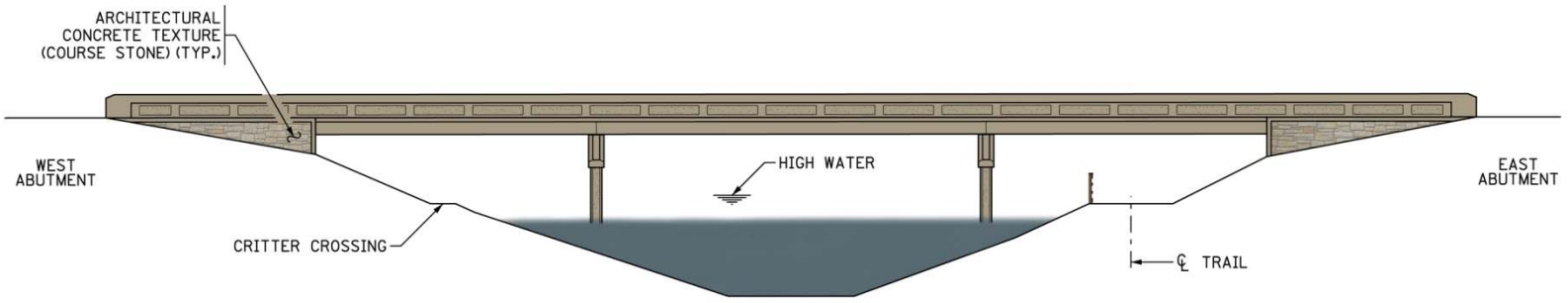
Boardwalk for trail to reduce the extent of retaining walls and minimize impact to wetlands

Concrete walkway under bridge with supports at end to accommodate boardwalk spans

Precast Element Concepts

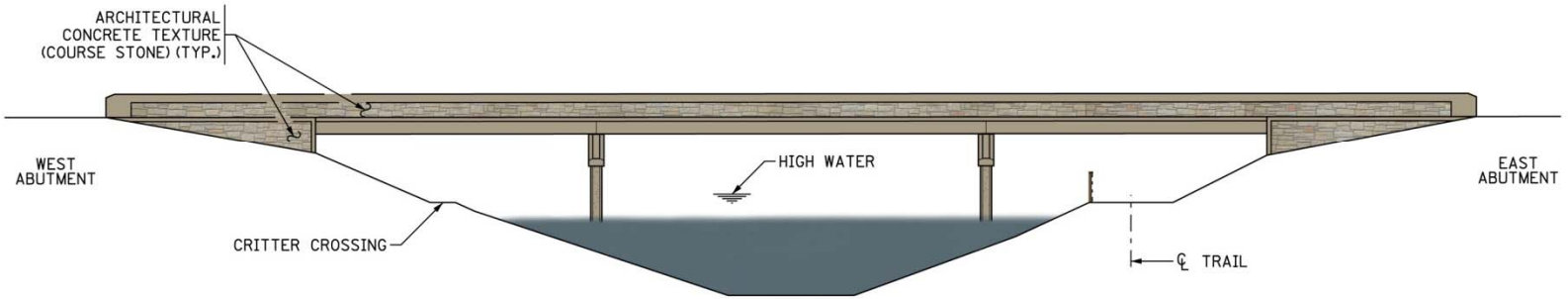


Aesthetics Concepts



CONCEPT 1

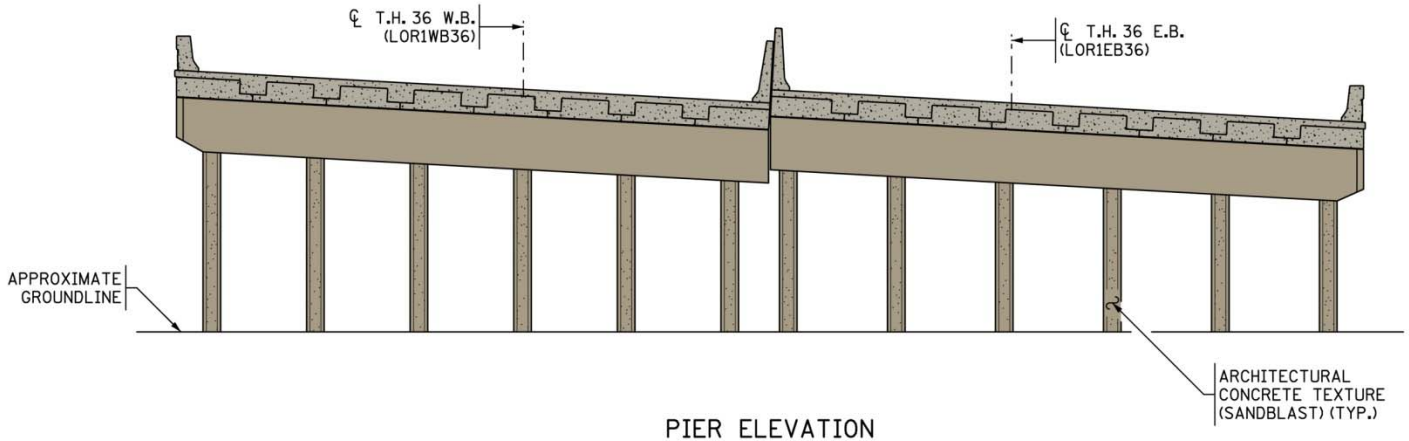
SOUTH ELEVATION



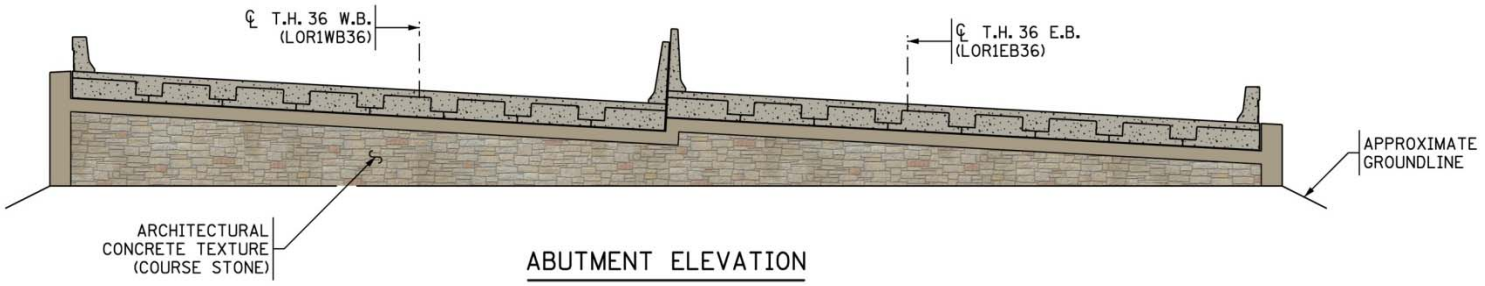
CONCEPT 2

SOUTH ELEVATION

Aesthetics Concepts



PIER ELEVATION



ABUTMENT ELEVATION

Questions